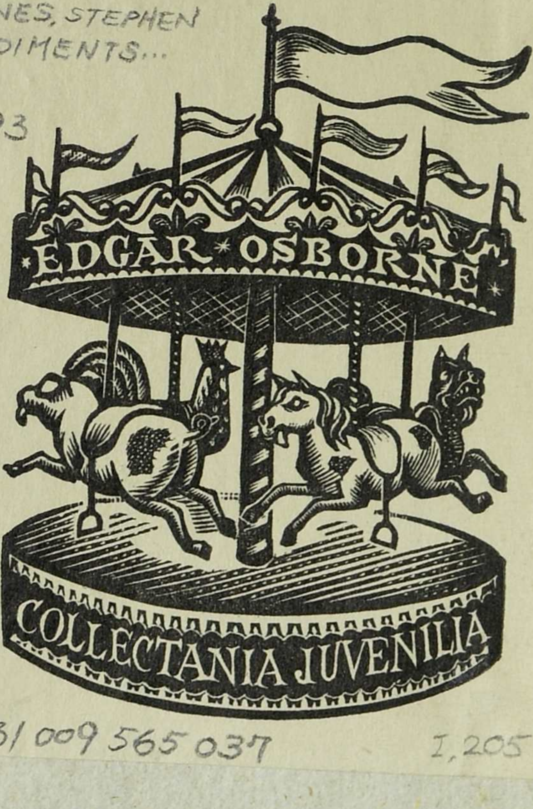
EDGAR OSBORNE
COLLECTANIA JUVENILIA

RUDIMENTS OF REASON:

OR, THE

YOUNG EXPERIMENTAL

PHILOSOPHER:

BEING A SERIES OF

FAMILY CONFERENCES;

IN WHICH THE CAUSES AND EFFECTS

OF THE VARIOUS

PHENOMENA

THAT NATURE DAILY EXHIBITS, ARE
RATIONALLY AND FAMILIARLY
EXPLAINED.

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RUDIMENTS

OF

R E A S O N.

THE SIXTH CONFERENCE.

ON FIRE.

SIR THOMAS.

WE are now, my dear children, about to enter upon a diſcuſſion of the nature, powers, and properties of Fire.

I ſhall, previous to the queſtions of Lady Caroline, lay down ſome definitions, which it is indiſpenſably neceſſary that you be made acquainted with:

1st. Fire is a very subtile body, differing from all others known to man. Considered in its principle, it must be something more than the intestine motion of heated parts, or the actual dissipation of inflamed bodies; for in the natural state, all motion once impressed, slackens at last, and ceases to be perceptible, by being distributed to a greater quantity of matter. Fire, on the contrary, is communicated with increase, a spark becomes a conflagration.

Fire, considered in its principle, is true matter: First, because it has all the most essential attributes of it, such as extension, solidity, &c. Secondly, because it likewise possesses the properties most common to matter, as mobility and gravity. This substance is a being apart from all others, and of which the nature is fixed and unalterable.

2d. Elementary fire should be considered as a fluid, but a fluid which never ceases to exist. It appears, that it is the origin

of

of all fluidity, ſince, by the help of this element, the different parts of bodies are ſtirred up and ſeparated from each other, when they partake of that reſpective mobility which diſtinguiſhes fluids from ſolid bodies.

3d. The matter of fire (which, beſides, is the ſame as that of light) is the moſt ſubtile, the moſt penetrating, and the moſt elaſtic of all matters we are acquainted with. Nothing can reſiſt it, and it reſiſts every thing, except a copious quantity of water. A diamond, that by chance may have dropped into fire, becomes unpoliſhed, its angles are blunted, and it loſes its tranſparency. In fire, likewiſe, all mixed bodies are diſcompoſed.

4th. There is fire every where, and in all things: this element fills the vacuities that are left betwixt the particles of a ſolid or fluid body; and it more or leſs diſtends them, according to the immediate degree of its activity. The ſmalleſt portions of matter, of whatever ſpecies they be, excepting atoms, contain within them a proportional quantity of fire, which cannot get vent, burſt forth, or ſhine, until it ſhall have forced its paſſage through the body that contains it; but which will not take place until it ſhall have received a degree of force ſuperior to the reſiſtance by which it is reſtrained. Now, as parts of matter are, according to their ſpecies, more or leſs difficult to diſunite in a mixed body, which is put into fire, the particles of a certain order will cede to the internal power which tends to diſſipate them; becauſe the degree of fire which actually reigns in the total maſs, is ſufficient to occaſion this effect, while others will reſiſt; not that they likewiſe contain an equal cauſe of diſunion, but only that this cauſe has not received the fire that acts outwardly, ſufficiently intenſe to produce this effect. Thus every thing is inflammable in this ſenſe; ſalt and earth, which make the aſhes of charçoal, and

which

which are almoſt always preſented under the form and colour of grey powder, would aſſume the redneſs of a burning coal, if we applied a degree of fire ſufficient to animate that which is retained in the fixed parts, and which would make its appearance on the ſurface. Even water would become burning, and ſhine like light, if the elementary parts which compoſe its particles, and which we alſo allow to be ſhut up within them, could be diſunited with as much facility as the particles themſelves relinquiſh the maſs in order to evaporate.

5th. Some people think that certain bodies are more inflammable than others, becauſe they contain more material fire; others believe that, this element being equally expanded in all bodies, a matter inflammable differs from another, not becauſe it contains more fire, but only that its own parts are of a nature more eaſily to yield to the action of fire, when excited; becauſe, ſay they, all bodies, when they have been a ſufficient time in one and the ſame place, aſſume the ſame temperature.

6th. There are two principal cauſes that may produce heat in bodies. The firſt is the preſence of the ſun, and the direction of the rays which it emits. Bodies receive, by the preſence of the ſun, a new fire in their pores, ſo much the more, as the incidence of his rays is more perpendicular. The ſecond cauſe which manifeſts fire, is to put it into action, which interrupts the equilibrium to which it tends. In a word, what gives to the parts of fire contained in bodies that motion and appearance which they produce, is their friction one againſt the other. Every method which we have of exciting and extracting fire, is only a modification of this ſecond cauſe, which ſhews itſelf ſo much the more powerfully, as the bodies on which we exert the friction are exactly and cloſely applied to each other.

These

These definitions, preparatory to the questions that Lady Caroline is about to put to you, I am sure must have the proper effect upon your minds. I now, my good children, resign to her the task of examining you.

LADY CAROLINE.

Why, George, is the weight of certain bodies diminished by the action of fire?

GEORGE.

Because the fire dissipates a great number of their parts; for instance, of water, &c.

There are, however, certain bodies whose weight is increased by calcination (burning to a cinder, or to powder); because there are mixed in these bodies heterogeneous particles of the atmosphere.

Iron placed in fire increases in volume; because the fire, insinuating itself into its pores, rarefies and dilates the parts of it.

LADY

LADY CAROLINE.

Whence, Kitty, comes it that the particles of fire which we draw with the ſteel from the flint are ſo very ſmall?

KITTY.

Tempered ſteel, which is very hard, is never impreſſed but with great difficulty.

The ſparks that we perceive when we ſtrike the ſteel, are round; becauſe theſe ſmall bodies which fall from the ſteel have been, for an inſtant or two, in a ſtate of fuſion; and ſuch is the figure of all ſoftened matters that are freely plunged into a fluid, as were theſe ſmall particles of ſteel in the air at the moment of their ſcintillation (ſparkling).

A magnetiſed knife attracts certain particles which we have carefully gathered together and put into a paper, becauſe, being very hard, they have been but ſimply melted.

The knife cannot draw the other particles, becauſe by a more violent degree of fire

they

they have paſſed the ſimple fuſion, and are transformed into droſs.

When we look at theſe ſmall bodies through a microſcope, we find ſome of them vitrified, and others like droſs. This comes from the flint, which is ſtruck in a ſliding manner againſt the ſteel, and does not perhaps attack with an equal degree of force all the particles that it tears off. Theſe particles themſelves are ſome larger than others, and we may ſtill ſuppoſe that the portions of fire which they incloſe are not all equally diſpoſed for action.

LADY CAROLINE.

How can the particles of ſteel in ſo ſhort a time, and apparently by ſo ſlight a cauſe as the ſtriking of the flint againſt it, redden, melt, and become droſs, William?

WILLIAM.

Becauſe the ſteel and the flint contain a very great quantity of inflammable matter; and that the ſtroke, which does not appear very conſiderable to the eye, is immenſe, with relation to the ſmall quantity of matter upon which it acts, and which it ſtrikes off.

LADY CAROLINE.

The bamboo, a ſort of Indian cane, when we rub two pieces of it together, produces fire in the ſame manner as the flint and ſteel. Give me the reaſon of this, Elizabeth.

ELIZABETH.

It is that the friction excites the ſulphur which this body contains in great quantity, and breaks the little incloſures in which it is pent up.

LADY CAROLINE.

How does it happen, Henry, that by applying oil or greaſe to the iron-work of certain machines, we hinder them from taking fire?

HENRY.

Becauſe the pivots of large machines, the axletrees of the wheels of carriages, &c. when we forget to greaſe them, ſet fire by fric-

friction to the wood in which they roll. As the greafe renders the furfaces more fmooth and eafy, they certainly muft experience lefs friction ; the fire, therefore, lefs agitated in its fmall receffes, does not fo eafily quit them. But in furfaces not greafed, the friction always acts more ftrongly upon the fire, and brings it forth, after having made its way through the obftacles that reftrained it : hence, but for this precaution, the machines would be deftroyed by it.

LADY CAROLINE.

The chifel with which cold iron, or any other hard metal, is cut, becomes in time fo hot, that thofe who ufe it are obliged to plunge it frequently into cold water to preferve its temper. Why fo, Fanny ?

FANNY.

The chifel is ftrongly preffed betwixt the two parts that it divides, which preffure is equivalent to the ftrokes of the hammer that the chifel receives on the two extremities of its edge.

All tools that are uſed for turning or perforating cold metals, burn the fingers of thoſe who heedleſsly touch them; for in this caſe they experience great friction. The particles of fire are put in motion in their minute retreats, through which they burſt and gain their liberty.

LADY CAROLINE.

Horſe-ſhoes, and the iron which girds the wheels of carriages, very often, by ſliding, ſtrike fire from the ſtones of the ſtreet. This does not happen when a piece of ſoft iron is ſtruck againſt a flint. What is the reaſon of this, Mary?

MARY.

In this laſt caſe the friction is not ſo rough, nor the ſliding of which you have ſpoken ſo continual. The particles of iron ſtruck off by the edge of the ſtone, are plainly too large to produce fire by the degree of heat which this friction excites.

A peaſant who has nails upon the ſoles of his ſhoes ſeldom ſtrikes fire like the horſe,

although

although he ſhould ſlip and ſlide as much as that animal, becauſe the friction is not ſo conſiderable.

As it is not, however, impoſſible for ſoft iron to produce ill conſequences, we act very prudently in removing, as we do, mills and magazines of powder as far as we can from every thing that might occaſion fire, as the ſofteſt kind of iron, when ſtruck againſt ſtreet ſtones, gravel, &c. would do.

LADY CAROLINE.

How, Edward, is the heat produced in a ball thrown from a cannon?

EDWARD.

By the fire which communicates the powder to the ball, from its friction againſt the ſides of the cannon, and from its ſhock upon the ſtones or the ground on which it falls, and not from the friction of the air, ſince the moſt violent winds never heat any kinds of bodies.

LADY CAROLINE.

According to ſome authors, the friction of branches of trees, in foreſts, againſt each other, frequently occaſion their taking fire when agitated by the wind, and which may be urged on by other circumſtances. Account for this if you can, Sophia.

SOPHIA.

If it be true, Madam, I ſhould imagine that the friction of the branches excites the fire of the vegetative bodies, of which a great portion of the ſubſtance is inflammable.

LADY CAROLINE.

You are very right, Sophia, nor can this happen in any other manner.

The degree of heat, Frederic, acquired by corn in grinding, is ſometimes ſo intenſe as to burn it. How does this happen?

FREDERIC.

The mill-ſtones either turn with too great velocity, or have not ſufficient room to play;

play; whichever it be, the motion, too rapid or too ſtrong ſimply to diſunite the parts of the grains themſelves, communicates even to the fire with which they are impregnated: and this cauſes burning.

LADY CAROLINE.

When a perſon ſlips down from any height by a rope which he cloſely holds betwixt his hands, why, George, does he experience a friction that burns the ſkin off and raiſes bliſters upon it, in the ſame manner as when we touch a too hot ſubſtance?

GEORGE.

Becauſe the rope, by the ſucceſſive aſperities of its ſurface, agitates the parts of the hand which are applied to it, and the fire which theſe parts contain, irritated by the cloſe and rapid friction, burſts out and produces this effect.

LADY CAROLINE.

When a perſon is agitated, or walks too

long, and with too much ſpeed, why, Kitty, does he feel very much fatigued?

KITTY.

Becauſe then the limbs of the body have reſpective motions, which reciprocally act one againſt the other, and give a kind of heat which exceeds that of the natural ſtate of the body; and this heat is accompanied or followed by the ſenſation of wearineſs.

LADY CAROLINE.

Friction, William, has leſs effect upon fluids than upon ſolids. What is the reaſon of this?

WILLIAM.

The particles of fluids being moveable, eſcape from the friction which is neceſſary to put in action the fire contained in their pores.

LADY CAROLINE.

Why, Elizabeth, does the mixture of two different fermenting bodies become hot?

ELIZA-

ELIZABETH.

Becaufe the parts of the two bodies ftrike againft each other, rub, penetrate, and drive forth the fire contained in their fmall pores.

Thus when we rapidly pour three ounces of fpirits of wine upon a fimilar quantity of water, the mixture becomes heated ; becaufe the fmall particles of water are carried with force into the fmall maffes of the rarefied fpirits of wine, which are fpongious and fit for being divided, diffolved, and extended in a liquor adapted to penetrate them. There is made a diffolution of fpirits of wine by water, fimilar to an exact fermentation. The fhock, the friction, the difunion of the parts which held the fire inclofed betwixt them, fet it at liberty and produce the heat.

We fee in this mixture bubbles of air that interrupt its tranfparency. Thefe bubbles, which were lodged in the pores of the refpective liquors, are driven out by the mutual penetration of the two maſſes. Dilated afterwards by the new degree of heat which reſults from them, they riſe to the ſurface on account of their reſpective lightneſs.

LADY CAROLINE.

I have here, my dear children, an apparatus with which I am about to make an experiment.

You obſerve here are three-eighths of an ounce of new oil of terebinth, which I put into this large glaſs. I pour on it, at two or three different intervals, as you may obſerve, one-eighth of an ounce of good ſpirit of nitre, and as much oil of vitriol concentered.

You now perceive a very thick ſmoke, from which a flame iſſues to the height of ſixteen or eighteen inches.

The vapours now having ſpread themſelves, we ſmell a great fragrance, which, as the vapours diſſipate, becomes more pleaſant,

ſant, as you muſt all experience. Explain theſe effects to me, Henry.

HENRY.

The eſſential oils of plants are very inflammable liquors, which chemiſts look upon as a large quantity of ſulphur, extended through a ſmall portion of phlegm. The particles of fire which are contained there, as in other ſubſtances, are only enveloped and confined by the other bodies which contain more of them, and which retain them only in as much as it is neceſſary to animate their action. When a very ſharp acid predominates in theſe oils, and when it penetrates them on all parts with precipitation, all the ſmall portions of fire irritate, if I may uſe the expreſſion, by friction, and diſengage themſelves from the boundaries which confined them before this diſſolution; they then get their liberty, and burſt out through every part. The moſt ſubtile parts of the mixture diſſipate in flame; the more groſs parts exhale in fume,

fume, which laſt produces the aromatic odour that ſo pleaſantly regales our ſenſe of ſmelling.

We know that vinegar diſſolves coral, becauſe its acids, penetrating the pores of the coral, invade, break, and ſeparate the parts.

But this kind of diſſolution is not ſenſibly heated, becauſe the particles of coral contain but little ſulphur, and likewiſe make but ſmall reſiſtance to the action of the acids; conſequently there is ſcarcely any agitation.

LADY CAROLINE.

When we pour ſpirits of nitre over mercury, why do they produce an effervescence, an ebullition, and a ſenſible heat. Can you tell me, Fanny?

FANNY.

Becauſe the acids of the ſpirits of nitre are introduced with vigour into the pores of the mercury, ſtrike violently againſt the ſides of the veſſel, and expel the particles of fire.

LADY CAROLINE.

A mixture of volatile ſpirits of ſal-ammoniac with ſpirits of wine, ſpirits of vitriol, and the oil of tartar, unite by coagulation. What cauſe, Mary, produces this effect?

MARY.

The acids blunted or abſorbed in the alkali, form with it little particles which interrupt the motion of liquidity.

LADY CAROLINE.

Why, Edward, do we feel heat on our ſkin when we rub it with the ſpirits of wine, or with any other liquid in which they are mixed?

EDWARD.

Becauſe the particles of tranſpiration partake very much of the nature of water, or that of urine, which, mixed with ſpirits of wine, produce in either caſe a very ſenſible heat.

LADY

LADY CAROLINE.

Pure ſpring water never ferments, Sophia; how does this happen?

SOPHIA.

All its parts are homogeneous, and after a conſiderable evaporation, that which remains in the veſſel is an aſſemblage of parts, certainly leſs in number, but exactly ſimilar to thoſe which have evaporated.

Water ſometimes corrupts, becauſe then it is not pure, but contains a matter foreign to it, which adulterates and diſcompoſes it when the parts are ſtirred up by fermentation.

LADY CAROLINE.

In a corrupt, muddy, and ſtagnant water, Frederic, we often ſee many inſects. Why ſo?

FREDERIC.

Becauſe the fermentation made by the heterogeneous particles in the water, gives heat ſufficient to hatch the eggs of theſe different

different animals which the air has conveyed thither.

LADY CAROLINE.

Why, George, does ſtraw become dung?

GEORGE.

Becauſe it putrefies and ferments with excrements of horſes, of cows, and of other animals. There riſes a heat in the dunghill; the parts which mutually diſagree, are at laſt diſcompoſed, and form another body.

LADY CAROLINE.

Whence, Kitty, proceeds that little wandering meteor, called *Will with a Wiſp*?

KITTY.

It is a ſmall cloud of inflamed exhalations, or perhaps a ſmall maſs of phoſphorus, which is the ſport of the winds, and which continues to ſhine until the matter that furniſhes inflammation be entirely conſumed, or that the light that glimmers at a diſtance be extinct.

This

This little meteor is very frequently ſeen in church-yards, in moraſſes, and in other ſoils that are of a flat and ſulphureous nature, becauſe from ſuch places there ariſe many exhalations.

Theſe fires hover before thoſe who purſue them, becauſe, as the perſon advances, he puſhes the air which conducts them onwards. They purſue the perſon who flies from them, becauſe the air which carries them on, ſeizes the ſpot which the perſon quits at every inſtant.

LADY CAROLINE.

How, Kitty, are thoſe meteors produced which we call *flitting* or *falling ſtars?*

KITTY.

By trains, or rather by ſmall clouds which kindle inflammable vapours, and of which the light takes a certain direction, and a certain degree of vivacity, according to the poſition and nature of the ſubſtance that produces the light. Theſe different bodies

being

being inflamed, their fermentation creates a light, which becomes viſible under the form in which we ſee them.

LADY CAROLINE.

To what muſt we attribute thoſe little meteors or lights, which, when the wind is tempeſtuous, we ſee clinging to the cordage, maſts, and yards of ſhips, &c. where two, three, or a greater number are frequently ſeen at once? Can you tell me, William?

WILLIAM.

I have heard Sir Thomas ſay, that well-experienced maſters of ſhips have informed him that this phenomenon is very common; that theſe luminous bodies are called Caſtor and Pollux, and are found to be nothing but a ſmall kind of fiſh, ſlimy, ropy, and glaring, which are thrown up by the waves at the ſame time as the froth of the ſea, and ſcattered here and there on different parts of the ſhip.

This, Madam, I think may very well

happen, ſince many ſorts of fiſh, and mackerel in particular, when placed in the dark, give a clear and ſhining light, ſimilar to that of phoſphorus.

LADY CAROLINE.

Your idea, William, is apt and ingenious, and with it I entirely agree.

Can you, Elizabeth, explain to me the nature and ſubſtance of thunder ?

ELIZABETH.

It is a mixture of exhalations, ſubject to inflammation by fermentation, or through the ſhock and preſſure of the clouds, which the winds agitate and violently impel againſt each other.

When a conſiderable number of theſe bodies take fire, an exploſion inſtantly follows, more ſtrong or more weak according to the quantity or nature of the inflamed ſubſtance, and in proportion to the greater or leſſer obſtacles that oppoſe their ſudden expanſion.

If the inflammation conſiſt but of a ſmall quan-

quantity of matter, and is confined to the ſurface of the cloud, this effect will take place without any noiſe, at leaſt without any that can reach our ſenſe of hearing; the reſult being only a ſudden flaſh of light, nearly like that of a quantity of powder when ſet on fire, and which we ſee blown up from afar, wholly free and unconfined. It is called lightning, and in this inſtance flaſhes without any noiſe.

LADY CAROLINE.

What do you underſtand, Henry, by the thunderbolt?

HENRY.

It is an inflamed vapour which burſts the cloud, ſometimes at the top, ſometimes at the bottom, or on its ſide, then darts with a velocity proportioned to its exploſion; as the powder which is inflamed in a bomb directs its action, and diſcharges its contents, againſt every thing that ſurrounds the ſpot on which it falls. At every clap of thunder, the bolt iſſues forth, which is always preceded by lightning; but it only ſtrikes terreſtrial objects when it flows in a direction that leads to them.

LADY CAROLINE.

Whence, George, comes the bolt, which deſcends with inexpreſſible velocity, inflames, melts, and conſumes every thing it touches?

GEORGE.

It is the effect of a violent exploſion and of a fire which ſurpaſſes all the ideas of man. The matter of the bolt, always of the ſame nature with that of lightning, differs from it only by being driven from the cloud before it makes its exploſion.

Thunder is very uncommon in Egypt and Ethiopia, becauſe in thoſe countries the earth is entirely free from ſulphureous particles; now we know that thunder is compoſed of different exhalations, but, above all, of thoſe of ſulphur.

Both men and animals periſh by the ſtroke of a bolt, without leaving one trace

of

of the cauſe of their deaths, or any mark by which it may be known how they have loſt their lives : this may proceed from the vapour of the fiery ſulphur, which is to animals of every kind, when large enough in quantity, a moſt inſtantaneous poiſon. We likewiſe believe, that when the bolt burſts forth, the air of that place at the ſame time ceaſes its elaſticity. Animals then finding themſelves in a void, die in the ſame manner as they would were they ſhut up in the recipient of an air-pump.

When it thunders, certain fluids ceaſe to ferment, ſuch as wine, beer, &c. whilſt others, which were not agitated before, begin to ferment ; the reaſon of this is, becauſe the motion that the thunder bolt produces, diſturbs and deranges that fermentation which the parts of the fluid had before the ſtorm, and makes it ceaſe ; on the contrary, of thoſe fluids which did not previouſly ferment, the parts begin to move, to be agitated, and to ferment.

Milk, cream, &c. very often coagulate in dairies, and even beer itſelf is ſpoiled, as ſoon as it has thundered, becauſe the turmoil excited in the air agitates ſo forcibly theſe bodies, that they can neither ſeparate nor fall to the bottom, which laſt is abſolutely neceſſary to the milk, in order that the cream may riſe.

The rain that falls during thunder, is more fertile than any other, becauſe it is loaded with ſulphureous, oleaginous, and ſaline exhalations, which greatly contribute to the vegetation of the fruits of the earth.

SIR THOMAS.

Your rational account, George, of a very difficult phenomen, gratifies me very much; but before we quit this ſubject, I have a few obſervations to make.

In the firſt place, if between the lightning and the exploſion, the pulſe beat ſix times, the bolt is about ſix thouſand feet diſtant.

In

In the ſecond place, if it beat five times, the bolt is five thouſand feet diſtant. In the third place, if it beat four times, it is four thouſand feet diſtant, and ſo on. For the ſound which comes ſucceſſively, and from the place where the thunder is, departs at the ſame time as the lightning; and, according to the moſt accurate experiments, it makes about a thouſand feet during the beat of one pulſation, or in one ſecond of time; if, therefore, the roar immediately follows the lightning, the thunder impends over you, and danger is very near.

LADY CAROLINE.

Why is the clap that follows the lightning uſually ſucceeded by a ſhower of rain? Tell me, Kitty.

KITTY.

The inflammation that cauſes the report, breaks and ſeparates part of the cloud, which then deſcends in rain.

When it rains very violently, it ſcarcely thunders

thunders at all; becaufe the exhalation, if I may fo fpeak, drowns it, or bears away the greateft part of it.

LADY CAROLINE.

When the bolt falls, William, why do we think we fee different fires darting all at once?

WILLIAM.

Becaufe the exhalations iffue from different parts, or the refiftance of the air feparates it.

We fee long ftreams of fire which touch at one and the fame time the earth and the cloud, becaufe the ftrong impreffion which the fiery turmoil makes upon the fight, when it fhoots from the cloud, ftill fubfifts, though it be far removed, and appears to be where it really is not.

Lightning winds in its defcent like the angular foldings or breaks of a filken ftring or a ribbon when fluttering in the wind; becaufe the center of gravity is not in the center of the figure, and the different parts of of the inflamed exhalations do not ſtrike the air with equal forces. This is what makes it ruſh forth in ſerpentine lines.

LADY CAROLINE.

How, Elizabeth, can a perſon make a ſpiral line run round a perpendicular glaſs, ſo that one oblique ſide of the glaſs may be taken from the other oblique ſide? that is, it ſeparates wherever this line has been drawn. How, I ſay, is this performed?

ELIZABETH.

I really, Madam, do not know.

LADY CAROLINE.

I will then explain both the experiment and the cauſe; to which, my dear children, you will all of you attend.

I have here an exact cylindrical tumbler, on which Sir Thomas has been ſo good as to draw from a point in the rim, a ſpiral line round the circumference of the glaſs to the bottom, with Indian ink. I now take this pointed common match, and dip it into a ſmall earthen veſſel of melted ſulphur,

about

about an inch above the point. The match, now dry, I put gently to the ſurface of this lighted candle, but avoid, as you muſt obſerve, putting it to the top of it, leſt the vapour touch it, which would ſpoil the experiment. I have, as you may ſee, faſtened the glaſs firmly to the table. I now light the match, and place it exactly upon the part of the rim where the ſpiral line commences. You now ſee that it uniformly keeps the ſame burning, and how ſteady my hand goes with it over the line, till I now come to the bottom of the glaſs, which I ſhall allow to ſtand for a few minutes, till the ſulphur may have thoroughly penetrated the line.

Now I take the glaſs gently by the top and the bottom, and you ſee how eaſily it comes aſunder in the very parts where the line has been deſcribed.

You cannot but be pleaſed, my dears, with this part of the experiment: I will

now

now perform the other part of it, which is that of again uniting the glafs.

I place the two divifions of the glafs together, exactly as they were before their difunion, and prefs them lightly. I take this cup of wine and pour it into the glafs, and not one drop will run through it, fo very clofely has it again joined itfelf.

Why, Henry, does the heat caufe the liquid in the thermometer to afcend?

HENRY.

It dilates the liquors, which confift, in one tube, of mercury, in the other, of fpirits of wine; as, on the contrary, the cold which condenfes them makes them defcend.

After a cold wind has made thefe liquids defcend, by their being expofed to the open air, if we cover the tubes with fnow, they re-afcend, becaufe the fnow is lefs cold than the wind.

LADY CAROLINE.

I divide this walnut fhell, Fanny, exactly

actly in two, in which I place a six-pence, and a mixture, consisting three parts of nitre, or fine salt-petre, well pulverised, and dried upon a fire shovel, which I make hot on the fire; to which I add two parts of flour of sulphur, and as much raspings of touchwood. To this preparation you see I set fire, the six-pence melts into a fine white liquid, and the half shell of the walnut is just as it was before I placed it with the ingredients upon the fire shovel. Explain all this.

FANNY.

The action of the fire is only of short duration, but has time to penetrate and melt the six-pence, which is attacked at the same time in all its parts; for I observed that you placed the money in the middle of the mixture. With respect to the half shell, the fire has only had time to act upon the internal surface, which it has a little singed. The great porosity of the half shell made the passage of the fire so free

to

to it, that it diſſipated without ſetting fire to any of its parts.

LADY CAROLINE.

Why, Mary, when we put a lighted candle into the ſmoke of one which has juſt been extinguiſhed, does it light again without the wick having touched the flame of the lighted one?

MARY.

The fire of the lighted candle gives to the particles of the greaſy vapour of the ſmoking candle, a ſmall degree of fire, which immediately re-lights it. For ſmoke differs from flame only in as much as it has leſs heat than the latter.

LADY CAROLINE.

Butter, and other fat or greaſy ſubſtances, Edward, that are melted in kitchens, boil very quick and with a great deal of noiſe. How does this happen?

EDWARD.

Becauſe theſe kinds of ſubſtances are almoſt always mixed with particles of water, or with the juice of certain herbs; and as ſoon as they have attained a certain degree of heat, the humidity which they incloſe is converted into dilated vapour, and forms a great number of ſmall bubbles, which produces that crackling noiſe that your Ladyſhip alludes to.

LADY CAROLINE.

When we put the flame of a large lighted candle into a thin glaſs tube of about ſeven or eight-twelfths of an inch diameter, and about four inches long, we immediately ſee it lengthen and extend itſelf very conſiderably, having almoſt as much volume at the top as at the bottom. What is the reaſon of this, Sophia?

SOPHIA.

It keeps its heat better in this tube, which heats itſelf, and like the air that continually renews itſelf, the inflamed particles remain longer in this ſituation.

LADY CAROLINE.

Whence, Frederic, proceed all thoſe colours which we obſerve in faggots and bundles of wood, when ſet on fire?

FREDERIC.

The colours of flames vary according to the different ſubſtances which we burn. Pure ſpirits of wine, and in general thoſe which we extract from all vegetables, give a clear white lambent flame; thoſe of oil and other greaſy ſubſtances give a bright jonquil, and thoſe of ſulphur blue. When we ſet fire to a body containing all theſe, the flame that riſes from it has more or leſs of all theſe hues, and beſides has mixed with it black, which proceeds from the ſmoke and vapour.

LADY CAROLINE.

Is there nothing, George, but active air that can animate fire?

Would not any other fluid which was not too denſe, or a vapour that flowed with great rapidity, do the ſame?

GEORGE.

Yes; for if we put the flame of a flambeau, or a large lighted piece of coal, to the pointed end of an eolipile, in which we have made water boil, the vapour that iſſues from it has all the effect of a pair of bellows. We cannot attribute this to the vapour containing any *air*, ſince it has been perfectly driven from it by the fire that heated the water.

LADY CAROLINE.

Why, Kitty, do we experience great warmth in cellars, caves, &c. during winter, and in ſummer quite the contrary.

KITTY.

They only appear ſo to us, by the difference that there is betwixt their temperature, which is always nearly the ſame, and that of the air we leave when we enter into theſe ſubterraneous places. Common experience obviouſly proves this: for if we have one hand very hot and the other very cold, and we plunge firſt one and then the other into a pail of cold ſpring water; this water will, without doubt, feel very warm to the cold hand, but extremely cold to the warm one.

LADY CAROLINE.

Your judicious illuſtration, Kitty, of the foregoing queſtion does you honour.

Having rubbed our hands with the juice of onions, William, we may dip them into melted lead, and handle red hot coals, without the leaſt danger of burning them. Can you explain this?

WILLIAM.

The juice, which covers the main ſkin, and fills the pores of the ſurface of the hand, hinders theſe burning ſubſtances from ſeizing and ſpreading upon the hands. Inſtead of this, however, we may uſe an equal mixture of ſpirits of ſulphur, of ſal-ammoniac, eſſence of roſemary, and juice of onions; by which we may be enabled to hold red-hot iron in our hands without burning them, to the great aſtoniſhment of all who behold us, and who are unacquainted with the means by which we effect it.

LADY CAROLINE.

Why, Elizabeth, do we feel ſo much refreſhed by cold bathing?

ELIZABETH.

Becauſe the agitation of the blood, of the ſpirits, and of the inſenſible parts of the body, communicate to thoſe of the water, which, being more cold than our bodies, receives the exceſs of heat which their different parts communicate to them.

LADY CAROLINE.

Why, Henry, do frozen fruits and vegetables reſume their former ſtate on being put into cold water in a warm place?

HENRY.

Becauſe the cold water gives to their particles a moderate agitation, and the fibres of them nearly taking their firſt ſituation, receive no damage.

Theſe ſame fruits would ſpoil were they

placed near the fire, becaufe it would melt their frozen juices too quickly, and at the fame time would break and alter the fibres, and thereby render the fruits infipid.

LADY CAROLINE.

How does it happen, Frederic, that when I take a leaden bullet, and wrap fmoothly round it a piece of paper, and hold it with thefe fmall tea-tongs over the lighted candles, the lead melts, and falls drop by drop through a little hole that it has made, without burning the reft of the paper?

FREDERIC.

It is owing to the action of the fire, which paffing freely through the large interftices of the paper, with which it always abounds, does not burn it; but finding refiftance in the clofe particles of the lead, it infinuates itfelf amongft them, and melts it, while the paper remains juft as it was.

LADY CAROLINE.

Can you tell me, Edward, the cauſe of earthquakes?

EDWARD.

The inflamed matter, prodigiouſly rarefied in deep caverns, not being able to make a free iſſue, quakes and raiſes the superimpending regions: like a mine, which, when the powder of it is ſet on fire, ſtruggles for vent, and when it gains it, blows up the earth that it was covered by, with terraces, ramparts, towers, and citadels.

Earthquakes, Madam, are frequently accompanied by formidable fires. I recollect Sir Thomas having read to us, that in the year 1677, an earthquake was univerſally felt through the whole of the Canary iſlands; and that there were ſeen torrents of ſtones and fire iſſuing from the boſom of the earth in the midſt of loud thunder, which rebounded through every iſland.

LADY CAROLINE.

Your account, Edward, is at once rational and true.

How does it happen, Henry, that the water in wells ſometimes becomes ſuddenly troubled, ſulphureous, and of a bad taſte? Whence alſo come ſubterraneous roarings, and the ſudden elevation of billows in the ocean, at a time when perhaps the weather is ſerene, and the heavens tranquil?

HENRY.

Theſe are commonly the effects of ſubterraneous fires, and conſequently dreadful ſigns, as threatening the neighbouring parts with an earthquake.

LADY CAROLINE.

New iſlands have been frequently known to appear ſuddenly. How, Sophia, is this cauſed?

SOPHIA.

The ſubterranean fires dilate, ſwell, and heave up the earth at the bottom of the ſea, and ſometimes divide upwards of three hundred

hundred and ſixty feet of water: the earth thus raiſed forms one or more iſlands.

LADY CAROLINE.

Why, George, are ſome lakes frozen even in the greateſt heats f ſummer?

GEORGE.

Becauſe they are ſituated in places that contain great quantities of nitre and ſalt-petre, which freeze the water, and of courſe hinder the melting of the ice.

LADY CAROLINE.

A *bougie*, or candle, when we turn their lighted ends downward, or when we plunge them into inflammable liquors, are extinguiſhed; and green wood, ſlightly ſet fire to, if the burning be not kept up by other wood that is more dry, likewiſe goes out. What is the reaſon of this, Mary?

MARY.

The fire in either caſe does not want for aliment; but in the firſt, this aliment has not ſufficient time to heat, and in the ſe-

cond

cond it cannot on account of the humidity which it contains.

LADY CAROLINE.

Why has the flame of a candle more diameter than the cotton? Tell me, Elizabeth.

ELIZABETH.

Becaufe the fire pufhes out the particles of tallow which are compofed of oil, water, air, falt, and *caput mortuum*. Thefe bodies dilated by the heat muft of neceffity occupy more fpace.

LADY CAROLINE.

What occafions the bubbling of boiling water, Kitty?

KITTY.

We may attribute the firft bubbles to the air, which, dilated by the fire in the pores of the water, rifes into bubbles and lifts up the aqueous particles: but as there is not a fufficient quantity of air in the water to produce all thofe bubbles which we perceive in it when it boils, even to drynefs, one

fhould

ſhould think that the veſſel receiving by the place which the fire touches, more heat than the water can ſupport while it is in the ſtate of a fluid; the firſt layer which is applied to this too hot part of the veſſel, is converted into vapour; and that many ſimilar portions of vapour, dilated by the force of the fire which penetrates the veſſel, roughly puſh forth the maſs which on all ſides environs their parts, and by their lightneſs gain the ſurface, where they diſſipate.

LADY CAROLINE.

Why, Mary, does fire always aſcend?

MARY.

Becauſe it is ſpecifically lighter than the air.

LADY CAROLINE.

Why, Frederic, does a ſquib always mount upwards?

FREDERIC.

Becauſe as the action of the powder towards the breach of a gun or cannon, makes it recoil, ſo in the ſame manner the aſtion of the powder which puſhes the ſquib upwards, finding no vent in the upper part of it, makes it recoil and mount.

LADY CAROLINE.

How does an artiſt, Henry, when he pleaſes, ſend off a ſquib parallel to the horizon, and make it return on its own track ?

HENRY.

By placing a ſmall wheel, and a like plane of wood, in the middle of the cartridge, of which the two extremities are open. Near the wheel, the artiſt makes a hole that goes in to a little channel which is terminated at one end of the ſquib. At one end, he fills with the uſual mixture the half of the cartridge up to the wheel; at the other end, he fills in the ſame manner the other half. He then ties to the ſquib thus charged, a couple of iron rings, or rather a wooden tube, through which he paſſes a rope ſtretched horizontally; he then ſets fire to it at the firſt end. The powder inflamed, puſhes the ſquib towards its other extremity which reſiſts: the ſquib darts up like thoſe that mount; and the horizontal cord directs it parallel to the horizon: the powder being conſumed up to the wheel, or to the little plane of wood, the fire penetrates through the ſmall channel to the other end, which now takes fire. The action of the inflamed ſubſtance is felt againſt the wheel, which reſiſts; the ſquib recoils, and returns rapidly the very ſame way that it ſet off.

By this ſecret we may make fly artificial birds, pigeons, and even angels.

LADY CAROLINE.

When we give vent to a mine of powder, Edward, why is the effect of the fire loſt?

EDWARD.

Becauſe as bodies in motion follow the direction where they find the leaſt impediment, the powder ſet on fire in the mine that has vent, exhales in part through the free iſſue that it finds. The more it exhales, the leſs effort it makes againſt the vault and the ſolid parts of the mine.

LADY

LADY CAROLINE.

How, Fanny, is the tallow of a lighted candle conveyed to the flame which is above it?

FANNY.

1ſt. Becauſe the threads of cotton which form the wick, and which are twiſted, perform the office of capillary tubes, or of a ſponge.

2d. Becauſe the *air* being extremely rarefied by the fire in the ſuperior part of the wick, the preſſure of it downwards may very well cauſe the melted particles of tallow to mount up to the fire.

LADY CAROLINE.

How, Mary, does the thunderbolt melt a ſword in its ſheath, and leave the ſheath untouched?

MARY.

The fire finding a free paſſage in the pores of the ſheath which the ſteel of the ſword denies it, aims all its effort againſt this laſt, and leaves the ſheath unhurt.

We may ſay the ſame thing of a ſilver watch melted in the fob, which takes place very often without doing any harm to the perſon. We frequently ſee ſalts make no impreſſion upon ſoft ſubſtances, while they will diſſolve the moſt hard. Thus ſpirits of nitre diſſolve neither wood nor wax, and yet change iron into a ſpecies of liquid.

Thus alſo the bolt abſorbs wine without perforating the veſſel; becauſe the light and ſubtile exhalations penetrate into it through the pores of the caſk, which give a free paſſage, and as the wine heats, it imperceptibly exhales through the pores of the veſſel.

LADY CAROLINE.

Why, Frederic, do glaſs veſſels of every kind break when we too ſuddenly pour boiling water into them?

FREDERIC.

The igneous parts exerting every effort to penetrate it, ſtrongly dilate its external

ſurface

furface before that within can be proportionally extended, and this occafions a folution of continuity.

LADY CAROLINE.

Fire, Elizabeth, inftead of dilating certain bodies, condenfes them ; fuch as the dirt of the ftreets, clay, bones, &c. How happens this ?

ELIZABETH.

It diffipates many particles which render them more foft, as thofe of the water, &c.

LADY CAROLINE.

Why, Kitty, do liquids dilate by heat ?

KITTY.

Becaufe the fire penetrates, difunites, and raifes the particles of the liquid mafs.

LADY CAROLINE.

Why are the chords of the harpfichord deranged, when the temperature of the place where it ftands in a certain degree varies ? Tell me, George.

GEORGE.

Becauſe the chord of a harpſichord, which lengthens by heat, conſequently becomes leſs tight than it was, if the fixed points by which it holds do not remove from each other in proportion to that lengthening; and a ſonorous chord, allowing every thing elſe to be equal, is of a more acute tone according to its degree of tenſion. Thus, the chords of this inſtrument, partly iron, and partly copper, differently lengthen betwixt themſelves, in the ſame degree of heat, and all of them much more than the wood of which the body of it is made, and upon which the pegs and bridges are faſtened.

In the ſame manner all ſolid bodies, ſuch as marble, ſtone, brick, glaſs, metal, the bark of vegetables, bones, leather, and the horns of animals, diamonds, inſtruments of every kind, furniture, wainſcots, and buildings, all dilate by heat and condenſe by cold.

LADY CAROLINE.

Why does a thunderbolt attack men lefs frequently than higher objects, fuch as trees, the tops of mountains and towers? Tell me, Edward.

EDWARD.

Bodies more elevated may fplit the bafis of the cloud, or force the wind by contracting its channel to carry off the cloud; and by fo doing, facilitate the fall of the exhalation upon them. Such exhalation may ftrike them, but for want of fupply would diffipate before they reached us.

Sometimes when a bolt would fall upon us, a reflected wind makes it fly over our heads, and carries it up to the tops of trees, mountains, and towers.

LADY CAROLINE.

Why, Mary, do farmers take care to dry hay well before they houfe it?

MARY.

Becaufe by this precaution the moft volatile parts of the plants exhale, and pro-

duce

duce no fermentation. When farmers neglect drying it, it acquires a bad taſte, and is heated, ſometimes ſo much as to take fire, which often cauſes very dreadful conflagrations.

SEVENTH

THE SEVENTH CONFERENCE.

ON WATER.

SIR THOMAS.

WATER is a humid fluid, without taste or smell, and generally extinguishes fire when this last is not too powerful for it.

Natural philosophers differ very much upon the subject of the formation of ice. According to Descartes, the defect or diminution of the motion of water is the cause of congelation; and repose alone is sufficient to unite the parts of it so as to form a hard body.

Rohault, and most of the Carthesians are nearly of opinion with Descartes. They believed that it is the motion of subtile matter that makes water liquid, and that the

the defect or diminution of motion converts it into ice.

Claudius Perrault, doctor of physic, contended, that bodies become liquid through the interposition of certain volatile parts, which he calls common corpuscula, which flow and pass through them; and that when a cessation of this flowing takes place, these bodies are no longer liquids. They harden by reason of the weight of the subtile portion of air compressed in the grosser particles of them, applied one against the other.

According to the system of Jean Baptiste Duhamel, the only difference betwixt water and ice is, that the particles of the first are agitated by a very subtile matter, and that those of the latter remain immoveable, and rest one upon the other.

The hypothesis of Hartsoeker is, that water is changed into ice by the absence of fire, and that it again becomes water on its return.

According to the celebrated Boerhaave, water is never without fire, and that in a very great quantity. If fire diminiſh in the thermometer only to the thirty-ſecond degree, the water becomes ice. Water, then, in its natural ſtate, is only a ſpecies of glaſs, which is melted by the thirty-third degree of heat, and again frozen by a very little greater degree of cold.

The illuſtrious Graveſand has recourſe to attraction, to explain the formation of ice: "Water," ſays he, "is only melted "ice; and it is liquefied by heat, which "naturally changes ſolids into fluid bodies." If water be deſtitute of the fire which dilates it, its particles re-unite, drawing themſelves to each other, and are transformed into ice. If ice be penetrated by fire, its particles acquire a repulſive force; they then move, ſeparate themſelves from each other, and become a perfect fluid; that is, water.

A ſtrange ſubſtance is introduced by Muſſchenbroek for the formation of ice. The want of fire, the repoſe of the parts, even attraction itſelf, which he, beſides, admits of, are not ſufficient in his opinion to turn water into ice. There is in the air, as he pretends, certain frigorific particles, which inſinuating into the water, make it change into ice. If it freeze very hard, the reaſon is, that the air is full of theſe particles; if but little, there are only few of them in the atmoſphere. It freezes often without being cold, and frequently produces great cold without freezing. When we demand of this philoſopher, what theſe frigorific particles may be, he fairly owns that he does not yet know them, but that they may be known ſome time or other.

By the help of certain principles founded upon the nature and properties of bodies which change into ice, De Mairan has undertaken to explain how, and by what mechan-

mechanifm fuch a change is brought about.

"Would you," fays he, "make ice, "that is, change a liquid body, fuch as "water, into a folid body, drive out a part "of the fubtile matter which flows betwixt "its interftices; diminifh its motion, or "weaken its fpring in fuch a manner that it "may no longer overcome the refiftance of "the integrant parts of the liquid, by all "of which cold is produced, and you will "have ice.

"On the contrary," continues he, "would you change a very hard body, fuch "as glafs, bronze, &c. into a liquid body, "introduce a fufficient quantity of fubtile "matter into its pores, or increafe the mo- "tion and fpring of that which is contained "in it, that it may feparate the parts that "are united by their furfaces, and difem- "barrafs thofe that are entangled by their "branches; you will then do what is done "by the heat, and have a liquid or thaw.

"It is to the rays of the ſun that this alte-
"ration of heat and cold muſt be attributed,
"which we experience according to dif-
"ferent circumſtances. Thus, the diſ-
"tance of this heavenly body, the obli-
"quity of its rays, and the quantity of air
"or of vapours which they may have to
"traverſe, are the moſt general cauſes of
"the diminution of motion, of ſpring, or
"of quantity of the ſubtile matter con-
"tained in liquids, and conſequently of
"their congelation. Other cauſes which
"may ſtill weaken the activity of this mat-
"ter, are either a ſubtile nitre, which
"ſometimes ſpreads itſelf in the air, a dry
"wind, or the ſuppreſſion of hot va-
"pours which exhale from the boſom of
"the earth."

Thus, my dear children, I have brought you acquainted with the different opinions of the greateſt philoſophers upon the ſubject of the element about which Lady Caroline is going to queſtion you. I leave every one free to adopt that which may appear the moſt natural and the moſt feaſible; but at the ſame time muſt acquaint you, that ſhe, as well as myſelf, falls in with that of Hartſoeker, for its ſimplicity, probability, and apparently inconteſtable truth.

LADY CAROLINE.

Why, George, is water a fluid?

GEORGE.

Becauſe the particles of fire with which for the moſt part it plentifully abounds in temperate climates, ſupport the reſpective mobility of its parts, and thereby render it a fluid body. Theſe particles of fire penetrating the water, ſet its parts into a ſtate of flowing one upon the other, and to obey the inclination of their own weight, or any other impulſion. But, independent of this general cauſe, we may ſay, that water is more fluid than many other liquids, becauſe its particles are extremely ſmall, and of a form apparently very fit for motion, being ſpherical.

LADY CAROLINE.

Why, Kitty, does not cold water penetrate bodies with as much eafe as that which is heated? and why does this laft raife more quickly to its furface bodies that adhere to it? Why is the folution of falts more quick and effectual as the degree of heat is greater? In a word, why do we cook victuals and fruits in boiling water, and not in that which is cold?

KITTY.

Becaufe all thefe bodies, dilated by heat, become more penetrable, more eafy to feparate, and even the water itfelf, animated by heat, becomes the more active for it. Add to this, that the fame heat, fubdividing the particles of water, makes them more fit to infinuate themfelves into fubftances that are diffoluble.

LADY CAROLINE.

Whence, William, originates fountains, wells, rivers, and all thofe current waters that are conftantly renewed?

WILLIAM.

WILLIAM.

From rains, ſnows, miſts, and, in general, from all vapours which exhale both from continents and iſlands. There are, however, ſome fountains which owe their immediate origin to the water of the ſea; but then they are cloſe to its borders, or at moſt not far removed from it.

LADY CAROLINE.

Since the water of the ſea is ſalt, Elizabeth, how happens it that we find in very ſmall iſlands ſweet freſh water, even upon their very coaſts?

ELIZABETH.

It is the rain, and not the ſea that produces theſe waters; hence they diſappear in dry weather.

LADY CAROLINE.

Waters that come to us from the boſom of the earth, Henry, are almoſt always freſh. Why ſo?

HENRY.

Becauſe theſe waters, in riſing into va-

 pours,

pours, ſimilar to thoſe that conſtitute the clouds, quit the ſalts with which they are charged, and every other heavy ſubſtance that might volatilize like them.

Sources that border near to the ſea are likewiſe as freſh as thoſe that are much farther removed from it, becauſe they all owe their origin to the waters which deſcend from the atmoſphere, and there never aſcends to this a ſingle exhalation that is not perfectly clear of every ſaline particle.

LADY CAROLINE.

How is it, Fanny, that ſprings are more commonly found at the bottoms of mountains than in any other place?

FANNY.

Theſe large maſſes being elevated in the atmoſphere, ſtop the clouds, preſent more ſurface to the rains and the miſts, and are for the moſt part covered with ſnow, which diſſolves by degrees, and produces perpetual flowings, the greateſt part of which remain hidden either in rocks or in the earth, and

ſhew

ſhew themſelves only in places ſituated very low.

We ſee ſprings even upon the tops of mountains; they come from others ſtill more high; if there be a valley betwixt theſe mountains, the water is conducted from the higheſt to the ſummit of the loweſt, by ſubterraneous channels, like communicating and curved tubes which carry water from reſervoirs to places the moſt elevated, down to the iſſue which lies the loweſt, and allows it to eſcape in form of a ſpring.

LADY CAROLINE.

Why, Mary, are there found in remote places, fountains of ſalt water that are ſubject to ebb and flow?

MARY.

They flow immediately from the ſea, which, agitated and raiſed by the tempeſt and the flood, may, by falling back, impel its ſalt waters, and raiſe them through ſubterraneous

terraneous channels into reſervoirs formed above the level of the ſprings.

LADY CAROLINE.

Why, Edward, in the heats of ſummer do we ſee fountains entirely dried up?

EDWARD.

Becauſe their ſubterraneous waters flowing too near the ſurface of the earth, are abſorbed in the great heats by the extreme drought of the ſoil. Beſides this, a ſpring may be dried up by an earthquake, which deranging the channels of the water, will force it to take another courſe.

Waters are leſs ſubject to dry up, and are more freſh and more pure, when the channels that convey them to the ſurface of the earth are more diſtant from them; becauſe then they are leſs agitated, and leſs troubled by the external air and the heat of the ſun.

We find at great diſtances from the ſea, ſprings of ſalt water; becauſe the waters of theſe ſources have paſſed through ſome

mine

mine of ſalt, of which they have carried off a great quantity of the particles.

Some fountains petrify certain bodies, becauſe their waters are charged in the earth with grains of ſand and extremely minute ſtones, which ſinking into the pores of the bodies that encounter them, through the agitation of the waters, immerſe them without their being able to diſengage themſelves. Theſe bodies then become more maſſive, more ſolid, and harder. Hence the name of petrifying fountains.

There are ſome rivers which in twenty-four hours change iron into copper, and fountains that require only five or ſix hours to change copper into iron: The reaſon is, that their waters in different mines have impregnated themſelves with particles of copper or of iron, which, penetrating like little wedges, inſerted and fixed in the interſtices of the bodies, detach a great quantity of their particles from them, of which they

they aſſume the place, and become either iron or copper.

LADY CAROLINE.

There is, Sophia, at Senlis, a village near Chevreuſe, in France, a public fountain, the water of which cauſes the falling out of the teeth without pain or bleeding. How can this poſſibly happen?

SOPHIA.

It very probably happens from this water paſſing through nitrous and aluminous places, and by this means becoming loaded with ſpirits of nitre, with long, round, and pointed corpuſcula, which may very eaſily ſeparate the teeth from the roots, and be the cauſe of the effects produced by this water.

LADY CAROLINE.

It is related by travellers, Frederic, that there is a fountain in China, the water of which towards the top is very cold but ſo hot at the bottom, that a man can ſcarcely bear

bear his hand in it. What can be the cause of this?

FREDERIC.

This water must flow through oily places, where it becomes impregnated with the corpuscula of oil, acids, salts, and alkalis; all of which are adapted to ferment together. It then becomes heated; and the cold towards the top, when the bottom is hot, proceeds from the fine particles being agitated and worked up to the surface, which very easily dissipate in the air; and that those of the bottom, being retained and kept down by superior ones, unite their forces, and hence produce the agitation that causes its heat.

LADY CAROLINE.

It is said, George, that the waters of some fountains are cold by day and hot in the night. How can this happen?

GEORGE.

The heat of the day renders the particles of the vapours and exhalations too minute, and too ſoon diſſipated to cauſe any ſenſible agitation: the cold of the night, on the contrary, condenſes and ſtops them, re-unites them, and thereby puts them in a ſtate of giving to the ſenſe of feeling, by their agitation and violence, ſufficient power to cauſe the heat that is then experienced.

LADY CAROLINE.

There is a fountain in Germany that emits fire to the height of three feet, as ſoon as fire is held one foot above its ſurface. What is the reaſon of this, Kitty?

KITTY.

The light ſpirits and volatile particles of ſulphur and bitumen, with which in its courſe it becomes charged, riſe, flutter upon the ſurface of the fountain, and in taking fire at the approach of the flambeau, ſpread flames over the top of the water.

The ſame thing does not happen if any portion of this water be removed from its original ſituation, becauſe the ſulphureous

particles

particles exhale and diſſipate in the agitation of ſuch a motion.

LADY CAROLINE.

Why, William, are certain fountains intermitting?

WILLIAM.

If the rays of the ſun, interrupted by the points and prominent parts of rocks, give many checks to the ſnow which ſupplies the waters of ſome ſources, this ſnow, melted at different intervals, muſt produce interrupted flowings, or intermitting ſources.

LADY CAROLINE.

Experienced miners, Elizabeth, have almoſt always remarked, that wherever they found water under ground, they likewiſe had air with it; but when this laſt failed, they could no longer draw breath, and that their lights went immediately out. Whence can proceed this air?

ELIZABETH.

The apertures that introduced the water, at the ſame time admitted the air with equal liberty.

The ſame workmen, in many mines, ſmell very far below ground the ſweet odours of flowerets and ſhrubs; becauſe the waters that have waſhed the mountains and bathed the meadows in the ſeaſon of their blooming, flow afterwards under ground in hollow tracks, and charge the air that they bring with them, with the ſpirits of odoriferous herbs over which they have flowed.

LADY CAROLINE.

Why are the waters of many public bathing places found hot? Tell me, Henry.

HENRY.

This heat comes from fumes or ſubterraneous vapours, ſuch as we perceive in the bottoms of very deep mines, or from ſome mixture of minerals, as iron or ſulphur, which, by their reciprocal ſhock,

 excite,

excite, in rolling with the water, the fire which they contain.

LADY CAROLINE.

Why, Fanny, does not a mineral water heat as quickly over the fire as common cold water?

FANNY.

Becauſe the heat that the mineral water brings from the boſom of the earth conſiſts only of light vapours, which the impreſſion of the fire at once diſſipates.

Mineral waters do not burn the tongue, although common water heated to the ſame degree as theſe, burn it: this is owing to the vapours that produce the heat in mineral waters being more fine than the particles of common water, which have leſs power to ſeparate the parts or fibres of the tongue. Mineral waters that are loaded with ſulphureous parts, may ſpread upon the tongue plentiful layers of them, which render it inacceſſible to the heat of theſe waters.

Mineral waters, however, that do not burn the tongue, burn the hand, becauſe the particles of ſulphur do not ſo eaſily adhere to the hand; or, on account of the different texture of the pores, the hot vapours inſinuate themſelves with more violence into thoſe of the hand.

LADY CAROLINE.

Whence, Mary, ariſe the ſalutary effects of mineral waters?

MARY.

From the different particles with which they are charged, calculated to render the blood clear, facilitate its circulation, and diſſipate obſtructions. Certain mineral waters are pernicious, becauſe they contain corpuſcula of a quality to tear the fibres of the body, to thicken and ſtop the blood, and to cauſe obſtructions.

LADY CAROLINE.

How happens it, Edward, that freſh water is ſometimes found at the bottom of the ſea?

EDWARD.

EDWARD.

This water is that of certain rivers which are brought into the ſea through ſubterraneous paſſages.

LADY CAROLINE.

In certain rivers, Sophia, are found ſmall ſpangles of gold, ſilver, &c. Whence come they?

SOPHIA.

The water in paſſing through different mines becomes charged with theſe bodies.

LADY CAROLINE.

Why, Frederic, does the Nile regularly overflow Egypt?

FREDERIC.

According to the obſervations of travellers, Abyſſinia, where the Nile takes its ſource, is full of mountains. It conſtantly rains there from June to September. The vapours raiſed at this time by the heat of the ſun ſituated in our tropic, are carried towards theſe mountains by the north winds, are re-united into large drops by the cold of the ſame mountains, and there fall in rain. During this time, the Nile receives ſtreams, torrents, and rivers, which, overflowing, pour down from theſe mountains; it then ſwells to a prodigious height, and at laſt, by its inundation, moiſtens the ſoil, waters the face of the whole country, and depoſes there its ſalts and fat rich earth: hence the overflowing and fruitfulneſs of Egypt.

LADY CAROLINE.

What cauſes the ſaltneſs and bitterneſs of ſea-water, and occaſions ſea-ſickneſs, George?

GEORGE.

It proceeds from the ſalts which the rivers and floods bear away with them, and from ſalt mines that are frequently found at the bottom of the ſea.

We muſt attribute the bitterneſs of ſea-water to the bitumen with which it is impregnated; ſince it is no longer ſo when this is taken away.

On ſea we experience great ſickneſs,

corand agitation of the inteſtines, becauſe the corpuſcula of ſalt and bitumen too ſtrongly act upon the body, ſearching and diſturbing the internal parts, ſtopping the courſe of the ſpirits, and diſtending the fibres. This is what we call ſea-ſickneſs.

LADY CAROLINE.

In ſea voyages, Kitty, freſh water alternately corrupts and purifies; in the courſe of three months, this change takes place three times. When it ſpoils, it is full of ſmall worms; when it becomes again ſweet, theſe worms diſappear. Every time that it ſpoils, there is a new ſpecies of inſect ſeen in it. Account for this.

KITTY.

The freſh water which is put into the barrels, is charged with the eggs of various inſects. The heat of the veſſel hatches them: they become a ſwarm of ſmall worms, and hence the water is ſpoiled. Soon after this they die, and the particles of them ſeparating, are loſt in the water: it then becomes ſweet by retaking its firſt

ſtate.

ſtate. After this, the heat gives riſe to others, from the eggs of another ſpecies of animals, which require a certain degree of time and heat, as did the firſt: the water is then ſpoiled a ſecond time. Theſe likewiſe very ſoon die, and the water reſumes its former goodneſs. The heat then produces a third kind of inſect; and hence the ſucceſſion of different animals, and the viciſſitudes of corruption and purity of the water.

All this may be prevented by throwing into a barrel of freſh water a very ſmall quantity of ſpirits of vitriol; or rather by waſhing it in hot water, and burning in it before we fill it a ſmall piece of ſulphur; becauſe ſpirits of vitriol and ſulphur render theſe eggs fruitleſs, kill the inſects before they appear, and preſerve the water perfectly freſh through the whole of a long voyage.

LADY CAROLINE.

Whence, William, ariſes the different

taſte

taſte we experience in rain water (though caught in very clean veſſels, without having paſſed over the roofs of buildings, or through gutters,) when compared to any other?

WILLIAM.

From the heterogeneous particles that it imbibes in the atmoſphere, which is always more or leſs charged with different exhalations.

After having ſettled, it improves and becomes more like other water; becauſe if it be not covered up, it purifies itſelf in a very ſhort time of its heterogeneous particles, the greateſt part of which are extremely volatile.

LADY CAROLINE.

How does it happen, Elizabeth, that the heat of the water upon the ſummit of a mountain is leſs ſenſible than that in a plain, or in any other ſituation that is lower?

ELIZABETH.

From a ſmaller quantity of fire being requiſite to heat water, when it is leſs preſſed by the weight and ſpring of the air. Now, upon the mountains, the air being more rarefied than in lower ſituations, it makes leſs reſiſtance to the fire, and gives it a freer paſſage; while that of valleys making a greater effort againſt the column of air, which is higher and conſequently more heavy, re-aſſembles and acts with ſo much the more force upon the water.

LADY CAROLINE.

When a certain quantity of ſalt is thrown into a veſſel full of water, how happens it, Henry, that this laſt does not run over the brim?

HENRY.

Becauſe the particles of the ſalt lodge themſelves in the pores of the water, and occupy only thoſe parts of the fluid where vacuities were found, or which were only filled with bodies foreign to the water.

LADY CAROLINE.

If we mix five or ſix ounces of ſal ammoniac, powdered, in half a pint of pure freſh water, in proportion as the ſalt diſſolves, the water becomes extremely cold. Why ſo, Fanny?

FANNY.

By the reciprocal penetration of the water into the ſalt, and of the ſaline particles into the pores of the water, the parts of fire are driven about for ſome time; which, in whatever it conſiſts, ſlackens this ſpecies of motion, and depends entirely upon itſelf for production and exiſtence. This authoriſes the conjecture that there are certain cold fermentations which exhale from hot vapours, and which by this effect ſeems to indicate that fire ſtrongly chaſed from bodies that mutually penetrate each other, carries off with it the moſt ſubtile parts of them.

The ſea is ſalter in hot than in cold coun-

tries,

tries, becauſe the water holds ſo much the more ſalt infuſion as it is warmer.

We ſee at once, that the pores of this fluid, dilated by heat, become much larger, and conſequently contain much more ſalt. Water, therefore, muſt be ſalter in the ſeas of hot countries than in thoſe of any other.

LADY CAROLINE.

You delight me, Fanny, by your rational, true, and explicit account. Now, Mary, tell me, if you can, why we ſee the water of certain wells fume in winter and not in ſummer?

MARY.

When a veſſel contains water warmer than the air that ſurrounds it, the fire which exhales from it carries with it the parts of the ſurface that are expoſed to its attack. Theſe ſmall maſſes, thus detached, riſe or extend as much by the impulſion they have received as by the ſuction of the air, which does the office of a ſponge, and form that kind

kind of vapour that we call fume, which is ſo much the thicker as the air is colder and fitter for condenſation. This is the reaſon that we ſee water freſh drawn from wells in winter, ſend up a ſteam or vapour. In ſummer this effect does not take place; for when the heat of the atmoſphere is greater than that of the well, the fire, very far from exhaling from the water, on the contrary, enters into it, and even could the vapour aſcend, the heat which reigns in the air would only ſubtilize it, and render it inſenſible to us.

LADY CAROLINE.

Why, Edward, does the water of lakes and marſhes evaporate quicker, and in greater quantity, than that of rivers and other current ſtreams?

EDWARD.

Becauſe the ſurface of the waters of the firſt is longer, and more expoſed to the rays of the ſun than that of the latter.

LADY CAROLINE.

What is it, Sophia, that produces the noiſe and hiſſing which water generally makes when it begins to boil?

SOPHIA.

This is cauſed by the bubbles of air which the particles of fire raiſe up and impel from the veſſel that contains it. When this air is gone out, we only hear a dull kind of noiſe produced by the parts of water thrown up by the fire, which again fall by their own weight. The noiſe is more or leſs loud, as the veſſel happens to be made of earth or metal, which laſt is of courſe more ſonorous.

LADY CAROLINE.

Whence comes it, Frederic, that when a cook throws into a frying-pan (particularly if it be very hot) fiſh, or any moiſt pulſe, we hear crackling for ſome time, and the boiling oil very often flies out upon the hands and face of thoſe who happen to be too near it?

FREDERIC.

FREDERIC.

Fat ſubſtances ſupport a greater degree of heat than water would do, without evaporating. When the particles of this enter into the frying-pan, they are at once tranſformed into vapours, and ſuddenly dilating, make the oil by which they are on all ſides enveloped, ſpout from them.

LADY CAROLINE.

How, George, is ice cauſed?

GEORGE.

When water does not contain a ſufficient quantity of fire, which is the general cauſe of the fluidity of bodies, its parts, touching each other too cloſely, loſe their reſpective mobility, attach themſelves the one to the other, and form a ſolid tranſparent ſubſtance, which we call ice; and this paſſage from one ſtate to another is called congelation.

LADY CAROLINE.

Why, Kitty, does a glaſs in which water is frozen, break?

KITTY.

The air that is in the water, as long as it occupies only the pores of this element, that is, the vacuities or ſimilar ſpaces, does not increaſe the volume of it; but as ſoon as it is changed into ſenſible globules, when by congelation the parts of the water draw to each other and chaſe it, this interrupts the continuity of the maſs, and makes it become much larger. Hence the external ſurface of the glaſs ſwells, becomes convex, and being at laſt overcome by the water (now converted into ice) it breaks.

LADY CAROLINE.

The ſame water, William, in the ſtate of ice, weighs leſs than in its fluid ſtate. Give me the reaſon of this.

WILLIAM.

The increaſe of volume gives to ice that lightneſs which makes it ſwim; for one body is lighter than another, when with an equal quantity of matter its volume becomes greater.

LADY CAROLINE.

It is ſaid, Elizabeth, that melted iron, the inſtant it loſes its liquidity, increaſes its volume in the ſame manner as water changed into ice. How can this happen?

ELIZABETH.

It is occaſioned by an imperfect arrangement of its parts. The moment that theſe are fixed by ſudden cold, a very intenſe heat being neceſſary to convert this metal to a liquid, and a very ſmall degree of cold ſufficient to make it loſe that liquidity again, its parts preſſed one againſt the other are already no longer in a ſtate of fluidity, although they may be ſtill flexible enough to ſink, nearly in the ſame proportion as the fire evaporates, and the motion ſlackens.

Implements caſt from this matter are commonly very expenſive, becauſe, inſtead of quitting the mould like other metals, it on the contrary unites itſelf to it as one body.

LADY CAROLINE.

How, Henry, did the hard froſt of 1709 kill trees of great ſtrength and of very long ſtanding?

FANNY.

Becauſe it ſurpriſed them at a time when they had thoroughly imbibed the water of a thaw: now, this water having frozen in the ſmall channels, dilated them, removed the fibres which obſtructed it, and broke them. Theſe trees were the oldeſt and the ſtrongeſt; on which account, their fibres being much leſs flexible than thoſe of later growth, great numbers periſhed.

LADY CAROLINE.

Water frozen in the barrel of a gun ſometimes burſts it; water in the ſame ſtate raiſes the pavements of ſtreets, and burſts the tubes of fountains when we uſe not the precaution to empty them; nay, it will even burſt a veſſel of copper, the force neceſſary to do which, Muſſchenbroek has calculated as equal to that which is capable

of

of lifting a weight of 27,720 pounds. Whence proceed theſe effects, Fanny?

FANNY.

From the water, by freezing, increaſing its volume; and the air gathering into bubbles, is, without doubt, the immediate cauſe of this increaſe of volume; ſince, without this interruption, the water would occupy leſs ſpace; things, however, would be thus, though this air made no effort to extend itſelf; but it gathers ſo much the more into theſe bubbles, as it comes out in greater quantity from the pores where it is naturally lodged. The expanſion of volume, therefore, proceeds from the ſame cauſe, whatever it may be, that contracts the pores of the water and condenſes it: now that which condenſes water, and makes a body become hard, is what hardens other bodies when their fluidity is unſupported by ſome internal cauſe; and we know by many common inſtances with what power it acts: for the condenſation of water is more

more powerful and more quick, as the cold is more intenſe. In like manner, ice muſt be more full of bubbles of air, to have a greater volume, and to be able to make a ſtronger effort, which agrees perfectly with common experience.

LADY CAROLINE.

Why, Mary, does water begin to freeze firſt upon the ſurface?

MARY.

Becauſe the cold which produces freezing, comes from the atmoſphere; and this cauſe cannot have its effect at the bottom, without firſt freezing every thing that is above it. It is therefore improperly ſaid, that ice comes from the bottom of the water.

LADY CAROLINE.

The middle of a great river, which we call the ſtream of the water, never freezes. Why is this, Edward?

EDWARD.

EDWARD.

Its motion being irregular, and as it were by leaps, the parts which ſhould attach and unite themſelves together, are never two inſtants at a time on the ſide of each other, ſo that the froſt has not time to fix and congeal them.

LADY CAROLINE.

How comes it, Sophia, that the ice of a river that is frozen is not united like that of a lake? And why do we commonly ſee piles of ice heaped one upon the other?

SOPHIA.

A great river is never entirely frozen, except when the arches of a bridge or ſome other obſtacle ſtops the heaps of ice that are borne by its current, and which have thereby opportunity given to unite, and ſolder as it were themſelves to each other.

LADY CAROLINE.

Pure and clear water, Frederic, freezes in a much ſhorter time, and becomes a great deal harder than any other. What is the reason of this?

FREDERIC.

Because, in pure water, there is nothing to make up for the loss of the fire, and to hinder the parts of it from approaching; now we know that the congelation of the water is only a closer and more intimate union of its parts, occasioned by the absence of the fire, which before kept them distinct from each other, and in a state of mobility.

Salt water freezes with more difficulty, because the parts of the salt oppose the union of those of the water, which, in their turn, hinder the salt from becoming hard, by their tendency to melt it, till it entirely moistens.

The ice of salt water is not every where equally salt, and the middle does not freeze at all, or only takes a very slight consistence; this is owing to the saline particles at last giving up to the force that condenses the water and contracts the pores of it, entering into the portion that is ſtill liquid, in the ſame proportion as they are compelled to abandon that which becomes ſolid. Thus the middle is too much loaded with ſalt, and freezes leſs.

LADY CAROLINE.

What is the cauſe, George, of the north ſeas freezing very deep ?

GEORGE.

They are expoſed to colds of much longer duration, and much more intenſe than thoſe of other climates ; add to this, that their waters are commonly leſs loaded with ſalt.

LADY CAROLINE.

Why, Kitty, is the dirt of the ſtreets, when it begins to freeze, always leſs hard than ice ?

KITTY.

The water is mixed with a great quantity of earth, which makes its congelation much

much more difficult, by hindering the aqueous particles from joining together.

LADY CAROLINE.

Why, William, do ice creams, and other delicate preparations by ice, require a much greater degree of cold to freeze them than common water.

WILLIAM.

Becauſe they are always charged with ſugar, or rather ſpirituous ſugar, which does the office of ſalt, and keeps the parts of the water diſunited.

When their freezing is only to a degree of ſimple congelation, ſome of them are ſenſibly colder than others, though all may have had the ſame degree of cold neceſſary for freezing; becauſe theſe liquids carry more or leſs ſugar, one than the other, and likewiſe as they are more or leſs ſpirituous.

LADY CAROLINE.

The water of a ſtanding pool, mixed with ſaline liquids, and fat ſubſtances, either

ther of animals or vegetables, which corrupt and there freeze, very often reprefent fingular figures refembling the works of art, and even thofe of nature. What produces this effect, Elizabeth?

ELIZABETH.

The parts of the ice are arranged relatively to each other, and to the quantity and order of the foreign bodies that are mixed with the water, and which interrupt or more or lefs retard congelation: or rather, they are the tracks that the particles of fire have taken, which evaporated in proportion as the water loft its fluidity.

LADY CAROLINE.

Fruits that freeze in bleak winters, when a thaw takes place, lofe their flavour, and very often become rotten. Why fo, Mary?

MARY.

Becaufe their juices confift in a great part of water, which freezes and difcompofes them: the aqueous particles become ſmall voluminous pieces of ice, which break and burſt the little veſſels in which they are incloſed.

LADY CAROLINE.

Why, Fanny, does meat that has been frozen eat more tender than other meat?

FANNY.

Becauſe the particles of ice formed from thoſe of the water, have removed (in dilating by the fire that roaſted the meat) thoſe fibres, the union of which conſtituted the hardneſs of it.

LADY CAROLINE.

In countries that are intenſely cold, the inhabitants ſometimes experience the dreadful calamity of loſing their ears and noſes. What can be the reaſon of this, Edward?

EDWARD.

The humours frozen by the cold ſwell and diſtend the organized parts; or rather, their principles remain diſunited, when their fluidity comes back to the parts to

which

which it agrees, before the veſſels that have been forced become conſolidated. It is for this reaſon, that in order to thaw them, they hold them ſome time in ſnow before they expoſe them to a warm air, which gives time for the parts to reſume the order which they have loſt.

LADY CAROLINE.

Why, Mary, are the ices of Greenland, and thoſe of almoſt all the north ſeas, of a blue colour, approaching a little to a green?

MARY.

This colour may be occaſioned in ſome degree by the condenſation and thickneſs of the air, which, reflecting the ſolar rays in a certain manner, may produce it: on the other hand, it may proceed from the quality of the bottom of theſe ſeas, particles of which may be detached, and mix with their waters, as it happens in many inſtances.

LADY CAROLINE.

We encircle with ground ice or ſnow, the ball of a ſmall thermometer, placed in a veſſel; then wait till the fluid be fixed to the point of congelation. We now throw upon the ice an ounce or two of any kind of ſalt. A ſhort time after, the bottom of the veſſel is immediately covered with ſalt water, and the liquor of the thermometer deſcends below the fixed point we have mentioned. Explain this effect, Frederic.

FREDERIC.

The cooling of the ice by the mixture of the ſalts is effected nearly as the freezing of water. Humidity penetrates the ſalt, divides it, and enables it to do the ſame thing in regard to the ice. The two ſubſtances mutually penetrate each other as they melt, and the parts of one rapidly running through the pores of the other, drive out for an interval the matter of the fire which is ſtill there;

there; and thence ariſes a great privation of heat in the mixture.

LADY CAROLINE.

If fire be the general cauſe of fluidity, and water become ice only when it is deſtitute of it to a certain point; how can it be that a greater want makes the ice liquid? Tell me, George.

GEORGE.

It is not becauſe there is leſs fire in the ice that it becomes water, but becauſe we ſubſtitute for the fire that comes out of it, and which continues to exhale, another ſubſtance that lodges betwixt its parts, continues to exhale, and renders them moveable in proportion one to the other. Though fire be the general cauſe of fluidity, it is not the only one that can give riſe to and ſupport this ſtate: it is ſufficient that an interpoſed body ſhould hinder the parts of a ſubſtance from joining, and that people ſhould not make uſe of it as a common link. This body becomes immediately a fluid, whatever degree of cold it may have besides: it is thus that spirits of wine, salt, nitre, &c. mixed with a sufficient quantity of water, hinders its congelation, and restores to it its fluidity after having lost it; the salt, thoroughly divided by dissolution, produces the same effect and for the same reason.

THE EIGHTH CONFERENCE.

ON COLOURS.

SIR THOMAS.

I AM now, my dear children, about to discuſs a beautiful and intereſting ſubject, that of Colours. It will inſpire you with ſublime thoughts, and you will be amazed at the novelty of the knowledge you are about to acquire. The definitions and illuſtrations which I ſhall now enter upon, will enable you to anſwer the queſtions which Lady Caroline may put to you, with as much preciſion and accuracy as you have exhibited throughout the former Conferences.

Definitions.

1ſt. Deſcartes and Malebranche preſumed to ſay, that colours were only modifications of light. Defcartes thinks that they are relations of the ftrait motion of celeftial globules, and of their circular motion round their center. If this circular motion be a great deal more rapid than the other, the colour is *red*; if the circular motion be but a little more rapid, the colour is *yellow*: if the ftrait motion, on the contrary, be much more rapid, the colour is *blue*: if it be but a little ftronger, the colour is *green*.

2d. According to the hypothefis of Newton, which ought to be preferred to all the inventions that had preceded him and have followed him, Colours are a very particular difpofition of luminous rays, adapted to give the perceptions of *red* or *yellow*, &c. Every ray takes the name of the colour that it bears; not that it is really coloured, but that it occafions one appearance rather than another.

3d. According to the fame author, one fpecies of rays produces in the organs vibra-

tions

tions of a certain magnitude, which raiſe in the ſoul a ſenſation of a certain colour; in the ſame manner, nearly, as the vibrations of a certain magnitude in the air give riſe in the mind to a ſenſation of a certain ſound. For inſtance, the rays of one ſpecies that produce the ſhorteſt vibrations, ſhew the *violet* colour; the rays of another ſpecies that produce vibrations the moſt expanſive, give the *red*. The firſt are the cauſes of ſhort vibrations, becauſe they are compounded of the ſmalleſt corpuſcula. The laſt of theſe, having leſs force than the others, make leſs impreſſion. Thus, the *violet* that they give riſe to, is the moſt gloomy and feeble of colours. The ſecond occaſions the moſt extended vibrations, becauſe they have larger corpuſcula, which having more ſtrength than the others, make a ſtronger impreſſion. The difference of ſize in the corpuſcula of other rays makes the difference of other colours. Hence red rays, orange rays, yellow rays, &c.

4th. Newton reckons ſeven principal rays or primitive colours: the firſt is *red*, or of the colour of fire; the ſecond *orange*; the third *yellow*; the fourth *green*; the fifth *blue*; the ſixth *purple* or *indigo*; the ſeventh *violet*.

We may be convinced by the following experiment:

Newton made in a ſhutter a ſmall aperture of one fourth of an inch diameter. When a bright ſun ſhines on the ſhutter, the rays are received through the orifice in a chamber well cloſed up, and tend to paint the likeneſs of the ſun, or of a circle on the wall oppoſite, or on a white ſheet, or on a ſcreen deſtined to receive them. If near this hole you place before the rays of the ſun the ſide of a priſm, that is, of a triangular ſolid of chryſtal well choſen, very equal in its ſides, and without ſtreaks, the figure which the rays form on this occaſion upon the linen is no more round as before; it preſerves the ſame width, but it

becomes

becomes very long, terminated by two ſtrait lines in its length, and only round at the two extremities. Toward one of the ends of this figure, we ſee the moſt beautiful *red*, then the *orange*, afterwards the *yellow*, the *green*, the *blue*, the *indigo* or *violet*. Theſe ſeven colours are not preciſely cut, but we ſee between them delicate ſhadowings, that bear a reſemblance to the neighbouring colours on the end, and which are nearly blended into one.

5th. After having carefully examined this ſingular figure, the diſcovery we make is, a compound of rays of different colours, and which being in themſelves of different natures, undergo folds, all of them different in the priſm, and then remove differently from themſelves, in ſuch a manner as to fall upon the linen at points unequally diſtant from thoſe to which they ſhould have gone, if they had not been broken by the priſm.

From

From the mixture of the ſeven rays ariſe all the colours of nature, and the whole of them re-united and reflected together from the ſurface of an object, produce the whiteneſs; and we only call them *red*, *green*, &c. becauſe the rays make ſuch and ſuch an impreſſion upon the retina, whether it be becauſe the globules of the rays are of different ſizes, or that they may have a different motion. And not only reflecting ſurfaces have their pores filled with light, to reflect that which falls from above; this light in coloured ſurfaces is of ſuch or ſuch a ſpecies, and by that means capable of receiving and of reſtoring to ſimilar globules the motion that is moſt proper to them. Thus cochineal dyes red, yet not of itſelf, but becauſe its particles, divided and lodged in the pores of wool, are like ſo many ſponges imbrued with red light, adapted to re-act againſt a ſimilar light, and upon which the rays of a different nature are deadened and extinguiſhed by the want of an effectual re-action.

6th. Let us conceive tranſparent bodies that have colours, not as ſimple ſieves, but as little beams of which the meſhes contain ſome particular ſpecies of light, adapted to receive and to tranſmit, beyond the motion communicated to it, by rays of one and the ſame nature. The pores of red wine contain a ſeries of globules, which, ſtruck by a compound light, only receive and tranſmit the motion that belongs to the rays of that colour.

I ſhall now reſign to Lady Caroline the taſk of illuſtrating what I have been ſaying, and hope that theſe preliminary obſervations have already prepared your minds for the explanation of what her Ladyſhip may propoſe to you.

LADY CAROLINE.

There are found, George, in certain places, ſtones, generally of the ſize of a hen's egg, of an irregular round figure, their colour grey, and in their nature ſome-thing like talc (a tranſparent mineral, of which a curious white-waſh is generally made.) This ſtone, or any other that may be ſubſtituted in its place, having been cal-cined in a coal fire, and kept in a box in-ternally covered with cotton or flannel, we expoſe to the free air and open day during a few minutes, but placed in the ſhade: we afterwards take it out of the box, to be ſeen in a darkened room; and that the experi-ment may ſucceed better, it is proper that thoſe who are to look at it ſhut their eyes for a few minutes before, or ſtay in the room till it is ſhewn. The ſtone then will appear luminous like a piece of iron reddened by fire, and beginning to extin-guiſh. This light laſts a few minutes, but becomes gradually more feeble, after which it entirely diſappears. Account for this.

GEORGE.

The odour exhaled by this ſtone (which,

I recollect, Sir Thomas told us was a native of Bologna in Italy) after having paſſed the fire, gives us to underſtand that its natural ſulphureous particles have been diſengaged from its earthy parts. Theſe ſubtilized particles of ſulphur contain like other particles of fire, but with this difference, that being very much diſpoſed to obey the expanſive force of this element, their inflammation begins in an inſtant. The moſt feeble light of the day is fire ſufficient to give light to this ſtone, which placed in the dark produces theſe effects.

LADY CAROLINE.

Why, Kitty, do bodies appear to us under ſeveral different colours?

KITTY.

It is that the figure of their pores, the texture, the conſiſtency, the inclination of their parts, reflect more rays of a certain ſpecies, while they tranſmit the greater part of the others; that is, they abſorb them.

The particles of which the surfaces of bodies consist, may be conceived as blades of a very minute thinness, of different natures; and as the rays are themselves entirely unlike to each other, they do not find in all these minute blades upon which they may fall, the same relations and the same dispositions. One blade, for instance, that will receive and break the yellow in its pores, will totally force the green. Certain bodies appear to us red, because they reflect and send back to our eyes a great quantity of red rays. Gold reflects yellow rays, while other rays pass over them; for if we place betwixt the light and the eye, a very minute blade of gold, the light traverses it, and appears blue or green.

A surface of a body which in a certain inclination would have admitted and bent the violet, being otherways inclined, refuses its passage, and wholly reflects it.

A pigeon, or a pheasant, cannot make the least motion with its head without exhibiting,

biting, ſometimes little ſurfaces adapted to reflect certain rays; at other times, other ſurfaces, calculated to reflect quite different rays from the firſt. In the mixture of ſome liquids, there are formed particles or layers that reflect many more rays of certain ſpecies than of others, which run through the mixture, or which are there abſorbed; hence the colours which we ſee ſuddenly riſing. It is eaſy to perceive that all theſe changes may be infinitely diverſified.

The ſmall irreſiſtible parts of the ſurfaces of all bodies may be looked upon as ſo many fine ſieves, which, if I may be allowed the expreſſion, ſift the light. The rays that may be received and admitted by the pores of one ſieve, may be rejected by another. The white is a very fine ſieve, which allows no ray to paſs; the black is the largeſt ſieve, and through it every ray flows. Hence it happens, that white woven ſubſtances are more cool, and leſs calculated to receive heat. It is upon this account alſo, that a ſheet of white paper pinned to the hat of a traveller, ſaves him from a too great heat, by ſending it off into the air; and for the very ſame reaſon, black cloths and all black bodies receive a vaſt deal of heat, and ſometimes are upon the point of being burned.

Colours are then eſſentially different in us, upon us, and in light, as well as upon all coloured bodies. In us, they are very different ſentiments, by which we are intimately affected in the appreciation of the appearance of objects. In light, they are ſo many darts, ſimple and diſtinguiſhed from each other. Upon coloured bodies there is a very certain foundation to ſay of one, that it is red, and of another, that it is blue; ſince particles that reflect one of theſe colours are, by the inequality of their ſtructure, their denſity, their delicacy, their arrangement, their inclination, very different from

from the particles which conſtitute a ſurface of another colour.

Black is not properly a colour: it is a privation of reflected light; and the leſs the reflection is, the greater is the blackneſs. Some opaque (dark) bodies ſend back but a very ſmall quantity of light, the remainder of which becomes extinct in theſe bodies by being diſperſed on all ſides through contrary reflections and refractions; and hence, it moſt undoubtedly proceeds, that a black ſubſtance is more rapidly heated than any other.

LADY CAROLINE.

Your diſcernment in the intricacies which you have rendered at once clear and obvious, ſhew you, my dear Kitty, to be a girl of great acuteneſs.

A ray of the ſun obliquely falling upon the *ſurface* of a tumbler of water, placed upon the border of a table, diſplays the priſmatic colours at the diſtance of ſome feet from it: this does not uſually happen, except

except the light, which traverſes the glaſs, be extended a little farther after its emerſion. To what, William, may this be attributed?

WILLIAM.

The maſs of water which the ſolar ray traverſes, is in this caſe a true priſm, of which the refracted angle is towards the rim of the glaſs; it muſt therefore produce ſimilar effects to thoſe of a ſolid piece of glaſs, with the ſame form as the water and the tumbler; but as the different degrees of refrangibility of the rays do not remove them one from the other, but under very acute angles, it is only at a conſiderable diſtance from the refractive body, that they are ſufficiently unmixed to appear with their own colours; nearer the glaſs, there can be at the moſt but the border of the emergent light, coloured, and that in a faint degree.

LADY CAROLINE.

Diamonds, eſpecially thoſe of the fineſt water, held in a ray of the ſun, produce by their angular cut, a vaſt number of ſmall, beautifully coloured figures. How does this happen, Elizabeth?

ELIZABETH.

From their facets, which form ſo many ſmall priſms. The incident light is divided into many ſmall ſhootings, which are ſtill ſubdivided upon the facets, differently inclined from the bottom, and which reflecting from this, fail not to be diſcompoſed by coming out, if they have not been ſo by entering. Colours are more vivid in the diamond than in glaſs, becauſe they are better ſeparated; the firſt being more refractive, and its tranſparency likewiſe more perfect. The light of a wax taper produces the ſame effect, though with leſs ſplendor than that of the ſun. It is for this reaſon that night aſſemblies are ſo favourable to thoſe parts of dreſs that are ornamented with diamonds: ſhootings of direct light, multiplied in a place where the light is leſs powerful than by day, render the effects of which we are ſpeaking more ſenſible and more numerous.

LADY CAROLINE.

Paper dyed blue becomes at firſt a fine red, and ſome time after turns pale, when it has been waſhed over with aquafortis, weakened by a little common water: nearly the ſame thing is obſerved when we apply to it any other acid, as the juice of citron, vinegar, ſpirits of vitriol, the ſimple diſſolution of nitre, &c. How does this happen, Henry?

HENRY.

Becauſe the particles that give the colour to the ſurface of the paper being freed by the action of the acid, change, probably, their ſize and figure, and thereby become fit to reflect red, rather than blue or violet rays; and as this action remains a certain time before it has all its effect, the red, which appears at firſt very deep and vivid, runs

runs through many ſucceſſive ſhadowings to a colour more weak and pale.

It is thus that certain ingredients, as ſoap, ſpoil variegated cottons, linens, &c. by interrupting and diſuniting the component parts of their dyes, which appear under other colours, and generally without remedy. A method to prevent theſe effects, in part, or wholly, is, to ſoak theſe ingredients in a good quantity of pure and clean water, and to beat it well up before we put in any of the draperies which I before mentioned for cleanſing; but it is ſtill neceſſary to obſerve, that the dye which we wiſh to preſerve, ſhould naturally be of itſelf a colour not calculated to yield to the water in which we mean to waſh it.

LADY CAROLINE.

At the cloſe of day, the ſhadows of bodies produced upon a white wall are of a blue colour. Give me the reaſon of this, Fanny.

FANNY.

FANNY.

The ſhadows of bodies that proceed from the red hue of the ſetting ſun, which is near the horizon, will always be of a celeſtial blue; and for this reaſon, that the ſurfaces of all opaque bodies take the colour of the body which enlightens it; therefore the whiteneſs of the wall being entirely deſtitute of colour, it takes the hue of its object, that is, the ſun and the heavens; becauſe the ſun towards evening is of a colour approaching to red, as the heavens to the blue; and the places where the ſhadows are, not being ſeen by the ſun (ſince no luminous body can ſee the ſhadow of the object it enlightens), as the places of this wall where the ſun does not ſhine are ſeen by the heavens, the ſhadow reflected by them upon the white wall will be of an azure colour; and the ſpot of this ſhadow being enlightened by the ſetting ſun, inclining to red, will likewiſe partake of this red colour; that is, the white wall

takes

takes the hue in a viſible manner of the celeſtial blue light of the heavens, and this colour appears only in the place of the ſhadow, becauſe the other parts of the wall are illuminated by a ſtronger light, which hinders the blue from appearing. This will take place, though the ſhadow be but faint, and on this we may rely when the ſun is not too much above his deſcent, or better if he be deſcended.

LADY CAROLINE.

To what cauſe can we attribute the beautiful red with which lobſters, crabs, and a variety of other ſhell-fiſh, are tinged when boiled? Tell me, Mary.

MARY.

It may be attributed to ſome change of their ſuperficial contexture, which becomes fit to reflect only the red rays: a change ſo delicate and ſo imperceptible, as not to be diſcoverable by the moſt piercing eye, aſſiſted by the beſt microſcope.

LADY CAROLINE.

I take this phial of thin glaſs, which is exceedingly tranſparent, and the figure of which is cylindric, about an inch in diameter, and ſeven or eight inches in length; this I fill nearly one half with clear water, and pour upon it as much ſpirit of terebinth; after which, without moving it from the place it ſtands on, I cork it as cloſely as I am able.

You now obſerve, that ſo long as I do not agitate this, the two liquors remain one above the other, and each of them preſerves all its tranſparency.

I then ſhake for a few moments the bottle, and the two liquors, you obſerve, mix in ſuch a way that the water is interrupted by an infinite number of ſmall globules of terebinth of a dull and thick white. How is this occaſioned, Frederic?

FREDERIC.

The ſpirit of terebinth, being lighter than the water, remained on the top when your

your Ladyſhip gently poured it into the bottle; and the two liquors, thus ſeparated, preſerve the qualities that are peculiar to them, and conſequently their natural tranſparency. But when, by the agitation of the bottle, the leaſt denſe of the two divides into ſmall globules, the continuity of the water is interrupted, and a mixture formed, of which the parts are heterogeneous as to the denſity; then the light is loſt by the irregular reflections and refractions which it undergoes in this maſs; and the reſt, repelled and making its way back again, ſhews the mixture under a white appearance.

LADY CAROLINE.

Water beaten in its fall by the wheel of a mill, the white of an egg whipped, and in general all mucilaginous ſubſtances, are opaque and white. Give me the reaſon of this, Sophia?

SOPHIA.

This happens becauſe the air, which introduces itſelf into them in ſmall globules, and is mixed with matters much more denſe than itſelf, compoſes with them maſſes, the parts of which are very different in denſity.

LADY CAROLINE.

Glaſs, ground, cracked, or unpoliſhed, which has loſt its tranſparency, retakes it, like an infinite number of other bodies, by being only moiſtened with water. Oiled paper is very often ſubſtituted for the pane of a window. Why ſo, George?

GEORGE.

Becauſe we ſupply for the air which is mixed with theſe bodies, or which fills the pores and inequalities of them, a liquid, of which the denſity approaches nearly to theirs.

We muſt obſerve that the glaſs is ſo much the more tranſparent, as it is more thin and more poliſhed, becauſe its pores are by this ſo much the more free, leſs interrupted,

and

and leſs cloſed; they give therefore an eaſier paſſage to the rays of light.

It is ſo much the leſs tranſparent as it is thicker; becauſe then its pores being more crooked, more obſtructed, and ſtopped with ſolid particles, the rays paſs with more difficulty.

Water, when frozen, is very tranſparent, while oil in this ſtate almoſt wholly loſes its tranſparency; becauſe the parts of the water in approaching are ſo arranged, the one next the other, in parallel lines, at the moment when they freeze, that they always preſerve a great number of pores, ſtrait, free, and diſpoſed in every direction; whereas the parts of the oil are intermixed in ſuch a manner, that the paſſages of the light become tortuous (twiſted or winding) and inacceſſible to the greateſt part of the rays.

LADY CAROLINE.

In froſty weather, the glaſſes of a carriage in which we are ſeated, become very ſoon dull and obſcured, ſo that we cannot diſtinguiſh any object on the outſide. What can be the cauſe of this, William?

WILLIAM.

It is occaſioned by the tranſpiration of the body, which attaches in ſmall drops to the ſurface of the glaſs. Theſe particles of water, with the partitions of air, ſeparate, compoſe a layer of matter very heterogeneous as to denſity, and on that account very little adapted to allow the light to paſs in a right line. What proves that the glaſs does not loſe its tranſparency is, that if we reunite the ſmall drops with the hand, or ſlightly paſs a handkerchief over them, the glaſs immediately reſumes its former tranſparency: it is even a means of preventing its becoming any more ſo obſcured, for the humidity that ariſes afterwards, only unites to that which is extended, and takes no more the form of drops.

LADY

LADY CAROLINE.

How, Fanny, do we fee any thing that is black, fince no kind of light is reflected from bodies of this caft?

FANNY.

When we look upon a black body, it is not that body that we fee, but the enlightened or luminous furfaces that encompafs it, and which ferve as a field: the light that they fend, makes impreffion upon the whole of the fight, except at the place which correfponds to the body that we have in view. This place of the organ which does not receive the light, is circumfcribed and terminated according to the figure of the black body, which is the caufe of this privation; and it is by this that we are enabled to judge of the magnitude, form, fituation, and nature of it. When we read a book, it is not the letters of ink that make impreffion upon our eyes, but the white of the paper that is betwixt them, fince it is from

from this that the light comes: we diſtinguiſh them only by the defects of ſenſation which they occaſion.

Black ſubſtances do not appear to us, as ſtains or ſhadows: a man dreſſed in black, and an animal of this caſt, look very different from ſhadows. We diſtinguiſh all the parts with their reliefs: it is that theſe objects are not entirely black, as we may imagine them; the parts the moſt prominent, and the moſt expoſed to full day, detach themſelves from the others by ſhadings more or leſs clear, and the reflection of the light, which ſhews the mouldings, contours, and projections of them. This is ſo true, that a painter who undertakes to repreſent them cannot effect it, but by employing white and other colours capable of reflecting the light; and if theſe bodies are not enlightened on the ſide by which we view them, they appear to us like real ſhades.

LADY

LADY CAROLINE.

Why, Edward, do aſtronomers burn the glaſſes black or ſmoke them, through which they look at the ſun?

EDWARD.

Becauſe all black bodies, as well ſolid as liquid, being generally the moſt fit to intercept the light, the eye is not overpowered by a too great reſplendence of rays. The ſun then appears of a yellowiſh red, becauſe of all the ſpecies of light that emanate from him, thoſe of the red and the yellow are the moſt ſtrong, piercing through ſubſtances and degrees of opacity in which the other colours ſtop and become extinct.

LADY CAROLINE.

When we look at a glaſs of red wine in which water is mixed, we diſtinguiſh neither the parts of the water, nor the ſolid parts of the glaſs. The ſenſation it gives riſe to within us, is only that we ſee the ſimple wine without any mixture or interruption. How happens this, Sophia?

SOPHIA.

SOPHIA.

It is becaufe the impreffion that comes from the red wine is ftronger than that which proceeds either from the glafs or the water; and this fpreading upon the retina renders both the latter infenfible.

Thus a green meadow fcattered over with white flowers, when viewed from a great diftance, appears entirely white.

LADY CAROLINE.

How, Frederic, is the rainbow produced?

FREDERIC.

We call by that name the arch that appears when a fpectator has his back turned towards the fun. It is feen in a dull thick part of the atmofphere, while it rains, betwixt this and the fun. It often happens that we fee at the fame time two of them parallel to each other. The colours of the uppermoft are more faint, and inverted, in relation to thofe of the lower, and are the

fame

fame as thofe we fee in the rays of the fun paffing through a prifm. We may fay, in general, that in the lowermoft bow, the rays of the fun make a double refraction, firft at the entrance into the drops of rain falling from the atmofphere, and again when they iffue from them, befides one reflection which the ray makes in the interior of the fame drops. In the upper bow, there is not only a double refraction, but, befides, a double reflection. It is not, therefore, furprizing that the rays in this bow being more faint, the colours fhould likewife be lefs vivid. In the fuperior arch, the rays entering into the drops of water by their inferior parts, proceed to the eye from their upper furface; and in the other arch, they penetrate at firft the fuperior parts, and then they advance towards us by their inferior part. Hence, it neceffarily follows, that the inverted order muft take place.

LADY CAROLINE.

I mix in this cup the tincture of ſun-flower with aquafortis and oil of tartar; the mixture gives a violet colour. Why ſo, Mary?

MARY.

The mixture is violet when it reflects more rays of this colour than any other: it is blue when it ſends forth more of the blue. On the ſame principle there ariſes a fine blue from the mixture of alum with the juice of corn flags.

LADY CAROLINE.

Again, Mary, I put into this cup a little water and oil of tartar upon the ſyrup of violets, which mixture immediately produces a beautiful green. In what manner is this effected?

MARY.

This mixture, abſorbing the other rays of light, reflects the green only.

LADY CAROLINE.

The ſpirit of vitriol in a tincture of the pomegranate gives a colour bordering upon orange. How happens this, Kitty?

KITTY.

Becauſe this mixture reflects back only the orange rays, abſorbing the others.

THE NINTH CONFERENCE.

ON VISION.

SIR THOMAS.

I SHALL now, my dear children, beg of Lady Caroline to proceed to that part of light which treats of *Viſion.*

LADY CAROLINE.

When we are in a chamber we ſee the paſſengers through the window panes much plainer than they ſee us. What is the reaſon of this, George?

GEORGE.

It is, that the light which comes from them to us, is more vivid than that by which they perceive us; beſides, their eyes, affected by the open light in which they are, cannot feel this weak light ſo well as our eyes, which are more remote from the full light, can feel a ſtronger: the effects are altogether different when it is night, and when we are in a place well illuminated; as the people within cannot ſee thoſe without, while theſe on the contrary are clearly ſeen by the latter.

LADY CAROLINE.

By drawing together the eye-lids in a kind of blinking poſition, if we look in a ſtrait line at a lighted candle, by night, we perceive from the upper and lower parts of the flame long rays of light, like thoſe which repreſent the glory that ſurrounds certain pictures; and if we let any obſtacle (the finger, for inſtance) gently deſcend before the eye, it will intercept the rays below: thoſe above in the ſame manner will diſappear, if we raiſe the obſtacle from the lower to the upper part of them. How does this happen, William?

WILLIAM.

It proceeds from the rays of light that come from the flame, and refract from the upper to the lower part, and from this to the upper part, traverſing a glairy water, which gathers on the borders of the eye-lids, at the place where they touch the ſecond coat of the eye, which contains the watery humour. We may remark, that the rays to which the queſtion alludes, are not repreſented under different colours, as it happens to refracted light, and this ſhould be attributed to the bendings of the rays in paſſing near the borders of the eye-lids, above as well as below.

LADY CAROLINE.

Purblind, or ſhort-ſighted people, ſee diſtinctly when the object is near, and even read with very little light, but at a diſtance they ſee confuſedly, and perceive not at all objects that are a little removed. Among this deſcription of people, ſome can only read by bringing the book to touch their noſes, others by holding it an inch or two farther off, others again remove it half a foot from them. Give me the reafon of this, Elizabeth.

ELIZABETH.

In fhort-fighted people, the eye is too round, the cryftalline too vaulted; the luminous rays re-unite there too fuddenly, they crofs each other in it before they arrive at the retina, where they often make only a fpot which has nothing diftinct. This inconvenience diminifhes as age brings on others. Children newly born are near-fighted; they have a very fpherical eye. Drynefs and weaknefs infenfibly flatten this too round eye; and hence people fay, that fhort fights laft long. It is not that they laft longer than others, but that at a certain age the dried eye is flattened: then he who was before under the neceffity of bringing a book within three or four inches of his eye, may fometimes read at the diftance of a foot: but even his fight becomes foon confounded and cloudy, and he can by no means fee diftant objects. To remedy the de-

fect

fect of the eye of the purblind perſon, which is too round, he muſt have a glaſs that will hinder the rays from re-uniting too quickly. This glaſs ought to be concave, that the rays becoming more divergent may be re-united upon the retina, that is, farther than they before were. The concavity of theſe glaſſes muſt be proportioned to the defects of the eyes.

LADY CAROLINE.

Perſons who ſee afar off diſtinctly, and nearer very confuſedly, have their ſight even to three degrees, or foci. The firſt is a foot and a half diſtant; the ſecond is two feet and a half; the third is farther than either of them. This ſight, which is oppoſed to that of the purblind, is proper to old men. Why and how does this happen, Henry?

HENRY.

The eyes of thoſe who cannot ſee but afar off, are too fat, either by the conformation of the ſecond coat of the eye, or by

that

that of the cryſtalline, which age or ſickneſs has dried up or flattened: then the refractions are more feeble and of leſs quantity; and the rays, inſtead of being reaſſembled upon the retina, ſhoot beyond it, and ſhew confuſed objects clearly to them. Nature has given to the muſcles of the eye the power of prolonging or of flattening the eye, to bring it near or to remove it from the retina. But when this ſtrength is loſt in old perſons, a remedy is applied through the interpoſition of a lens (a glaſs convex on both ſides), which renders the rays leſs divergent, by making them concur at a leſs diſtance. The eye then receives the rays, both more collectedly and in greater number; they terminate at a point of the retina, as they ſhould do; they come to the eye as if they had been ſhot from a point more remote, and which an old perſon might diſtinguiſh with eaſe.

LADY CAROLINE.

What conſtitutes a good ſight, Fanny?

FANNY.

FANNY.

It is that by which we can ſee to read well at about the diſtance of one foot. In this ſight the cryſtalline is in its perfection; we diſtinguiſh from afar, like the perſon who ſees objects moſt clearly at the greateſt diſtance, but not ſo accurately as he. This ſight has three degrees, or foci, the firſt is half a foot, the ſecond one foot, the third a little more than this laſt.

A good ſight is ſometimes changed into a ſhort ſight, particularly among people who read much, or who apply to fine works; and it is liable to be changed into the ſecond kind of ſight in an advanced age. The ſight of the purblind never changes, either into a good ſight, or into that of the ſecond kind of ſight. Theſe different variations of ſight happen only by the different changes in the convexity of the cryſtalline.

LADY

LADY CAROLINE.

What is ſtrabiſmus, or ſquinting? Can you explain it to me, George?

GEORGE.

We ſay a perſon ſquints, of whom one of the two eyes is not turned to the ſide of the object he looks at. People who have this defect, ſquint ſometimes with one eye and ſometimes with the other, and it often appears that the two eyes ſquint both at once. There are ſome who ſquint very little when they are near the object, but a great deal when they are more remote from it. Others ſquint with one eye near the object, and with the other at a more remote diſtance. When they ſhut the eye which does not ſquint, that which ſquinted is immediately rectified; and by opening the eye-lid, we find that the one that was ſtrait or right before is now ſquinting.

All this relates to thoſe who ſquint from their infancy, and it is all found to originate in the diſcord of one of the right

muſcles

muſcles of the eye. But when this inconvenience happens in an advanced age, we muſt attribute it to a palſy in one of theſe muſcles of the eye: ſuch perſons ſee two or three objects, and ſometimes more, when they look only at one.

The difference between thoſe who ſquint from their infancy, and theſe laſt, is, that the firſt do not ſee double, as the laſt do. In the firſt, the eye that ſquints turns equally to every ſide, on ſhutting the eye which appears ſound; while in the laſt, on ſhutting the ſound eye, the other cannot be carried to the ſide oppoſed to that towards which the prunella is turned. Thus, in infants, the cauſe is, the want of animal ſpirits, which are not equally conveyed in the muſcles of the eyes, whence it happens that the ball is turned on one ſide; whereas, in people of more advanced age, one of the muſcles being paralytic, the eye remains immoveable towards one ſide by the contraction of its oppoſed muſcle, and cannot be directed towards the part that contends with that which is relaxed.

LADY CAROLINE.

Why do we open the prunella so much when we wish to read any thing at the close of the evening, or when we are in places where we are stinted for light ; and in these cases, why do we look nearer than we do in common ? Tell me, Edward.

EDWARD.

By these two means, the prunella embraces more light ; but the last, in dusky places, exacts from the eye an effort to remove a too great divergence of rays ; and this effort, while it lasts, fatigues the organ very much.

LADY CAROLINE.

When the bile mixes with the watery humour of the eye, how happens it, Frederic, that every object appears yellow to the person thus afflicted ?

FREDERIC.

FREDERIC.

The light that is brought to their eyes is discompoſed, as if it paſſed through a yellow glaſs; and there are hardly any rays but of this colour that trace images to the bottom of the organ. We find ſome people who, in conſequence of ſickneſs or ſome great accident, ſee red, green, and blue; when this happens, it is believed that the humours of their eyes have received tints of theſe colours.

SIR THOMAS.

We ſhall now proceed to the ſcience of *light* in general.

1ſt. The ſcience of optics is that which demonſtrates the laws according to which the rays of light depart from a radius, and terminate at the eye.

The ſcience of catoptrics teaches us the laws that the rays of light follow, which are reflected by a body, and of which the image is conveyed to the ſight.

Dioptrics is that ſcience which treats of the laws according to which the luminous rays paſs through mediums more or leſs denſe, more or leſs rarefied, and changed or broken by them.

2d. Light is an infinitely ſubtile matter which ſtrikes upon our eyes, which paints objects to them over which it is reflected, and of which the impreſſion is followed in us by another which affects the ſoul, and acquaints us with the preſence, the arrangement, the figure, the ſituation, and the diſtance of objects. Viſible objects, as the eyes, by which they ſhould be perceived, are always plunged in a fluid that extends without interruption from one to the other: this intermedial matter is ſuſceptible of a ſpecies of motion that is fit, and cannot be felt but in the bottom of the eye, in the ſame manner as it can only be excited by blazing bodies, or thoſe ſimilar to them. As ſoon as it is agitated in this manner, the organ, placed wherever it may happen to be in the ſphere of activity, fails not

not to be affected by it; and on this occasion the mind perceives and judges at a certain diſtance, and in the direction of the motion by which impreſſion has been made, the object that is the cauſe of it. The matter of light is the ſame as that of fire, becauſe it enlightens and burns like fire; the ſame element produces theſe two effects, and if we ſee one without the other, it is that both do not depend upon the ſame circumſtances, although they have one and the ſame principle.

Thoſe who pretend that the ſun continually ſends the light to us, do not ſolidly anſwer an inſurmountable objection: for if the ſun ſend light, it ought inceſſantly to loſe its ſubſtance, and conſequently become ſmaller and leſs ſplendid; this, however, does not take place. Will the objectors ſay, that comets are thrown into the ſun to ſerve him as aliment? Or that the loſs ſuſtained by the ſun is always repaired by the ſame matter, which returns to it again?

These anſwers offer nothing ſolid, and it appears to me that we ought to prefer the ſyſtem in which it is ſaid that the matter of light is ſpread throughout the world, and in order to ſhine, it waits only for a certain motion which the ſun gives to it.

For a candle to enlighten three miles round, it is not neceſſary that it ſend the luminous matter every where. It is ſufficient that it impreſs a certain motion to the ſubtile matter expanded in that place. If that be eaſily comprehended, why ſhould we not ſay the ſame thing of the ſun? May we not conſider it as the candle, and of courſe ſay, that this luminous ſtar, impreſſing a certain motion to the matter of light of which the univerſe is full, occaſions it to enlighten us?

3d. We may conſider the particles of a luminous ray that is extended from a ſtar to our eye, as ſo many little balls or ſmall elaſtic cluſters, and very contiguous, whence it happens, that the action of the luminous

body

body in all the length of the ray which ought to tranſmit it, is not inſtantaneous but to our ſenſes, and in the caſe of a very ſhort diſtance: but this tranſmiſſion, however rapid, however imperceptible it may be, requires a real ſucceſſion of inſtants, of which the ſum will become very conſiderable, if the way that the light ſhould run through be very long.

We may conſider the particles of matter as globules, becauſe this figure agrees better than any other with the phenomena. We muſt believe that theſe minute balls are ſo many little elaſtic bodies, by the vibrations of which is tranſmitted from one to the other the re-iterated ſhock of the luminous body, nearly in the ſame manner as that of a ball of ivory paſſes in an inſtant from one extremity to the other, of a row of equal balls: we ſhall conceive, that if any perſon ſhould apply his finger againſt the laſt ball, he would feel this ſhock every time that we ſhould impreſs the firſt: thus the organ, at the bottom of which a ſeries of globules terminate, with which we ſuppoſe light is made, fails not to be ſhaken by the vibrations, which the re-iterated impulſion of the inflamed body that ſhines at ſome diſtance effects on theſe little ſprings.

4th. We call *divergent rays*, two rays, which, departing from the ſame point, are always removed one from the other in proportion as they advance. We give the name of *convergent rays* to thoſe which coming from different points of the ſame object, approach each other in proportion as they continue their way. By *optic* or *viſual angles*, we underſtand the angles formed by the rays that dart from the extremities of the object, and croſs each other in the prunella.

5th. We may believe that light is reflected by the globules of light with which all bodies are charged, as is a ſponge with water, and which globules are, as it were, framed in the imperceptible pores of bodies,

dies, the ſolid or elementary parts of which aſſiſt the reſiſtance of globules of every ſpecies, upon which the different rays fall.

6th. *The angle of incidence* is that which is made by a train of oblique light, with the perpendicular that we ſuppoſe drawn upon the reflective ſurface. *The angle of inclination* is that which is made by the incident ray with the axis of incidence. *The angle of reflection* is formed by the ſame ray, reflected from one point into another. The angle of reflection is always equal to that of incidence.

7th. *The radiant point* is that whence depart many divergent rays. *The focus*, or *point of concourſe*, is that where the convergent rays are gathered together.

8th. The rule of the diminution of light is in an inverſe ratio of the ſquare of the diſtance, and the rule of its increaſe is likewiſe in an inverſe proportion of the ſquare of the diſtance. The following example will explain what this proportion is, which

is

is one of the foundations of our new philosophy.

I ſay, in the firſt place, that the ratio of the decreaſing of the force of light is in the inverſe ratio of the ſquare of the diſtance. I will here inſtruct you, my dear children, how to underſtand this expreſſion. If after having meaſured the diſtance from a hole of a window in a darkened chamber to the wall, you preſent to the opening a ſpiral ſmall tube of wax of any colour, lit on its ſtand, you will perceive that the light received at one foot from the hole upon a piece of paſteboard, is very ſtrong; that at two feet from the hole it diminiſhes, not by the half, but by the quadruple; multiplying two by two, you have four for the ſquare of the diſtance; that at four feet, the paſteboard will be ſixteen times leſs lightened than if it were at one foot, ſixteen being the ſquare of four; ſo that at five or ſix feet, the light is no more than the twenty-fifth or the thirtieth part of what

what it was when it firſt iſſued from the luminous body.

I ſay, in the ſecond place, that the ratio of the increaſe of the ſtrength of light, is an inverſe ratio of the ſquare of the diſtance. When, for inſtance, the rays of light, inſtead of ſtraying, converge and tend towards one and the ſame point, departing from the baſe of a cone to join in its apex (point or ſummit), they fortify each other in proportion as they approach the common point, where they will re-unite; and this convergent light continues now to increaſe as the ſquare of the diſtance diminiſhes; ſo that it is four, nine, ſixteen, twenty-five times more ſtrong, or the diſtance in reſpect of the ſame point is found, four, nine, ſixteen, twenty-five leſs than it was before. We all know, beſides, that the ſquare of a number is the number multiplied by itſelf. Thus ſixteen is the ſquare of four, becauſe four times four make ſixteen.

9th,

9th. If parallel rays in their incidence be reflected by a plane mirror, they conſtantly remain parallel as they were before.

10th. If divergent rays in their incidence be reflected by a plane mirror, their divergency does not change.

11th. If convergent rays in their incidence are reflected by a plane mirror, the rays preſerve the ſame degree of convergency.

12th. If the convergent rays in their incidence be reflected by a convex mirror, their convergency diminiſhes.

13th. If the rays which fall parallel together, are reflected by a convex mirror, they become divergent by the reflection.

14th. If divergent rays are reflected by a convex mirror, they become more divergent.

15th. If parallel rays are together reflected by a concave mirror, they become more converging.

16th. If convergent rays are together reflected

reflected by a concave mirror, they become more converging than before they had touched the mirror.

17th. If diverging rays in their incidence be reflected, they become less diverging.

18th. *Refraction of light* is a deviation which its rays undergo in certain circumstances, by passing from one medium into another. Light is refracted in these two re-united emergencies; that is, when it passes from one medium into another, more or less dense, and that its direction is oblique to the plane which separates the two media; that is, that (with whatsoever direction) the ray of light would not suffer any refraction; if issuing from the air, for instance, it should enter into a diaphanous (transparent) matter, which should be neither less nor more penetrable for it than this fluid; and that even where there is a difference of penetrability betwixt the two media, the ray of light would traverse through them into a right line, if, when it goes out of one, it falls perpendicularly upon the ſurface of the other.

The true cauſe of refraction is this; the ſtrength of the ſolar ray from a rarefied medium into a more denſe one, is broken at the moment of its entrance into a denſer medium, and flies off from the perpendicular line which falls through this laſt.

19th. We give the name of *point of incidence* or of *refraction* to the point or the ray of incidence, which with the broken ray makes the angle. The rays of light are always refracted when they obliquely paſs from one medium into another, that is, of a greater denſity or of a different nature.

20th. When light is refracted by paſſing from a rarer medium into one more denſe, the angle of refraction is ſmaller than the angle of incidence, and reciprocal to the former.

This law admits of ſome exceptions: fat or ſulphureous matters for the moſt part,

which

which are tranſparent, refract the light more ſtrongly than a perſon might expect, if he did not attend to their denſity. There are in them two cauſes of refraction, one belongs to their denſity, the other depends on their particular nature: this laſt may amply ſupply that which the other cannot do, or produce a juſt compenſation; whence it may happen that light paſſing from a rarefied medium into a more denſe one, may make its angles of refraction much larger than that of its incidence, or it may make them both equal, that is, that the ray is not refracted at all. We might even cite examples of theſe caſes, which are contrary to the general law; but as this law is true in the common courſe of things, and particularly as to bodies in which it is the moſt neceſſary to follow the motions of light, we ſhould always look on the general propoſition as a principle of dioptrics.

21ſt. Although the refraction of light become more or leſs great, either by the degree of obliquity of the incident ray, or by the nature of the refractive medium, the ſines of the two angles of refraction and of incidence remain always in conſtant proportion.

22d. Neither refraction nor reflection can ſenſibly alter the activity of light; ſince a refracted ray forced to return on itſelf, reſumes, as it iſſues from the refracted medium, the very direction that it had in its incidence.

23d. The refracted and incident ray are always found in the ſame plane, which is perpendicular to the ſurface of the refracted medium.

24th. If parallel rays in their incidence fly through a rarefied medium into one more denſe, which may be terminated by a plane ſurface, the refracted rays remain parallel.

25th. If converging rays in their incidence

dence traverſe a medium more denſe than air, and terminated by two plane parallel ſurfaces, the convergency of theſe rays diminiſhes when they enter it, and increaſes when they depart from it.

26th. If diverging rays in their incidence enter into a medium more denſe or more rarefied, bounded by plane and parallel ſurfaces, they loſe a part of their divergency, and reſume it when they leave it.

27th. If parallel rays paſs from a rarefied medium into one more denſe, bounded by a convex ſurface, they become converging.

28th. If the converging rays which flow from a rarefied medium, are received in one more denſe, and bounded by a convex ſurface, they become more and more converging than they naturally are, or remain ſuch as they were by paſſing through the air in this refractive medium.

29th. If diverging rays paſs from a rarefied medium into a denſer, bounded by a convex ſurface, they loſe a part of their divergency, and may become parallel, or even converging.

30th. If parallel rays paſs from a rarefied medium into one more denſe, terminated by a concave ſurface, they diverge.

31ſt. If converging rays paſs from a rarefied medium into a denſe one, bounded by a concave ſurface, they neceſſarily become leſs converging than they were, and can become parallel or even diverging.

32d. If diverging rays iſſue from a rarefied medium to enter into a denſer one, terminated by a concave circle, they can undergo no change; but they may become more or leſs diverging than they naturally are.

33d. Surfaces perfectly reflecting, I mean thoſe which we call mirrors, and which ſend back every ſpecies of light, ſeparately or altogether, contain in their

pores,

pores, like limpid bodies, as glaſs, water, &c. globules of every order, and in proportion ſimilar to that which nature has obſerved in the compoſition of ſolar light: whence it happens that theſe bodies are always ready to repel or tranſmit the action of the homogeneous rays, ſeparated or reunited.

34th. White ſurfaces, and bodies that have but an imperfect and colourleſs tranſparency, differ from theſe laſt only in this, that the incident light is there reflected or paſſes through with loſs and irregularity, either from the want of order in the pores, or by the figure, the ſize, or the arrangement being unfavourable to the parts of theſe bodies.

35th. What we call duſky, obſcure, and black, is only a privation of a greater or leſs light tranſmitted or reflected: for the ſame reaſon that enlightened bodies, which appear ſuch to us, abſorb or extinguiſh the action; and this effect ought to be attributed to the light that fills the pores which is too much engaged among the parts of the matter that contains it, and by this means is incapable of receiving and communicating a great part of the ſhock inflicted by the incident rays.

36th. Since gold, which is of all known matter the moſt denſe, becomes tranſparent when it is made infinitely thin by gold-beaters to a certain point, it is reaſonable to think that there is not a body which in its nature is of abſolute opacity; and as we ſee bodies the moſt diaphanous, tranſmit ſo much the leſs light as their thickneſs increaſes, we may ſurely ſay that there is no medium perfectly tranſparent, and which may not become opaque: we only allude here to relative and comparative opacity and tranſparency, and to ſhow how one body is more opaque or more diaphanous than another.

You ſee, my dear children, that I have gone very much at large into the ſubject of light;

light; yet I have dwelt on nothing but what is eſſentially neceſſary; and it will require all your attention to underſtand and retain the different principles that I have been laying down. I ſhall now, having given you the cleareſt inſight into the ſubject that my reaſoning powers are capable of, reſign you to Lady Caroline.

LADY CAROLINE.

Why do certain inſects, as glow-worms, ſhine in country places during night, George?

GEORGE.

The light ſent forth by theſe animals, proceeds from a fluid matter which they have in their bowels, and which even after we have preſſed it from the part which contains it, ſtill ſhines ſome minutes. It ſeems, however, that it is in the power of the animal to allow it to ſhine, or to extinguiſh it at pleaſure; for it does not always ſhine with the ſame brightneſs, and ſometimes it will not be ſeen at all. This gives us reaſon to believe that it is a ſpecies

of

of phosphorus which makes a part of the animal. This composition is a matter, in which the element of fire is but very slightly engaged, so that it is easily animated to the point that is necessary for lighting a matter, very similar in its nature, residing in the air.

We must think the same of an infinite number of other animals that have the singular property of shining in the dark.

In the islands of the Antilles, as I have heard Sir Thomas say, the natives place on their feet and on their hands, glowing flies, to enable them to travel by night; and that these flies send forth so much light, that they resemble small brilliant stars.

LADY CAROLINE.

A multitude of people see all at once, whatever single object presents itself to their eyes; thus a numerous troop of soldiers obey a signal given by one person; a star may be perceived in one and the same instant by a great number of the inhabitants of the

the earth, &c. How are theſe things to be accounted for, Kitty?

KITTY.

I conceive, that around a luminous body ſtanding by itſelf, there is not one place ſo large as the prunella of the eye of the ſmalleſt animal, that may not receive the baſis of a pyramid of rays animated or ſent back by that object: it is therefore painted in the eye, and the mind attending to this repreſentation perceives the object.

LADY CAROLINE.

The fowler aims his gun in the direction of the partridge; an engineer, to make ſtrait any way or ditch of a rampart, plants ſmall white ſticks, of which the extremities are found ranged in the viſual ray; a geometrician judges an object in the line of direction of the ſights or glaſſes of his inſtrument. Why ſo, William?

WILLIAM.

Becauſe the pyramids of light which come

come from the radiant point to the eye, and which we call rays, are perfectly right in a homogeneous medium. This is received as an axiom (or ſelf-evident propoſition), and it is very neceſſary that it ſhould be ſo; for if we were not ſure that the ray which goes from the object to the eye were perfectly ſtrait in the whole of its length, we could not lawfully conclude and determine the poſition of this object by the part of the viſual ray which would have followed the inſtrument in reaching the eye; and in that caſe how very much ſhould we be embarraſſed!

LADY CAROLINE.

The crew of a veſſel in coming from full ſea to land, perceive the ſteeples and roads of a town before they ſee the ſtones of edifices, or any of the lower parts of them; and thoſe who are already in port, firſt diſcern the arrival of a veſſel by the heights of the maſts and ſails, before they diſcover the body of it. How does this happen, Elizabeth?

LADY CAROLINE.

It proceeds from the convexity of the ſea, which follows that of the globe of the earth, of which it makes a part; but this happens thus only through the curve of the ſurface of the water, which interrupts the viſual ray of the ſpectator, who ſeeks for the lower parts of the object.

LADY CAROLINE.

What is a ſhadow, Henry?

HENRY.

Properly ſpeaking, it is nothing more than a light extinguiſhed by the interpoſition of an opaque body: it ſhould conſequently occupy all the ſpace that would be enlightened by this portion of light, if it had the motion which it can no longer receive.

Thus a very ſmall obſtacle produces much ſhade when it is very near the luminous body, and makes leſs in proportion as

it

it is farther removed from it: the proportion is ſuch, that the number of the intercepted rays diminiſh as the ſquare of the diſtance augments; that is, when the obſtacle is at a double, triple, or quadruple diſtance, it intercepts four, nine, or ſixteen times leſs light than when it was at the firſt diſtance.

LADY CAROLINE.

Why, Fanny, by looking too far do we miſs the object of our ſearch?

FANNY.

The viſual rays, occaſioned by their divergency, are too rarefied for what enters into the prunella to be ſufficiently felt. But this degree of diſtance in which the ſight fails, varies according to the ſtate of the eye, the nature or the qualities of the object, and the intenſity of the light which makes the object viſible.

LADY CAROLINE.

Owls, cats, and other animals who prowl by by night, perceive objects in the dark. How does this happen, Mary?

MARY.

These animals have very open eyes; and as they in general only see by rays of light very faint and rarefied, nature has given to them the means of receiving a greater number of them; and, without doubt, has joined to this advantage, that of a very sensible organ: for we may remark, that great light hurts the eyes of these animals, and that when they are exposed to it, they take care to draw in the prunella, to enable them to do which nature has given to it a particular organization.

LADY CAROLINE.

Although the eye change place, it always perceives the same object before which it is situated. How, Edward, does this happen?

EDWARD.

The eye which is performing its function, or which looks, becomes the common baſis of an infinite number of pyramids of light which have their apices (tips or ends) in the radiant points of the viſible body; and although the eye change its place, it perceives always the ſame object, not by thoſe rays by which it was firſt ſtruck, but by others altogether ſimilar; ſince every point of the ſurface which it contemplates, animates a whole hemiſphere by theſe diverging rays, of which each luminous pyramid is only a very ſmall portion.

LADY CAROLINE.

In a room cloſe ſhut, and where light enters only by a hole bored in the window-ſhutter or in the door, we ſee on the ceiling and on the wall, in an inverſe order, the figures and motions of objects paſſing without. What have you to obſerve upon this, Sophia?

SOPHIA.

All the cluſters of light tend from the different points of the object to the eye, and croſs each other in the prunella.

It

It is a known truth, that every enlightened object which is placed before the eye, is painted at the bottom of this organ ; and that its image there takes a ſituation exactly oppoſite to that which it really has. A man who ſtands before it, is there repreſented with his head downwards, and his right-hand where his left ſhould be. We may be convinced of this by a very curious experiment, but which requires a little dexterity in order to perform it with ſucceſs. We muſt ſhut up the doors and the windows of a room, by which it will be rendered totally dark ; then bore in one of the ſhutters a round hole of a diameter equal to ſix-twelfths of that of the eye, and in that hole place the eye of an ox newly killed, and from which all the teguments have been taken, excepting the laſt, which immediately touches the vitreous humour. If this preparation be well made, and we have taken care not to change the natural form of the eye by preſſing it, thoſe who are in the room will ſee at the bottom of the eye, in an inverted poſition, the objects without, with all their motions and natural colours, and with a peculiarly bright appearance.

LADY CAROLINE.

How is it, George, that on a lake we are leſs certain of ſtriking the birds at which we aim our gun, than in any other place?

GEORGE.

It is not, as is commonly ſuppoſed, that the ball ſenſibly preſerves there leſs velocity than upon the open plain; but that, not being able to aim well at a diſtance, through the deception of the water, we ſhoot too far without being aware of it.

LADY CAROLINE.

When we enter a long avenue, it appears to us to be lower and more narrow at the other extremity, although the trees with which it is formed be every where equally high, and the rows accurately parallel. What is the cauſe of this, Kitty?

KITTY.

KITTY.

It is occafioned by the rays that come to the eye from the fartheft of the trees, taken two by two, and which form angles more acute than thofe that are fituated nearer; we may fay the fame thing of thofe which proceed from the root of each of thefe trees and their fummits.

LADY CAROLINE.

We entirely lofe fight of, or fee but very confufedly, an object of which the likenefs is diminifhed beyond a certain point. Give me the reafon of this, William.

WILLIAM.

Becaufe then the different parts are no longer painted upon the places of the organ, that are feparated fufficiently each from the other: it is faid that the human fight ceafes to be diftinct when the optic angles come under one minute of a degree.

LADY CAROLINE.

Why, Elizabeth, do the fun and moon,

which are really globular, offer to our eyes only circular and luminous planes, as if they were ſimple diſks?

ELIZABETH.

Becauſe all the lines which conſtitute their convex ſurface, are preſented to us as ſtrait lines.

LADY CAROLINE.

If we look at a man who is about an hundred paces from us; according to the rules of the viſual angles, he ſhould appear to us about as ſmall again as if we ſaw him at fifty paces; for his image in the bottom of the eye diminiſhes in this proportion, notwithſtanding he appears to us in both theſe caſes nearly of the ſame magnitude. What is the reaſon of this, Henry?

HENRY.

It is by being thoroughly aſſured that a full grown man, has, in general, not leſs than five feet in height; and perceiving in his air and exterior every thing that conſtitutes man's eſtate, we implicitly give in

to

to this, without paying attention to any thing that might break down the limits of ſenſation, and overpower the judgement.

LADY CAROLINE.

We ſee the ſun and full moon much larger in the horizon than in any other place of the heavens, although it is well known that theſe bodies are more remote from us than when we ſee them in the zenith. Can you explain the cauſe of this, Fanny?

FANNY.

As objects are uſually preſented to our eyes with ſo much the more brightneſs as they are nearer to us, the habit of thus ſeeing them inclines us to think that theſe ſame objects are very far diſtant when they are more duſky. Thus, as the light of theſe bodies is then much enfeebled, we fancy that this proceeds from their being at a greater diſtance; and we judge in the ſame manner that they have approached us, when in riſing more above the horizon they become more ſplendid. Now, though the viſual angle be always the ſame, the object which it embraces ſhould appear larger if we think it more diſtant. We therefore ſuppoſe the diameters of theſe bodies greater when they are in the horizon than when they are more elevated, becauſe in this laſt caſe we think them nearer to us.

LADY CAROLINE.

Why, Mary, have the heavens the figure of an arched vault?

MARY.

Becauſe they are much more enlightened toward the zenith, than toward the horizon; and thence it muſt happen that the hemiſpherical curve is changed into another apparent curve, which is extremely arched.

LADY CAROLINE.

An object does not appear double, although each of the eyes receives an image of the

the ſame object. Give a reaſon for this, Edward.

EDWARD.

If the mind refer the two images of the ſame object to the ſame place, the object cannot appear double. The mind cannot ſee an object preciſely double at the ſame point and at the ſame place. Now, it refers the two images to the ſame point, for it refers them to the extremities of the two optic axes; and theſe two extremities terminate in the ſame point. Preſs the angle of one eye, ſo that the optic axes may not terminate at the ſame point as the other, the object appears double. This inconvenience is often occaſioned by ſickneſs. Sometimes infants bring it along with them, and as they grow up are in perpetual embarraſſment when the intention is to ſee a ſingle object.

LADY CAROLINE.

How is it, Sophia, that an object which is differently coloured, for inſtance, one half

half red and the other blue, does not appear of a mixed colour?

SOPHIA.

It is that the prunella is not the laſt boundary of the rays which aſſemble there: this part of the eye is only a ſimple opening. We ſhould therefore conceive, that all theſe pyramids of light which terminate in the eye, paſs without confuſion through the prunella, and increaſe in it; after which they continue their road to the bottom of the eye, where each of them makes its impreſſion ſeparately from the other. Now it is all theſe impreſſions collectively that form the image of the object.

LADY CAROLINE.

Why, Mary, cannot we move one of our eyes without moving the other?

MARY.

It is that the immediate cauſe of muſcular motion is ſuch, that the ſpirits cannot penetrate into the one without flowing in the ſame manner and at the ſame inſtant into the other.

LADY

LADY CAROLINE.

Why do objects, when the eye looks too near them, appear confused? Tell me, George.

GEORGE.

The angles made by the rays being too great, and those which shoot from every point of the object too much asunder, are not re-united enough upon the same part of the retina.

LADY CAROLINE.

What is the reason, Kitty, that we do not see the stars in the day-time?

KITTY.

The impression of the sun is a great deal too strong, and the vibrations of which it is the source in the organ of sight, repel that of the stars, and render them invisible.

From the bottom, however, of a deep tower, we see the stars in open day; because in the dark bottom the impression of the stars is stronger in its turn, since the

rays

rays of the ſtars fall therein perpendicularly upon the eyes, without having been weakened by any reflection; while the rays of the ſun can only enter obliquely, and do not arrive at the eyes; or, if they do, it is not till they have been much weakened by a great number of reflections.

LADY CAROLINE.

Why, William, does a ſquare tower, ſeen from afar, appear round to us?

WILLIAM.

As the angles of the tower do not make in the eye a ſenſible angle of viſion, on account of its great diſtance, we cannot diſcern them; and as ſoon as we fail to diſtinguiſh the angles of the tower, it muſt of courſe appear round.

LADY CAROLINE.

When we come out of a very light place, and enter into one that is rather dark, for ſome ſeconds after our entrance we cannot ſee any thing. What is the reaſon of this, Elizabeth?

ELIZA-

ELIZABETH.

The prunella, which is contracted when in a place very bright, that it may not admit the rays that might wound the organ of ſight, remains thus for ſome moments after we have entered the darkened place, and admits not of the weaker rays of light ſufficiently to perceive the objects.

When, on the contrary, we paſs from a dark room into one that is very light, the impreſſion of the latter is at firſt painful, becauſe the prunella, which has been dilated in obſcurity, in order to receive a greater quantity of the feeble rays, remains ſome time dilated in full light, and receives too many vivid rays; which exceſs wounds the organ of ſight.

LADY CAROLINE.

What is the cauſe of the twinkling of the ſtars, Henry?

HENRY.

We may attribute it to the motion of the media through which the images of theſe

 ſtars

ſtars paſs to come to us. Theſe media, which are the air, &c. have a motion that is communicated to the rays of light, which enable us to ſee the ſtars. Hence they appear to twinkle.

LADY CAROLINE.

Why do certain portraits ſeem to look at us, let them be viewed whichever way they may? Tell me, Fanny.

FANNY.

Such portraits have the noſe a little turned on one ſide, and the eyes toward the other. According as you are placed, they ſometimes appear to look on one ſide, becauſe the eyes are turned to that ſide; at others, we ſhould think they looked on the other, becauſe the point of the noſe is turned thither; and the picture being flat, we do not perceive that the eyes are turned towards the oppoſite ſide.

SIR THOMAS.

Every neceſſary principle having been previouſly laid down to you, we ſhall

now

now proceed to that part of the present subject, which relates to

REFLECTED LIGHT.

LADY CAROLINE.

Water alters the whiteness of paper, by making it appear more brown. How happens this, Mary?

MARY.

From the light which falls upon it, finding the pores filled with a transparent matter, absorbing itself in its thickness, passing beyond it, and returning with much less reflection. Now, we know that a body appears more obscure, when it reflects less rays.

LADY CAROLINE.

Why can we not make use of a simply plane mirror, however large it be, to collect the solar rays, and to increase the degree of heat that they produce? Can you explain this, Edward?

EDWARD.

Becauſe ſuch a reflection changes nothing of their natural paralleliſm; and we cannot expect an effect to happen that is produced only by their convergency: the direct light of the ſun would be more efficacious, the mirror never being ſufficiently perfect to reflect regularly all the rays that fall upon it.

LADY CAROLINE.

The light of wax candles has commonly an increaſed effect in places where there are cut-glaſs luſtres and chandeliers. What is the reaſon of this, Sophia?

SOPHIA.

Independently of thoſe ſmall flames, of which the images are multiplied, more light returns from the poliſhed glaſs than from any other reflecting body that may ornament them.

LADY CAROLINE.

Why have burning glaſſes ſuch extraordinary power, Frederic?

FREDERIC.

They re-unite the rays of the ſun in a focus, which only contains a very ſmall ſpace. The rays of the ſun being in a particular manner deemed parallel, thoſe which are diſperſed on the ſurface of the mirror are re-united in one point; and as this re-union much increaſes their ſtrength, it is not ſurpriſing, that, ſeparately having much heat, they burn and melt whatever is expoſed to the point of their re-union.

LADY CAROLINE.

The rays of the ſun which fall upon the mirrors have more ſtrength to burn than thoſe of a lighted fire. How happens this, George?

GEORGE.

The rays of the ſun which fall on mirrors, being parallel, or nearly ſo, the reflection or refraction re-unites them in a greater number upon the combuſtible body; and this ſuperabundance of rays re-united is an excess of strength. The rays which proceed from the fire are less parallel, perhaps on account of the nearness of the fire, or because they are impelled with less force; they are therefore re-united in a smaller number upon combustible bodies, and the result of this defect of the re-united rays is a want of force.

LADY CAROLINE.

Why does a large mirror produce more effect than a small one, Kitty?

KITTY.

It receives more rays, and reflects more of them to its focus.

An eminent philosopher (M. Buffon) by the means of a mirror of six square feet, was able to melt tin at 150 feet distance, lead at 140, silver at 50 feet, and set fire to a block of wood, distant 200 feet.

LADY CAROLINE.

The burning mirror of the royal palace in Paris has less power in great heats than in common heats. It had scarce any power at all in the extremely hot ſummer of the year 1705, and ſometimes it hardly has eight favourable days during all the whole ſummer. What is the cauſe of this, William?

WILLIAM.

It muſt undoubtedly be from ſulphureous exhalations which are raiſed from the earth in the great heats, and which are the cauſes in the air, and in the light, of thoſe trepidations and undulations which from time to time we there obſerve; theſe intercept a great part of the rays, and hinder them from falling on the mirror, envelop the rays which flow over it and tend to reunite in the focus, and take from the extreme ſubtility neceſſary to enable them to penetrate and inſinuate themſelves into a hard body. This exceſs of weakneſs ſurpaſſes the exceſs of ſtrength that proceeds from great heats.

When we place betwixt the mirror and the focus, a chafing-diſh full of lighted

coal,

coal, under the rays which tend to the focus of the mirror, the power of the rays is confiderably weakened; the reafon is, that the rays become faint by traverfing the fulphureous exhalations that arife from the coal.

LADY CAROLINE.

How did the mirrors of Archimedes (as we are told) burn the veffels of the Romans, Elizabeth?

ELIZABETH.

I have heard Sir Thomas fay, that this relation is hard to be believed; for though, according to the rules, a mirror may be made of which the focus may be very diftant, yet the rays would not be better united, on account of the great difficulties it would encounter in traverfing the air, and of the uncertainty of the accurate conftruction of the mirror.

The portion of fphere of the concave mirror which Archimedes made ufe of, confidering the diftance of the veffels, which was thirty paces, ſhould have been one hundred and twenty feet.

LADY CAROLINE.

Why do we in vain make uſe of convex mirrors to increaſe the heat that flows from the ſolar rays? Tell me, Henry.

HENRY.

The light of the ſun being naturally almoſt parallel to itſelf, far from converging as it ſhould to acquire more ſtrength, can only diverge and be rarefied when it is reflected by ſuch ſurfaces.

LADY CAROLINE.

Why is the light which comes from the planets to us ſo very much weakened, Fanny?

FANNY.

It not only makes a longer paſſage by flowing from its ſource to other celeſtial bodies, and from theſe to our globe, but, beſides, there is only a ſmall part of it reflected towards us, and the portion of light which

which is given to us, is very rarefied by the divergency it receives from the ſpherical nature of the reflecting ſurfaces.

LADY CAROLINE.

The heat of the ſun is leſs powerful upon the ſummits of high mountains, than in valleys. Explain this, Mary.

MARY.

Among the cauſes which contribute to this effect, we may reckon the divergency of the rays of light, conſiderably increaſed by the round figure of the mountains; for the heat experienced on the ſurface of the earth darts not only from direct rays of the ſun, but alſo from thoſe that are reflected; theſe being rarefied or diſperſed by the manner in which they reflect, the total effect muſt be leſs.

LADY CAROLINE.

By fixing the ſight upon a gold or ſilver button, a watch-caſe, &c. well burniſhed, we may there ſee our faces as in miniature paintings; they are ſeen alſo in their natural

tural ſituations, and very near behind the reflecting ſurface, but we ſeldom ſee them correctly deſigned; and the motions of ſuch repreſentations do not correſpond to thoſe who conſult them. What is the reaſon of this, Edward?

EDWARD.

This is occaſioned, without doubt, by the irregularities of thoſe little mirrors which are adapted to ſhine, rather than to repreſent objects; but even if they were fitted for this laſt effect, they would always in common circumſtances have the imperfections I before mentioned.

LADY CAROLINE.

Why does a concave mirror which has a very ſmall curvature repreſent pretty accurately the figure of a ſmall object; and the contrary, if it be more hollow in regard to its diameter, and the object be larger, Sophia?

SOPHIA.

The dimenſions of a large object not being

ing parallel to the reflecting ſurface, and the viſible points being repreſented at diſtances proportionate to the degree of the diſtance which they have before the mirror, it is natural that the images which reſult from all theſe particular repreſentations ſhould make us ſee in curve lines that which is repreſented in the mirror in ſtrait lines; or, which is the ſame thing, the apparent figure is not conformable to the real figure of the object.

LADY CAROLINE.

Why do plane mirrors repreſent objects juſt as they are, without changing either the colour or the arrangement, or the ſize of them? Tell me, Frederic?

FREDERIC.

Hard, uniform, and poliſhed, they ſend back to us the rays, ſuch as they have received them, in the ſame order, and with the ſame modification; the angle of reflection being equal to that of incidence.

LADY

LADY CAROLINE.

The object appears beyond plane mirrors at the ſame diſtance as it is, or appears to be, on this ſide of the mirror. In proportion as I approach the glaſs, or remove from it my image, which is ſeen beyond it, ſeems to approach or remove as I do. What is the cauſe of this, George?

GEORGE.

The rays before they repreſent the object, go from the ſame object to the glaſs, and come back from beyond the glaſs even to the eyes. They have therefore, when they enter into the eyes, not only the ſame diſpoſition and the ſame inclination, but likewiſe the ſame force and the ſame direction, which they would have, if they had actually come from the point, and the diſtance where the object appears beyond the mirror. Of courſe, they ought to repreſent it there as they really do, ſo much the more as the mind naturally refers objects to the extremity of the right rays, which approach to ſtrike the organ, or which face you.

LADY CAROLINE.

Sometimes the light of a ſingle wax-candle, falling upon a pane of glaſs with an obliquity of forty-five degrees, appears double beyond it. Why ſo, Kitty?

KITTY.

It is, that there is a ſtronger light and one more weak; the ſtronger one is reflected by the foremoſt ſurface of the plane of the glaſs, and the weaker one is ſent back, at leaſt in part, by the air expanded upon the hindmoſt ſurface. If we moiſten with water, clear oil, or tranſparent and liquid honey, that ſurface, a great part of the rays will no more return, becauſe theſe fluids will allow them to paſs. The rays return, however, when the air alone immediately covers the ſurface.

LADY CAROLINE.

Why do convex mirrors repreſent objects ſmaller than they really are; and concave

mirrors

mirrors, on the contrary, larger. Can you tell me, William?

WILLIAM.

The convexity of the firſt is the cauſe that the moſt powerful rays are reflected to the eye only by a very little ſurface. They ſtrike the eye under very ſmall angles. Thence the angle of viſion is extremely minute, and the image of the object correſponds to this angle.

The concavity of the latter is, that the rays reflected by the concave ſurface make a much greater angle; and if we look within it, the object of a point where the eye may be more remote than the focus of the rays, or than the point of their re-union, the object appears inverted, becauſe the rays muſt croſs each other in their focus, and then ſeparate in ſuch a manner, that thoſe which come from the ſuperior part of the object are downwards, before they enter into the eye; and thoſe which come from the inferior part are upwards.

SIR THOMAS.

The part of this ſubject with which we are now about to cloſe, is called

REFRACTED LIGHT.

LADY CAROLINE.

We ſhould infallibly miſs a fiſh in water if we ſhot at the place where we ſee it. How does this happen, Elizabeth?

ELIZABETH.

For two reaſons; the firſt is, becauſe the fiſh is always lower than the ſpot in which it appears to be. In the ſecond place, the ball undergoing a refraction in a contrary direction to that of the light, neceſſarily riſes above the direction which we intend to give it.

LADY CAROLINE.

We ſometimes ſee the moon on her riſing, totally eclipſed, while the ſun is ſtill wholly ſeen in the oppoſite part of the horizon. How happens this, Henry?

HENRY.

HENRY.

It is not the moon that is ſhewn upon the horizon, but only its repreſentation raiſed by the effect of refraction.

LADY CAROLINE.

Plane glaſſes, as thoſe which we put in windows, thoſe of which we make mirrors, &c. cannot be uſed to condenſe the ſolar light which runs through them. Give me the reaſon of this, Fanny.

FANNY.

Theſe rays, being parallel to each other, can never be more inclined one than the other to any ſingle plane: thus, refractive ſurfaces that are even, do not change any thing in their reſpective poſition.

LADY CAROLINE.

How is it that we ſee, Mary, through the glaſſes of carriages, almoſt, if not quite, as well as if we looked ſimply through an homogeneous medium.

MARY.

When media more denſe than the air

have even ſurfaces, and theſe are very fine, their interpoſition does not cauſe any ſenſible change in images, becauſe the light is but little refracted.

LADY CAROLINE.

Denſe media, very thick, although with plane ſurfaces, make us ſee objects much larger than they are; fiſh, for inſtance, appear larger in water than when they are taken out; gravel, ſtones, plants, in like manner, deceive us when we ſee them at the bottom of baſons, fountains, rivers, &c. The ſpaces alſo appear to us more extended, and the limits which ſurround them ſeem to us to leave betwixt each other a greater diſtance. What reaſon, Edward, can be given for this?

EDWARD.

All this may be accounted for by the rays, which become more and more converging when they dart from the water to enter into the air.

LADY CAROLINE.

Having the eye placed directly above a veſſel full of water, or of any other clear liquid, if we look at a piece of money, or any ſimilar thing at the bottom of the veſſel, and ſufficiently lightened, we ſee it larger than in the air; but it does not appear to us to be out of its place, like another ſubſtance of which we ſhall hereafter ſpeak. What is the reaſon of this, Sophia?

SOPHIA.

We may comprehend the reaſon of this, by conſidering that in this caſe, the eye perceives a part of the piece; its center, for inſtance, through a cluſter of rays, of which the axis ſuffers no refraction, perpendicularly paſſing from the water into the air; this part of the piece is therefore ſeen in its true place, and in its natural direction; the others are ſeen by oblique rays, of courſe reflected, which apparently diſperſes them from the firſt, as if it were immoveable; hence the object appears magnified, but

but not difplaced as to its direction: the figure itfelf is not fenfibly altered, if we di-rect our look in fuch a manner that the di-rect ray may come from the middle of the object which we propofe to fee, at leaft if it be not too large.

LADY CAROLINE.

Solid bodies put in glafs veffels full of water, or any other tranfparent liquid, ap-pear to us under deformed fhapes when we look at them through the fides of thefe vef-fels, which are often curved in one fenfe and ftrait in another. What is the caufe of this, George?

GEORGE.

There are certain dimenfions, as in thefe inftances, which admit more than others of the effects of refraction.

LADY CAROLINE.

If we put a crown piece or any other piece of money into an empty bafon, and withdraw till we juft lofe fight of it, and another perfon come and put a certain quan-

quantity of water gently into it, ſo as not to move the piece, it will, nevertheleſs, ſuddenly appear again to you. Can you, Kitty, explain the cauſe of this?

KITTY.

The oppoſite ſides of the baſon hinder the rays which ſhoot from the ſurface of the piece of money from coming in a ſtrait line to our eyes. If we fill the baſon with water, we may ſee the money at the ſame diſtance in the oppoſite points of the curve of the baſon, beyond and above the ſpot where it really lies.

LADY CAROLINE.

Certain artiſts in fine works, as engravers, &c. for the purpoſe of procuring light for their evening labour, have lamps, of which they make the light paſs through a glaſs bottle, thin, round, and clear, which they call the jug, and which they fill with clean ſpring water. For what purpoſe have they recourſe to this expedient, William?

WILLIAM.

WILLIAM.

The flame of a candle or of a lamp being placed near this bottle throws upon a great part of its spherical surface diverging rays, which become by degrees a great deal less; and this light afterwards loses the rest of its divergency by passing through the water into the air, because on each part it is refracted; the rays of course are contracted into a smaller space, and become parallel or converging.

LADY CAROLINE.

Why, Elizabeth, does a straight stick put obliquely into water, appear broken?

ELIZABETH.

The rays which shoot from the end of the stick are refracted in their entrance from the water into the air, and the eye receiving them as if they were shot from a point where the end of the stick is not, the mind is referred thither, and thinks it broken in two.

LADY

LADY CAROLINE.

Why do round magnifying glaſſes, or lenſes, enable us to ſee more clearly? Tell me, Henry.

HENRY.

As they are convex on both ſides, they force rays to enter into the eye, which would not have entered had we looked at the object without them; it is a natural conſequence that they will render the light leſs diverging, for the refracted rays being more contracted between themſelves, the prunella muſt ſeize thoſe which might have eſcaped.

SIR THOMAS.

We are now, my dear children, arrived at the end of our labour. My deſign is completed. I am convinced that you perfectly underſtand all the queſtions and principles which have been propoſed and expounded by your good mother Lady Caroline and myſelf.

You will now be able with confidence to account

account for every phenomenon that can occur in common life. Many things of which great numbers of people, who are considered as having been well educated, are completely ignorant, you will be enabled to explain to their great astonishment and admiration.

We shall now leave you to cultivate and improve whatever new ideas may arise upon the subjects of which we have been treating; and I trust that your own ingenuity will prompt new and useful experiments, which your industry will bring to perfection.

THE END.

DEFINITIONS

OF

TERMS OF SCIENCE, &c.

OCCURRING

IN THESE VOLUMES.

A

Absolute—complete, unlimited.

Abſorbent---the property of ſucking up or drying away moiſture.

Accelerated---one increaſe of ſwiftneſs continually added to a former increaſe.

Accord---when two or more ſonorous bodies form ſounds, the union of their impreſſion is called an *accord*.

Acids--- liquors and ſubſtances which being compoſed of pointed particles affect the taſte in a ſharp and piercing manner, as vinegar, lemon-juice, &c.

Action---the power of one body exerted on another; compreſſion.

Active---a body that can exert its power on another.

Acute---ſharp; ending in a point; the higheſt ſound of an inſtrument.

Adherence---the union of

of two bodies ſimply touching each other.

Adipous---fat, greaſy.

Adulterated--the mixture of ſome baſe matter, which renders a ſubſtance corrupt, unwholeſome, or nauſeous.

Agate---a hard, party-coloured, and ſmooth ſtone.

Air-pump--a machine by which the air contained in all bodies may be exhauſted.

Alkali--any ſubſtance which when mingled with acids produces fermentation and effer-veſcence.

Alternatives---the various ſucceſſions or ſituations of one thing to another; the choice given of two things, ſo that if one be rejected, the other muſt be taken.

Aluminous--belonging to, or containing alum.

Amphibious --- having power to live either on land or in the water indifferently.

Analogous --- bearing ſome reſemblance or proportion.

Angle---the ends of two lines inclining to, and meeting each other, form an opening or corner called an *angle*. An angle is called *acute* when the two lines that form it contain between their open ends a leſs portion than one-fourth of a circle's circumference. It is called *obtuſe*, when its lines contain more than one-fourth of a circle's circumference. It is a *right angle*, when they contain exactly one-fourth of a circle's circumference.

Angle of Incidence. See the 6th definition of *Light*, Vol. 3, p. 151.

Angle of Inclination. See the 6th definition of *Light*, Vol. 3, p. 151.

Angle, optic. See the 4th definition of *Light*, Vol. 3, p. 150.

Animalculæ ----- the ſmalleſt of all poſſible inſects, which, without the help of glaſſes, eſcape the moſt piercing eye.

Antipathy---a natural contrariety to any thing, ſo as to ſhun it involuntarily; averſion, diſlike; the contrary to *ſympathy*.

Apex—

Apex---top, point, or ſummit.

Apices ---- plural of *apex*.

Apparatus---things to be provided for the purpoſe of experiments.

Application---the fitting of one thing to another, and the agreement of both.

Aqua Fortis---a powerful liquid compoſed of ſalt-petre and vitriol.

Aquatic---reſiding in water.

Aqueous---watery.

Aqueducts --- conveyances for water.

Arcana---ſecrets; alluding to the ſecret ſtores of truth found by philoſophy in the womb of nature.

Arquebuſe --- a hand-gun larger than the common muſquet.

Aſperities--roughneſſes on the ſurface of any natural body.

Atmoſphere --- the air that ſurrounds the globe of the earth; the odorous particles which ſurround a flower; the effluvia of a heated body.

Atoms---the moſt minute and inviſible parts which conſtitute bodies; any thing extremely ſmall.

Auditive Nerves---the ſeventh pair of nerves, and which convey ſounds to the ear.

Axis---a direct line paſſing through the center of any body on which it may turn.

Axes---plural of *axis*.

B

Bamboo--a reed found in the Eaſt Indies.

Baſis---the foundation or ground-work of all bodies.

Bas Relief---projected ornaments which do not ſtand out from their ground in full proportion.

Biped--any two-footed animal.

Bodies ---- all thoſe things which can be called ſubſtances, have a ſhape or form, and may be felt or known by the ſenſes.

Boerhaave --- a celebrated Dutch natural philo-

philosopher, born 1668, died 1738.

Bomb---a shell or hollow ball of cast iron, charged with powder, nails, &c. formidable in war.

Breadth --- the measure of a body from side to side.

C

Calcination--reducing of bodies to powder by fire.

Calculate --- to compute, to number, to reckon.

Capacity---the quantity of room that a body has to receive other bodies within it.

Capillary--small tubes or conveyances in different bodies, resembling hairs in their capacities.

Caput mortuum---passive or inactive dry earth.

Cardinal point --- one of the four principal points in the compass.

Catoptrics --- that part of optics which treats of vision by reflection.

Cause --- that which produces an effect.

Center of gravity---is a point through which any body may be divided into two equal parts, that is, one as heavy as the other; the very center point of the weight of all bodies.

Chrysalis---any insect in its *coque* or egg-shell.

Cinnabar --- vermilion, a heavy red mineral, consisting of united particles of mercury and sulphur.

Circle---a circle contains 360 degrees, 21,600 minutes of degrees, and 1,296,000 seconds of degrees.

Coagulate --- to congeal, thicken, or curdle together.

Cochineal---an insect, which, when properly dried, is used in the dyeing-trade.

Cohesion---the union of two bodies in such a manner as to require force to disjoin them.

Column---a round pillar; any body of certain dimensions pressing vertically upon its base.

Combination---the different ways that quantities

tities or ſubſtances may be varied in order to produce a new form.

Compaſs---an inſtrument dividing the horizon into 32 equal parts; by this inſtrument mariners ſteer their courſe.

Compoſition --- a mixture of different ingredients to conſtitute one whole.

Compound ---- a ſubſtance made up of many ingredients.

Compreſſion---a thickening or ſqueezing together, ſo that, though the bulk leſſens, the contained matter is ſtill the ſame.

Concave---a cavity or regular curved hollow.

Concuſſion---a ſudden ſhock, or loud and tremendous claſhing.

Condenſation--the ſame with *compreſſion*; the oppoſite to *rarefaction*.

Conformation--the way in which the elementary parts of a body are diſpoſed and arranged.

Congenial ---- ſimilar diſpoſition and temperature.

Conglomerated ---- gathered together, as in a ſwarm or a ball, or any round maſs.

Conſecutively ---- following in train, ſucceſſive, uninterrupted.

Conſtituent--thoſe parts which placed together form a whole.

Conſumption---the expending of ſtrength.

Contiguity---the nearneſs of two bodies ſo as to touch each oth r.

Continued body--a ſubſtance ſo conceived that its parts are not ſeparated from each other.

Contraction---that kind of motion which makes a body collect its parts into each other, gather up, as it were, and ſhorten itſelf.

Converging --- rays which incline towards each other till they meet in a point.

Convex--a form round like the top of a watch-glaſs, as a concave is hollow like the inſide of a watch-glaſs.

Cornea--the ſecond or horny coat of the eye, containing the watery humour.

Corpuſcula--the ſmalleſt of all bodies.

Cubic inch---is an inch

 ſquare

ſquare made into a ſolid body like a die, whoſe length, breadth, and depth are equal.

Curving ---- crooked, bent, arched.

Cylinder--a body having two flat ſurfaces and one circular; a tube or pipe completely round and uniform from one end to the other.

D

Day---- contains 24 hours, or 1440 minutes.

Degree---contains 60 minutes, or 3600 ſeconds. Equal to 69½ Engliſh miles.

Denſity --- thickneſs; or that property by which bodies contain ſuch a quantity of matter under ſuch a bulk; ſo that more matter under the ſame bulk is greater denſity.

Depth ---the meaſure of a body in the direction of from head to foot.

Deſcartes---a celebrated French philoſopher, born 1596, died 1650.

Deterioration--the contrary of improvement, the act or ſtate of becoming worſe.

Determined---fixed to one direction, ordered, neceſſitated, limited.

Diagonal--a line drawn from angle to angle, and dividing a ſquare into equal parts.

Diameter--a ſtrait line paſſing through the center of a round table (for inſtance) and ending in two oppoſite points of the rim.

Diaphanous--tranſparent, allowing the light to paſs through, as glaſs, air, water, &c.

Diffuſion of odours--the diſperſion and ſpreading round of fine vapours.

Digeſtion--the action by which the groſſer parts of food are ſeparated by the heat of the ſtomach, and certain internal juices from thoſe which are more fine and ſubtile.

Dilatation---the act of becoming thin and wide, ſo as to preſerve the ſame quantity of matter, but acquire a larger volume; contrary to *contraction*.

Dilute

Dilute--to melt down; the word is generally uſed to imply ſeveral ſubſtances waſhed into each other by long mingling and beating together.

Dimenſion---the meaſure of a body either as it is long, broad, or deep.

Dioptrics---that part of optics which treats of the different refractions of light paſſing through different mediums, as air, water, glaſs, &c.

Direction---a ſtrait or crooked line from the place of ſetting-off to the place of arrival.

Diſk---the body or face of the ſun or moon being round, and appearing to our ſight as flat.

Diſſeminated---ſpread throughout, like ſeed in a field.

Diſſolution---a looſening aſunder, ſo as to divide the particles of ſolid bodies from each other.

Divergent--rays which going from the point of any viſible object, depart from each other.

Diviſibility---the quality of admitting diviſion or ſeparation of parts.

Ductility of metals—the quality that metals have of becoming flexible, pliable, and extendible.

E

Ebullition---boiling or bubbling upwards thro' great motion.

Effervеſcence---a boiling over.

Effluvia --- the ſmall and inſenſible particles that fly off from bodies.

Elaſticity---the power to return to a firſt ſituation, as a cane that is forcibly bent flies back again.

Electrical ---- bodies which have the power of attracting light ſubſtances to them without magnetiſm; amber, ſealing-wax, &c. when heated by friction, are of this deſcription.

Elements--are the original, unmixed, ſimple parts of any created ſubſtance.

Emanation of Light—

flowing

flowing round in all directions from a ſource or center, as the rays of light from a taper or from the ſun.

Enveloped --- inwrapped, covered, ſurrounded, incloſed.

Eolipile--a hollow ball of metal with a long pipe; which ball filled with water, and expoſed to the fire, ſends out as the water heats, at intervals, blaſts of cold wind through the pipe.

Equilibrium ---- equipoiſe, equality of weight at each end.

Eſſence---the very *being* of a thing.

Evacuation---the act of emptying.

Evaporate --- ſending out vapours from the ſubſtance of the body itſelf.

Exhale ---- throwing forth vapours from the ſurface only.

Expanſion---the ſwelling or increaſe of bulk of fluids when ſtirred up by heat.

Experiment --- a trial made on natural bodies for the purpoſe of diſcovering their qualities or their properties, and aſcertaining their cauſes and effects.

Expirate ---- vapours thrown forth from a hollow ſubſtance.

External--from without; that is, a cauſe not within the body itſelf, but proceeding from ſome other body.

Exudation---a forcing out of the juices.

F

Faces --- ſmall ſurfaces; a ſuperficies cut into ſeveral angles.

Fermentation---an internal motion of the imperceptible parts of a body, accompanied with great expanſion occaſioned by the *acids* making their way into the *alkali*.

Fibres--fine ligaments or ſtrings, tough and long, the middle part of which is very fleſhy.

Filaments---thin ſlender threads; alſo ſmall fibres which make up the texture of the muſcles.

Fluids---liquids, any thing

thing not ſolid; thoſe bodies which are made up of particles ſo very ſmall and round, that they are eaſily put in motion by touching each other only in one point, like ſo many ſmall globes.

Finite --- that which has an end; it alſo means determinate.

Focus ---- the point wherein the rays are collected after they have undergone refraction or reflection.

Foci---plural of *focus.*

Force --- power, impulſe.

Form --- the external appearance or ſhape of any thing.

Frangible--eaſily broken.

Friction--the rubbing of two bodies againſt each other, ſo as to hinder or leſſen motion.

Fulcrum---a prop.

Function --- the office allotted to any active power.

Fuſion --- the act of melting, the ſtate of being melted.

G

Globules--ſmall round bodies.

Gold putty---a cement or paſte made of gold in the way of common putty.

Graduation --- by degrees, ſtep by ſtep, regularly ſlow.

Grain---The following weights are generally uſed in the experiments of natural philoſophy:

One pound contains 12 ounces, or 240 pennyweights, or 5,760 grains.

One ounce contains 20 pennyweights or 480 grains.

One pennyweight contains 24 grains.

Gravity--weight, heavineſs, tendency to the center.

H

Hartſoeker---an eminent Dutch philoſopher and mathematician, born 1596, died 1650.

Hemiſphere---the half of a globe or ſphere

when

when divided in two by a plane paſſing through its center.

Heterogeneous --- conſiſting of parts unlike each other.

Homogeneous -- having the ſame nature or principles; ſuitable to each other.

Horizon--the line that terminates our view of the ſky.

Horizontal--level with the horizon.

Hour --- contains 60 minutes, or 3,600 ſeconds.

Humidity --- moiſture, wetneſs.

Hypotheſis --- ſuppoſition; principle laid down, and to be taken for granted.

I

Igneous--the property of thoſe bodies which communicate fire.

Impelled --- puſhed or driven onwards.

Impregnated --- filled, ſo as to admit no more.

Inch ſquare ---is a portion of any ſubſtance of four equal ſides, every one of which is an inch in length; natural philoſophers uſe the following meaſures in their experiments on ſpace:

12 inches make 1 foot.
3 feet —— 1 yard.
6 feet —— 1 fathom.
$5\frac{1}{2}$ yards —— 1 pole, perch, or rod.
40 poles, &c. —— 1 furlong.
8 furlongs —— 1 mile.
1 linear foot makes 12 linear inches.
1 linear inch makes 12 linear parts.
1 ſquare foot —— 144 ſquare inches.
1 ſquare inch —— 144 ſquare parts.
1 cubic foot —— 1728 cubic inches.
1 cubic inch —— 1728 cubic parts.

Inclined plane---a ſurface that ſlopes or inclines to the level of the horizon.

Incorporated--two bodies ſo joined that a diſtinction of either becomes difficult.

Inertneſs---the ſtate of being quite ſtill.

Infinite--without end; indeterminate.

Inflexibility --- incapable of being bent or wrought upon.

Influ-

Influence---the power of one body flowing in upon another, and giving or depriving it of exertion.

Infusion---the ſtate of being ſteeped in moiſture, or poured upon.

Integrant parts --- are thoſe which collectively make up a whole body.

Internal--inward, not external.

Interpoſition--a placing betwixt, or one body placed between two others.

Interſtice ---ſpace between one thing and another.

Intimately --- cloſely, with intermixture of parts.

Inverſe ratio---inverted proportion; reciprocal; oppoſed to *direct*.

Julian month --- contains 4 weeks, or 28 days, or 672 hours, or 40,320 minutes.

Julian year---contains 13 months, 1 day, and 6 hours; or 52 weeks, 1 day, 6 hours; or $365\frac{1}{4}$ days; or 8766 hours; or 525,960 minutes.

K

Kind---the word *kind* makes one's thought general, as *mankind* means all the human race together. See *Species*.

L

Layer---a thin covering of any one ſubſtance ſpread upon another, or a continued bed of any kind of ſubſtance, ſuch as a bed of a peculiar ſort of clay in the bowels of the earth.

Length---is the meaſure of a body from the face onwards; from end to end.

Lever---any contrivance to enable us to raiſe a body that is either too heavy or too inconveniently placed to be raiſed by the mere ſtrength of the arm.

Line of Direction---is that line which proceeds from the center of gravity, and determines the motion of the body to ſuch and ſuch a direction.

Litharge --- a coarſe kind of reddiſh mineral; properly, lead vitrified, either alone or with a mixture of copper.

Local--being in a particular place.

M

Machine---any complicated work in which one part contributes to the motion of another.

Magnetiſed --- having the power of a magnet given to it.

Mairan --- a French natural philoſopher of the preſent century.

Maſs--a body, a lump, a continuous quantity.

Matter--is every ſubſtance that may be felt, divided, put in motion, or ſtopped, and is extended in length, breadth, and depth.

Medium---a peculiar conſtitution or frame of any ſpace through which bodies move, as air, water, vapour, &c.

Media---plural of *medium*.

Membrane---this term is uſed to expreſs a filmy web of fibres or ſmall threads which envelop or cover the particular parts of an animated body.

Mercury or *Spirit*---is a white fluid mineral, the great principle of all metals, the firſt of fluid or flowing bodies, and only the ſecond of heavy ones, as gold alone is heavier.

Microſcope---an inſtrument by means of which the moſt minute objects are repreſented to the eye as of a prodigious ſize, and every part diſtinctly.

Miles reduced--In this place it may not be amiſs to remind the young reader of the following meaſures:

3 inches make a hand breadth or a palm.
3 palms —— a ſpan,
$1\frac{1}{3}$ ſpan —— a foot,
$1\frac{1}{2}$ foot —— a cubit,
2 cubits —— a yard,
$1\frac{1}{4}$ yard —— an ell,
$1\frac{1}{4}$ ell —— a pace,
$1\frac{1}{5}$ pace —— a fathom,
$2\frac{3}{4}$ fathoms —— a perch,
4 perches —— a furlong,
8 furlongs —— a mile.

Minute---contains 60 ſeconds.

Mixed bodies--implies whatever ſubſtance is made up of a mixture of the firſt principles or elements.

Modification---a qualifying or modifying; ſetting a meaſure or limit to any thing.

Muller---a ſtone held in the hand with which any powder is ground upon a horizontal ſtone. It is often improperly called *mullet*.

Muſchenbroek --- a famous Dutch philoſopher and mathematician, died 1761, aged 69.

Muſcles---the principal organs or promoters of motion in all animated bodies.

Mutual---the quality of two bodies partaking of each other's powers.

N

Nature --- a regular courſe of things; a diſpoſition of bodies, a ſtate, a ſyſtem.

Nitre---a very ſharp and corroſive body drawn from ſalt-petre.

Nitreous--impregnated with nitre.

Non-elaſtic ---- bodies that do not reſtore themſelves to their former figures after having been ſtruck and bent by other bodies.

Nutrition---the act of nouriſhing.

O

Object---is the knowledge reſulting from any particular ſtudy; as *ſubject* is the means of arriving at that knowledge.

Oblique --- aſlant, or forming an angle with the perpendicular line.

Obliquity—ſlantneſs.

Obtuſe — blunt, the contrary to *acute*.

Oleaginous—partaking of the nature of oil; oily.

Opacity—cloudineſs; want of tranſparency.

Opaque — dark, obſcure, cloudy, the contrary to *tranſparent*.

Organ — the inſtrument of ſome faculty; thus,

thus, the *eye* is the *organ of sight.*

Orifice--hole, opening.

Orpiment, yellow—a species of arsenic.

P

Parallel—equally or every where alike distant.

Particles—the very smallest points or atoms that can be conceived to enter into the composition of bodies.

Passive--a body which must receive action from another, being incapable of action in itself.

Percussion, direct—a striking in a straight line.

Perpendicular—in the direction of a straight line up and down.

Perrault—a French natural philosopher, which profession he quitted for that of an architect. Died 1688.

Phenomenon—an uncommon appearance, difficult to be accounted for.

Philosopher—a man deep in knowledge, either moral or natural; literally, a lover of wisdom.

Phlegm--(pronounced *fleme*) a watery humour of the body so called; water, one of the five chymical principles.

Phosphorus—a chemical preparation which shines only in the dark, and being exposed to the air, takes fire.

Physics—natural philosophy, or that science which treats of the powers and properties of bodies in their *natural* state.

Plane—a flat surface level with the horizon.

Platen—a plate upon which objects are placed in the air-pump.

Pores—small openings found between the particles of all bodies.

Porphyry—a fine species of hard and reddish marble.

Precipitated--expresses the idea of suddenly sinking.

Precipitation—the sinking down of the particles of any mixed body

that

that were kept propped up in a diſſolving liquid.

Preliminary — going before; principles laid down previous to entering on the main ſubject.

Preſſure — one body lying upon another, and forcing it to remain motionleſs by its weight upon it.

Principles — the firſt particles that the mind can conceive in the conſtitution of any being.

Priſm — a priſm of glaſs is a glaſs bounded with two equal and parallel triangular ends, and three plain and well-poliſhed ſides which meet in three parallel lines, running from the three angles of one end, to the three angles of the other end.

Proceſs—the way of proceeding in and conducting any experiment.

Prominences —- little heights on the apparently ſmooth ſurfaces of bodies.

Proportion— comparative relation of one thing to another; ratio.

Prunella--a ſmall aperture in the middle of the eye; the pupil.

Q

Quality—thoſe properties by which one thing is diſtinguiſhed from another.

Quantity—that property of any thing which may be increaſed or diminiſhed.

Quicklime—lime unſlaked with water.

Quotient—in arithmetic, the number produced by the diviſion of two given numbers one by the other.

R

Radiant point. See the 7th definition on *Light*, Vol. iii. p. 151.

Rarefaction—the ſame with *dilatation*; which ſee.

Ray, or *Radius*—that line which proceeds from the center of a circle, and ends in ſome points of its circumference;

ence; a beam of light. *Solar Ray*, ray of the ſun.

Reaction—reſiſtance.

Recipient—that part of the air-pump which incloſes the bodies that are put therein.

Reciprocally—returning equally on both ſides; affecting both parties alike.

Reflection—means a *return back*, or the regreſſive motion of a body flying back from an obſtacle.

Reflective—capable of reflection; that which reflects or returns back.

Refraction—means *breaking againſt*, or a bending and ſliding of a body from its direct courſe.

Relation—the connection that two quantities have to each other with regard to their ſize or magnitude.

Reparation—the regaining of ſtrength conſumed.

Repulſion—a beating or driving back.

Reſpective—relative to any other body; the reſpective or different properties of each body.

Retarded—velocity or ſwiftneſs continually diminiſhed; the contrary to *accelerated*.

Retina—the expanſion of the optic nerve on the inner ſurface of the eye, is ſo called from its reſemblance to a net.

Reverberation—cauſing the light of a body to ſtrike and beat back again; beating or driving back.

Rotation—a wheeling round itſelf.

S

Saline—partaking of the nature of ſalt, one of the five chymical principles.

Salt—a mixed body, of which earth is the predominant or firſt principle, water the ſecond, and fire the third.

Science—a clear, obvious, and certain knowledge of things founded on truth.

Scintillation—ſparkling;

ling; the trembling and twinkling motion of the ſtars.

Second—the 60th part of a minute.

Seroſity—wateriſhneſs; the thin or watery part of the blood.

Sine — a right line drawn from one end of an arch perpendicularly upon the diameter drawn from the other end of that arch.

Solar—belonging to, or proceeding from the ſun.

Solids—the parts containing the fluids; hard bodies having length, breadth, and thickneſs.

Space — room, local extenſion, any quantity of place, any quantity of time.

Species — this word makes our thought particular; as the Moors are a part of mankind. It is a ſubdiviſion of *kind*, as the peacock is a *ſpecies* of the feathered *kind*.

Specifically — peculiar to, and diſtinguiſhed from others; the relation of different bodies to each other.

Sphere—a globe, an orb, a body of which the center is at the ſame diſtance from every point of the circumference.

Stalactites — petrified drops of water hanging like icicles from the tops of caves, &c.

Sublunary—any thing conſidered as being under the moon, or within her orbit.

Subſtance — being; ſomething exiſting; ſolid, not empty; that which makes a being perceivable by the ſenſes.

Subtile--thin, not denſe nor groſs; any inviſibly fine matter, as the particles of fire, ſpirits, &c.

Succedaneum--one ſubſtance or body ſubſtituted in place of another.

Sucker—that part of the air-pump which draws up and exhauſts the air.

Sulphur, or *Oil*—is a mixed, inflammable body, made up of fire, oil, water, and earth. In this mixture fire occupies the firſt place, oil the ſecond, water the

third,

third, and earth the laſt.

Superficies—the whole of the outward parts of bodies; ſurfaces.

Surface — ſuperficies, outſide; that of which we only conſider the length and breadth; thus an acre of ground is looked upon as a ſurface, becauſe when it is meaſured, its breadth is never taken into conſideration.

Suſceptibility — a diſpoſition of eaſily receiving impreſſions.

Sympathy—ſomething felt by two beings in the ſame way; the contrary to *antipathy*.

Syphon—an incurvated chymical tube or pipe. [Perhaps more properly written *Siphon*.]

Syringe—a pipe thro' which any liquor is ſquirted.

T

Tangent—a line that juſt grazes the ſurface of a circle, or touches it in only one point.

Tenſion—a bending or ſtretching out by the force of another body; the ſtate of being ſtretched.

Tenuity — thinneſs; ſmallneſs, minuteneſs.

Terebinth—a clear gum or reſin iſſuing from ſeveral ſorts of trees; turpentine; oil.

Texture—the manner in which the elements of any particular body are interwoven with each other.

Tranſpiration — emiſſion in vapour; a ſuffering of the juices to evaporate.

Treble—the moſt acute ſtring of any inſtrument of muſic.

Trepidation — trembling; a gentle agitation; a kind of ſoft trilling motion.

Trigged—the uſe of an iron cramp or hook, that being affixed to one of the wheels of a carriage when going down a hill, prevents its turning round like the other wheels, and thereby hinders the too quick motion of the carriage down the declivity.

U

Vacuum—a very ſmall ſpace intervening between all globules.

Vapours—the minuteſt particles of any fluid raiſed into the air by means of the ſun's heat, or by any other fire.

Velocity — ſwiftneſs; the property of a moving body to run over ſuch and ſuch a quantity of ſpace in ſuch and ſuch a portion of time.

Vertical—in a direction perpendicular to the horizon.

Vibration — the quivering of a muſical ſtring with quick or ſlow trepidation producing ſound. *Particular vibrations*, the imperceptible parts of a muſical ſtring; they vibrate like the *total vibrations*; they produce ſound, and are of courſe their elements. *Total Vibrations* are the trepidations of the whole ſonorous body, which quivers only, but produces no ſound.

Vitrify — to become glaſs, to be changed into glaſs.

Void — a vacuity or ſpace wherein nothing is contained; a total emptineſs and abſence of every kind of matter.

Volatile—bodies that are apt to evaporate or reſolve themſelves into air, are ſaid to be *volatile*.

Volume—the quantity of room that any ſubſtance or body takes up in ſpace.

Vortex—a fluid of any kind, in which the ſuction is circular.

Undulation—a motion like that of the waves, waving to and fro in the air, the motion of a worm on the ground.

Uniſon—one and the ſame ſound; the agreement of two notes or ſtrings of an inſtrument in one and the ſame tone.

Water

W

Water—a tranſparent elementary liquid, taſteleſs, without colour or odour, penetrating the pores of moſt bodies, convertible into ice, and capable of extinguiſhing fire.

Week—contains 7 days, or 168 hours, or 10,080 minutes.

Z

Zenith—the point over head, the vertical point.

Zone—a girdle, belt, ſpaces or boundaries circularly deſcribed on certain bodies; a diviſion of the earth; circuit, circumference.