Draft Versions of 'The Queries'

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When I made the foregoing Observations, I designed to repeat most of them with more care & exactness, & to make some new ones for determining the manner how the rays of light are bent in their passage by bodies, for making the fringes of colours with the dark lines between them. But I was then interrupted, & cannot now think of taking these things into further consideration. And since I have not finished this part of my designe, I shall conclude, with proposing only some Quæres in order to a further search to be made by others.

Quære 1. Do not Bodies act upon light at a distance & by their action bend its rays & is not this action (cæteris paribus) strongest at the least distance?

Qu. 2. Do not the rays which differ in refrangibility differ also in flexibility & are they not by their different inflexions separated from one another so as after separation to make the colours in the three fringes [above described? And after what manner are they inflected to make those fringes?

Qu. 3. Are not the rays of Light in passing by the edges & sides of bodies bent several times backwards & forwards with a motion like that of an Eele? And do not the three fringes of coloured light above mentioned arise from three such bendings?

Qu. 4. Do not the rays of Light which fall upon bodies & are reflected or refracted, begin to bend before they arrive at the bodies; & are they not reflected refracted & inflected by one & the same Principle acting variously in various circumstances?

Qu. 5. Do not Bodies & Light act mutually upon one another, that is to say, Bodies upon Light in emitting, reflecting, refracting & inflecting it, and Light upon bodies for heating them & putting their parts into a <232r> vibrating motion wherein heat consists?

Qu. 6. Do not black bodies conceive heat more easily from light then those of other colours do, by reason that the light falling on them is not reflected outwards but enters the bodies & is often reflected & refracted within them untill it be stifled & lost?

Qu. 7. Is not the strength & vigor of the action between Light & sulphureous Bodies observed above, one reason why sulphureous bodies take fire more readily & burn more vehemently then other Bodies do?

Qu. 8. Do not all fixt bodies when heated beyond a certain degree, emit light & shine, & is not this emission performed by the vibrating motions of their parts?

[Qu. 9. Is not fire a body heated so hot as to emit Light copiously? For what else is a red hot Iron then fire, & what else is a burning coale then red hot wood?

Qu. 10. Is not flame a vapour, fume or exhalation heated red hot, that is so hot as to shine? For Bodies do not flame without emitting a copious fume, & this fume burns in the flame. † The Ignis fatuus – < insertion from f 231v > † The Ignis fatuus is a vapour shining without heat, & is there not the same difference between this

vapour & flame as between rotten wood shining without heat & burning coales of fire? In destilling hot spirits if the head of the still be taken off the vapour which ascends out of the still will take fire at the flame of a candle & turn into flame & the flame will run along the vapor from the candle to the Still. Some Bodies heated by motion or fermentation if the heat grow intense fume copiously, & if the heat be great enough the fume will shine & become flame. Metals in fusion do not flame for want of a copious fume except Spelter which fumes copiously & thereby flames. All flaming bodies as oyle, tallow, wax, wood, fossil coales, pitch, sulphur, by flaming wast & vanish into burning smoke, which smoke if the flame be put out is very thick & visible & sometimes smells strongly but in the flame loses its smell by burning, & according to the nature of the smoke the flame is of several colours, as that of sulphur blue, that of Copper opened with Sublimate green, that of tallow yellow. Smoke passing through flame cannot but grow red hot & red hot smoke can have no other appearance then that of flame.

Qu. 11. Do not great bodies conserve their heat the longest their parts heating one another, & May not great dense & fixt bodies when heated beyond a certain degree emit light so copiously as by the emission & reaction of its light & the reflexions & refractions of it's rays within its pores to grow still hotter till it comes to a certain period of heat, such as is that of the Sun. And are not the Sun & Fixt Stars great Earths vehemently hot, whose heat — — — < text from f 232r resumes > is conserved by the greatness of the bodies and the mutual action & reaction between them & the Light which they emit, & whose parts are kept from fuming away not only by their fixity but also by the vast weight & density of the Atmospheres incumbent upon them & very strongly compressing them & condensing the vapours & exhalations which arise from them.

Qu. 12. Do not the rays of light in falling upon the bottom of the eye excite vibrations in the Tunica Retina? which vibrations being propagated along the solid fibres of the Optic nerves into the Brain cause the sense of seeing? For because dense bodies conserve their heat a long time & the densest bodies conserve their heat the longest, the vibrations of their parts are of a lasting nature & therefore may be propagated along solid fibres of uniform dense matter to a great distance for conveying into the brain the impressions made upon all the Organs of sense. For that motion which can continue long in one & the same part of a body can be propagated a long <233r> way from one part to another, supposing the Body homogeneal so that the motion may not be reflected, refracted interrupted or disordered by any uneavenness of the body.

[Qu. 13. Do not several sorts of rays make vibrations of several bignesses which according to their bignesses excite sensations of several colours much after the manner that the vibrations of the air according to their several bignesses excite sensations of several sounds? And particularly do not the most refrangible rays excite the shortest vibrations for making a sensation of deep violet, the least refrangible the largest for making a sensation of deep red, & the several intermediate sorts of rays, vibrations of several intermediate bignesses to make sensations of the several intermediate colours?

Qu. 14. May not the harmony & discord of colours arise from the proportions of the vibrations propagated through the fibres of the Optick nerves into the brain, as the harmony & discord of sounds arises from the proportions of the vibrations of the Air. For some colours are agreable as those of Gold & Indigo, & others disagree.

Qu. 15. Are not the species of Objects seen with both eyes united where the Optick nerves meet before they come into the brain, the fibres on the right side of both Nerves uniting there & after union going thence into the brain in the Nerve which is on the right side of the head & the fibres on the left side of both Nerves uniting in the same place & after union going into the brain in the Nerve which is on the left side of the head & these two Nerves meeting in the brain in such a manner that their fibres make but one entire species or picture, half of which on the right side of the sensorium comes from the right side of both eyes through the right side of [both Optick Nerves to the place where the Nerves meet & from thence on the right side of the head into the brain, & the other half on the left side of the sensorium comes in like manner from the left side of both eyes. For the Optick Nerves of such animals as look the same way with both eyes (as of Men, Dogs, Sheep, Oxen &c.)

Qu.16. Is not the free passage of light through pellucid bodies an argument that all bodies are very porous. Water is nineteen times lighter in specie then Gold & therefore since the matter in bodies is proportional to their gravity water would have eighteen times more pores then parts of gold were perfectly solid or void of all pores. But gold is also very porous as appears by the soaking of quicksilver into it & by the squeezing of water through it & principally by the passage of light through its particles when foliated or dissolved in Aqua regia. Were the pores of gold but equal to its parts the pores of rain water would contain 37 times more space then its parts. And he that shall invent a rational Hypothesis for explaining how water can be so porous & yet be uncapable of compression by force, may doubtless by the same Hypothesis explain how gold may be as porous as he pleases & all other bodies as much more porous then gold as they are lighter in specie. Suppose a body were composed of parts lying together with as much pores between them, & that these parts were composed of smaller parts lying together with as much pores between them & that these parts were composed of parts still smaller with as much pores between them & so on for as many compositions as you please untill you come at solid parts void of all pores. And if in this progression there were ten compositions, the body would have above a thousand times more pores then parts; if twenty compositions, it would have above a thousand thousand times more pores then parts; if thirty compositions, it would have above a thousand thousand thousand times more pores then parts & so on perpetually. But whatever be the texture of bodies, they must be so porous as in all positions to give passage to the rays of light in right lines through their pores. For whatever the rays of light be whether they consist in the vibrations of a medium, or be bodies trajected, if in passing through the pores of pellucid bodies they do not find room enough to go on in right lines whenever they are once disturbed & turned out of their direct courses, they will go on in their new courses till they are disturbed again, & the more they are disturbed the more they will err & return no more to their first courses unless by very great accident. To suppose that as often as the rays of light are turned out of their way by some parts of the bodies, they will be turned into way again by others is as precarious & extravagant as to suppose that the suns light can pass through a heap of sand & after many reflexions emerge in the same right lines in which it came from the sun, the sands being so disposed that some reflexions shall turn the rays into their right course as often as others turn them out of their way. The great porousness & admirable structure of bodies is further argued from the lastingness of the vibrating motions of their parts wherein heat consists, For without great porousness the parts of bodies could no more vibrate then a spring can tremble in the middst of a heap of sand. And it may be further argued from the great capacity of by corruption & generation to put off & put on all manner of forms, & be changed into all sorts of shapes. The contrivance of the bodies of living creatures is admirable. Not a member but has its use & is mighty well fitted for that use. And can we beleive that he who contrived the bodies of animals with so much artifice was not as skilful & curious in contriving the texture of matter for those ends for which it is fitted. For the forms & uses of matter are innumerable & therefore <234v> we are not to consider it as composed of irregular particles casually laid together like stones in a heap, but as formed wisely for all those uses. One use of matter is to admit menstruums easily into its pores in order to new mixtures & actions by fermentation putrefaction corruption & generation, another to conceive heat easily & keep it long for promoting changes by putrefaction & generation, a those to transmit refract & reflect light for producing all the colours of bodies where in the beauty of nature chiefly consists. Without these uses the earth would have been a dead lump void of heat & motion & alteration & variety of colours: & therefore it is reasonable to allow that he who contrived all things with wisdome, framed matter in such a manner as to fit it best for these uses, & by consequence made it very porous.

Qu. 17 Is there not something diffused through all space in & through which bodies move without resistance & by means of which they act upon one another at a distance in harmonical proportions of their distances.

Qu. 8. — — — And do not all bodies which abound with sulphureous or terrestrial parts emit light whenever those parts are sufficiently agitated by heat attrition percussion putrefaction or any other cause ? 1 So the waves of the salt water of the sea in a storm by dashing against one another emit light, 5 the shavings of steel being scraped of by a stroke with a flint grow hot & melt by the action & shine like sparks of fire . 3 The back of a Cat being struck obliquely with ones hand emits a faint light in a dark room. 6 Iron may be hammered till it grows red hot 7 The wheel of a cart or chariot by vehement attrition sometimes heats the axes so to great a degree as to set it on flame 7 Moist stacks of hay or corn by fermentation & putrefaction grow hot till they emit a shining flame. 2 Quicksilver by any vehement agitation in vacuo shines with a faint light & so does rotting wood & rotting flesh or fish tho all the parts of the body be not agitatted so vehemently as to make the body sensibly warm. And so do the putrid vapours called Ignes fatui 4 One sort of Phosphorus being placed some time in the Suns light conceives an agitation by which it shines for some after in the dark: another sort

by the access of fresh air is easily put into motion emits a copious fume with a sulphureous smell & shines & by rubbing it grows hot & takes flame. Some liquors by mixing with one another grow hot & some grow so hot as to emit a shining vapour or flame.

sed quo ipsœ nos latent, et ex hoc nomine quaetatibus specificis causes Phænomenon nondum patentibus imposito deterremar a causis hisce indagandis, quasi quidem illæ penitus essent deploratæ postquam magnus ipse Philosophus Aristoteles in eas penetrare non potuerat. Hoc sensu gravitas qualitas manifesto, et sola gravitatis causa de qua Newtonus nihil statuit, dici potest occulta. Occultam tamen esse in sensu Scholasticorum, ita scilicet ut manifestari non poterit, Newtonus minima statuit. Su D. Leibnitius ludit in verbis et Newtonum calumnia adoritur. Ludit etiam in verbis ub Deum vocat qui non est Dominus Universorum, et animam vocat quo corpus non animatur.

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conjungi quiant ut cohærescunt. p. 340. lin. 27.

Quæst.24. May not the forces by which the small particles of bodies cohere & act upon one another at small distances for producing the above mentioned phænomena of nature, be electric? For altho electric bodies do not act at a sensible distance unless their virtue be excited by friction, yet that vertue may not be generated by friction but only expanded. For the particles of all bodies may abound with an electric spirit which reaches not to any sensible distance from the particles unless agitated by friction or by some other cause & rarefied by the agitation. And the friction may not rarefy the spirit not of all the particles in the electric body but of those only which are on the outside of it: so that the action of the particles of the body upon one another for cohering & producing the above mentioned phænomena may be vastly greater then that of the whole electric body to attract at a sensible distance by friction. And if there be such an universal electric spirit in body, certainly it must very much influence the motions & actions of the particles of the bodies amongst one another. so that without considering it, philosophers will never be able to give an account of the phænomena arising from those motions & actions. And so far as these phænomena may be performed by the spirit which causes electric attraction it is unphilosophical to look for any other cause.

Quæst 25 Do not all bodies therefore abound with a very subtile active potent elastic spirit by which light is emitted refractec & reflected, electric attractions & fugations are performed, & the small particles of bodies cohere when contiguous, agitate one another at small distances & regulate almost all their motions amongst themselves. For electric – – – – uniting the thinking soul & unthinking body. This spirit may be also of great use in vegetation, wherein three things are to be considered, generation, nutrition & præparation of nourishment.

Generation is nothing else then separating a branch from the tree & giving it better nourishment. If a separated branch takes root in the earth or a separated twigg or bud by grafting or inoculation is nourished from the root of a young stock, it grows into a new tree as big a the tree from which it was separated being better nourished from a young root then from an old one. The seed of a tree has the nature of a branch or twig or bud, while it grows upon the tree it is a part of the tree: but if separated & set in the earth to be better nourished, the embryo or young tree conteined in it takes root & grows into a new tree. like manner The egg of a female with the embryo formed in it while it grows in the ovarium is a branch of the mothers body & partakes of her life, & The embryo is as capable of being separated from the mother & growing great by due nourishment as a branch or twigg or budd or seed of a tree is of being separated from the tree & growing into a new tree. For by the act of generation nothing more is done then to ferment the sperm of the female by the sperm of the male that it may thereby become fit nourishment for the Embryo. For the nourishment of all animals is prepared by ferment & the ferment is taken from animals of the same kind , & makes the nourishment subtile & spiritual. In adult animals the nourishment is fermented by the choler & pancreatic juice, both which come from the blood. The Embryo not being able to ferment its own nourishment which comes from the mothers blood has it fermented by the sperm which comes from the fathers blood, & by this nourishment it swells, drops off from & Ovarium & begins to grow with a life distinct from that of the mother. And in Oviparous creatures if the sperm of the female be not fermented with the sperm of the male the white & the yolk of the egg will not be fit nourishment for the Embryo. [So then the Embryo grows upon the body of the mother before generation as a twig grows upon a tree & all generation is nothing else than the preparation of due nourishments for the Embryo to grow with a distinct life when separated.]

Now in all fermentation which generates spirits, the ferment abounds with a suppрest acid which being more attracted by the other body forsakes its own <235v> to rush upon & dissolve the other & by the violence of the action breaks both its own particles & the particles of the other body into smaller particles & these by their subtilty volatility & continual digestion resolve the whole mass into into as subtile parts as it can be resolved by putrefaction. [And by this means bodies must lose their old form & texture & be destroyed & broken into the last parts before they can be formed.] For as an old house must be pulled down & its stones separated before a new house can be built out of its materials: So natural bodies must be dissolved broken & separated into their least parts by fermentation & putrefaction & lose their old form & texture before a new natural body can be formed out of them.

And when the nourishment is thus prepared by dissolution & subtiliation, the particles of the body to be nourished draw to themselves out of the nourishment the particles of the same density & nature with themselves. For particles of one & the same nature draw one another more strongly then particles of different natures do. And therefore in the bowels of the earth particles of the same nature are apt to assemble in the same masses & those of different natures in different masses. And when many particles of the same kind are drawn together out of the nourishment they will be apt to coalesce in such textures as the particles which drew them did before because they are of the same nature as we see in the particles of salts which if they be of the same kind always crystallize in the same figures. And for faciliating this assimilation of the nourishment & presering the nourished bodies from corruption it may be presumed that as electric attraction is excited by friction so it may be invigorated also by some other causes & particularly by some agitation caused in the electric spirit by the vegetable life of the particles of living substances: & the ceasing of this vigour upon death may be the reason why the death of Animals is accompanied with putrefaction.

These things I have proposed under the heads of Quæres & leave them to be examined.

by such a fermentation as generates convenient spirits.

For all the use which nature makes of such fermentations as generate spirits & are the beginning of putrefaction seems to be for destroying the texture & forms of bodies & breaking their particles into less particles whereby they may become subtile & spiritual & fit nourishment for things which grow. For fermentation & putrefaction destroys & subtilizes & reduce all things to their least particles & nutrition recomposes those particles & sets them together in such an order as to make them become of the same nature with the things nourished.]

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De Motu et Sensatione Animalium.

1 Attractionem electricam per spiritum quendam fieri qui corporibus universis inest, et aquam vitrum Crystallum aliaque corpora solida libere permeat libere pervadit. Nam corpora electrica post fortiter attrita aurum foliatum per interpositam aquæ vel vitri substantiam trahunt.

3 Capillamenta utique solida uniformia et pellucida a cerebro per omnes sensuum nervos ad organa sensuum produci et spiritum electricum in his capillamentis latentem esse medium elasticum et cujus vibratio**{**eibus**}** per totam capillamentorum longitudinem in sensorium quam celerrime propagatis sensationem peragi.

2 Spiritum hunc electricum dilatari et contrahi et propterea elasticum esse eundemque in nervis animalium latentem esse medium quo objecta sentimus et ictu oculi membra movemus. [Nam Spiritus quos vocant animales ob densitatem tarde moventur.] & vibrationes per eundem quam celerrime propagari.

4 Et capillamenta alia solida uniformia & pellucida a cerebro per medullam spinalem in musculos produci; ac per quae vibrationes Spirituum electricorum [in his capillamentis latentium] a cerebro in musculos propagari ad substantiam musculorum agitandam et membra movenda. Liquores enim sicagitati expandi debent perinde ac si per calorem agitarentur, & musculi per expansionem liquorum suorum contrahentur, & membra movebunt.

4 Et capillamenta alia solida uniformia & pellucida a cerebro per medullam spinalem et ejus ramos in musculos pergere per quæ vibrationes spirituum electricorum a cerebro propagentur ad substantiam

musculorum agitandam & membra movenda. Liquores enim per has vibrationes agitati expandi debent perinde ac si per calorem agitarentur.

Vibrationes in spiritu elastico per radios lucis excitari.

Spiritum electium lucere reflectere refrangere & per lucem agitari

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De vita & morte vegetable.

1 Corpora omnia vim habent electricam & vim illam in superficiebus particularum fortissimam esse sed non longe extendi nisi frictione vel alia aliqua actione cieatur.

3 Particulas corporum per vim electricam diversimonde coalescere & cohærere. Et particulas minores fortius agere & artius cohærere.

Particulas menstrui quæ vi electrica particulas linguæ fortissime agitant sensationem acidi ciere.

Menstruum acidum corpora densa dissolvere per particulas suas acidas, vi attractrice in intersticia partium ultimæ compositionis irruentes & partem unamquamque circumeuntes ut cortex nucleum vel atmosphæra terram. partes vero acido circumdatas corpus suum linquere et in Menstruo fluitare, atque acido ambiente linguam pungere excitando sensationem salis. Nam acidum a nucleo incluso attractum retentum & impeditum minus agit in linguam quam prius.

Acidum salis ab externo corpore magis attractum quam a nucleo proprio, in externum illud ruit & nucleus acido nudatus pondere suo decidit & in fundum præcipitatur.

His dissolutionibus particulas acidas vehementer agitari et earum vim electricam per agitationem et frictionem, intendi & longius propagari quam prius & dissolutionem promovere.. Nam vis electrica per frictionem cieri solet.

Particulas acidas dissovendis corporum partibus compositionis ultimæ longe minores esse ut in earum insterstitia irruere possint sed non adeo parvas tamen ut poros harum partium permeent. Ideoque partes immutatæ manent acidoque ambiente nudatæ ut supra & præcipitatæ, si sint metallici generis ut fundi possint per fusionem in corpus antiquum redeunt. Mercurius itidem cum metallis amalgamando commixtum interstitia partium compositionis ultimæ ingreditur, poros autem harum partium ingredi non potest idioque per destillationem abstractus relinquit partes immutatas, & hæ partes per fusionem in corpus pristinum revertuntur.

Si dissolutio ejusmodi est ut per actionem Menstrui et reactionem corporis spiritus aliqui subtiliores excitentur qui poros partium compositionis ultimæ possint ingredi , tunc spiritus illi paulatim permeant & dissolvunt has partes et in particulas compositionis penultimæ separant, perinde ut Menstruum acidum dissolvebat corpus totum et in partes compositionis ultimæ, in casu priore separabat. Et corpus formam veterem jam amisit. Nam particulæ compositionis penultimæ in partes compositionis ultimæ non nisi per generationemm redeunt. Et par est ratio dissolutionis particularum compositionis penultimæ in particulas compositionis ante penultimæ &c. Hasce vero dissolutiones corruptionem corporis et putrefactionem dicere solemus.

Putrefactio per fermentum quandaque inducitur, et fermentum est corpus vegetabile spiritibus abundans qui poros partium compositionis ultimæ permeare possunt & partes illas dissolvere, & dissolvendo novos ejusdem generis spiritus paulatim excitare quibus putrefactio compleatur. Nutrimentum animalium per succos in stomacho et maxime per bilem fermentatur.

Dissolutio corporis in partes compositionis ultimæ violentior est, & cito perficitur & cessat. Ea partium illarum in parti**{**bus**}** compositionis penultimæ lente fit diuturnior est & modico peragitur calore qui spiritus subtiliores dissolventes non abigat sed actionem eorum juvet.

Corpus per putrefactionem fractum comminutum & in partes minimas redactum, formam veterem amisit & formarum innumerabilium novarum per generationem est capax. Nam putrefactio corpus comminuit generatio partes minimas congregat. conjungit & in ordinem denuo redigit idque diversimode secundum naturam corporis vivi cui substantia fermentata et putrefacta in nutrimen**{}** præbetur. Ut cum vegetabilia innumera eodem fimo, animalia innumera eodem cibo per bilem fermentato nutriuntur.

Ut frictione corporis electrici intenditur ejus attractio sic et etiam Actione vivendi intenditur vis electrica partium viventis, & forti attractione fit ut partes illæ formam propriam & situm inter se conservent & nutrimento suo paulatim communicent <237v> perinde ut Manges convertit ferrum in magnetem & ignis convertit corpora in ignem & fermentum convertit pastam in fermentum: at cessante vita vegetabili cessat attractio illa vitalis et ejus defectu simul incipit actio moriendi quam corruptionem & putrefactionem dicimus.

In generatione animalium per misturam et fermentationem seminum attractio vegetabilis cietur & quasi flamma vitalis accenditur qua languescente animal debilitatur & cessante moritur & putrescit: et contra. Ovum in ovario matris ante generationem vivit tantum ut pars corporis materni: at per fermentationem seminum vitam propriam vegetabilem acquirit ut animal a matre diversum, & per hanc vitam statim incipit vegetare ac crescere & nutrimentum in se convertere. [Fermentatio autem per attractionem uti diximus perficitur et motu suo attractionem illam intendit & fortiorem reddit]. Per fermentum itaque corpora mortua dissolvuntur, viva nutriuntur & crescunt. Mortua propter debilem partium attractionem non dissolvuntur sed menstruum vincunt.

2 Corpora vi electrica plerumque trahi quadoque vero dispelli per experimenta constat; et particulas aeris & vaporum sese dispellere. Particulas etiam olei dispellere particulas aquæ.

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Si posset Menstruum alios illos pervadere, vel si auri partes primæ et secundæ compositionis possent separari, fieret aurum vel fluidum vel saltem magis malleabile. Si aurum fermentescere posset [et per digestionem in fimum mollem resolvi vegetabilibus nutriendis aptum, idem & per generationem] in aliud quodvis corpus transformari posset. [Eadem intellige de aliis corporibus duris & eorum partibus compisitionis ultimæ.

Fluiditas sita est in partium parvitate qua facile commoveantur et lubricitate qua facile labantur inter se. Intellige partes ultimæ compositionis. Visciditas est imperfecta fluiditas cum per attractione partium. Hujus visciditatis acidum sæpe causa est, sæ spiritus alius lubricus terræ junctus: ut cum Oleum Terebinthinæ capiti suo mortuo redditum fit tenax.

Charta oleo inuncta transitum oleo , non aquæ, concedit, propterea quod aqua oleo non miscetur sed fugatur ab eo.

Acidum primigenium videtur2 constare1 particulis compositis figuram sphæricam per attractionem induentibus [perinde ut Terra per gravitatem sphærica fit]; et particulæ hae sunt majores aquæ & minores terræ partibus, seu inter eas mediæ, et utrarumque attractrices.

Cum acidæ Menstrui particulæ corpus aliquod dissolvunt, hæ ob parvitatem poros corporis ingrediuntur & singulas ejus particulas compositionis ultimæ, seipsis utique longe majores, circumeunt & includunt undique [ut cortex nucleum vel mare terram et includendo separant a corpore. Unaquæque vero corporis particula mediante acido attracto et circumposito in Menstro deinceps fluitat & linguam pungit, hoc est in particulam salis convertitur. Deinde actione et reactione lenta et continua inter particulam corporis et acidum ambiens per fermentationem naturalem spiritus subtilus generantem excitata spiritus illi poros particulæ paulatim ingrediuntur, texturam ejus lente dissolvunt & cum ea tandem miscentur per minima: quam operationem putrefactionem dicimus. Corpus jam maxime comminutum et cum particulis acidis inseparabiliter commixtum formam veterem amisit & formarum innumerabilium novarum factum est capax, siquidem particulæ compositi per generationem iterum congregari, coalescere et in ordinem redigi possint, idque diversimode pro natura corporum vivorum quibus nutrimentum præbeant. Viva enim per fortem attractionem & magnitudinem particularum formam seu texturam suam et servant et nutrimento suo paulatim communicant: at cessante vita cessat attractio illa vitalis et incipit actio moriendi quam corruptionem et putrefactionem dicimus.] Nam quemadmodum vis electrica per frictionem cietur & vis magnetis in ferrum

transfertur et vis urendi in corpora ignem nutrientia propagatur: sic vis quædam attractiva per fermentationem naturalem in corpore fermentato cieri videtur et in corporibus vivis per actionem vegetandi conservari & in nutrimentum paulatim transferri, et cessante vita cessare.] Et hæc vis electrici videtur esse generis propterea quod per motum et attritionem particularum corporis vegetantis cieatur. Corpora utique omnia quantum sentio vi electrica pollent, et particulæ electricæ ad minimas distantias semper agere possunt fortissime et per actiones illas diversimode coalescere et cohærere; et actiones illæ electricæ in fermentatione et vegetatio**{**ne**}** <238v> per motum et frictionem particularum intendi possunt et longius propagari, et cessante motu remitti.

Si aurum ferementescere posset [& per corruptionem in fimum verti vegetabilius nutriendis aptum, idem per o

Nam quemadmodum domus antiqua dirui debet et in lapides singulos separari priusquam ex ejus materia domus nova construatur deinde ex lapidibus novo ordine compositis domus nova formæ cujuscunque componi possit: sic fit in resolutione & compositione corporum naturalium. Corpus antiquum per putrefactionem dirui debet et in particulas minimas ex quibus generatum fuit resolvi priusquam ex ejus materia corpus novum generari potest, [deinde ex materia putrefacta corpora nova diversarum formarum generari posunt] Generatio autem illa Et ubi particulæ illæ subtilissimæ diversarum densitatum magnitudinum & virtutum per fermentationem & putrefactionem separantur & inter se confuse miscentur, & menstruum dissolvens & corrumpens aciditatem suam agendo amissit;tum apta est materia illa per fermentationem & putrefactionem attenuata ad nutriendum corpus vivum ejusdem generis cum corpore ex quo fermentum desumptum fuit.

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Various Conjectures.

Flame is red hot fume & differs from fume which is not red hot as red hot iron differs from iron which is not red hot.

Heat consists in the trembling agitation of the smallest parts of bodies all manner of ways; & the parts of all bodies are always in some agitation.

Earth is the condensed sediment of water & water is fluid earth.

Burning spirits are oyles united with phlegm by fermentation.

Tincture of Cochinell extracted with spirit of wine being powered in small quantity into a great mass of water, tinges the whole water because the particles of the Cochinell are more attracted by the water then by one another, & therefore recede from one another.

Water has but a small power of attracting because it has but a small quantity of acid in its composition. For we call that an acid which attracts & is attracted strongly. Whence it is that those things which dissolved in water are dissolved slowly & without effervescence. But where the attraction is strong & the particles of the menstruum are on all sided attracted by the particles of the metal or rather a particle of the metall is on all sides attracted by the particles of the menstruum, these agitate the particles with violence it & carry it of from the metall, that is they corrode & eat the metall And the same particles applied to the tongue leave the subtile earth to which they adhered & by a greater attraction rush into the liquids of the tongue agitate & disjoyne its parts & cause a painfull sensation by reason of which we call them acid.

In every solution made by a menstruum, the particles to be dissolved are more attracted by the particles of the menstruum then by one another; & therefor leave one another to float in the menstruum.

In every fermentation there is a supprest acid which is coagulated by precipitation upon the body suppressing it

Oyle intimately mixed with a very great quantity of flegm becomes of a nature something saline & so constitutes vinegre whose acid particles if separated from the flegm would be a volatile salt. Under this head tartar is also to be considered

Mercury is attracted that is corroded by acids. And as by its weight it opens obstructions, so by it attractive force it draws acids to it self & suppresses them. suppresses acids. Mercury is volatile & rises easily by heat because its particles of the last composition are small & are easily separated, & being separated endeavour to recede from one another, as happens also in the particles of vapour & rarefied fluids.

Water cannot be comprest because its particles already touch one another. And if air was so far comprest as to make its particles touch one another it might become a stone.

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Corpora utique omnia densa particulis electricis constare videntur & nonnullas etiam habere particulas magneticas. Et quemadmodum attractio gravitatis ad majores Planetarum Cometarum & maris nostri motus explicandos sufficit: sic vires electricæ ad explicandas actiones et motus particularum corporis cujuscunque inter se sufficere videntur; posito scilicet quod particulæ electricæ ad parvas distantias semper agant fortissime ad magnas vero distantias non agant nisi virtus earum frictione vel actione vegetandi vel alia aliqua actione cieatur.

Corpus jam comminutum attenuatum & cum particulis acidis inseparabiliter commixtum formam veterem amisit & formarum innumerabilium novarum factum est capax siquidem particulæ compositi per generationem iterum congregari coalescere et in ordinem redigi possit, idque diversimode pro natura corporum vivorum quibus nutrimentum præbeant. Viva enim

Et hæc vis electrici videtur esse generis propterea quod per motum & attritionem particularum corporis vegetantis cieatur. Corpora utique omnia quantum sentio vi electrica pollent, & particulæ electricæ ad minimas distantias semper agere possunt fortissime, & per actiones illas diversimode coalescere et cohærere et actiones illæ electricæ in fermentatione & vegetatione per frict particularum intendi possunt & longius propagari et cessante motu remitti. Quinetiam vires magneticæ particularum ferri ad formationem corporum conducere possunt. Nam particulæ ferri per terrestria omnia sparguntur.

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Si aurum naturaliter fermentescere posset, idem per putrefactionem particulas minimas separantem (ad instar animalium ac vegetabilium) formam suam amittere & in fimum abire & subinde per generationem vel nutritionem in aliud quodves corpus vivum transformari posset. Et similis est ratio gemmarum et mineralium omnium.

Si aurum fermentescere posset [& per putrefactionem in particulas minimas resolvi, idem, ad instar substantiarum vegetablium & animalium putrescentium, formam suam amitteret, in fimum abiret vegetabilibus nutriendis aptum & subinde per generationem] in aliud quodvis corpus transformari posset. [Et similis est ratio Gemmarum & mineralium omnium.]

Visciditas fit per defectum fluiditatis quæ utique sita est in partium parvitate qua facile moveantur & lubricitate seu lævore quo facile labuntur inter se. Intellige partes ultimæ compositiones. Hujus visciditatis —

Visciditas est imperfecta fluiditas cum attractione partium. Fluiditas autem sita est in partium parvitate qua facile moveantur & lubricitate qua facile labantur inter se. Intellige partes ultimæ compositionis. Hujus

Cum acidi particulæ corpus aliquod dissolvunt, hæ poros corporis majores ingrediuntur & singulas ejus particulas externas seipsis utique longe majores circumeunt & includunt undique ut cortex nucleum vel mare terram, & includendo separant a corpore et unaquæque corporis particula mediante acido attracto & circumposito in menstruo deinceps fluitat adeoque in particulam salis convertitur.

Deinde actione & reactione lenta et continua inter acidum et particulam inclusam per fermentationem naturalem excitata, acidum poros particulæ paulatim ingreditur, texturam ejus lente dissolvit, & cum ea tandem miscetur per minima: Quam operationem putrefactionem dicimus. Corpus, jam fractum formam veterem amisit & compositum sic contritum attenuatum & inseparabiliter comminutum ⊙ < insertion from lower down f 240v > ⊙ et informe redditum. < text from higher up f 240v resumes > formarum novarum

innumerarum capax est propterea quod ejus particulæ inter se per novam generationem in particulas majores modis innumeris coalescere possunt.

Nam corporum omnium particulæ per putrefactionem dividuntur separantur, & confuse miscentur per generationem congregantur & coalescunt & in ordinem rediguntur idque diversimode pro natura viventium quibus nutrimentum præbent

Viva enim per fortem attractionem formam suam et servant et nutrimento paulatim communicant, at cessante vita cessat attractio vitalis et incipit actio moriendi quam corruptionem vel putrefactionem dicimus. Nam quemadmodum vis electrica per frictionem cietur, & vis magnetica in ferrum Magneti appositum transfertur & vis urendi in corpora ignem nutrientia propagatur: sic vis vis quædam attractiva per fermentationem naturalem cieri videtur, in qua vita vegetabilis consistit quæque ideo attractio vitalis dici mereatur, & hæc vis ab actione vivendi conservari et a corpore vivente in nutrimentum paulatim transferri potest, et cessante vita cessare.

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Quæst. Do not all bodies abound with a very subtile active vibrating spirit by which light is emitted reflected & refracted, electric & magnetic attractions & fugations are performed, the small particles of bodies cohære when contiguous, agitate one another at small distances & regulate almost all their motions amongst themselves as the great bodies of the Universe regulate theirs by the power of gravity? For electric bodies could not act at a distance without a spirit reaching to that distance. And by several experiments shewn by M^{r} Hawksby before the R. Society it appears that a cylindrical rod of glass or hard wax strongly rubbed emitts an electric spirit or vapour which pushes against the hand or face so as to be felt, & upon application of the finger to the electric body crackles & flashes, & that the electric spirit reaches to the distance of half a foot or a foot from the glass or above & passes readily through the solid body of a plate or vessel of glass , the electric body attracting things beyond the glass; & that if a globe of glass be nimbly turned round upon an axis & in turning rub upon a man's hand to excite its electric virtue, the the hand if the glass be empty of air shines through the glass with a purple light, if some air be let into the glass, the whole cavity of the glass appears illuminated with flashes of a whiter light; if the air be let in freely the glass emitts an electric vapour or spirit which may be felt by the hand & which in dashing upon the hand or upon white paper or a handkerchief at the distance of a quarter of an inch or half an inch from the glass or above, illuminates the hand or paper or handkerchief with a white light while the glass continues in motion, the spirit by striking upon those bodies being agitated so as to emit the light. & that if some threds of cotton or worsted yorn hanging by one end at a little distance from one another be attracted at the other end towards the glass, & a mans finger be advanced towards the attracted ends of the threds, the threds will recede from the finger, & this they will do as well when they are within the glass as when they are without it. There is therefore an electric spirit by which bodies are in some cases attracted in others repelled & this spirit is so subtile as to pervade & pass through the solid body of glass very freely in both cases, & is capable of contraction & dilatation expanding it self to great distances from the electric body by friction, & therefore is elastic & susceptible of a vibrating motion like that of air whereby sounds are propagated, & this motion is exceeding quick so that the electric spirit can thereby emit light. And that which emits light in the experiments above mentioned, may emitt it in all shining bodies whenever sufficiently agitated either by heat or by putrefaction. And the Medium which emitts light may also be able to refract & reflect it as was noted above. This spirit may be also the Medium by whose vibrating agitations stirred up within dense bodies, the bodies receive heat & communicate it to contiguous bodies; the vibrations being propagated from one body into another where the bodies are contiguous, but reflected at the surface where they are not contiguous & by reflections kept within the hot body. The like vibrations may be excited in the bottom of the eye by light & propagated thence through the solid capillamenta of the optick nerves into the sensorium for causing vision & the like of other senses. The like vibrations may be also propagated from the brain through the solid fibres of the spinal marrow & its branches into the muscles for agitating & expanding the liquors therein & thereby contracting the muscles to cause the motions of animals. For liquors are expanded <241r> by heat & by consequence by the vibrating agitations of this spirit. If the agitations be of short continuance they expand the liquors without heating them for want of time to do it. If lasting (as in running a race, or in supporting a burden without external motion of the body) they heat the body by degrees & at length excite sweat. This spirit therefore may be the medium of sense of animal motion & by consequence of uniting the thinking soul & unthinking body.

[The vegetable life may also consist in the power of this spirit supposing that this power in substances which have a vegetable life is stronger then in others & reaches to a greater distance from the particles. For as the electric vertue is invigorated by friction so it maybe by some other causes. And by being stronger in the particles of living substances then in others it may preserve them from corruption, & [from the parti] act upon the nourishment to make it of like form & vertue with the living particles as a magnet turns iron to a magnet & fire turns its nourishment to fire & leaven turns past to leaven. For the living particles may propagate the vibrating motions of their spirit into the contiguous particles of the nourishment & cause the spirit in those particles to vibrate & act after the same manner & by that action to modify the nourishment after the same manner with the living particles.

The life of a vegetable is in the whole vegetable & in every part of it. For every branch & every bud & every seed being duly nourished will grow into a new tree. And in like manner the life of an animal is in the whole female & in every egg of the female. And as the branch or seed of a tree being separated from the tree & put into the earth where it may receive due nourishment may grow into a new tree: so the egg of a female being separated from the body of the female & converged into the womb & duly nourished may grow into a new animal. The nourishment of the seed of a plant is putrid rain water, This sinks into the seed, softens it & sets its parts at liberty to exercise their vegetable life in retaining digesting & converting some part of the water into their own nature. The nourishment of the egg of an animal is the seed of the male & female mixed & fermented together in the act of generation. For all nourishment of animals is prepared by fermentation. That of adult animals is fermented by the choler & pancreatic juce both which come from the blood. That of an Egg or Embrio therin is the feminine sperm fermented with the masculine both which also come from the blood. By fermentation the nourishment is subtilized replenished with spirit & put into motion whereby it acts upon the egg swells it & makes it fall off from the Ovarium But the egg (or Embrio therein) having a vegetable life is not corrupted by the nourishment but overcomes it & digests it into its own nature & grows into an animal. In oviparous creatures where the white & the yolk of the egg are the nourishment of the embrio; if the seed of the male doth not enter the composition of the egg the Embrio will not grow. for want of due nourishment. So then generation is nothing else then preparation of due nourishment for making the Embrio begin to grow. Before generation it grew as a parts of the mothers body, & by growing in that manner was shaped into an Embryo (for the seeds of trees have young plants in them) by generation it receives new nourishment whereby it begins to grow as an animal distinct from is mother. & the mixture of male & female sperms is only for preparing this nourishment.

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All bodies seem to be composed of hard particles for otherwise fluids would not congeale, as water, oyles, Vinegre, & Spirit or oyle of Vitriol do by freezing, Mercury by fumes of Lead, Spirit of Nitre & Mercury by dissolving the Mercury & evaporating the flegm, spirit of wine & spirit of Urin deflegming & mixing them & spirit of Urin & spirit of salt by subliming them together to make salarmoniack. Even the rays of light seem to be hard bodies, for otherwise they would not retain different properties in their different sides. And therefore hardness may be recconed the property of all uncompounded matter. < insertion from the top of f 242v > And therefore since all bodies so far as experience reaches are either hard or may be hardened, we may conclude affirm from experience that they all consist of hard particles. < text from f 242r resumes > At least this seems to be as evident as the universal impenetrability of matter For all bodies so far as experience reaches are either hard or may be hardened & we have no other evidence of universal impenetrability besides a large experience without exception. < insertion from f 242v > A property of all uncompounded matter. This seems to be as evident at least as the universal impenetrability of matter. For all bodies so far as experience reaches are either hard or may be hardened & we have no other evidence of universal impenetrability besides a large experienc without any thing appearing to the contrary. < text from f 242r resumes > < insertion from f 242v > property of all uncompounded matter. At least this seems to be as evident as the universal impenetrability of matter. For all bodies, so far as experience reaches are either hard or may be hardened & we have no other evidence of universal impenetrability besides a large experience without exception. And if compound bodies may be so very hard as we find some of them to be — — — — their cohesion. < text from f 242r resumes > And if compound bodies may be so very hard as we find many of them to be, & yet are very porous & consist of parts which are only layed together, the simple particles which are void of pores & were never yet divided, must be much harder. For such hard particles being heaped up together can scarce touch one another in more then a few points & therefore must be separable by much less force **{**then**}** is requisite to break a solid particle whose parts touch in all the space between them without any pores or interstices to

weaken their cohesion ; And how such very hard particles which are only laid together & touch only in points can stick together, & that so firmly as they do, without the assistance of something which causes them to be attracted or prest towards one another is very difficult to conceive.

As in Mathematicks so in Natural Philosophy the investigation of difficult things by Analysis ought ever to precede their Composition. In the two first Books I proceeded by Analysis to discover & prove the original differences of the rays of light in respect of refrangibility reflexibility & colour & their alternate fits of easy reflexion & easy transmission & the properties of bodies both opake & pellucid on which their colours depend: & these discoverys being proved may be assumed as Principles in the Method of Composition for explaining the phænomena arising from them: an instance of which Method I gave in the end of the first Book In this third Book I have only begun the Analysis of what remains to be discovered hinting several thing**{}** about light & its effects upon the frame of Nature & leaving the hints to be examined & improved by the further experiments & observations of such as are inquisitive.. And because the knowledge of the degrees of heat may be of use in making & reporting some sorts of experiments relating to this matter, I shall add the following Question.

that God [Deus O. M.] in penetrable moveable properties, & in such for which he created them. And that these original particles being solids are incomparably harder then any porous bodies compounded of them; even so very hard as never to weare or break in pieces; no ordinary power being able to divide what God himself made one in the first creation. While these particles continue entire they may compound bodies of like nature & texture in all ages; but should they weare or break in pieces, the nature of things depending on them would be changed. Water & Earth composed of old worn particles & fragments of particles would not be of the same nature & texture now with water & earth composed of entire particles in the beginning[2] < insertion from f 242v > 2 It seems to me further that these particles have not only a Vis inertiæ accompanied with such passive Laws of motion as naturaly result from that force, but also that they are endued with certain active Principles of motion such as is that of gravity & that which causes fermentation & the cohesion of bodies. These principles I consider not as occult Qualities resulting from the specific forms of things, but as the general laws of Nature from whence the forms themselves result. To tell us that every species of things is endowed with an occult quality by which it acts is to tell us nothing, but to dening two or three general Principles of motion from Phænomena & afterwards to tell us how the properties & actions of all corporeal things follow from those Principles would be a very great step in Philosophy tho the causes of those Principles were not yet discovered, & therefore I sinple not to propose the Principles of force & motion above mentioned.

Now by the help of these Principles all material things seem to be composed of the hard & solid particles above mentioned variously associated in the first creation, but not without the counsel of an intelligent Agent. For it became him who created them to set them in order < text from f 242r resumes > . Of these solid particles all material things seem to have been composed in the first creation, but not without the intervention of an intelligent Agent. For it became him who created them, to set them in order. And if he did so, its unphilosophical to seek for any other origin of the world, or to pretend that it might arise out of Chaos by the mere laws of nature tho being once formed it may continue by those laws for many ages.. For while Comets move in very excentrick orbs in all manner of positions, blind fate could never make all the Planets move one & the same way in orbs concentrick[6]. This uniformity must be allowed the effect of choise. And so the first contrivance of the eyes, ears, brain, heart, lungs, hands, wings,swimming **{**bodies**}** & other organs of <242v> sense & motion in animals & the instinct of brutes & insects can be the effect of nothing else then the wisdome & skill of a powerfull ever living Agent who being indivisibly in all places after some such manner as that which thinks in us is in all parts of our sensorium, perceives all things accurately in their true solid dimensions by the immediate presence of the things themselves while that which thinks in us perceives only the superficial pictures of things made in our sensorium by motion; & who is more able by his will to move the bodies in his sensorium & thereby to form & reform the parts of the Universe then we are by ours to move our own bodies. And since space is divisible in infinitum & matter is not necessarily in all places, it must be also allowed that God is able to create particles of matter of several sizes & figures & in several proportions to space & thereby to vary the Laws of Nature, & make worlds of different sorts in several parts of the Universe.

The business of Experimental Philosophy is to find out by experience & observation not how things were created but what is the present frame of Nature. This enquiry should proceed first by Analysis in arguing

from things more known to things less known & particularly from effects to causes & from compositions to their ingredients. And when we have found out & established any new causes or ingredients of things we may proceed by Synthesis from those causes as ingredients as Principles to explain their effects & compositions. Of this Method I gave an instance in the first book of these Opticks, investigating first by Analysis the original differences of the rays in respect of refrangibility reflexibility & colour & then from these differences considered as principles compounding explications of the colours made by Prisms, the colours of the Rainbow & those of natural bodies. Most of the second Book was written some years before the First & so is not in so good a method. However it proceeds by Analysis to discover the fits of easy reflexion & easy transmission of the rays, & from thence the explication of the colours of **{illeg}**les & other then transparent plates, & those of feathers & tinctures are easily compounded.. In this third Book I have only begun the Analysis of what remains to be discovered about light, hinting several things about its nature & effects & leaving the hints to be examined & improved by the further experiments & observations of such as are curious, till some further Principles shall be established & the explication of their effects compounded. And by pursuing this method till we come to as clear & full a knowledge of the first cause as we can expect from Phænomena, Natural Philosophy will be perfected, & a good foundation will be laid for enlarging the bounds of Moral Philosophy. Fo

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All bodies seem to be composed of hard particles. for otherwise fluids would not congeale as water, Byles, vinegre & spirit or oyle of Vitriol, do by freezing, Mercury by fumes of Lead, Spirit of Nitre & Mercury by dissolving the Mercury & evaporating the flegm, spirit of wine & Spirit of Urin by mixing & spirit of Urin & spirit of salt by subliming to make salarmoniac. Even the rays of light seem to be hard bodies for otherwise they would not retain different properties in their different sides. And thefefore hardness may be recconed the property of all uncompounded matter. I say uncompounded because compounded matter may be soft or fluid by the sliding of the hard particles amongst one another. But as for uncompounded matter there seems to be the same evidence of its hardness as of its impenetrability: For we account matter impenetrable only because we find it so by experience in all bodies in which we can try experiments. And if compound bodies are so very hard as we find many of them to be & yet are very porous & consist of parts which are only layed together, the simple bodies which are void of pores & were never yet divided, must be much harder. Now such hard bodies being heaped up together can scarce touch one another in more then points. And how bodies which touch only in points can stick together without the assistance of something which causes them to be attracted or prest towards one another is very difficult to conceive.

And by pursuing this method in other things as well as in light we may hope to discover more & more of the causes of things & to put the discoveries out of dispute till we come to as clear & full a knowledge of the very first cause as we can expect from phænomena. And thereby we shal not only perfect Natural Philosophy but also enlarge the bounds of Moral Philosophy, establishing upon the clear light of Nature the worship of a Deity as well as the love of our Neighbour.

All these things being considered, it seems to me that Deus O. M. in the beginning) created matter (consisting of hard solid impenetrable moveable & **{illeg}** particles of such sizes & figures & with such other properties & in such proportion to space as most conduced to the ends for which he created them. That these particles are so very hard as never to weare or break in pieces, no ordinary power being able to divide what the power of God himself made one in the fir creation. While these particles continue entire they wil be fit to compound bodies of one & the same nature & texture in all ages, but should they weare or break in pieces the nature of things depending on them would be changed. Water & Earth composed of old worn particles & fragments of particles would not be of the same nature & texture now with water & earth composed of entire particles in the beginning. Of these particles all material things seem to have been composed in the first creation but not without the intervention of an intelligent Agent. For it became him that created them to set them in order . And if he did so, its unphilosophical to seek for any other origin of the world or to pretend that it might arise out of a Chaos by the mere laws of Nature. For while Comets move in very excentrick Orbs in all manner of positions, blind fate could never make all the Planets move one & the same way in orbs concentric. This uniformity must be allowed the effect of choise. And so the first contrivance of the eyes ears heart & other organs of sence & motion in animals can be the effect of nothing else then the wisdome & skill of a powerful ever living Agent who being indivisibly in all places perceives all things in their **{**more**}** solid dimensions by the immediate presence of the things themselves more perfectly than that which thinks in us

perceives only the superficial pictures of things made in our sensorium by motion, & who is more able by his will to move alter & reform them then we are by ours to move our bodies. ‖ The business of Experimental Philosophy is only to find out by experience & Observation not how things were created but what is the present frame of nature. This inquiry must proceed first by Analysis in arguing from effects to causes & from compositions to ingredients. And when we have found the principles [the causes & ingredients of things we may proceed by Synthesis from those Principles to explain the things of this method I gave instances in the two first books. proceeding first by Resolution & then by composition But in this third Book I have only begun the Analysis of what remains to be discovered, hinting several things here about the nature of light & its effects upon the frame of Nature, & leaving the hints to be examined & improved by the further experiments & observations of such as are curious. And because the knowledge of the degrees of heat may be of use in making & reporting some sorts of Experiments relating to this matter I shal conclude with the following Question.

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The air in which we breath resists about 10000 times less then quicksilver &if the resistance in a glass well emptied of air should be but two hundred times less then that of the open air it would be two millions of times less then that of quicksilver. And in the heavens it would be still much less, there being exp of rarefying airs above 8000 times. And therefore the Vis inertiæ of the matter in the heavens is much above 2000000 of times less than that of quicksilver.

The Peripateticks in their Ph

For these particles I reccon to be solid least

I reccon these particles to be solid, least compound bodies should be porous in infinitum [I reccon them the least in Nature least matter should be actually divided in infinitum &] I reccon them to be hard & heavy as well, as impenetrable because I meet with equal evidence for all three Qualities. For We have the whole course of a large experience for the universal gravity of matter & for the hardness of its particles without any instance to the contrary & we have nothing more for its universal impenetrability. These particles being solid seem to be so very hard as never to wear or break in pieces no ordinary power being able to divide what the power of God himself made one in the first creation. While these particles continue entire they remain fit to compound bodies of one & the same nature & texture in all ages but should they weare or

so that the resistance seems still to decrease in the same proportion with the density of the resisting fluid. For I do not find by any experiments that bodies moving in Quicksilver water & air meet with any other sensible resistance then what arizes from the density & tenacity of those sensible fluids. Now If the resistance in a vessel well emptied of air was but 100 times less then in the open air it would be about a million of times less then in quicksilver. But it seems to be much less in such a vessel & still much less in the heavens above the orb of the Moon. For M^{r} Boyle has shewed that Air may be rarefied eight or ten thousand times & the heavens are much emptier of air then any vacuum we can make below [& therefore have much less resistance then any such vacuum, & by consequence, are very much above a million of times rarer & emptier of matter then quicksilver.] For since the air is comprest by the weight of the incumbent atmosphere & the density of air is proportional to the force compressing it it follows by computation that at the height of seven miles from the earth the air is twice rarer then at the surface of the earth & at the hight of 14 miles it is four times rarer then at the surface of the earth & at the height of 21, 28, 35, 42, 49, 56, 63, 70 miles it is 8, 16, 32, 64, 128, 256, 512, 1024 times rarer of thereabouts & at the height of 140, 210, 280, miles it is about 1000000, 1000000000, 1000000000000 times rarer & so on

‡ Bodies are therefore resisted in the heavens much less then in any Vacuum we can make below † < insertion from f 244v > < text from f 243v resumes >

Heat makes many bodies fluid which are not fluid in cold & increases the fluidity of tenacious fluids as of **{illeg}** & basams 2 & oyles, & thereby decreases their resistance: but it decreases not the resistance of water considerably as it would do

Qu. 24. What are the degrees of heat by which bodies emitt light

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Qu. 24 What are the degrees of heat requisite for the emission of light & which may be mutually produced by light?

This will be best understood by the following Table

For sulphureous steams ascend frequently out of the bowels of the earth & the Air abound with acids fit to promote fermentation as may be peceived by the rusting of iron & copper in it & by the kindling of fire with a pair of Bellows, & by the dependence of the beating of the heart upon respiration.

And even the gross body of Sulphur beaten into powder & with an equal weight of iron filings & a little water made into a past, acts upon the iron & in four or five hours grows too hot to be touched & emits a flame. And by these experiments compared with the warmth of the interior earth & hot springs, burning mountains, damps earthquakes, hot suffocating exhalations Hurricanes & spouts we may learn that sulphureous steams abound in the bowels of the earth & ferment with minerals &

Qu. 25. Are not the particles of light hard bodies & do not all sensible bodies consist of hard particles.

sometimes take fire & with a great explosion & shaking of the earth burst the caverns in which they are sent up & then the vapor **{illeg}** by the explosion ex**{**pirength**}** through the pores of & earth feels hot & suffocates man & makes Tempests & Hurricanes & causes the land to glide & the sea to bogle & carrys up the water thereof in drops which with their weight fall down again in spouts. Also some sulphureous steams at all times when the earth is dry ascending into the air ferment there with nitrous acids & sometimes taking fire cause lighting & thunder. For the air abounds with acid vapors fit to promote fermentations , as appears by the rusting of iron copper in it & the kindling of fire by blowing & by the dependence of the beating of the heart upon respiration.

[‡ Now the above mentioned motions are so great & violent as to shew that in fermentations there is new motion in the world generated from other Principles then the usual laws of motion.] Now the above mentioned motions are so great & violent as to shew that in fermentations bodies which almost rest are put into new motions by a very potent Principle which acts upon them only when they approach one another, [& which is much more potent then are the passive laws of motion arising from the Vis inertiæ of the matter.]

It seems therefore that God Deus O. M. in the beginning created hard particles of matter of such sizes & figures & with such other properties & in such a quantity in proportion to space as most conduced to the ends for which they were created, & of these variously convening & moveing amongst one another formed the corporeal **{**part**}** of the Univers: & that the various forms & changes which matter dayly undergoes consist only in the various coalitions & separations of these particles while the particles themselves continue entire & unaltered no ordinary power in nature being able to divide what God himself united in the first creation. While these particles continue entire corporeal nature may continue the same, & produce the same sorts of fluids & solids in all ages but should these be broken into less particles, the nature of things would be altered. For the broken particles would scarce **{**move**}** & convene & stick together any more in the same manner & form as they do at present, unless reunited by a divine power.

I have hitherto proceeded in this Book by way of Analysis, arguing from effects to causes & from compound bodies to their ingredients. In the first Book I proceeded first by Analysis in searching into the different refrangibility of the rays & the corresponding colours of light & then from those Principles compounded the explications of the colours of light refracted by Prisms those of the Rainbow & those of Natural bodies. In the second Book I proceeded by Analysis in searching oout the fits of easy Reflexion & easy transmission of the rays of light, & then from this Principle compounded a further explication of the colours of natural bodies The subject of those two books is complein <244v> but that of this third Book is very incomplete. Much remains to be discovered concerning the nature of Light , much more concerning the nature of fire & other bodies which emit reflect, refract inflect & stifle it & concerning the heat, motion & powers by which it is emitted reflected refracted inflected & stifled. Many experiments are wanting for completing the Analysis of this part of Nature & coming to a clear & distinct knowledge of all the causes of these things, many more for perfecting the Analysis of all Nature & making a full & clear discovery of all the first Principles of Natural

Philosophy. To compass this is a work which requires many heads & hands & a long time & yet this ought to be done before we proceed from the first Principles by Composition to explain {all} Nature.

some inconsiderable irregularities excepted which may have risen from the mutual actions of Comets & Planets upon one another & which will be apt to increase till this systeme wants a reformation. Such a wonderfull uniformity in the Planetary Systeme must be allowed the effect of choise. And so must the uniformity in the bodies of animal, they having generaly a right side & a left side shaped alike & on either side of their bodies two leggs behind & two arms or two leggs or two wings before upon their shoulders & between their shoulders a neck with a head upon it & in the head two ears, two eyes, a nose, a mouth, & a tongue alike situated.

— — —Moral Philosophy. For if we see clearely by the light of Nature that there is a God, we shall see clearly by the same light of Nature that he is to be acknowledged feared & adored.

This Analysis consists in arguing from from compositions to ingredients, & from motions to the forces producing them & in general from phænomena to their causes, & from particular causes to more general ones till to argument end in the most general. The Synthesis in assuming the causes discovered & established as principles of Philosophy & from them explaining the Phænomena proceeding from them & proving the Explanations. In the two first Books of these Opticks I proceeded — — — — inquisitive. And if Natural Philosophy in all its parts by pursuing this method shall at length be perfected, the bounds of Moral Philosophy will be also enlarged For so far as we can know by Natural Philosophy what power the first cause has over us & what benefits we receive or may expect from him, so far our duty towards him as well as that towards one another will appear to us by the light of nature. And no doubt, if the worship of fals Gods had not blinded the Heathens, their Moral Philosophy would have gone further then to the four Cardinal Vertues, & instead of teaching us to worship the Sun & Moon & dead mens Souls, they would that tought us to worship our true Benefactor

These forces are to be considered here not as occult Qualities which arise from the specific forms of things but as general Principles by which the things themselves are formed; their truth appearing to us Phænomena,, tho their causes be not yet explained.

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thence it may understood that the parts of all fusible bodies stick together as well in a slate of fusion as in a slate of congelation.

Now the smallest particles of matter

Whence its easy to understand that what ever cause makes the parts of ice & other hard bodies stick together the same cause will make them stick together when the bodies are melted, tho perhaps not so firmly. For in fusion the parts of bodies are in a motion of sliding amongst themselves.

And so sulphureous & nitrous spirits meeting in the air ferment with violence & make thunder & lightning.

If equal weights of sulphur poudered & iron filings be make into a past with a little water, though both the ingredients be dry bodies indissolvable in the water yet they act upon one another & in four or five hours grow too hot to be touched & emit a flame. And thence it may be understood that the sulphureous steams which abound in the bowels of the earth meeting with fit matter may cause great fermentations below & heat mineral waters set mountains on fire & getting out into the air may ferment & flash with the acids they meet with there for causing thunder & lightning. For the air abounds with nitrous acids which are very apt to inflame sulphureous exhalations as be seen by blowing a fire

world. ‖Some other Principle was necessary for putting bodies into motion & now they are in motion some other Principle is necessary for conserving the motion. For from the various composition of motion — — — warms all things by the light, Mountains take fire & the inward parts of the earth are constantly warmed & generate hot sulphureous healthful exhalations which breaking forth with violence cause earthquakes tempests & hurricanes, raise or subvert Islands & mountains & sink lakes & carry up the sea in columns & in drops which convening above fall down in spouts.

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Why the Barometer stand 60 or 80 inches high.

Why sulphur & iron grow hot & fire & whence Earthquakes Hurricanes & Spouts.

Air promotes the burning of sulphureous bodies & therefore apt to ferment sulphureous vapors for causing Thunder & lightning.

The same thing I infer also from the cohering of two polished marbles in Vacuo & from the standing of Mercury in the barometer at the height of 40 or 60 or 70 inches or above when ever it is will purged of air & carefully poured in so that its parts, be every where contiguous both to one another & to the glass. Some imagin that the Marbles are prest together by an ambient æther | Mercury is prest up into the Tube by the same Ethereal Medium . But if this æther can pass through either the Quicksilver or the glass it will not buoy up the Mercury, & if it can pass through neither of them then Mercury will not subside, as it doth when the glass is knocked to make the quicksilver {part} from it or when the quicksilver hath any bubbles in it which hinder the contact & cohesion of its parts. The like experiment hath been tried with water well purged from Air. If water be congealed by freezing or quicksilver by the fumes of Lead or by being fried with Virdegris, the parts of the congealed fluid stick together so as to compose a hard body: & this experiment of the Barometer shews that they stick together also in a fluid state . And then

Nam calores quos Thermometer calefacta

Thermometer prima vice in calescendo crepuit tanquam si vitrum frangeretur at crepitus post horas tres vel quatuor cessarunt & Thermometer luto obteclas calorem stanni liquefacti pertulit, Deinde in loco frigido posita temporibus æqualibus calores amisit in proportione geometrica. Sia et calores quos ferrum candens in loco frigido positum temporibus æqualibus amisit erant in ratione geometrica et inde innotuere per Tabulam Logarithmorum.

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the matter into smaller parts & making the parts more smooth & slippery: but that part of the resistance which arises from the Vis inertiæ is proportional to the density of the matter cæteris paribus & cannot be diminished by dividing the matter nor by any other means then by decreasing the density. And for these reasons the density of fluid Mediums is very nearly proportional to their resistance. Liquors which differ not much in density, as water, spirit of vine, spirit of turpentine, hot oyle, differ not much in resistance. Water is thirteen or fourteen times lighter then quicksilver & by consequence 13 or 14 times rarer, & its resistance is less then that of quicksilver in the same proportion or thereabouts, as I have found by experiments made with Pendulums. The open Air in which we breath is eight or nine hundred times lighter then water, & by consequence eight or nine hundred times rarer, & accordingly its resistance is less then that of water in the same proportion or thereabouts, as I have also found by experiments made with pendulums; & in thinner Air the resistance is still less & at length by rarefying the Air becomes insensible. For small feathers falling in the open air meet with great resistance but in a tall glass well emptied of air they fall as fast as lead or gold as I have seen tried several times. Whence the resistance seems still to decrease in proportion to the density of the fluid. For I do not find by any experiments that bodies moving in Quicksilver Water or Air meet with any other sensible resistance then what arizes from the density & tenacity of those sensible fluids as they would do if the pores of those fluids & all other spaces were pervaded by a more subtile resisting fluid.. Now if the resistence in a vessel well emptied of Air was but an hundred times less then in the open Air it would be about a million of times less then in quicksilver. But it seems to be much less in such a vessel & still much less in the heavens at the height of three or four hundred miles from the earth or above. For M^{r} Boyle has shewed that Air may be rarified above ten thousand times in vessels of glass; & the heavens are much emptier of air then any vacuum we can make below. For since the Air is comprest by the weight of the incumbent atmosphere & the density of Air is proportional to the force compressing it, it follows by computation that at the height of about seven miles from the earth the air is four times rarer then at the surface of the earth, & at the height of 14 miles it is sixteen times rarer then at the surface of the earth; & at the height of 21, 28, or 35, miles it is respectively 6{4}, 256, or 1024, times rarer or thereabouts; & at the

height of 70, 140, or 210, miles it is about 1000000, 1000000000000 or 1000000000000000000 times rarer, & so on.

Heat promotes fluidity very much by diminishing the tenacity of bodies. It makes many bodies fluid which are not fluid in cold & increases the fluidity of tenacious liquids as of Oyle Balsam & Honey, & thereby decreases their resistance. But it decreases not the resistance of water considerably as it would do if any considerable part of the resistance of water arose from the attrition or tenacity of its parts And therefore the resistence of water arises chiefly almost entirely from the Vis inertiæ of its matter: & by consequence, if the heavens were as dense as water they would not have much less resistence then water; if as dense as quicksilver they would not have much less resistence then quicksilver; if absolutely dense or full of matter without any vacuum, let the matter be never so subtile & fluid, they would have a greater resistence then quicksilver. A solid globe in such a Medium would lose above half its motion in moving three times the length of its diameter & a globe not solid (such as are the Planets) would be retarded sooner. And therefore to make way for the lasting & regular motions of the Planets & Comets, its necessary to empty the heavens of all matter except <247r> perhaps some very thin vapors steams or effluvia arising from the Atmospheres of the Earth Planets & Comets. & such an ethereal Medium as we described above. A dense fluid can be of no use for explaining the phænomena of Nature, the motions of the Planets & Comets being better explained by gravity without it & gravity not being hitherto explained by it. It serves only to disturbe & retard the motions of those great bodies, & make the frame of nature languish & in the pores of bodies it serves only to stop the vibrating motions of their parts wherein their heat & activity consists. And as it is of no use & hinders the operations of Nature & makes her languish, so there is no evidence for its existence & therefore it ought to be rejected. And if it be rejected, the Hypotheses that light consists in pression or motion propagated through such a Medium are rejected with it. And for rejecting such a Medium we have the authority of those the oldest & most celebrated Philosophers of Greece & Phenicia who made a Vacuum, Atoms & the gravity of Atoms the first Principles of their Philosophy; tacitely attributing gravity to some other cause then dense matter or mechanism. Later Philosophers banish the consideration of other causes then mechanism out of natural Philosophy, framing Hypotheses for explaining all things mechanically & referring other causes to Metaphysicks: whereas the main business of natural Philosophy is to argue from Phænomena without feigning Hypotheses & to deduce causes from effects till we come to the very first cause which certainly is not mechanical; & not only to unfold the mechanism of the world but chiefly to resolve these & such like questions. What is there in places almost empty of matter, & whence is it that the Sun & Planets gravitate towards one another without dense matter between them? Whence is it that Nature doth nothing in vain & whence arises all that beauty that we see in the world? To what end are Comets, & whence is it that Planets move all one & the same way in orbs concentric while Comets move all manner of ways in Orbs very excentrick; & what hinders the fixt Stars from falling upon one another? How come the bodies of animals to be contrived with so much art, & for what ends were their severall parts? Was the eye contrived without skill in Opticks & the ear without the knowledge of sounds? How do the motions of the body follow from the will, & whence is the instinct in animals? Is not the sensory of animal that place to which the sensitive substance is present, & into which the sensible species of things are carried through the nerves & brain that there they may be perceived by their immediate presence to that substance? And these things being rightly dispatcht, Does it not appear from phænomena that there is a Being incorporeal living intelligent omnipresent, who in infinite space as it were in his sensory, sees the things themselves intimately, & throughly perceives them, & comprehends them wholy by their immediate presence to himself; of which things the images only carried through the organs of sense to it self, that which in us perceives & thinks, sees & beholds in its little sensorium. And tho every true step made in this Philosophy brings us not immediately to the knowledge of the first cause, yet it brings us nearer to it, & on that account is to be highly valued.

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— tacitely attributing gravity to some other cause then dense matter. Later Philosophers banish the consideration of the supreme cause out of natural Philosophy framing Hypotheses for explaining all things without it & referring it to Metaphysicks : whereas the main business of natural Philosophy is to argue from effects to causes till we come to the very first cause, & not only to unfold the mechanim of the world but chiefly to resolve these & such like questions What is there in places almost empty of matter & whence is it that the Sun & Planets gravitate towards one another without dense matter between them? Whence is it that Nature does nothing in vain ? And whence arises all that beauty that we see in the world? To what end are Comets & whence is it that they move all manner of ways in Orbs very excentric & Planets all one way in

{obs**}** concentric, & what hinders the fixt stars from falling upon one another? How come the bodies of animals to be contrived with so much art? & for what ends were their several parts? Was the eye contrived without skill in Opticks & the ear without the knowledge of sounds? & how do the motions of the body follow from the will & whence is the instinct in animals? And tho every true step made in this Philosophy brings us not immediately to the knowledge of the first cause yet it brings us nearer to it & on that account is to be highly valued.

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Qu 23. Have not the small partciles of bodies certain powers virtues or forces by which they act at a distance not only upon the rays of light for reflecting refracting & inflecting them but also upon one another for producing a great part of the phænomena of nature? For its well known that bodies act one upon another by the attractions of gravity magnetism & electricity & these instances shew the course & tenour of nature & make it not improbable but that there may be more attractive powers then these. ‡ < insertion from f 248v > ‡ Or that bodies may act at very small distances act by electricall attraction even without friction For Nature is very consonant & conformable to her self. How these attractions may be performed I do not here consider. What I call attraction may be performed by impulse or by some other means unknown to me. I use that word here to signify only in general any force by which bodies tend towards one another whatever be the cause. For we must learn from the phænomena of Nature what bodies **{**do**}** attract one another & what are the laws & properties of the attractio before we enquire the cause by which the attraction is performed. The attractions of gravity magnetism & electricity reach to very sensible distances & so have been observed by vulgar eyes & there may be others which reach to so small distances as hitherto to escape observations, & perhaps electrical attraction may reach to small distances even without being excited by friction.

For when salt of Tartar runs — — — — < text from f 248r resumes >

For when salt of Tartar runs per deliquium is not this done by an attraction between the particles of the salt of Tartar & the particles of water which float in the air in the form of vapors? And why does not common salt or saltpeter or vitriol run per deliquium but for want of such an attraction? Or why does not salt of Tartar draw more water out of the air then in a certain proportion to its quantity, but for want of an attractive force after it is satiated with water? And whence is it but from this attractive power that water which alone distills with a gentle lukewarm heat will not destill from salt of Tartar without a great heat? And is it not from the like attractive power between the particles of oyle of Vitriol & the particles of water that Oyle of Vitriol draws to it a good quantity of water out of the air, & after it is satiated draws no more, & in destillation lets go the water very difficultly? And when water & oyle of Vitriol poured successively into the same vessel grow very hot in the mixing, does not this heat argue a great motion in the parts of the liquors? & does not this motion argue that the parts of the two liquors in mixing coalesce with violence & by consequence rush towards one another with an accelerated motion. And when Aqua fortis or Spirit of Vitriol poured upon filings of iron dissolve the filings with a great heat & ebullition is not this heat & ebullition effected by a violent motion of the parts & does not that motion argue that the acid parts of the liquor rush towards the parts of the metal with viloence, & run forcibly into its pores till they get between its outmost particles & the main mass of the metal & surrounding those particles loosen them from the main mass & set them at liberty to flote off into the water? And when the acid particles which alone would destill with an easy heat will not separate from the particles of the metal without a very violent heat does not this confirm the attraction between them?

When salt of Tartar per deliquium being poured into the solution of any metal precipitates the metal & makes it fall down to the bottom of the liquor in the form of mud, does not this argue that the acid particles are attracted more strongly by the salt of Tartar then by the metal & by the stronger attraction go from the metal to the salt of Tartar? And so when a solution of in Aqua fortis dissolves the Lapis Calaminasis & lets go the iron or a solution of Copper dissolves iron immersed in it & lets go the copper, or solution of Silver dissolves Copper & lets go the silver <249r> or a solution of Mercury in aqua fortis being poured upon iron copper tin or lead dissolves the metal & lets go the Mercury, does not this argue that the acid particles of the Aqua fortis are attracted more strongly by the Lapis Calamiriaris then by Iron & more strongly by iron then by copper & more strongly by copper then by silver & more strongly by iron, copper tin & lead then by Mercury? And is it not for the same reason that iron requires more Aqua fortis to dissolve it then copper & copper more then the other metals; & that of all metals iron is dissolved most easily & is most apt to rust; & next after iron, copper?

When spirit of Vitriol poured upon common salt or saltpeter makes an ebullition with the salt & unites with it & in destillation the spirit of the common salt or saltpeter comes over much easier then it would do before & the acid part of the spirit of Vitriol stays behind; does not this argue that the fixed Alcaly of the salt attracts the acid spirit of the Vitriol more strongly then its own spirit, & not being able to hold them both, lets go its own? And when oyle of Vitriol is drawn off from its weight of Nitre & from both the ingredients a compound spirit of Nitre is destilled two parts of which being poured on one part of oyle of cloves or larvy seeds, or of any ponderous vegetable oyle or oyle of animal substances, or oyle of Turpentine thickened with a little balsam of sulphur, grows so very hot in mixing as presently to send up a burning flame: does not this very great & sudden heat argue that the the two liquors mix with violence & that their parts in mixing run towards one another with an accelerated motion & clash with the greatest force? And is it not for the same reason that well rectified spirit of wine poured on the said compound spirit flashes & that the pulvis fulminans composed of sulphur Nitre & salt of Tartar goes off with a more sudden & violent explosion then Gun-powder, the acid spirits of the Sulphur & Nitre rushing towards one another & towards the salt of Tartar with so great a violence as by the shock to turn the whole at once into vapour & flame? Where the dissolution is slow it makes a slow ebullition & a gently heat & where it is quicker it makes a greater ebullition with more heat, & where it is done at once, the ebullition is contracted into a sudden blast or violent explosion with a heat equal to that of fire & flame.

So when a drachm of the above mentioned compound spirit of Nitre was poured upon half a drachm of oyle of Carvi seeds in Vacuo the mixture immediately made a flash like gunpowder & burst the exhausted Receiver which was a glass six inches wide & eight inches deep. And ‡

< insertion from f 248v >

‡And even the gross boy of Sulphur poudered & with an equal weight of iron filings & a little water made into a past, acts upon the iron & in five or six hours grows too hot to be touched & emits a flame. And by these experiments compared with the great quantity of sulphur with which the earth abounds & the warmth of the interior parts of the earth & hot springs & burning mountains, & with damps mineral corruscations, earthquakes, hot suffocating exhalations, hurricanes & spouts; we may learn that sulphureous steams abound in the bowels of the earth & ferment with minerals & sometimes take fire with a sudden corruscation & explosion & if pent up in subterraneous caverns burst the caverns with a great shaking of the earth as in springing of a Mine, & then the vapor generated by the explosion expiring through the pores of the earth feels hot & suffocates & makes tempests & hurricanes & sometimes causes the land to slide or the sea to boyle & carries up the water thereof in drops which by their weight fall down again in spouts. Also some sulphureous steams, at all times when the earth is dry, ascending into the Air, ferment there with nitrous acids, & sometimes taking fire cause lightning & thunder & fiery Meteors. For the Air abounds with acid vapors fit to promote fermentations, as appears by the rusting of iron & copper in it, the kindling of fire by blowing, & the beating of <249v> the heart by means of respiration. Now the above mentioned motions are so great & violent as to shew that in fermentations the particles of bodies which almost rest are put into new motions by a very potent principle which acts upon them only when they approach one another & causes them to meet & clash with great violence & grow hot with the motion & dash one another into pieces & vanish into air & vapour & flame.

< text from f 249r resumes >

When Oyle of Vitriol is mixed with a little water or is run per deliquium & in destillation the water ascends difficultly & brings over with it some part of the Oyle of Vitriol in the form of spirit of Vitriol & this spirit being poured upon iron copper or salt of Tartar unites with the body & lets go the water, does not this shew that the acid spirit is attracted by the water & more attracted by the fixt body then by the water & therefore lets go the water to close with the fixt body? And is it not for the same reason that the water & acid spirits in Vinegar, Aqua fortis & Spirit of Salt cohere & rise together in destillation; but if the Menstruum be poured on salt of Tartar, or on Lead or Iron or any fixt body which it can dissolve, the acid by a stronger attraction adheres to the body & lets go the water? And is it not also from a mutual attraction that the spirits of soot & sea salt unite & compose the particles of Salarmoniac which are less volatile then before because grosser & freer from water; & that the particles of Salarmoniac in sublimation carry up the particles of Antimony which will not sublime alone; & that the particles of Mercury uniting with the acid particles of spirit of salt compose Mercury sublimate, & with the particles of sulphur compose cinnaber; & that the particles of spirit of wine &

spirit of urine well rectified unite & letting go the water which dissolved them compose a consistent body;; & that in subliming cinnaber from Salt <250r> of tartar or quick lime the sulphur by a stronger attraction of the salt or lime lets go the Mercury & stays with the fixt body, & that when Mercury sublimate is sublimed from Antimony or from Regulus of Antimony, the spirit of salt lets go the Mercury & unites with the Antimonial metal which attracts it more strongly & stays with it till the heat be great enough to make them both ascend together, & then carries up the metal with it in the form of a very fusible salt called butter of Antimony, although the spirit of salt alone be almost as volatile as water & the Antimony alone as fixt as lead?

When Aqua fortis dissolves silver & not gold & Aqua regia dissolves gold & not silver may it not be said that Aqua fortis is subtile enough to penetrate Gold as well as silver but wants the attractive force to give it entrance, & that Aqua regia is subtile enough to penetrate silver as well as Gold but wants the attractive force to give it entrance. For Aqua regia is nothing else then Aqua fortis mixed with some spirit of salt or with salarmoniac & even common salt dissolved in Aqua fortis enables the menstruum to dissolve Gold tho the salt be a gross body. When therefore spirit of salt precipitates silver out of Aqua fortis is it not done by attracting & mixing with the Aqua fortis & not attracting or perhaps repelling the silver; & when water precipitates Antimony out of the sublimate of Antimony & Salarmoniac or out of butter of Antimony is it not done by dissolving mixing with & weakning the salarmoniac or spirit of salt & not attracting or perhaps repelling the Antimony? And is it not from the want of an attractive vertue between the parts of water & oyle, of Quicksilver & Antimony, of Lead & Iron that these substances do not mix & by a weak attraction that quicksilver & copper mix difficultly & from a strong one that Quicksilver & Tin, Antimony & iron, water & salts mix readily? And in general, is it not from the same principle, that heat congregates homogeneal bodies & separates heterogeneal ones?

When Arsenick with soap gives a Regulus & with Mercury sublimate a volatile fusible salt like butter of Antimony, does not this shew that Arsenick is compounded of fixt & volatile parts strongly cohering by a mutual attraction so that the volatile will not ascend without carrying up the fixed? And so when an equal weight of spirit of wine & oyle of Vitriol are digested together & in destillation yeild two fragrant volatile spirits which will not mix with one another & a fixt black earth remains behind, doth not this shew that oyle of Vitriol is composed of volatile & fixed parts strongly united by attraction so as to ascend together in form of a volatile acid fluid salt, untill the spirit of wine attracts & separates the volatile parts from the fixed? And therefore since oyle of Sulphur per campanam is of the same nature: with oyle of Vitriol, may it not be inferred that sulphur is also a mixture of volatile & fixed parts so strongly cohering by attraction as to ascend together in sublimation. By ♁

< insertion from f 250v >

By dissolving flowers of Sulphur in oyle of Turpentine & destilling the solution, it is found that sulphur is composed of an inflammable volatile thick oyle or fat bitumen, an acid salt, a very fixt earth & a little metal. The three first were found not much unequal to one another, the fourth in so small a quantity as scarce to be worth considering. The acid salt dissolved in water is the same with oyle of sulphur per campanam, & abounding much in the bowels of the earth & particularly in Markasites, unites it self to the other ingredients of the Markasite, which are Bitumen, Iron, Copper & earth & with them compounds Alume Vitriol & Sulphur. With the earth alone it compounds Alume, with the metal alone or metal & earth together it compounds Vitriol, & with the Bitumen & Earth it compounds Sulphur whence it comes to pass that Markasites abound with those three minerals. And is it not from the mutual attraction of the ingredients that they stick together for compounding these minerals, & that the Bitumen carries up the other ingredients of the sulphur, which without it would not sublime? And the same Question may be put concerning all or almost all the gross bodies in nature. For all the parts of animals & vegetables are composed or substances volatile & fixed fluid & solid as appears by their Analysis, & so are salts & minerals so far as Chymists have been hitherto able to examin their composition

< text from f 250r resumes >

When Mercury sublimate is resublimed with fresh Mercury & becomes Mercurius dulcis which is a white tastless earth scarce in dissolvable in water, <251r> and Mercurius dulcis resublimed with spirit of salt returns into Mercury sublimate & when Metals corroded with a little acid turn into rust which is an earth tastless & indissolvable in water & this earth imbibed with more acid become a metallic salt & when some

stones, as spar of Lead, dissolved in proper menstruums become salts, does not these things shew that salts are dry earth & watry acid united by attraction, & that the earth will not become a salt without so much acid as makes it dissolvable in water? †

< insertion from f 250v >

†Doe not the sharp & pungent tasts of acids arise from the strong attraction whereby the acid particles rush upon & agitate the particles of the tongue? And when metalls are dissolved in acid menstruums & the acids in conjunction with the metal act after a different manner so that the compound has a different tast much milder then before & sometimes a sweet one is it not because the acids adhere to the metallick particles & thereby lose much of their activity?? And if the acid be in too small a proportion to make the compound dissolvable in water, will it not by adhering strongly to the metal become unactive & lose its tast & the compound be a tastless earth? For such things as are not dissolvable by the moisture of the tongue act not upon the tast.

As gravity makes the sea flow round < text from f 251r resumes > makes the sea flow round the denser & weightier parts of the globe of the earth so the attraction may make the watry acid float round the denser & compacter particles of earth for composing the particles of salt. For otherwise the acid would not do the office of a medium between the earth & common water for making salts dissolvable in the water nor would salt of tartar readily draw off the acid from dissolved metalls. nor metals the acid from Mercury. Now as in the great globe of the earth & sea the densest bodies by gravity sink down in water & always endeavour to go towards the center of the globe so in particles of salt the densest matter will always endeavour to approach the center of the particle: so that a particle of salt may be compared to a chaos, being dense hard dry & earthy in the center & rare soft moist & watry in the circumference. And hence it seems to be that salts are of a lasting nature being scarce destroyed unless by drawing away their watry parts by violence or by letting them soak into the pores of the central earth by a gentle heat in putrefaction untill the earth be dissolved by the water & separated into smaller particles which by reason of their smalness make the rotten compound appear of a black colour. Hence also it may be that the parts of animals & vegetables preserve their several forms & assimilate their nourishment, the soft & moist nourishment easily changing its texture by a gentle heat & motion till it becomes like the dense hard dry & durable earth in the center of each particle. But when the nourishment grows unfit to be assimilated or the central earth grows too feeble to assimilate it, the motion ends in putrefaction & death.

If a very small quantity of any salt or Vitriol be dissolved in a great quantity of water the particles of the salt or Vitriol will not sink to the bottom tho they be heavier in specie then the water but will eavenly diffuse themselves into all the water so as to make it as saline at the top as at the bottom. And does not this imply that the parts of the salt or Vitriol recede from one another & endeavour to expand themselves & get as far asunder as the quantity of water will allow in which they float? And does not this endeavour imply that they have a repulsive force by which they fly from one another or at least that they attract the water more strongly then they do one another? For as all things ascend in water which are less attracted then water by the gravitating power of the earth, so all the particles of salt which float in water & are less attracted then water by any one particle of salt must recede from that particle & give way to the more attracted water

When any saline liquor is evaporated to a cuticle & let cool, the salt concretes in regular figures, which argues that the particles of salt <252r> before they concreted, floated in the liquor at equal distances in rank & file & by consequence that they acted upon one another by some power which at equal distances is equal at unequal distances unequal. For by such a power they will range themselves uniformly & without it they will float irregularly & come together as irregularly. And since the particles of Island Crystal act all the same way upon the rays of light for causing the unusual refraction, may it not be supposed that in the formation of this crystal the particles not only ranged themselves in rank & file for concreting in regular figures but also by some kind of polar vertue turned their homogeneal sides the same way.

The parts of all homogeneal hard bodies which fully touch one another stick together very strongly. And for explaining how this may be some have invented hooked atoms which is begging the question; & others tell us that bodies are glued together by rest i.e. by an occult Quality, or rather by nothing, & others that they stick together by conspiring motions, that is, by rest amongst themselves.: I had rather infer from their cohesion that their particles attract one another by some force which in immediate contact is exceeding strong, at small distances performs the chymical operations above mentioned & reaches not far from the particles with any

sensible effect. ✣ ✣ < insertion from f 253r > All bodies seem to be composed of hard particles, for otherwise fluids would not congeale, as water, oyles, Vinegre, & spirit or oyle of Vitriol do by freezing, Mercury by fumes of Lead, Spirit of Nitre & Mercury by dissolving the Mercury & evaporating the flegm, spirit of Wine & spirit of Urine by deflegming & mixing them, & spirit of Urine & spirit of salt by subliming them together to make salarmoniac. Even the rays of light seem to be hard bodies, for otherwise they would not retain different properties in their different sides. And therefore hardness may be recconed the property of all uncompounded matter. At least this seems to be as evident as the universal impenetrability of matter. For all bodies, so far as experience reaches, are either hard or may be hardened, & we have no other evidence of universal impenetrability besides a large experience without exception. Now if compound bodies are so very hard as we find some of them to be & yet are very porous & consist of parts which are only laid together the simple particles which are void of pores & were never yet divided must be much harder. For such hard particles being heaped up together can scarce touch one another in more then a few points & therefore must be separable by much less force then is requisite to break a solid particle whose parts touch in all the space between them without any pores or interstices to weaken their cohesion. And how such very hard particles which are only laid together & touch only in a few points can stick together, & that so firmly as they do, without the assistance of something which causes them to be attracted or prest towards one another, is very difficult to conceive. < text from f 252r resumes > < insertion from f 252v > ✣The same thing I infer also from the cohering of two polished marbles in Vacuo, & from the standing of Quicksilver in the Barometer at the height of 50 60 or 70 inches or above whenever it is well purged of air & carefully poured in, so that its' parts be every where contiguous both to one another & to the glass. Some imagin that the Marbles are prest together by an ambient æther, & that the Quicksilver is prest up into the Tube by the same æther. But if this æther can pass through either the Quicksilver☞ or the glass it will not press the Quicksilver up into the glass & if it can pass through neither of them it will not let the Quicksilver subside, as it doth whenever the glass is knocked to make the Quicksilver part from it or whenever the Quicksilver hath any bubbles in it which hinder the contact & cohesion of its parts.⛢ ⛢ < insertion from the bottom of f 253r > ⛢Yet if the æther be rarer between the particles then in open & free spaces, it may press them together by its excess of density. < text from f 252v resumes > The like experiment hath been tried with water well purged from air. If Quicksilver be congealed by the fumes of Lead or water be congealed by freezing, the parts of the congeled fluid stick together so as to compose a hard body: & by this experiment of the Barometer it appears that they stick together also in a state of fluidity. Whence its easy to understand that what ever cause makes the parts of ice & hard metalls stick together the same cause makes them stick together when the bodies are melted, tho perhaps not so firmly. For in fusion the parts of bodies are in a motion of sliding amongst themselves. ✣ < insertion from the bottom of f 252v > ✣ And of the same kind with these experiments is this experiment that water ascends in very slender glass pipes (even in Vacuo as soon as the lower ends of the pipes are dipped into the stagnant water; & the narrower are the pipes, the greater is the ascent. And there is the same cause of philtration, & of the ascent of water in the form of an Hyperbola between two planes of glass inclined to one another in a very acute angle & dipt perpendicularly into the liquor, whether the experiment be tried in the open air or in vacuo. < text from f 252v resumes >

Now the smallest particles of matter may cohere by the strongest attractions & compose bigger particles of weaker vertue &c < text from f 252r resumes > Now the smallest particles of matter may cohere by the strongest attractions and compose bigger particles of weaker vertue & many of these may cohere & compose bigger particles whose vertue is still weaker & so on for divers successions untill the progression end in the biggest particles on which the operations in chymistry & the colours of natural bodies depend, & which by cohering compose bodies of a sensible magnitude. If the body is compact & bends or yeilds inward to pression without any sliding of its parts, it is hard & elastic

returning to its figure with a force arising from the mutual attraction of its parts. If the parts slide upon one another the body is malleable or soft. If they slip easily & are of a fit size to be agitated by heat & the heat is big enough to keep them in agitation, the body is fluid, & if it be apt to stick to things it is humid; & the drops of every fluid affect a round figure by ‡ < insertion from f 252v > ‡ the mutual attraction of their parts as the globe of the earth & sea affects a round figure by the mutual attraction of its parts by gravity. < text from f 252r resumes >

Since metals dissolved in acids attract but a small quantity of the acid, their attractive force can reach but to a small distance from them. And as in Algebra, where affirmative quantities vanish & cease there negative ones begin: so in Mechanicks, where attraction ceases there a repulsive vertue ought to succeed. And that there is

such a vertue seems to follow from the reflexions & inflexions] of the rays of light. For the rays are repelled by bodies in both these cases without the immediate contact of the reflecting or inflecting body. It seems also to follow from the emission of light, the ray so soon as it is shaken off from a shining body by the vibrating motion of the parts of the body & gets beyond the reach of attraction, being driven away with exceeding great velocity. For that force which is sufficient to turn it back in reflexion may be sufficient to emit it. It seems also to follow from the production of air & vapor: The particles when they are shaken off from bodies by heat or fermentation so soon as they are beyond the reach of the attraction of the body, receding from <254r> it & also from one another with great strength, & keeping at a distance. # < insertion from the top of f 253v > # so as sometimes to take up above a million of times more space then they did before in the form of a dense body. Which vast contraction & expansion seems unintelligible by feigning the particles of Air to be springy & ramous or rolled up like hoops, or by any other means then a repulsive power. < text from f 254r resumes > The particles of fluids which do not cohere too strongly & are of such a smalness as renders them most susceptible of those agitations which keep liquors in a fluor, are most easily separated & rarefied into vapour, & in the language of the Chymists they are volatile, rarefying with an easy heat & condensing with cold. But those which are grosser & so less susceptible of agitation or cohere by a stronger attraction are not separated without a stronger heat or perhaps not without fermentation And these last are the bodies which Chemists call fixed & being rarefied by fermentation become true permanent air: those particles receding from one another with the greatest force & being most difficulty brought together which upon contact cohere most strongly. And because the particles of permanent air are grosser & arise from denser substances then those of vapors, thence it is that true air is more ponderous then vapor & that a moist Atmosphere is lighter then a dry one quantity for quantity, . ⊙ < insertion from the middle of f 253v > ⊙ < text from f 254r resumes > From the same repelling power it seems to be that flys walk upon water without wetting their feet; & that the Object-glasses of long Telescopes lye upon one another without touching; & that dry pouders are difficultly made to touch one another so as to stick together, unless by melting them or wetting them with water which by exhaling may bring them together, & that two polished Marbles which by immediate contact stick together are difficultly brought so close together as to stick.

And thus Nature will be very conformable to her self & very simple, performing all the great motions of the heavenly bodies by the attraction of gravity which intercedes those bodies, & almost all the small ones of their particles by some other attractive & repelling power which intercedes the particles. . The Vis inertiæ is a passive principle by which bodies persist in their motion or rest, receive motion in proportion to the force impressing it, & resist as much as they are resisted. By this principle alone there could never have been any motion in the world. < insertion from f 252v > ‖ < text from f 254r resumes >

Some other Principle was necessary for putting bodies into motion, & now they are in motion some other Principle is necessary for conserving the motion. For from the various composition of two motions tis very certain that there is not always the same quantity of motion in the world. For if two globes joyned by a slender rod revolve about their common center of gravity with an uniform motion while that center moves on uniformly in a right line drawn in the plane <255r> of their circular motion, the summ of the motions of the two globes as often as the globes are in the right line described by their common center of gravity will be bigger then the summ of their motions when they are in a line perpendicular to that right line. By this instance it appears that motion may be got or lost; but by reason of the tenacity of fluids & attrition of their parts & the weakness of elasticity in solids, motion is much more apt to be lost then got, & is always upon the decay. For bodies which are either so absolutely hard or so soft as to be void of elasticity, will not rebound from one another. Impenetrability makes them only stop. If two equal bodies meet directly in vacuo they will be the laws of motion stop where they meet & lose all their motion & continue to rest, unless they be elastick & receive new motion from their spring. If they have so much elasticity as suffices to make them rebound with a quarter or half or three quarters of the force with which they came together they will lose three quarters or half or a quarter of their motion. And this may be tried by letting two equal pendulums fall against one another from equal heights. If the pendulums be of lead or soft clay they will lose all or almost all their motion: if of elastic bodies, they will lose all but what they recover from their elasticity. If three equal round vessels be filled the one with water the other with oyle the third with molten pitch & the liquors be stirred about alike to give them a vortical motion: the pitch by its tenacity will lose its motion quickly, the oyle being less tenacious will keep it longer & the water being least tenacious will keep it longest but yet will lose it in a short time. Whence its easy to understand that if many contiguous Vortices of molten pitch were each of them as large as the Cartesian, yet these & all their parts would by their tenacity & stifness communicate their motion to one another till they all rested among themselves. Vortices of oyle or water or some fluider matter

might continue longer in motion but unless the matter were void of all tenacity & attrition of parts & communication of motion (which is not to be supposed) the motion would constantly decay. Seing therefore the variety of motion which we see in the world is always decreasing, there is a necessity of conserving & recruiting it by active principles; such as are the cause of gravity by which Planets & Comets keep their motions in their Orbs & all bodies acquire great motion in falling; & the cause of fermentation by which the heart & blood of animals are kept in perpetual motion & heat, the inward parts of the earth are constantly warmed bodies burn & shine, mountains take fire, the caverns of the earth are blown up & the Sun continues violently hot & lucid & warms all things by his light. <256r> . For we meet with very little motion in the world besides what is visibly oweing to these active principles, & the power of the will

All these things &

<257r>

Qu. 21. Are not the rays of light very small bodies emitted from shining substances & refracted by mean of certain attractions which intercede them & the parts of pellucid bodies. For such bodies will pass through uniform Mediums in right lines without bending into the shadow, which is the nature of the rays of light. They will also be capable of several properties & be able to conserve their properties unchanged in passing through several Mediums, which is another condition of the rays of light. Pellucid substances act upon the rays of light at a distance in refracting reflecting & inflecting them & the rays mutualy agitate the parts of those substances at a distance for heating them; & this action & reaction at a distance very much resembles an attractive force. If refraction be performed by attraction of the rays, the sines of incidence must be to the sines of refraction in a given proportion as we shewed in our Principles of Philosophy, & this Rule is true by experience. The rays of light in going out of glass into a Vacuum are bent towards the glass, and if they fall too obliquely on the Vacuum they are bent backwards into the glass & totaly reflected, & this reflexion cannot be ascribed to the resistance of the Vacuum, but must be caused by the power of the glass attracting the rays at their going out of it into the Vacuum & bringing them back. For if the further surface of the glass be moistened with water or clear oyle or liquid & clear honey, the rays which would otherwise be reflected will go into the water oyle or honey, & therefore are not reflected before they arrive at the further surface of the glass & begin to go out of it. If they go out of it into water oyle or honey they go on, because the attraction of the glass is almost ballanced & rendred ineffectual by the contrary attraction of the liquor; but if they go out of it into a vacuum which has no attraction to ballance that of the glass, the attraction of the glass either bends & refracts them or brings them back & reflects them. † < insertion from f 257br > †And this is still more evident by laying together two Prisms of Glass or two Object glasses of very long Telescopes the one plane the other a little convex, & so compressing them that they do not fully touch nor are too far asunder. For the light which falls upon the further surface of the first glass where the interval between the glasses is not above the ten hundred thousandth part of an inch will go through that surface & through the air or **{**vacuum**}** between the glasses & enter into the second glass as was explained in the 1st 4th & 8th Observations of the first Part of the second Book. But if the second glass be taken away the light which goes out of the second surface of the first glass into the Air or Vacuum will not go on forward but turns back into the 1st glass & is reflected; & therefore it is drawn back by the power of the first glass there being nothing else to cause it to turn back. < text from f 257r resumes > Nothing more is requisite for producing all the variety of colours & degrees of refrangibility then that the rays of light be bodies of different sizes, the least of which may make violet the weakest & darkest of colours & be more easily diverted by refracting surfaces from the right course, & the rest as they are bigger & bigger may make the stronger & more lucid colours blue green yellow & red, & be more & more difficultly diverted. Nothing more is requisite for putting the rays of light into fits of easy reflexion & easy transmission then that they be small bodies which by their attractive powers or some other force stir up vibrations in what they act upon, which vibrations being swifter then the rays, overtake them successively & agitate them so as by turns to increase & decrease their velocity & thereby putt them into those fits. And lastly the unusual refraction of Island Crystal looks very much as if it were performed by some kind of attractive vertue lodged in certain sides both of the rays & of the particles of the crystal. For were it not for some kind of disposition or vertue lodged in some sides of the particles of the crystal & not in their other sides, & which inclines & bends the rays towards the coast of unusual refraction; the rays which fall perpendicularly on the crystall would not be refracted towards that coast rather then towards any other coast both at their incidence & at their emergence, so as to emerge perpendicularly by a contrary situation of the coast of unusual refraction at the second surface; the crystal acting upon the rays after they have past through it & are emerging into the air, or, if you please, into a vacuum. And <258r> since

the crystal by this disposition or vertue does not act upon the rays unless when one of their sides of unusual refraction looks towards that coast, this argues a vertue or disposition in those sides of the rays which answers to & sympathizes with that vertue or disposition of the crystal, almost as the poles of two Magnets answer to one another. And as magnetism may be intended & remitted, & is found only in the Magnet & in iron: so this vertue of refracting the perpendicular rays is greater in Island Crystal less in Crystal of the rock & is not yet found in other bodies. I do not say that this vertue is magnetical: It seems to be of another kind. I only say that what ever it be, its difficult to conceive how the rays of light unless they be bodies can have a permanent vertue in two of their sides which is not in their other sides & this without any regard to their position to the space or medium through which they pass.

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Qu. 22. Are not gross bodies & light convertible into one another: & may not bodies receive their activity from the particles of light which enter their composition? For all fixt bodies being heated emit light so long as they continue sufficiently hot, & light mutualy stops in bodies as often as its rays strike upon their parts, as we shewed above. I know no body less apt to shine then water, & yet water by frequent destillations changes into fixed earth as M^{r} Boyle has tried & then this earth being enabled to endure a sufficient heat shines by heat like other bodies. The changing of bodies into light & light into bodies is very conformable to the course of nature, which seems delighted with transmutations Water, which is a very fluid volatile tastless salt, she changes by heat into vapour which is a sort of air, & by cold into ice which is a hard pellucid brittle fusible stone: & this stone returns into water by heat & vapour returns into water by cold. Earth by heat becomes fire & by cold returns into Earth. Dense bodies by fermentation rarefy into several sorts of air & this air by fermentation & sometimes without it returns into dense bodies. Mercury appears sometimes in the form of a fluid metal, sometimes in the form of a hard brittle metal, sometimes in the form of a corrosive pellucid salt called sublimate, sometimes in the form of a tastless pellucid volatile white earth called Mercurius dulcis, or in that of a red opake volatile earth called Cinnaber, or in that of a red or white precipitate, or in that of a fluid salt, & In destillation it turns into vapour. & Being agitated in vacuo it shines like fire. And after all these changes it returns again into Mercury. Eggs grow from insensible magnitudes & change into animals, Tad-poles into Frogs & worms into Flyes. All Birds Beasts & Fishes Insects Trees & other Vegetables with their several parts, grow out of water & watry tinctures & salts, & by putrefaction return again into watry substances. And water standing a few days in the open air yeilds a tincture which (like that of Mault) by standing longer yeilds a sediment & a spirit, but before putrefaction is fit nourishment for animals & vegetables. And among such various & strange transmutations why may not Nature change bodies into light & light into bodies?

Now in bodies of the same kind & vertue attraction is strongest in the smallest bodies in proportion to their bulk. It is found stronger in small magnets for their weight then in great ones. For the parts of small ones being closer together unite their forces more easily. And therefore since the rays of light are the smallest bodies known to us we may expect to find their attractions very strong. And how strong they are may be gathered by this Rule. The attraction of a ray of light in proportion to the quantity of its matter is to the gravity of a projectile in proportion to the quantity of its matter in a compound ratio of the velocity of the ray of light to the velocity of the projectile twice & of the bent or curvity of the ray in the place of refraction to the bent or curvity of the line described by the projectile supposing the inclination of the ray to the refracting surface & that of the projectile to the horizon to be alike. And by this proportion I reccon the attraction of the rays of light to be above <260r> ten hundred thousand thousand millions of times greater then the weight of bodies on the surface of this earth in proportion to the matter in them, supposing that light comes from the sun to us in about seven or eight minutes of an hour. And in immediate contact of the rays their force may be still much greater. And so great a force in the rays cannot but have a very great effect upon the particles of matter with which they are compounded for causing the particles to attract one another & for putting them in motion amongst themselves: for the better understanding of which I will propose the following Quæstion.

<261r>

Qu. 17. If a stone be thrown into stagnating water, the waves excited thereby continue some time to arise in the place where the stone fell into the water, & are propagated from thence in concentric circles upon the surface of the water to great distances. And the vibrations or tremors excited in the Air by percussion continue a little time to move from the place of percussion in concentric spheres to great distances. And in

like manner when a ray of light falls upon the surface of any pellucid body & is there refracted or reflected: may not vibrations be thereby excited in the refracting or reflecting Medium at the point of incidence, & continue to arise there & to be propagated from thence as long as when they are excited in the bottom of the eye by the pressure & motion of the finger, or by the light which comes from the coale of fire in the experiments above mentioned? And are not these vibrations propagated from the point of incidence to great distances? And do they not overtake the rays of light, & by overtaking them successively, do they not put them into the fits of easy reflexion & easy transmission described above? For if the rays endeavour to recede from the densest part of the vibration they may be alternately accelerated & retarded by the vibrations overtaking them.

Qu. 18. If in two large & tall cylindrical vessels of glass inverted, two little Thermometers be suspended so as not to touch the vessels; & the air be drawn out of one of these vessels, & these vessels thus prepared be carried out of a cold place into a warm one: the Thermometer in vacuo will grow warm as much & almost as soon as the Thermometer which is not in vacuo. And when the Vessels are carried back into the cold place, the Thermometer in vacuo will grow cold almost as soon as the other Thermometer. Is not the heat of the warm room conveyed through the Vacuum by the vibrations of a much subtiler Medium then Air, which, after the Air was drawn out, remained in the Vacuum? And is not this Medium the same with that Medium by which light is refracted & reflected, & by whose vibrations light communicates heat to bodies & is put into fits of easy reflexion & easy transmission? ⊙ < insertion from the top of f 261v > ⊙ And Do not the vibrations of this Medium in hot bodies, contribute to the duration of their heat? And do not hot bodies communicate their heat to contiguous cold ones by the vibrations of this Medium propagated from them into the cold ones? And is not this Medium exceedingly more rare & subtile then the Air & exceedingly more elastic & active? < text from f 261r resumes > And doth not this Medium readily pervade all bodies? And is it not by its elastic force expanded through all the heavens?

Q. 19. Doth not the refraction of light proceed from the different density of this æthereal Medium in different places, the light receding from the denser parts of the Medium? And is not the density thereof greater in free & open spaces void of Air & other grosser bodies, then within the pores of water glass crystal gemms & other compact bodies? For when light passes through glass or crystall & falling very obliquely upon the further surface thereof is totally reflected , the total reflexion ought to proceed rather from the density & vigour of the Medium without & beyond the glass, then from the rarity & weakness thereof.

Qu. 20. Doth not this Æthereal Medium in passing out of water glass crystal & other compact & dense bodies into empty spaces grow denser & denser by degrees, & by that means refract the rays of light not in a point but by bending them gradually in curve lines? And doth not the gradual condensation of this Medium extend to some distance from the bodies, & thereby cause the inflexions of the rays of light which pass by the edges of compact bodies at some distance from the bodies?

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Qu. 21. Is not this Medium much rarer within the dense bodies of the Sun, Starrs, Planets & Comets, then in the celestial spaces, between them, & in passing from them to great distances doth it not grow denser & denser perpetually & thereby cause the gravity of those great bodies towards one another, & their parts towards the bodies; every body endeavouring to go from the denser parts of the Medium towards the rarer? For if this Medium be rarer within the Sun's body then at its surface, & rarer there then at the distance of the hundredth part of any inch from its body, & rarer there than at the tenth part of an inch from its body, & rarer there then at the orb of Saturn: I see no reason why the increase of density should stop any where & not rather be continued through all distances from the Sun to Saturn, & beyond. And tho this increase of density may at great distances be exceeding slow yet if the elastick force of this Medium be exceeding great, it may suffice to impell bodies from the denser parts of the Medium towards the rarer with all that power which we call gravity. And that the elastick force of this Medium is exceeding great, may be gathered from the swiftness of its vibrations. Sounds move about 1140 English feet in a second minute of time, & in seven or eight minutes of time they move about one hundred English miles. Light moves from the Sun to us in about seven or eight minutes of time, which distance is about 70000000 English miles, supposing the horizontal Parallax of the Sun to be about 12″. And the vibrations or pulses of this Medium, that they may cause the alternate fits of easy transmission & easy reflexion, must be swifter then light, & by consequence above 700000 times swifter than sounds. And therefore the elastick force of this Medium in proportion to its density must be above

700000 x 700000 times greater then the elastic force of the Air is in proportion to its density. For in elastic Mediums of equal density, the elasticity must be in a duplicate ratio of the velocity of the pulses. And if the density be increased or diminished & the elasticity be increased or diminished in the same proportion, the velocity will remain the same < insertion from the middle of f 261v > & if the elasticity & density be encreased or decreased in one & the same proportion the velocity will remain the same. < text from f 262r resumes >

< insertion from f 261v > Qu. 22. May not Planets & Comets & all other gross bodies perform their motions more freely & with much less resistance in this Æthereal Medium then in a fluid which fills all space adequately without leaving any pores, & by consequence is much denser then quicksilver or gold? And may not its resistance be so small as to be inconsiderable? For instance: If this Æther (for so I will call it) should be supposed 700000 times more elastick then Air & above 700000 times more rare; its resistance would be above 600000000 times less then that of water. And so small a resistance would scarce make any sensible alteration in the motions of the Planets in ten thousand years. If any one would ask how a Medium can be so rare, let him tell me first how the Air in the upper parts of the Atmosphere can be above ten hundred thousand times rarer then gold. < text from f 262r resumes >

Qu. 23. Is not vision performed by the vibrations of this Medium excited in the bottom of the eye by the rays of light & propagated through the solid pellucid & uniform capillamenta of the optic nerves into the place of sensation? And is not hearing performed by the vibrations either of this or some other Medium excited in the auditory nerves by the tremors of the Air & propagated through the solid pellucid & uniform capillamenta of those nerves into the place of sensation? And so of the other senses. < insertion from f 261v > < text from f 262r resumes >

Qu. 24. Is not animal motion performed by the vibrations of this Medium excited in the brain by the power of the will, & propagated from thence through the solid pellucid & uniform capillamenta of the nerves into the muscles for contracting & dilating them? I suppose the single capillamenta of the nerves to be solid & uniform that the motion may be propagated along them uniformly & without interruption. For obstructions in the Nerves create Palsies. And that they may be uniform, I suppose them when viewed singly to be pellucid, tho the reflexions in their surfaces may make the whole nerve (composed of a great number of capillamenta) appear opake & while. For if the capillamenta be not pellucid the reflexions of light from their inward parts, will argue that those parts are not continued but have reflecting surfaces by which they are interrupted & distinguished from one another.

The force of resistance arises only from the density of the Medium & is proportionall to the □ of the velocity of the moving body & will not put a resting body into motion. the force of gravity is here deduced from the elasticity of the medium, & from the variation of it density without any regard to the velocity of the body & may put a resting body into motion. And while these two forces depend upon different causes, the one may be very small & the other very great.

Resistance & Gravity are here ascribed to different causes; [resistance to the density of the Medium & velocity of the body, gravity to the variation of elasticity] the one to the variation of elasticity, the other to the

And if any / And yet the elasticity for causing gravity may be exceeding great.

& by consequence exceedingly less able to resist the motions of projectiles & exceedingly more able to press upon gross bodies by endeavouring to expand it self.

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Qu. 17. If a stone be thrown into stagnating water, the waves excited there by continue some time to arise in the place where the stone fell into the water, & are propagated from thence in concentric circles upon the surface of the water to great distances. And the vibrations or tremors excited in the Air by percussion continue a little time to move from the place of percussion in concentric spheres to great distances. And in like manner, when a Ray of light falls upon the surface of any pellucid body & is there refracted or reflected may not waves of vibrations or tremors be thereby excited in the refracting or reflecting Medium at the point of incidence & continue to arise there & to be propagated from thence as long as they continue when they are excited in the bottom of the eye by the pressure or motion of the finger or by the light which comes from the

coale of fire in the experiments above mentioned? And are not these vibrations propagated from the point of incidence to great distances? And do they not overtake the rays of light, & by overtaking them successively do they not put them into the fits of easy reflexion & easy transmission described above? For if the rays endeavour to recede from the densest part of the vibration, they may be alternately accelerated & retarded by the vibrations overtaking them.

Qu. 18. If in two large tall cylindricall vessels of glass inverted, two little Thermometers be suspended so as not to touch the vessels, & the Aer be drawn out of one of these vessels, & these vessels thus prepared be carried out of a cold place into a warm one: the Thermometer in vacuo will grow warm as much & almost as soon as the Thermometer which is not in vacuo. And when the Vessels are carried back into the cold place, the Thermometer in vacuo will grow cold almost as soon as the other Thermometer. Is not the heat of the warm room conveyed through the Vacuum by the vibrations of a much subtiler Medium then Air, which after the Air was drawn out remained in the Vacuum? And is not this Medium the same with that Medium by which light is refracted & reflected, & by whose vibrations light communicates heat to bodies, & is put into fits of easy reflexion & easy transmission? And do not the vibrations of this Medium in hot bodies contribute to the intenseness & duration of their heat? And do not hot bodies communicate their heat to contiguous cold ones by the vibrations of this Medium propagated from them into the cold ones? And is not this Medium exceedingly more rare & subtile then the Air & exceedingly more elastick & active? And doth it not readily pervade all bodies? And is it not (by its elastic force) expanded through all the heavens?

Qu. 19. Doth not the refraction of light proceed from the different density of this æthereal Medium in different places, the light receding always from the denser parts of the Medium? And is not the density thereof greater in free & open spaces void of Air & other grosser bodies then within the pores of water glass crystal gemms & other compact bodies? For when light passes through glass or crystal & falling very obliquely upon the further surface thereof is totally reflected, the total reflexion ought to proceed rather from the density & vigour of the Medium without & beyond the glass, than from the rarity & weakness thereof.

Qu. 20. Doth not this æthereal Medium in passing out of water glass crystal & other compact & dense bodies into empty spaces grow denser <264r> & denser by degrees, & by that means refract the rays of light not in a point but by bending them gradually in curve lines? And doth not the gradual condensation of this Medium extend to some distance from the bodies & thereby cause the inflexions of the rays of light which pass by the edges of dense bodies at some distance from the bodies?

Qu. 21. Is not this Medium much rarer within the dense bodies of the Sun Stars Planets & Comets then in the empty celestial spaces between them, & in passing from them to great distances doth it not grow denser & denser perpetually & thereby cause the gravity of those great bodies towards one another, & of their parts towards the bodies; every body endeavouring to go from the denser parts of the Medium towards the rarer? For if this Medium be rarer within the Sun's body then at its surface, & rarer there then at the hundredth part of an inch from its body, & rarer there then at the fiftith part of an inch from its body, & rarer there then at the Orb of Saturn: I see no reason why the increase of density should stop anywhere & not rather be continued through all distances from the Sun to Saturn & beyond. And tho this increase of density may at great distances be exceeding slow, yet if the elastick force of this Medium be exceeding great, it may suffice to impell bodies from the denser parts of the Medium towards the rarer with all that power which we call gravity. And that the elastick force of this Medium is exceeding great may be gathered from the swiftness of its vibrations. Sounds move about 1140 English feet in a second minute of time, & in seven or eight minutes of time they move about one hundred English miles. Light moves from the sun to us in about seven or eight minutes of time, which distance is about 70000000 English miles, supposing the horizontal Parallax of the Sun to be about 12″. And the vibrations or pulses of this Medium, that they may cause the alternate fits of easy transmission & easy reflexion, must be swifter then light, & by consequence above 700000 times swifter then sounds. And therefore the elastick force of this Medium in proportion to its density must be above 700000 x 700000 times greater then the elastick force of the Air is in proportion to its density. For

‡ < insertion from f 263v > ‡ For the velocities of the pulses of elastic Mediums are in a subduplicate ratio of the elasticities & the rarities of the Mediums taken together.

As attraction is stronger in small magnets then in great ones in proportion to their bulk, & gravity is greater in the surfaces of small planets then in those of great ones in proportion ot their bulk, & small bodies are

agitated much more by electric attraction then great ones: so the smallness of the rays of light may contribute very much to the power of the agent by which they are refracted. And so if any one should suppose that Ether (like our air) may contein particles which endeavour to recede from one another (for I do not know what this Æther is) & that its particles are exceedingly smaller then those of air, or even then those of light: the exceeding smallness of its particles may contribute to the greatness of the force by which those particles may recede from one another, & thereby make that Medium exceedingly more rare & elastic then Air, & by consequence exceedingly less able to resist the motions of projectiles & [exceedingly more able to press upon gross bodies by endeavouring to expand it self. < text from f 264r resumes >

Qu. 22. May not Planets & Comets & all gross bodies perform their motions more freely & with much less resistance in this æthereal Medium then in any fluid which fills all space adequately without leaving any pores, & by consequence is much denser then quicksilver or gold? And may not its resistance be so small as to be inconsiderable? For instance. If this Æther (for so I will call it) should be supposed 700000 times more elastic then our Air & above 700000 times more rare; its resistance would be above 600000000 times less then that of water. And so small a resistance would scarce make any sensible alteration in the motions of the Planets in ten thousand years. If any one would ask how a Medium can be so rare; let him tell me how the Air in the upper parts of the Atmosphere can be above an hundred thousand thousand times rarer then Gold.

Qu. 23. Is not vision performed by the vibrations of this Medium excited in the bottom of the eye by the rays of light, & propagated through the solid pellucid & uniform capillamenta of the optick nerves into the place of sensation? And is not hearing performed by the vibrations either of this or some other Medium excited in the auditory nerves by the tremors of the Air, & propagated through the solid pellucid & uniform capilla <265r> menta of those nerves into the place of sensation? And so of the other senses.

Qu. 24. Is not animal motion performed by the vibrations of this Medium excited in the brain by the power of the will, & propagated from thence through the solid pellucid & uniform capillamenta of the nerves into the muscles for contracting & dilating them? I suppose that the vibrating motion of the ethereal Medium may be propagated along them from one end to the other uniformly & without interruption For obstructions in the Nerves create palsies. And that they may be sufficiently uniform I suppose them to be pellucid when viewed singly, tho the reflexions in their cylindrical surfaces may make the whole nerve (composed of many capillamenta) appear opake & white. For opacity arises from reflecting surfaces, such as may disturbe & interrupt the motions.

Qu. 25. Are there not other original properties of the rays of light besides those already described? An instance of another original property we have in the refraction of Island Crystal described first by Erasmus Bartholine & afterwards more exactly by Hugenius in his Book De la lumiere. This crystal is a pellucid fissile stone clear as water or crystal of the rock, & without colour; enduring a red heat without loosing it's transparency, & in a very strong heat calcining without fusion. Steeped a day or two in water it looses its natural polish. Being rubbed on cloth it attracts pieces of straws & other light things like Ambar or Glass: & with Aqua fortis it makes an ebullition. It seems to be a sort of Talk & is found in form of an oblique Parallelopiped [with six parallelogram sides & eight solid angles. The obtuse angles of the Parallelogramms are each of them 101 degrees & 52 minutes; the acute ones 78 degrees & 8 minutes. Two of the solid angles opposite to one another, as C & E, are compassed each of them with three of these obtuse angles, & each of the other six with one obtuse & two acute ones. It cleaves easily in planes parallel to any of its sides, & not in any other planes. It cleaves with a glossy polite surface not perfectly plane but with some little uneavenness. It is easily scratcht, & by reason of it's softness it takes a polish very difficultly. It polishes better upon polished looking-glass then upon metal, & perhaps better upon pitch leather or parchment. Afterwards it must be rubbed with a little oyle or white of an egg to fill up its scratches: whereby it will become very transparent & polite. But for several experiments, it is not necessary to polish it. If a piece of this crystalline stone be laid upon a book, every letter of the Book seen through it will appear double by means of a double refraction. And if any beam of light falls either perpendicularly or in any oblique angle upon any surface of this crystal, it becomes divided into two beams by means of the same double refraction. Which beams are of the same colour with the incident beam of light, & seem equal to one another in the quantity of their light, or very nearly equal. One of these refractions is performed by the usual Rule of Opticks, the sine of Incidence out of Air into this Crystal being to the sine of Refraction, as five to three. The other Refraction, which may be called the unusual Refraction, is performed by the following Rule.

Let ADBC represent the refracting surface of the crystall, C the biggest solid angle at that surface, GCHF the opposite surface, & CK a perpendicular on that surface. This perpendicular makes with the edge of the crystal CF an angle of $19^{degr.}$ 3′. Ioyne KF & in it take KL so that the angle KCL be $6^{degr.}$ 40′, & the angle LCF $12^{degr.}$ 28′. And if ST represent any beam of light incident at T in any angle upon the refracting surface ADBC, let TV be the refracted <266r> beam determined by the given proportion of the sines 5 to 3 according to the usual rule of Opticks. Draw VX parallel & equal to KL. Draw it the same way from V in which L lieth from K; & joyning TX, this line TX shall be the other refracted beam carried from T to X by the unusual refraction.

If therefore the incident beam ST be perpendicular to the refracting surface, the two beams TV & TX into which it shall become divided, shall be parallel to the lines CK & CL; one of those beams going through the crystall perpendicularly as it ought to do by the usual laws of Opticks, & the other TX by an unusual refraction diverging from the perpendicular & making with it an angle VTX of about $6\frac{2}{3}$ degrees, as is found by experience. And hence the plane VTX & such like planes which are parallel to the plane CFK, may be called the planes of perpendicular refraction. And the coast towards which the lines KL & VX are drawn, may be called the coast of unusual refraction.

In like manner Crystal of the rock has a double refraction: but the difference of the two refractions is not so great & manifest as in Island crystall.

When the beam ST incident on Island Crystal, is divided into two beams TV & TX, & these two beams arrive at the further surface of the glass; the beam TV which was refracted at the first surface after the usual manner, shall be again refracted entirely after the usual manner at the second surface; & the beam TX which was refracted after the unusual manner in the first surface shall be again refracted entirely after the unusual manner in the second surface: so that both these beams shall emerge out of the second surface in lines parallel to the first incident beam ST.

And if two pieces of Island Crystall be placed one after another in such manner that all the surfaces of the latter be parallel to all the corresponding surfaces of the former: the rays which are refracted after the usual manner in the first surface of the first crystall shall be refracted after the usual manner in all the following surfaces: & the rays which are refracted after the unusual manner in the first surface shall be refracted after the unusual manner in all the following surfaces. And the same thing happens tho the surfaces of the crystalls be any ways inclined to one another, provided that their planes of perpendicular refraction be parallel to one another.

And therefore there is an original difference in the rays of light by means of which some rays are in this Experiment constantly refracted after the usual manner, & others constantly after the unusual manner For if the difference be not original but arises from new modifications imprest on the rays at their first refraction it would be altered by new modifications in the three following refractions: whereas it suffers no alteration but is constant & has the same effect upon the rays in all the refractions. The unusual refraction is therefore performed by an original property of the rays. And it remains to be enquired whether the rays have not more original properties then are yet discovered.

Qu. 26. Have not the rays of light several sides endued with several original properties? For if the planes of perpendicular refraction of the second crystall, be at right angles with the planes of perpendicular refraction of the first crystall: the rays which are refracted after the usual manner in passing through the first crystall will be all of them refracted after the unusual manner in passing through the second crystall; & the rays which are refracted after the unusual manner in passing through the first crystall will be all of them refracted after the usual manner in passing through the second crystall. And therefore there are not two sorts of rays differing in their nature from one another, one of which is constantly & in all positions refracted after the usual manner, & the other constantly & in all positions after the unusual <267r> manner. The difference between the two sorts of rays in the Experiment mentioned in the 25^{th} Question, was only in the positions of the sides of the rays to the planes of perpendicular refraction. For one & the same ray is here refracted sometimes after the usual & sometimes after the unusual manner according to the position which its sides have to the crystalls. If the sides of the rays are posited the same way to both crystalls, it is refracted after the same manner in them both: but if that side of the ray which looks towards the coast of the unusual refraction

of the first crystall be 90 degrees from that side of the same ray which looks towards the coast of the unusual refraction of the second crystall, (which may be effected by varying the position of the second crystall to the first, & by consequence to the rays of light the ray shall be refracted after several manners in the several crystalls. There is nothing more required to determin whether the rays of light which fall upon the second crystall shall be refracted after the usual or after the unusual manner, but to turn about this crystal so that the coast of this crystalls unusuall refraction may be on this or on that side of the ray. And therefore every ray may be considered as having four sides or quarters, two of which opposite to one another incline the ray to be refracted after the unusual manner as often as either of them are turned towards the coast of unusual refraction, & the other two whenever either of them are turned towards the coast of unusual refraction, do not incline it to be otherwise refracted then after the usual manner. The two first may therefore be called the sides of unusual refraction. And since these dispositions were in the rays before their incidence on the second third & fourth surfaces of the two crystalls, & suffered no alteration (so far as appears) by the refraction of the rays in their passage through those surfaces, & the rays were refracted by the same laws in all the four surfaces; it appears that those dispositions were in the rays originally, & suffered no alteration by the first refraction, & that by means of those dispositions the rays were refracted at their incidence on the first surface of the first crystal, some of them after the usual & some of them after the unusual manner, accordingly as their sides of unusual refraction were then turned towards the coast of the unusual refraction of that crystal or sideways from it.

Every ray of light has therefore two opposite sides originally endued with a property on which the unusual refraction depends, & other two opposite sides not endued with that property. And it remains to be enquired whether there are not more properties of light by which the sides of the rays differ & are distinguished from one another.

In explaining the difference of the sides of the rays above mentioned, I have supposed that the rays fall perpendicularly on the first crystall. But if they fall obliquely on it, the success is the same. Those rays which are refracted after the usual manner in the first crystall will be refracted after the unusual manner in the second crystall; supposing the planes of perpendicular refraction to be at right angles with one another as above: & on the contrary.

If the planes of the perpendicular refraction of the two crystalls be neither parallel nor perpendicular to one another but contein an acute angle: the two beams of light which emerge out of the first crystall, will be each of them divided into two more at their incidence on the second crystall. For in this case the rays in each of the two beams will some of them have their sides of unusual refraction & some of them their other sides turned towards the coast of the unusual refraction of the second crystall.

Qu. 27. Are not all Hypotheses erroneous which have hitherto been invented for explaining the phenomena of light by new modi <268r> fications of the rays? For those phenomena depend not upon new modifications as has been supposed, but upon the original & unchangeable properties of the rays.

Qu. 28. Are not all Hypotheses erroneous in which light is supposed to consist in pression or motion propagated through a fluid Medium? For in all these Hypotheses the phænomena of light have been hitherto explained by supposing that they arise from new modifications of the rays: which is an erroneous supposition.

If light consisted only in pression propagated without actual motion it would not be able to agitate & heat the bodies which refract & reflect it. If it consisted in motion propagated to all distances in an instant it would require an infinite force every moment in every [shining particle to generate that motion. And if it consisted in pression or motion propagated either in an instant or in time it would bend into the shadow. For pression or motion cannot be propagated in a fluid in right lines beyond an obstacle which stops part of the motion, but will bend & spread every way into the quiescent Medium which lyes beyond the obstacle. Gravity tends downwards, but the pressure of water arising from Gravity tends every way with equal force & is propagated as readily & with as much force sideways as downwards & through crooked passages as through streight ones. The waves on the surface of stagnating water, passing by the sides of a broad obstacle which stops part of them, bend afterwards & dilate themselves gradually into the quiet water behind the obstacle. The waves, pulses or vibrations of the Aer wherein sounds consist, bend manifestly tho not so much as the waves of water. For a Bell or a Canon may be heard beyond a hill which intercepts the sight of the sounding body, &

sounds are propagated as readily through crooked pipes as through streight ones. But light is never known to follow crooked passages nor to bend into the shadow. For the fixt stars by the interposition of any of the Planets cease to be seen. And so do the parts of the Sun by the interposition of the Moon, Mercury or Venus. The rays which pass very neare to the edges of any body are bent a little by the action of the body, as we shewed above, but this bending is not towards but from the shadow, & is performed only in the passage of the ray by the body & at a very small distance from it. So soon as the ray is past the body, it goes right on.

To explain the unusual refraction of Island Crystal by pression or motion propagated has not hitherto been attempted (to my knowledge) except by Huygens who for that end supposed two several vibrating Mediums within that Crystall. But when he tryed the refractions in two successive pieces of that crystall, & found them such as is mentioned above: he confessed himself at a loss for explaining them. For pressions or motions propagated from a shining body through an uniform Medium must be on all sides alike: whereas by those experiments it appears that the rays of light have different properties in their different sides. He suspected that the pulses of Æther in passing through the first crystall might receive certain new modifications which might determin them to be propagated in this or that Medium within the second crystal according to the position of that crystall. [1] But what modifications those might be he could not say, nor think of any thing satisfactory in that point. And if he had known that the unusual refraction depends not on new modifications but on the original & unchangeable dispositions of the rays, he would have found it as difficult to explain how those dispositions which he supposed to be imprest on the rays by the first crystall, could be in them before their incidence on that crystall; & in general, how all rays emitted by shining bodies, can have those dispositions in them from the beginning. To me at least this seems inexplicable if light be nothing else then pression or motion propagated through Æther.

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And it is as difficult to explain by these Hypotheses how rays can be alternately in fits of easy reflexion & easy transmission; unless perhaps one might suppose that there are in all space two ethereal vibrating Mediums, & that the vibrations of one of them constitute light, & the vibrations of the other are swifter, & as often as they overtake the vibrations of the first, put them into those fits. But how two æthers can be diffused through all space, one of which acts upon the other & by consequence is reacted upon, without retarding shattering dispersing & confounding one anothers motions is inconceivable. And against filling the heavens with fluid Mediums unless they be exceeding rare, a great objection arises from the regular & very lasting motions of the Planets & Comets in all manner of courses through the heavens. For thence it is manifest that the heavens are voyd of all sensible resistance & by consequence of all sensible matter.

For the resisting power of fluid Mediums arises partly from the attrition of the parts of the Medium & partly from the vis inertiæ of the matter. That part of the resistance of a spherical body which arises from the attrition of the parts of the Medium is very nearely as the diameter, or, at the most, as the factum of the diameter & the velocity of the spherical body together. And that part of the resistance which arises from the vis inertiæ of the matter is as the square of that factum. And by this difference the two sorts of resistance may be distinguished from one another in any Medium; & these being distinguished, it will be found that almost all the resistance of bodies of a competent magnitude moving in Aer, Water, Quicksilver, & such like fluids with a competent velocity, arises from the Vis Inertiæ of the parts of the fluid

Now that part of the resisting power of any Medium which arises from the tenacity friction or attrition of the parts of the Medium may be diminished by dividing the matter into smaller parts & making the parts more smooth & slipery: but that part of the resistance which arises from the vis inertiæ, is proportional to the density of the matter & cannot be diminished by dividing the matter into smaller parts nor by any other means then by decreasing the density of the Medium. And for these reasons the density of fluid Mediums is very nearely proportional to their resistance. Liquors which differ not much in density as water, spirit of wine, spirit of Turpentine, hot oyle, differ not much in resistance. Water is thirteen or fourteen times lighter then Quicksilver, & by consequence thirteen or fourteen times rarer, & its resistance is less then that of quicksilver in the same proportion or thereabouts, as I have found by experiments made with Pendulums. The open Air in which we breath is eight or nine hundred times lighter then water & by consequence eight or nine hundred times rarer, & accordingly its resistance is less then that of water in the same proportion or thereabouts; as I have also found by experiments made with Pendulums. And in thinner Air the resistance is sitll less, & at length, by rarefying the Air, becomes insensible. For small feathers falling in the open Air meet with great

resistance, but in a tall glass well emptied of Air they fall as fast as lead or gold, as I have seen tried several times. Whence the resistance seems still to decrease in proportion to the density of the fluid. For I do not find by any experiments that bodies moving in Quicksilver, Water or Air, meet with any other sensible resistance then what arises from the density & tenacity of those sensible fluids, as they would do if the pores of those fluids & all other spaces were filled with a dense & subtile fluid. Now if the resistance in a vessel well emptied of Air, was but an hundred times less then in the open Air, it would be about a million of times less then in quicksilver. But it seems to be much less in such a vessel, & still much less in the heavens at the height of three or four hundred miles from the earth or above. For M^{r} Boyle has shewed that Air may be rarefied above ten thousand times in vessels of glass: & the heavens are much <270r> emptier of Air then any vacuum we can make below. For since the Air is comprest by the weight of the incumbent atmosphere, & the density of Air is proportional to the force compressing it, it follows by computation that at the height of about seven English miles from the Earth the aer is four times rarer then at the surface of the Earth, & at the height of 14 miles it is sixteen times rarer then at the surface of the earth, & at the height of 21, 28, or 35 miles it is respectively 64, 256 or 1024 times rarer or thereabouts; & at the height of 70, 140 or 210 miles it is about 1000000, 1000000000000 or 1000000000000000000 times rarer; & so on.

Heat promotes fluidity very much by diminishing the tenacity of bodies. It makes many bodies fluid which are not fluid in cold, & increases the fluidity of tenacious liquids as of Oyle Balsam & Honey, & thereby decreases their resistance. But it decreases not the resistance of water considerably as it would do if any considerable part of the resistance of water arose from the attrition or tenacity of its parts. And therefore the resistance of water arises principally & almost entirely from the Vis inertiæ of its matter; & by consequence, if the heavens were as dense as water they would not have much less resistance then water; if as dense as quicksilver they would not have much less resistance then quicksilver; if absolutely dense or full of matter without any vacuum, let the matter be never so subtile & fluid, they would have a greater resistance then quicksilver. A solid globe in such a Medium would lose above half its motion in moving three times the length of its diameter, & a globe not solid (such as are the Planets) would be retarded sooner. And therefore to make way for the regular & lasting motions of the Planets & Comets, its necessary to empty the heavens of all matter, except perhaps some very thin vapors steams or effluvia arising from the Atmospheres of the Earth, Planets & Comets, & such an exceedingly rare æthereal Medium as we described above. A dense fluid can be of no use for explaining the Phænomena of nature, the motions of the Planets & Comets being better explained without it. It serves only to disturb & retard the motions of those great bodies & make the frame of nature languish: & in the pores of bodies, it serves only stop the vibrating motions of their parts wherein their heat & activity consists. And as it is of no use & hinders the operations of nature & makes her languish, so there is no evidence for its existence, & therefore it ought to be rejected. And if it be rejected, the Hypotheses that light consists in pression or motion propagated through such a Medium, are rejected with it.

And for rejecting such a Medium we have the authority of those the oldest & most celebrated Philosophers of Greece & Phenicia who made a Vacuum & Atoms & the gravity of Atoms the first Principles of their Philosophy; tacitely attributing gravity to some other cause then dense matter. Later Philosophers banish the consideration of such a cause out of Natural Philosophy, feigning Hypotheses for explaining all things mechanically & referring other causes to Metaphysicks: whereas the main business of natural Philosophy is to argue from Phænomena without feigning Hypotheses, & to deduce causes from effects till we come to the very first cause, which certainly is not mechanical; & not only to unfold the mechanism of the world but chiefly to resolve these & such like questions. What is there in places almost empty of matter, & whence is it that the Sun & Planets gravitate towards one another without dense matter between them? Whence is it that Nature doth nothing in vain, & whence arises all that order & beauty which we see in the world? To what end are Comets, & whence is it that Planets move all one & the same way in Orbs concentric, while Comets move all manner of ways in Orbs very excentric, & what hinders the fixt stars from falling upon one another? How came the bodies of animals to be contrived with so much art, & for what ends were there several parts? Was the eye contrived without skill in Opticks, & the ear without knowledge of sounds? How do the motions of the body follow from the will, & <271r> whence is the instinct in animals? Is not the sensory of animals that place to which the sensitive substance is present, & into which the sensible species of things are carried through the nerves & brain that there they may be perceived by their immediate presence to that substance? And these things being rightly dispatcht, does it not appear from phænomena that there is a Being incorporeal, living, intelligent, omnipresent, who in infinite space, as it were in his sensory, sees the things themselves intimately, & throughly perceives them & comprehends them wholy by their immediate presence to himself: of which things the images only carried through the organs of sense into our little sensoriums, are

there seen & beheld by that which in us perceives & thinks. And tho every true step made in this Philosophy brings us not immediately to the knowledge of the first cause, yet it brings us nearer to it, & on that account is to be highly valued.

Qu. 29. Are not the rays of light very small bodies emitted from shining substances? For such bodies will pass through uniform mediums in right lines without bending into the shadow, which is the nature of the rays of light. They will also be capable of several properties & be able to conserve their properties unchanged in passing through several Mediums, which is another condition of the rays of light. Pellucid substances act upon the rays of light at a distance in refracting reflecting & inflecting them, & the rays mutually agitate the parts of those substance at a distance for heating them; & this action & reaction at a distance very much resembles an attractive force between bodies. if refraction be performed by attraction of the rays, the sines of incidence must be to the sines of refraction in a given proportion, as we shewed in our Principles of Philosophy; & this Rule is true by experience. The rays of light in going out of glass into a Vacuum, are bent towards the glass, & if they fall too obliquely on the vacuum they are bent backwards into the glass & totaly reflected; & this reflexion cannot be ascribed to the resistance of an absolute Vacuum, but must be caused by the power of the glass attracting the rays at their going out of it into the Vacuum & bringing them back. For if the further surface of the glass be moistened with water or clear oyle or liquid & clear honey: the rays which would otherwise be reflected will go into the water oyle or honey, & therefore are not reflected before they arrive at the further surface of the glass & begin to go out of it. If they go out of it into the water oyle or honey, they go on, because the attraction of the glass is almost ballanced & rendred ineffectual by the contrary attraction of the liquor. But if they go out of it into a Vacuum which has no attraction to ballance that of the glass, the attraction of the glass either bends & refracts them, or brings them back & reflects them. And this is still more evident by laying together two Prisms of glass, or two Object-glasses of very long Telescopes, the one plane the other a little convex, & so compressing them that they do not fully touch nor are too far asunder. For the light which falls upon the further surface of the first glass where the interval between the glasses is not above the ten [hundred thousandth part of an inch, will go through that surface, & through the air or vacuum between the glasses, & enter into the second glass, as was explained in the first fourth & eighth Observations of the first Part of the second Book. But if the second glass be taken away, the light which goes out of the second surface of the first glass into the Air or Vacuum, will not go on forwards but turns back into the first glass & is reflected; & therefore it is drawn back by the power of the first glass, there being nothing else to turn it back. Nothing more is requisite for the producing all the variety of colours & degrees of refrangibility then that the rays of light be bodies of different sizes, the least of which may make violet the weakest & darkest of the colours, & be <272r> more easily diverted by refracting surfaces from the right course; & the rest as they are bigger & bigger, may make the stronger & more lucid colours, blue, green, yellow, & red, & be more & more difficultly diverted. Nothing more is requisite for putting the rays of light into fits of easy reflexion & easy transmission, then that they be small bodies which by their attractive powers or some other force, stir up vibrations in what they act upon, which vibrations being swifter then the rays, overtake them successively, & agitate them so as by turns to increase & decrease their velocities & thereby put them into those fits. And lastly the unusual refraction of Island Crystal looks very much as if it were performed by some kind of attractive vertue lodged in certain sides both of the rays & of the particles of the crystal. For were it not for some kind of disposition or vertue lodged in some sides of the particles of the crystall & not in their other sides, & which inclines & bends the rays towards the coast of unusual refraction; the rays which fall perpendicularly on the crystall, would not be refracted towards that coast rather then towards any other coast, both at their incidence & at their emergence, so as to emerge perpendicularly by a contrary situation of the coast of unusual refraction at the second surface; the crystall acting upon the rays after they have past through it & are emerging into the Air, or, if you please, into a Vacuum. And since the crystall by this disposition or vertue does not act upon the rays unless when one of their sides of unusual refraction looks towards that coast, this argues a vertue or disposition in those sides of the rays, which answers to & sympathizes with that vertue or disposition of the crystall as the poles of two magnets answer to one another. And as magnetism may be intended & remitted, & is found only in the Magnet & in iron: so this vertue of refracting the perpendicular rays is greater in Island Crystall, less in Crystall of the rock, & is not yet found in other bodies. I do not say that this vertue is magnetical. It seems to be of another kind. I only say that what ever it be, it's difficult to conceive how the rays of light unless they be bodies, can have a permanent vertue in two of their sides which is not in their other sides, & this without any regard to their position to the space or Medium through which they pass.

What I mean in this Question by a Vacuum & by the attractions of the rays of light towards glass or crystall may be understood by what was said in the 18th 19th & 20th Questions.

Qu. 30. Are not gross bodies & light convertible into one another, & may not bodies receive much of their activity from the particles of light which enter their composition? For all fixt bodies being heated emit light so long as they continue sufficiently hot, & light mutually stops in bodies as often as its rays strike upon their parts, as we shewed above. I know no body less apt to shine then water; & yet water by frequent destillations changes into fixed earth, as Mr Boyle has tried, & then this earth being enabled to endure a sufficient heat, shines by heat like other bodies.

The changing of bodies into light & light into bodies is very conformable to the course of nature, which seems delighted with transmutations. Water which is a very fluid volatile tastless salt, she changes by heat into vapour which is a sort of air, & by cold into ice which is a hard pellucid brittle fusible stone: & this stone returns into water by heat & vapour returns into water by cold. Earth by heat becomes fire & by cold returns into earth. Dense bodies by fermentation rarefy into several sorts of air, & this air by fermentation & sometimes without it; returns into dense [bodies. Mercury appears sometimes in the form of a fluid metall, sometimes in the form of a hard brittle metall; sometimes in the form of a corrosive pellucid salt called sublimate, sometimes in the form of a tastless pellucid volatile white earth called <273r> Mercurius dulcis, or in that of a red opake volatile earth called Cinnaber, or in that of a red or white Precipitate, or in that of a fluid salt; & in destillation it turns into vapour, & beign agitated in Vacuo it shines like fire. And after all these changes it returns again into its first form of Mercury. Eggs grow from insensible magnitudes & change into animals, Tadpoles into Froggs, & Worms into flyes. All Birds Beasts & Fishes, Insects Trees & other Vegetables with their several parts, grow out of water & watry tinctures & salts, & by putrefaction return again into watry substances. And water standing a few days in the open air, yeilds a tincture, which (like that of Mault) by standing longer yeilds a sediment & a spirit, but before putrefaction is fit nourishment for animals & vegetables. And among such various & strange transmutations, why may not nature change bodies into light & light into bodies?

Qu. 31. Have not the small particles of bodies certain powers virtues or forces by which they act at a distance, not only upon the rays of light for reflecting refracting & inflecting them, but also upon one another for producing a great part of the phænomena of nature? For its well known that bodies act one upon another by the attractions of gravity magnetism & electricity, & these instances shew the tenour & course of nature, & make it not improbable but that there may be more attractive powers then these. For Nature is very consonant & conformable to her self. How these attractions may be performed I do not here consider. What I call attraction may be performed by impulse or by some other means unknown to me. I use that word here to signify only in general any force by which bodies tend towards one another whatsoever be the cause. For we must learn from the phænomena of nature what bodies attract one another, & what are the laws & properties of the attraction, before we enquire the cause by which the attraction is performed. The attractions of gravity magnetism & electricity reach to very sensible distances, & so have been observed by vulgar eyes, & there may be others which reach to so small distances as hitherto escape observation, & perhaps electrical attraction may reach to such small distances even without being excited by friction.

For when salt of Tartar runs per deliquium, is not this done by an attraction between the particles of the salt of Tartar & the particles of the water which float in the Aer in the form of vapors? And why does not common salt or saltpeter or vitriol run per deliquium but for want of such an attraction? Or why does not salt of Tartar draw more water out of the Air then in a certain proportion to its quantity, but for want of an attractive force after it is satiated with water? And whence is it but from this attractive power that water which alone distills with a gentle lukewarm heat will not destill from salt of Tartar without a great heat? And is it not from the like attractive power between the particles of oyle of Vitriol & the particles of water, that Oyle of Vitriol draws to it a good quantity of water out of the Air, & after it is satiated draws no more, & in destillation lets go the water very difficultly? And when water & oyle of Vitriol poured sucessively into the same vessel grow very hot in the mixing, does not this heat argue a great motion in the parts of the liquors? And does not this motion argue that the parts of the two liquors in mixing coaless with violence & by consequence rush towards one another with an accelerated motion? And when Aqua fortis or spirit of Vitriol poured upon filings of iron dissolves the filings with a great heat & ebullition, is not this heat & ebullition effected by a violent motion of <274r> the parts, & does not that motion argue that the acid parts of the liquor rush towards the parts of the metall with violence, & run forcibly into its pores till they get between its outmost particles & the main mass

of the metall, & surrounding those particles loosen them from the main mass & set them at liberty to flote off into the water? And when the acid particles which alone would destill with an easy heat will not separate from the particles of the metall without a very vio[lent heat, does not this confirm the attraction between them?

When spirit of Vitriol poured upon common salt or saltpeter makes an ebullition with the salt & unites with it, & in destillation the spirit of the common salt or saltpeter comes over much easier then it would do before, & the acid part of the spirit of Vitriol stays behind; does not this argue that the fixed Alcaly of the salt attracts the acid spirit of the Vitriol more strongly then its own spirit, & not being able to hold them both, lets go its own? And when oyle of Vitriol is drawn off from its weight of Nitre, & from both the ingredients a compound spirit of Nitre is destilled, two parts of which being poured on one part of oyle of cloves or Carvy seeds, or of any ponderous vegetable oyle, or oyle of animal substances, or oyle of Turpentine thickened with a little Balsam of sulphur, grows so very hot in mixing as presently to send up a burning flame: does not this very great & sudden heat argue that the two liquors mix with violence, & that their parts in mixing run towards one another with an accelerated motion, & clash with the greatest force? And is it not for the same reason that well rectified spirit of wine poured on the same compound spirit flashes, & that the pulvis fulminans composed of sulphur Nitre & salt of Tartar, goes off with a more sudden & violent explosion then Gun-powder, the acid spirits of the sulphur & nitre rushing towards one another & towards the salt of Tartar with so great a violence, as by the shock to turn the whole at once into vapour & flame? Where the dissolution is slow it makes a slow ebullition & a gentle heat, & where it is quicker it makes a greater ebullition with more heat, & where it is done at once the ebullition is contracted into a sudden blast or violent explosion with a heat equal to that of fire & flame. So when a drachm of the above-mentioned compound spirit of Nitre was poured upon half a drachm of oyle of Carvi sees in vacuo, the mixture immediately made a flash like gunpowder & burst the exhausted Receiver, which was a glass six inches wide and eight inches deep. And even the gross body of sulphur poudered, & with an equal weight of iron filings & a little water made into past, acts upon the iron, & in five or six hours grows too hot to be touched, & emits a flame. And by these experiments compared with the great quantity of Sulphur with which the Earth abounds, & the warmth of the interior parts of the earth & hot springs & burning mountains & with damps, mineral corruscations, earthquakes, hot suffocating exhalations, hurricanes & spouts: we may learn that sulphureous steams abound in the bowells of the earth & ferment with mineralls, & sometimes take fire with a sudden corruscation & explosion, & if pent up in subterraneous caverns, burst the caverns with a great shaking of the earth as in springing of a Mine. And then the vapour generated by the explosion, expiring through the pores of the earth, feels hot & suffocates & makes tempests & hurricanes, & sometimes causes the land to slide, or the sea to boyle, & carries up the water thereof in drops which by their weight fall down again in spouts. Also some sulphureous steams, at all times when the earth is dry, ascending into the Air, ferment there with nitrous acids, & sometimes taking fire cause lightning & thunder & fiery meteors. For the Air abounds with acid vapours fit <275r> to promote fermentations, as appears by the rusting of iron and copper in it, the kindling of fire by blowing, & the beating of the heart by means of respiration. Now the above mentioned motions are so great & violent as to shew that in fermentations, the particles of bodies which almost rest are put into new motions by a very potent principle which acts upon them only when they approach one another, & causes them to meet & clash with great violence, & grow hot with the motion, & dash one another into pieces, & vanish into air & vapour & flame.

When salt of Tartar per deliquium, being poured into the solution of any metal, precipitates the metall, & makes it fall down to the bottom of the liquor in the form of mud: does not this argue that the acid particles are attracted more strongly by the salt of Tartar then by the metall, & by the stronger attraction go from the metal to the salt of Tartar? And so when a solution of iron in Aqua fortis dissolves the Lapis Calaminaris & lets go the iron, or a solution of Copper dissolves iron immersed in it & lets go the copper, or a solution of silver dissolves copper & lets go the silver, or a solution of Mercury in Aqua fortis being poured upon Iron Copper Tin or Lead, dissolves the metall & lets go the Mercury, does not this argue that the acid particles of the Aqua fortis are attracted more strongly by the Lapis Calaminaris then by Iron, & more strongly by iron then by copper, & more strongly by Copper then by silver, & more strongly by Iron Copper Tin & Lead then by Mercury? And is it not for the same reason that iron requires more Aqua fortis to dissolve it then Copper, & Copper more then the other metalls; & that of all metalls, Iron is dissolved most easily, & is most apt to rust; & next after Iron, Copper?

When Oyle of Vitriol is mixed with a little water, or is run per deliquium, & in destillation the water ascends difficultly, & brings over with it some part of the oyle of Vitriol in the form of spirit of Vitriol, & this spirit upon being poured upon iron copper or salt of Tartar unites with the body & lets go the water, doth not this shew that the acid spirit is attracted by the water, & more attracted by the fixt body then by the water, & therefore lets go the water to close with the fixt body? And is it not for the same reason that the water & acid spirits which are mixed together in Vinegar, Aqua fortis, & spirit of salt, cohere & rise together in destillation; but if the Menstruum be poured on salt of Tartar, or on Lead or Iron or any fixt body which it can dissolve, the acid by a stronger attraction adheres to the body & lets go the water? And is it not also from a mutual attraction that the spirits of soot & sea-salt unite & compose the particles of Salarmoniac, which are less volatile then before because grosser & freer from water; & that the particles of Salarmoniac in sublimation carry up the particles of Antimony which will not sublime alone; & that the particles of Mercury uniting with the acid particles of spirit of salt compose Mercury sublimate, & with the particles of Sulphur compose cinnaber; & that the particles of spirit of wine & spirit of urin well rectified unite, & letting go the water which dissolved them compose a consistent body; & that in subliming cinnaber from salt of Tartar or from quick lime, the sulphur by a stronger attraction of the salt or lime lets go the Mercury & stays with the fixt body; & that when Mercury sublimate is sublimed from Antimony or from Regulus of Antimony, the spirit of salt lets go the Mercury, & unites with the Antimonial metall which attracts it more strongly, & stays with it till the heat be great enough to make them both ascend together, & then carries up the metall with it in the form of a very fusible salt called Butter of Antimony, although the spirit of salt alone be almost as volatile as water, & the Antimony alone as fixt as Lead?

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When Aqua fortis dissolves silver & not gold, & Aqua regia dissolves gold & not silver; may it not be said that Aqua fortis is subtile enough to penetrate gold as well as silver, but wants the attractive force to give it entrance, & that Aqua regia is subtile enough to penetrate silver as well as gold, but wants the attractive force to give it entrance? For Aqua regia is nothing else then Aqua fortis mixed with some spirit of salt or with Salarmoniac; & even common salt dissolved in Aqua fortis enables the Menstruum to dissolve gold tho the salt be a gross body. When therefore spirit of salt precipitates silver out of Aqua fortis, is it not done by attracting & mixing with the Aqua fortis, & not attracting or perhaps repelling silver? And when water precipitates Antimony out of the sublimate of Antimony & Salarmoniac, or out of butter of Antimony, is it not done by its dissolving, mixing with & weakening the Salarmoniac or spirit of salt & its not attracting or perhaps repelling the Antimony? And is it not for want of an attractive vertue between the parts of water & oyle, of Quicksilver & Antimony, of Lead & Iron, that these substances do not mix; and by a weak attraction that Quicksilver & Copper mix difficultly; & from a strong one that Quicksilver & Tin, Antimony & Iron, water & salts mix readily? And in general, is it not from the same principle that heat congregates homogeneal bodies & separates heterogeneal ones?

When Arsnick with soap gives a Regulus & with Mercury sublimate a volatile fusible salt like butter of Antimony; doth not this shew that Arsnick, which is a substance totally volatile, is compounded of fixt & volatile parts strongly cohering by a mutual attraction so that the volatile will not ascend without carrying up the fixed? And so, when an equal weight of spirit of wine & oyle of vitriol are digested together, & in destillation yeild two fragrant volatile spirits which will not mix with one another, & a fixt black earth remains behind; doth not this shew that oyle of Vitriol is composed of volatile & fixed parts strongly united by attraction so as to ascend together in form of a volatile acid fluid salt, untill the spirit of wine attracts & separates the volatile parts from the fixed? And therefore since oyle of sulphur per campanam is of the same nature with oyle of Vitriol; may it not be inferred that Sulphur is also a mixture of volatile & fixed parts so strongly cohering by attraction as to ascend together in sublimation. By dissolving flowers of sulphur in oyle of Turpentine & destilling the solution, it is found that Sulphur is composed of an inflamable thick oyle or fat bitumen, an acid salt, a very fixed earth & a little metall. The three first were found not much unequall to one another, the fourth in so small a quantity as scarce to be worth considering. The acid salt dissolved in water is the same with Oyle of Sulphur per Campanam, & abounding much in the bowells of the earth & particularly in Markasites, unites it self to the other ingredients of the Markasite, which are, Bitumen, Iron, Copper & Earth, & with them compounds Alume, Vitriol, & Sulphur. With the earth alone it compounds Alume; with the Metall alone or Metal & earth together it compounds Vitriol; & with the Bitumen & Earth it compounds Sulphur. Whence it comes to pass that Marcasites abound with those three Mineralls. And is it not from the mutual attraction of the ingredients that they stick together for compounding these mineralls, & that the

Bitumen carries up the other ingredients of the sulphur, which without it would not sublime? And the same Question may be put concerning all or almost all the gross bodies in nature. For all the parts of animals & vegetables are composed of substances volatile & fixed, fluid & solid, as appears by their Analysis; & so are salts & minerals so far as Chymists have been hitherto able to examin their composition.

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When Mercury sublimate is resublimed with fresh Mercury & becomes Mercurius dulcis, which is a white tastless earth scarce dissolvable in water, and Mercurius dulcis resublimed with spirit of salt returns into Mercury sublimate; & when Metalls corroded with a little acid turn into rust, which is an earth tastless & indissolvable in water, & this earth imbibed with more acid becomes a metallic salt; & when some stones, as Spar of Lead, dissolved in proper menstruums become salts; do not these things shew that salts are dry earth, & watry acid united by attraction, & that the earth will not become a salt without so much acid as makes it dissolvable in water? Do not the sharp & pungent tasts of acids arise from the strong attraction whereby the acid particles rush upon & agitate the particles of the tongue? And when metalls are dissolved in acid menstruums, & the acids in conjunction with the metall act after a different manner so that the compound has a different tast much milder then before, & sometimes a sweet one; is it not because the acids adhere to the metallic particles, & thereby, lose much of their activity? And if the acid be in too small a proportion to make the compound dissolvable in water, will it not by adhering strongly to the metall become unactive & lose its tast, & the compound be a tastless earth? For such things as are not dissolvable by the moisture of the tongue, act not upon the tast.

As gravity makes the sea flow round the denser & weightier parts of the globe of the earth; so the attraction may make the watry acid flow round the denser & compacter particles of earth for composing the particles of salt. For otherwise the acid would not do the office of a medium between the earth & common water for making salts dissolvable in the water: nor would salt of Tartar readily draw off the acid from dissolved metalls; nor metalls the acid from Mercury. Now as in the great globe of the earth & sea, the densest bodies by their gravity sink down in water, & always endeavour to go towards the center of the globe; so in particles of salt the densest matter may always endeavour to approach the center of the particle: so that a particle of salt may be compared to a chaos, being dense hard dry & earthy in the centre, & rare, soft, moist, & watry in the circumference. And hence it seems to be that salts are of a lasting nature, being scarce destroyed unless by drawing away their watry parts by violence or by letting them soak into the pores of the central earth by a gentle heat in putrefaction, untill the earth be dissolved by the water, & separated into smaller particles, which by reason of their smallness make the rotten compound appear of a black colour. Hence also it may be that the parts of animals & vegetables preserve their several forms & assimilate their nourishment; the soft & moist nourishment easily changing its texture by a gentle heat & motion, till it becomes like the dense hard dry & durable earth in the centre of each particle. But when the nourishment grows unfit to be assimilated, or the central earth grows too feeble to assimilate it, the motion ends in confusion, putrefaction, & death.

If a very small quantity of any salt or Vitriol be dissolved in a great quantity of water, the particles of the salt or vitriol will not sink to the bottom, tho they be heavier in specie then the water, but will eavenly diffuse themselves into all the water, so as to make it as saline at the top as at the bottom. And does not this imply that the parts of the salt or Vitriol recede from one another, & endeavour to expand themselves, & get as far asunder as the quantity of water in which they float, will allow?

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And does not this endeavour imply that they have a repulsive force by which they fly from one another, or at least that they attract the water more strongly then they do one another? For as all things ascend in water which are less attracted then water by the gravitating power of the earth: so all the particles of salt which float in water & are less attracted then water by any one particle of salt, must recede from that particle & give way to the more attracted water.

When any saline liquor is evaporated to a cuticle & let cool, the salt concretes in regular figures, which argues that the particles of the salt before they concreted, floated in the liquor at equal distances in rank & file, & by consequence that they acted upon one another by some power which at equal distances is equal, at unequal distances unequal. For by such a power they will range themselves uniformly, & without it they will

float irregularly & come together as irregularly. And since the particles of Island Crystall act all the same way upon the rays of light for causing the unusual refraction, may it not be supposed that in the formation of this crystall, the particles not only ranged themselves in rank & file for concreting in regular figures, but also by some kind of polar vertue turned their homogeneal sides the same way.

The parts of all homogeneal hard bodies which fully touch one another stick together very strongly. And for explaining how this may be some have invented hooked atoms, which is begging the question; & others tell us that bodies are glued together by rest, that is, by an Occult Quality, or rather by nothing; & others that they stick together by conspiring motions, that is, by relative rest amongst themselves. I had rather inferr from their cohesion, that their particles attract one another by some force, which in immediate contact is exceeding strong, at small distances performs the chymical operations above mentioned, & reaches not far from the particles with any sensible effect.

All bodies seem to be composed of hard particles: For otherwise fluids would not congeale, as water, oyles, vinegre, & spirit or oyle of Vitriol do by freezing, Mercury by fumes of Lead, spirit of Nitre & Mercury by dissolving the Mercury & evaporating the flegm, spirit of Wine & spirit of Urin by deflegming & mixing them, & spirit of urine & spirit of salt by subliming them together to make Salarmoniac. Even the rays of light seem to be hard bodies: for otherwise they would not retain different properties in their different sides. And therefore hardness may be recconed the property of all uncompounded matter. At least this seems to be as evident as the universal impenetrability of matter. For all bodies so far as experience reaches, are either hard or may be hardned, & we have no other evidence of universal impenetrability besides a large experience without an experimental exception. Now if compound bodies are so very hard as we find some of them to be, & yet are very porous, & consist of parts which are only laid together: the simple particles which are void of pores & were never yet divided, must be much harder. For such hard particles being heaped up together, can scarce touch one another in more then a few points, & therefore must be separable by much less force then is requisite to break a solid particle, whose parts touch in all the space between them without any pores or interstices to weaken their cohesion. And how such very hard particles which are only laid together & touch only in a few points, can stick together, & that so firmly as they do, without the assistance of something which causes them to be attracted or prest towards one another, is very difficult to conceive.

The same thing I inferr also from the cohering of two polished Marbles in Vacuo, & from the standing of Quicksilver in the Barometer at the height <279r> of 50, 60 or 70 inches or above, when ever it is well purged of air & carefully poured in, so that its parts be every where contiguous, both to one another & to the glass. The Atmosphere by its weight presses the Quicksilver ‡ < insertion from the top of f 279v > ‡ into the glass to the height of 29 or 30 inches. And some other Agent raises it higher, not by pressing it into the glass but by making its parts stick to the glass & to one another. For upon any discontinuation of parts made either by bubbles or by shaking the glass, the whole Mercury falls down to the height of 29 or 30 inches. < text from f 279r resumes >

And of the same kind with these experiments are those that follow. If two plane polished plates of glass (suppose two pieces of a polished looking-glass) be laid together so that their sides be parallel & at a very small distance from one another, & then their lower edges be dipped into water; the water will rise up between them. And the less the distance of the glasses is, the greater will be the height to which the water will rise. If the distance be about the hundredth part of an inch, the water will rise to the height of about an inch; & if the distance be greater or less in any proportion, the height will be reciprocally proportional to the distance very nearly. For the attractive force of the glasses is the same whether the distance between them be greater or less; & the weight of the water drawn up, is the same, if the height, of it be reciprocally proportional to the distance of the glasses. And in like manner, water ascends between two Marbles polished plane, when their polished sides are parallel, & at a very little distance from one another. And if slender pipes of glass be dipped at one end into stagnating water, the water will rise up within the pipe, & the height to which it rises will be reciprocally proportional to the diameter of the cavity of the pipe, & will equal the height to which it rises between two planes of glass, if the semidiameter of the cavity of the Pipe be equal to the distance between the planes, or thereabouts. And these Experiments succeed after the same manner in Vacuo as in the open Aer, & therefore are not influenced by the weight or pressure of the Atmosphere.

And if a large Pipe of glass be filled with sifted ashes well pressed together in the glass, & one end of the Pipe be dipped into stagnating water: the water will rise up slowly in the ashes so as in the space of a week or

fortnight to reach up within the glass to the height of 30 or 40 inches above the stagnating water. And the water rises up to this height by the attraction only of those particles of the ashes which are upon the surface of the elevated water; the particles which are within the water, attracting it as much downwards as upwards. And therefore the attraction of the particles is very strong. But the particles of the ashes being not so dense & close together as those of glass their attraction is not so strong as that of glass which keeps Quicksilver suspended to the height of 60 or 70 inches & therefore attracts with a force which would keep water suspended to the height of above fifty feet.

By the same principle, a Sponge sucks in water, & the Glands in the bodies of animals, according to their several natures & dispositions, suck in various juices from the blood.

If two plane polished plates of glass three or four inches broad & twenty or twenty five long, be laid, one of them parallel to the horizon, the other upon the first so as at one of their ends to touch one another & contein an Angle of about 10 or 15 minutes, & the same be first moistened on their inward sides with a clear cloth dipt into oyle of Oranges or spirit of Turpentine, & a drop or two of the Oyle or Spirit be let fall upon the lower glass at the other end: so soon as the upper glass is laid down upon the lower so as to touch it at one end as above, & to touch the drop at the other end, making with the lower glass an angle of about 10 or 15 minutes; the drop will begin to move towards the concourse of the glasses, & will continue to move with an <280r> accelerated motion till it arrives at that concourse of the glasses. For the two glasses attract the drop & make it run that way towards which the attractions incline. And if when the drop is in motion you lift up that end of the glasses where they meet & towards which the drop moves: the drop will ascend between the glasses & therefore is attracted. And as you lift up the glasses more & more the drop will ascend slower & slower & at length rest being then carried downward by its weight as much as upwards by the attraction. And by this means you may know the force by which the drop is attracted at all distances from the concourse of the glasses.

Now by some experiments of this kind it has been found that the attraction is almost reciprocally in a duplicate proportion of the distance of the middle of the drop from the concourse of the glasses; [viz, reciprocally in a simple proportion by reason of the spreading of the drop & its touching each glass in a larger surface; & again reciprocally in a simple proportion by reason of the attractions growing stronger within the same quantity of attracting surface. The attraction therefore within the same quantity of attracting surface, is reciprocally as the distance between the glasses. And therefore where the distance is exceeding small, the attraction must be exceeding great. By the Table in the second part of the second Book, wherein the thicknesses of coloured plates of water between two glasses are set down, the thickness of the Plate where it appears very black, is three eighths of the ten hundred thousandth part of an inch. And where the oyle of Oranges between the glasses is of this thickness, the attraction collected by the foregoing Rule, seems to be so strong, as within a circle of an inch in diameter to suffice to hold up a weight equal to that of a cylinder of water of an inch in diameter & two or three furlongs in length. And where it is of a less thickness the attraction may be proportionally greater, & continue to increase untill the thickness do not exceed that of a single particle of the Oyle. There are therefore Agents in nature able to make the particles of bodies stick together by very strong attractions. And it is the business of experimental Philosophy to find them out.

Now the smallest particles of matter may cohere by the strongest attractions & compose bigger particles of weaker vertue, & many of these may cohere & compose bigger particles whose vertue is still weaker, & so on for divers successions untill the progression end in the biggest particles on which the operations in Chymistry & the colours of natural bodies depend & which by cohering compose bodies of a sensible magnitude. If the body is compact & bends or yeilds inward to pression without any sliding of its parts, it is hard & elastick, returning to its figure with a force arising from the mutual attraction of its parts. If the parts slide upon one another the body is malleable or soft. If they slip easily & are of a fit size to be agitated by heat, & the heat is big enough to keep them in agitation the body is fluid; & if it be apt to stick to things it is humid; & the drops of every fluid affect a round figure by the mutual attraction of their parts, as the globe of the Earth & Sea affects a round figure by the mutuall attraction of its parts by gravity.

Since metalls dissolved in acids attract but a small quantity of the acid, their attractive force can reach but to a small distance from them. And as in Algebra, where affirmative quantities vanish & cease, there negative ones begin, so in Mechanicks, where attraction ceases there a repulsive vertue ought to succeed. And that there is such a vertue seems to follow from the reflexions & inflexions of the rays of light. For the rays are

repelled by bodies in both these cases without the immediate contact of the reflecting or inflecting body. It seems also to follow from the emission of light, the ray so soon as it is shaken off from a shining body by the vibrating motion of the parts of the body, & gets beyond the reach of attraction, being driven away with exceeding great velocity. For that <281r> force which is sufficient to turn it back in reflexion may be sufficient to emit it. It seems also to follow from the production of Air & Vapor. The particles when they are shaken off from bodies by heat or fermentation, so soon as they are beyond the reach of the attraction of the body, receding from it, & also from one another with great strength, & keeping at a distance, so as sometimes to take up above a million of times more space then they did before in the form of a dense body. Which vast contraction & expansion seems unintelligible by feigning the particles of Air to be springy & ramous, or rolled up like hoops, or by any other means then a repulsive power. The particles of fluids which do not cohere too strongly & are of such a smallness as renders them most susceptible of those agitations which keep liquors in a fluor, are most easily separated & rarefied into vapor, & in the language of the Chymists, they are volatile, rarefying with an easy heat & condensing with cold. But those which are grosser & so less susceptible of agitation or cohere by a stronger attraction, are not separated without a stronger heat, or perhaps, not without fermentation. And these last are the bodies which Chemists call fixed, & being rarefied by fermentation become true permanent air: those particles receding from one another with the greatest force, & being most difficultly brought together, which upon contact cohere most strongly. And because the particles of permanent Air are grosser & arise from denser substances then those of vapors, thence it is that true Air is more ponderous then vapor, & that a moist atmosphere is lighter then a dry one quantity for quantity. From the same repelling power it seems to be that flyes walk upon the water without wetting their feet; & that the Object-glasses of long Telescopes lye upon one another without touching; & that dry pouders are difficultly made to touch one another so as to stick together, unless by melting them, or wetting them with water which by exhaling may bring them together; & that two polished marbles which by immediate contact stick together, are difficultly brought so close together as to stick.

And thus Nature will be very conformable to her self & very simple, performing all the great motions of the heavenly bodies by the attraction of gravity which intercedes those bodies, & almost all the small ones of their particles by some other attractive & repelling powers which interceede the particles. The Vis inertiæ is a passive principle by which bodies persist in their motion or rest, receive motion in proportion to the force impressing it, & resist as much as they are resisted. By this Principle alone there never could have been any motion in the world. Some other Principle was necessary for putting bodies into motion; & now they are in motion some other Principle is necessary for conserving the motion. For from the various composition of two motions tis very certain that there is not always the same quantity of motion in the world. For if two globes joyned by a slender rod, revolve about their common center of gravity with an uniform motion while that center moves on uniformly in a right line drawn in the plane of their circular motion; the summ of the motions of the two globes, as often as the globes are in the right line described by their common center of gravity, will be bigger then the summ of their motions when they are in a line perpendicular to that right line. By this instance it appears that motion may be got or lost. But by reason of the tenacity of fluids, & attrition of their parts, & the weakness of elasticity in solids, motion is much more apt to be lost then got, & is always upon the decay. For bodies which are either absolutely hard, or so soft as to be void of elasticity, will not rebound from one another. Impenetrability makes them only stop. If two equal bodies meet directly in Vacuo <282r> they will by the laws of motion stop where they meet & lose all their motion & remain in rest unless they be elastick & receive new motion from their spring. If they have so much elasticity as suffices to make them rebound with a quarter or half or three quarters of the force with which they come together, they will lose three quarters or half or a quarter of their motion. And this may be tried by letting two equal Pendulums fall against one another from equal heights. If the Pendulums be of lead or soft clay they will lose all or almost all their motions: if of elastick bodies they will lose all but what they recover from their elasticity. If it be said that they can lose no motion but what they communicate to other bodies; the consequence is that in Vacuo they can lose no motion, but when they meet they must go on & penetrate one anothers dimensions. If three equal round Vessels be filled the one with water, the other with oyle, the third with molten pitch, & the liquors be stirred about alike to give them a vortical motion: the pitch by its tenacity will lose its motion quickly, the oyle being less tenacious will keep it longer, & the water being least tenacious will keep it longest, but yet will lose it in a short time. Whence it is easy to understand that if many contiguous Vortices of molten pitch were each of **{**them**}** as large as those which some suppose to revolve about the Sun & fixt starrs, yet these & all their parts would by their tenacity & stifness communicate their motion to one another till they all rested among themselves. Vortices of oyle or water or some fluider matter might continue longer in motion, but unless the matter were void of all tenacity & attrition of parts & communication of motion

(which is not to be supposed,) the motion would constantly decay. Seing therefore the variety of motion which we find in the world is always decreasing, there is a necessity of conserving & recruiting it by active principles, such as are the cause of gravity by which Planets & Comets keep their motions in their Orbs & bodies acquire great motion in falling; & the cause of fermentation by which the heart & blood of animals are kept in perpetual motion & heat, the inward parts of the earth are constantly warmed & in some places grow very hot, bodies burn & shine, mountains take fire, the caverns of the earth are blown up, & the Sun continues violently hot & lucid & warms all things by his light. For we meet with very little motion in the world besides what is oweing to these active Principles. And if it were not for these Principles the bodies of the Earth, Planets, Comets, Sun, & all things in them would grow cold & freeze & become inactive masses, & all putrefaction generation vegetation & life would cease, & the Planets & Comets would not remain in their Orbs.

All these things being considered, it seems to me that God in the beginning formed matter in solid massy hard impenetrable moveable particles of such sizes & figures & with such other properties & in such proportion to space as most conduced to the end for which he formed them, & that these primitive particles being solids are incomparably harder then any porous bodies compounded of them; even so very hard as never to wear or break in pieces: no ordinary power being able to divide what God himself made one in the first creation. While the particles continue entire they may compose bodies of one & the same nature & texture in all ages: but should they weare away, or break in pieces, the nature of things depending on them, would be changed. Water & Earth composed of old worn particles & fragments of particles would not be of the same nature & texture now with water & earth composed of entire particles in the beginning. And therefore that nature may be lasting, the changes of corporeal things are to be placed only in the various separations & new associations & motions of these permanent particles; compound bodies being apt to break, not in the midst of solid particles, but where those particles are laid together & only touch in a few points.

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It seems to me further that these particles have not only a Vis inertiæ accompanied with such passive laws of motion as naturally result from that force, but also that they are moved by certain active principles such as is that of Gravity & that which causes fermentation & the cohesion of bodies. These Principles I consider not as Occult Qualities supposed to result from the specific forms of things, but as general laws of nature by which the things [themselves are formed: their truth appearing to us by phænomena though their causes be not yet discovered. For these are manifest qualities, & their causes only are occult. To tell us that every species of things is endowed with an occult specific quality by which it acts & produces manifest effects, is to tell us nothing: but to derive two or three general Principles of motion from Phænomena, & afterwards to tell us how the properties & actions of all corporeal things follow from those manifest Principles, would be a very great step in Philosophy, tho the causes of those Principles were not yet discovered: & therefore I scruple not to propose the Principles of motion above mentioned, they being of very general extent, & leave their causes to be found out.

Now by the help of these Principles all material things seem to have been composed of the hard & solid Particles above mentioned variously associated in the first creation by the counsell of an intelligent Agent. For it became him who created them to set them in order. And if he did so, it's unphilosophical to seek for any other origin of the world, or to pretend that it might arise out of a Chaos by the mere laws of nature; tho being once formed it may continue by those laws for many ages. For while Comets move in very excentric Orbs in all manner of positions, blind fate could never make all the Planets move one & the same way in Orbs concentrick, some inconsiderable irregularities excepted which may have risen from the mutual actions of Comets & Planets upon one another, & which will be apt to increase till this Systeme wants a reformation. Such a wonderfull uniformity in the Planetary Systeme must be allowed the effect of choise. And so must the uniformity in the bodies of Animals, they having generally a right & a left side shaped alike & on either side of their bodies two leggs behind & either two arms or two leggs or two wings before upon their sholders & between their sholders a neck running down into a back bone & a head upon it, & in the head two ears, two eyes, a nose, a mouth & a tongue alike situated. Also the first contrivance of those very artificial parts of animals, the eyes, ears, brain, muscles, heart, Lungs, Midriff, Glands, Larynx, Hands, Wings, Swimming-bladders, natural Spectables, & other organs of sense & motion, & the Instinct of Brutes & Insects, can be the effect of nothing else then the wisdome & skill of a powerful ever living agent, who being in all places is more able by his Will to move the bodies within his boundless unorganized uniform Sensorium & thereby to

form & reform the parts of the Universe, then we are by our will to move the parts of our own bodies. And yet we are not to consider the world as the body of God or the several parts thereof as the parts of God. He is an uniform Being void of Organs, Members, or Parts, & they are his Creatures subordinate to him & subservient to his will, & he is no more the soul of them then the Soul of a man is the Soul of the Species of things carried through the Organs of Sense into the place of its sensation, where it perceives them by means of its immediate presence without the intervention of any third thing. The Organs of Sense are not for enabling the soul to perceive the Species of things in its Sensorium, but only for conveying them thither, & God has no need of such Organs, he being every where present to the things themselves. And since space is divisible in infinitum & matter is not necessarily in all places, it may be also allowed that God is able to create particles o**{**f**}** <284r> matter of several sizes & figures & in several proportions to space, & perhaps of different densities & forces, & thereby to vary the Laws of Nature, & make worlds of several sorts in several parts of the Universe. At least I see nothing of contradiction in all this.

As in Mathematicks so in Natural Philosophy the investigation of difficult things by the Method of Analysis ought ever to precede the method of composition. This Analysis consists in making Experiments & observations & in drawing general conclusions from them by Induction, & admitting of no objections against the Conclusions but such as are taken from experiments or other certain truths. For Hypotheses are not to be regarded in experimental Philosophy. And altho the arguing from experiments & observations by Induction be no demonstration of general Conclusions yet it is the best way of arguing which the nature of things admits of, & may be looked upon as so much the stronger by how much the Induction is more general And if no exception occur from Phænomena the conclusion may be pronounced generally. But if at any time afterwards any exception shall occur from experiments, it may then begin to be pronounced with such exceptions as occur. By this way of Analysis we may proceed from compounds to ingredients, & from motions to the forces producing them, & in general from effects to their causes, & from particular causes to more general ones, till the Argument end in the most general. This is the Method of Analysis: & the Synthesis consists in assuming the causes discovered & established as Principles, & by them explaining the Phenomena proceeding from them, & proving the explanations.

In the two first books of these Opticks, I proceeded by this Analysis to discover & prove the original differences of the rays of light in respect of refrangibility, reflexibility, & colour, & their alternate fits of easy reflexion & easy transmission, & the properties of bodies both opake & pellucid on which their reflexions & colours depend. And these discoveries being proved may be assumed in the method of Composition for explaining the Phænomena arising from them: an instance of which Method I gave in the end of the first Book. In this third Book I have only begun the Analysis of what remains to be discovered about light & its effects upon the frame of nature, hinting several things about it & leaving the hints to be examined & improved by the farther experiments & observations of such as are inquisitive. And if natural Philosophy in all its parts, by pursuing this method, shall at length be perfected, the bounds of moral Philosophy will be also enlarged. For so far as we can know by Natural Philosophy what is the first Cause, what power he has over us, & what benefits we receive from him, so far our duty towards him as well as that towards one another, will appear to us by the light of Nature. And no doubt, if the worship of fals Gods had not blinded the heathen, their moral Philosophy would have gone further then to the four Cardinal Vertues; & instead of teaching the transmigration of souls & to worship the Sun & Moon & dead Heroes, they would have taught us to worship our true Author & Benefactor.

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All these things being considered it seems to me that God [Deus O. M.] in the beginning $_{\text{created}}$ | $^{\text{formed}}$ matter in solid massy hard impenetrable moveable particles of such sizes & figures & with such other properties & in such proportion to space as most conduced to the end for which he created them. And that these primitive particles being solids are incomparably harder then any porous bodies compounded of them; even so very hard as never to weare or break in pieces: no ordinary power being able to divide what God himself made one in the first creation. While these particles continue entire they may compose bodies of the same nature & texture in all ages: but should they weare away or break in pieces, the nature of things depending on them would be changed. Water & Earth composed of old worn particles & fragments of particles would not be of the same nature & texture now with water & earth composed of entire particles in the beginning. And therefore that nature may be lasting, the changes of corporeal things are to be placed only in the various separations &, new associations & motions of these permanent particles, compound bodies

being apt to break not in the midst of solid particles but where those particles are laid together & only touch in a few points.

It seems to me further that these particles have not only a Vis inertiæ accompanied with such passive laws of motion as naturally result from that force, but also that they are moved by certain active principles such as is that of Gravity & that which causes fermentation & the cohesion of bodies. These Principles I consider not as occult Qualities supposed to result from the specific forms of things but as general Laws of Nature by which the things themselves . are formed: Their Truth appearing to us by phænomena, though their causes be not yet explaind. To tell us that every species of things is endowed with an occult specificly Quality by which it acts, is to tell us nothing; but to derive two or three general Principles of motion from Phænomena, & afterwards to tell us how the properties & actions of all corporeal things follow from those manifest Principles, would be a very great step in Philosophy, tho the causes of those Principles were not yet discovered: & therefore I scruple not to propose the Principles of motion above mentioned, they being of very general extent.

Now by the help of these Principles all material things seem to have been composed of the hard & solid Particles above mentioned variously associated in the first creation, by the counsel of an intelligent Agent. For it became him who created them to set them in order. And if he did so, it's unphilosophical to seek for any other origin of the world, or to pretend that it might arise out of a Chaos by the mere laws of Nature; tho being once formed it may continue by those laws for many ages. For while Comets move in very excentrick Orbs in all manner of positions, blind fate could never make all the Planets move one & the same way in orbs concentrick, some inconsiderable irregularities excepted which may have risen from the mutual actions of Comets & Planets upon one another, & which will be apt to increase till this Systeme wants a reformation. Such a <286r> wonderful uniformity in the Planetary Systeme must be allowed the effect of choise. And so must the uniformity in the bodies of Animals, they having generaly a right side & a left side shaped alike & on either side of their bodies two leggs behind & either two arms or two leggs or two wings before upon their shoulders, & between their shoulders a neck with a head upon it, & in the head two ears, two eyes, a nose, a mouth & a tongue alike situated. Also the first contrivance of those very artificial parts of animals, the Eyes, Ears, Brain, Muscles, Glands, heart, Lungs, Midriff, Larynx, Hands, Wings, Swimming bladders, natural Spactacles, & other Organs of sense & motion, & the instinct of Brutes & Insects, can be the effect of nothing else then the wisdome & skill of a powerfull ever living Agent; who is ; & who is more able by his will to move the bodies within his boundless uniform unorganized sensorium & thereby to forme & reform the parts of the Universe, then we are by our will to move the parts of our own bodies. † < insertion from the middle of f 285v > †And yet we are not to consider the world as the body of God or the several parts thereof as the parts of God. They are his creatures subordinate to him & subservient to his will. And he is no more the soul of them then the soul of a man is the soul of the species of things carried through the Organs of sense into the place of sensation where the soul by means of its immediate presence perceives them. < text from f 286r resumes > And since space is divisible in infinitum & matter is not necessarily in all places, it must be also allowed that God is able to create particles of matter of several sizes & figures & in several proportions to space & perhaps of different densities & forces, & thereby to vary the laws of Nature & make worlds of different sorts in several parts of the Universe. At least I see nothing of contradiction in all this.

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over us, & what benefits we receive from him, so far our duty towards him as well as that towards one another will appear to us by the light of Nature. And no doubt, if the worship of false Gods had not blinded the Heathens, their Moral Philosophy would have gone further then to the four Cardinal Vertues. & instead of teaching us the transmigration of Souls, & to worship the Sun & Moon & dead Heroes, they would have tought us to worship our true Author & Benefactor.

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Qu. 20. Are not the rays of light very small bodies refracted by means of certain attractions which intercede then & the parts of pellucid bodies? The common opinions are that light is made either by pression or motion propagated through a fluid or by bodies projected. If it consisted only in pression propagated without actual motion, it would not be able to agitate & heate the bodies which refract & reflect it. If it consisted in motion propagated to all distances in an instant, it would require an infinite force to generate that motion. Light moves in right lines without bending or spreading into the shadow beyond the bounds of those right lines in which it begins to move. But pression or motion cannot be propagated in a fluid in right lines beyond an obstacle which stops part of the motion; but bends & spreads every way into the quiescent medium which lies beyond the obstacle. Gravity tends downwards, but the pressure of water arising from gravity tends every way with equal force & is propagated as readily & with as much force side ways as downwards & through crooked passages as through streight ones. The waves on the surface of water passing by the sides of a broad obstacle bend & dilate themselves gradually into the quiet water behind the obstacle. The waves pulses or vibrations of the Air wherein sounds consist bend manifestly tho not so much as the waves of water. For a Bell or a Canon may be heard beyond a hill which intercepts the sight of the sounding body & sounds are propagated as readily through crooked pipes as through streight ones. But light is never known to follow crooked passages nor to bend into the shadow For the fixt stars by the interposition of any of the Planets cease to be seen & so do the parts of the Sun by the interposition of the Moon Mercury or Venus. The rays which pass very neare to the edges of any body are bent a little by the action of the body as we shewed above; but this bending is not towards but from the shadow & is performed only in the passage of the ray by the body. So soon as the ray is past the body it goes right on.

To explain the unusual refraction of Island-Crystal by pression or motion propagated has not hitherto been attempted (to my knowledge) except by Hugenius who for that end supposed two several vibrating Mediums within that crystal: but when he tried the refractions in two successive pieces of that crystal & found them such as is mentioned in the two last preceding Questions; he confest himself at a loss for explaining them: For pressions or motions propagated from a shining body through an uniform medium must be on all sides alike: whereas by those experiments it appears that the rays of light have different properties in their different sides. He suspected that the pulses of Æther in passing through the first crystal might receive certain new modifications which might determin them to be propagated in this or that Medium within the second crystal according to the position of that crystal: but what modifications those might be he could not say nor think of any thing satisfactory in this point.: And its more difficult to conceive how such modifications can be in the rays originally, if light be nothing else then pression or motion propagated through fluids. For the refractions reflexions <288r> inflexions & colours of light depend on such properties as are in the rays originaly & suffer no change by the passing of the rays through several mediums: & therefore all Hypotheses are to be laid aside in which those phænomena are derived from new modifications of the rays.

By the regular & very lasting motions of Comets & Planets through the heavens in all manner of positions its manifest that the heavens are void of all sensible resistence [& therefore may let the rays of light go through them in right lines with an uniform motion to very great distances, although those rays should be bodies]. The resistance of fluid Mediums arises partly from the attrition of the parts of the Medium & principally from the Vis inertiæ of the matter. That part of the resistance which arises from the attrition of the parts may be diminished by dividing the matter into smaller parts & making the parts more smooth & slippery: but that part of the resistance which arises from the Vis inertiæ is proportional to the density of the matter & cannot be diminished by dividing the matter nor by any other means then by decreasing the density. And for these reasons the density of fluid Mediums is very nearly proportional to their resistance Water is 13 or 14 times lighter then Quicksilver, & by consequence 13 or 14 times rarer, & it's resistance is less then that of Quicksilver in the same proportion or thereabouts as I have found by Pendulums. The open Air in which we breath is eight or nine hundred times lighter then water, & by consequence eight or nine hundred times rarer, & accordingly its resistance is less then that of water in the same proportion or thereabouts as I have also

found by Pendulums.. And if the Air be made still thinner & thinner its resistance becomes less & less untill it be insensible. < insertion from the middle of f 287v > And in thinner Air the resistance is still less & by rarefying the air becomes at length insensible. < text from f 288r resumes > For feathers falling in the open Air meet with great resistance but in a tall glass wall emptied of Air they fall as fast as lead or gold as I have seen tried several times. And the heavens are emptier of Air then any Vacuum we can make below & therefore have less resistance. Liquors which differ not much in density, as water spirit of wine spirit of Turpentine, hot oyle, differ not much in resistance, & the reason is because their rersistances arise chiefly from the Vis inertiæ. Heat increases fluidity & makes many bodies fluid which are not fluid in cold & accordingly decreases their resistance as may be tried in oyle but decreases not the resistance of water considerably as it would do if any great part of its resistance arose from the attrition or tenacity of its parts, & therefore the resistence of water arises chiefly from the Vis inertiæ; & by consequence if the heavens were as dense as water they would not have much less resistence then water, if as dense as quicksilver they would not have much less resistence then quicksilver, if absolutely dense or full of matter without any Vacuum, let the matter be never so fluid, they would have a greater resistance then Quicksilver. A solid globe in such a Medium would lose above half its motion in moving three times the length of its diameter & a globe not solid would be retarded sooner. And therefore to make way for the lasting motions of Comets & Planets its necessary to empty the heavens of all matter except perhaps some very thin vapors steams or effluvia arising from the Atmospheres of the Earth Planets & Comets. Such matter is of no use for explaining the Phenomena of nature, the motions of the Planets & Comets being better explained by gravity without it, & gravity not being hitherto explained by it. It serves only to disturbe & retard the motions of those great bodies & make the frame of nature languish & in the pores of bodies it serves only to stop the vibrating motions of their parts wherein their heat & activity consists.. And as it is of no use & hinders the operations of nature & makes her languish so there is no evidence for its existence; & therefore it ought to be rejected. And if it be rejected, the Hypotheses that light consists in pression or motion propagated <289r> through such a Medium are rejected with it. And for rejecting such a Medium we have also the authority of those the oldest & most celebrated Philosophers of Greece & Phenicia, who made a Vacuum, Atoms & the gravity of Atoms the first principles of their philosophy

I have therefore proposed the Question whether the rays of light may not be small bodies emitted by shining substances. Certainly the resemblance between the rays & such bodies is very great. For such bodies will pass through uniform Mediums in right lines without bending into the shadow which is the property of the rays of light. Pellucid substances act upon the rays of light at a distance in refracting reflecting & inflecting them, & the rays mutually agitate the parts of those substances at a distance for heating them, & this action & reaction very much resembles an attractive force. If refraction be performed by attraction of the rays, the sines of incidence must be to the sines of refraction in a given proportion as we shewed in our Principles of Philosophy; & this Rule is true by experience. If the rays of light in going out of a glass into a Vacuum fall too obliquely on the Vacuum, they are totaly reflected which seems to argue an attraction of the glass. Colours & Refractions depend not on new modifications of light but on the original & unchangeable properties of its rays, & such properties are best conserved in bodies projected. Pressions & motions are apt to receive new modifications in passing through several Mediums but the properties of bodies projected will scarce be altered thereby. Nothing more is requisite for producing all the variety of colours & degrees of refrangibility then that the rays be bodies of different sizes the least of which may make violet the weakest & darkest of colours & be more easily diverted by refracting surfaces from the right course, & the rest, as they are bigger & bigger may make the stronger & more lucid colours, blue green yellow & red & be more & more difficultly diverted. And lastly the unusual refraction of Island Crystal looks very much as if it were performed by some kind of attractive vertue lodged in certain sides both of the rays & of the particles of the crystall. For were it not for some kind of disposition or vertue in some sides of the particles of the crystal which is not in their other sides & which inclines & bends the rays towards the coasts of unusual refraction the rays which fall perpendicularly on the crystal would not be refracted towards that coast rather then towards any other coast, Both at their incidence & at their emergence, so as to emerge perpendicularly by a contrary situation of the coast of unusual refraction at the second surface; the crystal acting upon the rays after they have past through it & are emerging into the air or if you please into a vacuum. And since the crystal by this disposition or vertue does not act upon the rays unless when one of their sides of unusual refraction are $_{\text{look}}$ | $^{\text{are}}$ turned towards that coast this argues a vertue or disposition in those sides of the rays which answers to & sympathizes with that vertue or disposition of the crystal, as the poles of two Magnets answer one to another. And as magnetism may be intended & remitted & is found only in the Magnet & in

iron, so this vertue of refracting the perpendicular rays is greater in Island Crystal less in Crystal of the rock & is not yet found in other bodies. But what ever this vertue be <290r> tis very difficult to conceive how the rays of light, unless they be bodies, can have a permanent vertue in two of their sides opposite one to another which is not in their other sides, & this without any dependence on the Medium through which they are propagated; the like sides of several rays not looking all towards the same coast but being turned several ways before their incidence on the first crystal, & looking indifferently towards any coast as the rays happen to be emitted from shining substances in several positions, & accordingly as they are turned to this or that coast, being refracted at their incidence on the first crystal & again at their emergence out of it some after the usual & some after the unusual manner.

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What is it by means of which bodies act on one another at a distance. And To what Agent did the Ancients attribut the gravity of their atoms. Or what did they mean by calling God an harmony & comparing him & matter to the God Pan & his Pipe.

Can any space be without something in it & what is that something in space void of matter [& what are its properties & operations]

When Oyle of Vitriol is run per deliquium & in destillation the water ascends difficultly & brings over with it some part of the oyle of Vitriol in the form of spirit of Vitriol & this spirit being poured upon iron copper or salt of tartar unites with the body & lets go the water: does not this shew that the acid spirit is attracted by the water & more attracted by the fixt body then by the water & therefore lets go the water to close with the fixt body. And is it not for the same reason that the water & acid spirits in Vinegar, Aqua fortis or Spirit of salt cohere & rise together in destillation; but if the menstruum be poured on salt of tartar of on Lead or iron or any fixt body which it can dissolve the acid by a stronger attraction adheres to the body & lets go the water. And is it not from

of tartar or quick lime the sulphur lets go the Mercury & by a stronger attraction u unites with the fixt body & that Mercury sublimate is sublimed from ♁ or from Regulus of ♁ the spirit of salt lets go the ☿ & by a stronger attraction unites with the antimonial metall & stays with it till the heat be big enough to make them both ascend together & then carries up the metal in the form of a very fusible salt called butter of Antimony, although the Antimony will not ascend, alone being almost as fixed as lead.

When aqua fortis dissolves silver & not gold & aqua regis dissolves gold & not silver may it not be said that Aqua fortis is subtile enough to penetrate ☉as well as silver but wants the attractive force to give it entrance & that Aqua Regis is subtile enough to penetrate silver but wants the attractive force to give it entrance. For aqua Regis is compounded of Aqua fortis [which is subtile enough to enter silver:] &: common salt added to Aqua fortis enables the menstruum to dissolve gold tho the common salt be a gross body. When therefore spirit of salt precipitates silver out of Aqua fortis is it not by attracting mixing with the aqua fortis & repelling the silver. And when water precipitates Antimony out of sublimate of Antimony & Salarmoniac or out of butter of Antimony, is it not done by attracting dissolving & weakening the salarmoniac or the spirit of salt & repelling the Antimony. Is it not also for want of an attractive vertue between the parts of water & oyle, of Quicksilver & Antimony, Lead & Iron that these substances do not mix & by a strong attractive vertue that some bodies mix readily as Quicksilver & Tin, Antimony & Iron, Water & salts & by a weaker one that others mix difficultly as {Q}uicksilver & copper? And is it not in general from the same principle that heat congregates homogeneal bodies & seperates heterogeneal ones.

When Arsnick with soap — — — in sublimation.

When Mercury sublimate sublimed with fresh Mercury becomes dulcis — — — — more strongly. by adhering strongly to the metal

And Doe not the sharp & pungent tasts of acids arise from the strong attraction whereby the acid particles rush upon & agitate the particles of the tongue? And when metals are dissolved in acid menstruums, do not the acids adhering to the metallic particles loose much of their activity & act in a different manner so that the compound has a different tast much milder then before. & sometimes a sweet one. And if the acid be in too small a proportion to make the compound dissolvable in water, will it not become unactive & lose its tast &

the compound be a tastles earth? For such things as are not dissolvable by the moisture of the tongue act not upon the tast

As

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And from the endeavour of the particles of Air to reced from gros bodies it comes to pass that Air is rarer in very slender pipes of glass then in free spaces & by reason of its {rarify} presses less upon the surface of water into which the lower end of the pipe is dipt, then the air presses upon it & so gives leave to the water to ascend in the pipes which is the ground of philtration.

Qu. 21. Do not bodies & light mutualy change into one another. And may not bodies receive their most active powers from the particles of light of which enter their composition? For all fixt bodies emit light so long as they continue sufficiently hot & light mutualy stops in bodies as often as its rays strike upon their parts, as we shewed above. I know no body less apt to shine then water & yet water by frequent destillations changes into fixed earth & this earth shines as much by heat as any other body. The changing of bodies into light & light into bodies is very conformable to the course of nature which seems to delight in transmutations. Water which is a very fluid volatile tastles salt she changes by heat into vapour which is a sort of air & by cold into into ice which is a hard pellucid brittle fusible stone, & this stone returns into water by heat & vapour returns into water by cold. Earth by heat becomes fire & by cold returns into earth. Dense bodies by fermentation rarefy into several sorts of aer & this aer & this aer by fermentation & sometimes without it return into dense bodies. [Quicksilver dropt into a red hot earthen {r}etort ascends in the form of vapour which recondenses into a pellucid liquor like common water in appearance & this liquor being left a few days in the cold air returns in Quicksilver]. All Birds Beasts & Fishes, Trees & other Vegetables with their several parts grow out of water & watry tinctures & by putrefaction return again into watry substances. And water standing a few days in the open Air yeilds a tincture which (like that of Mault) by standing longer yeilds a sediment & a spirit, but before putrefaction is fit nourishment for animals & vegetables And if bodies turn into light & light return into bodies, 'tis a transmutation agreable to the proceeding of Nature in the rest of her works.

Mercury appears sometimes in the form of a fluid ponderous opake bright tastles Metal, sometimes in the form of a hard brittle metal sometimes in the form of a corrosive pellucid salt called sublimate or in that of a tastles pellucid volatile earth called Mercurius dulcis, or of a red opake volatile earth called cinnaber or of a red or white precipitate, or in the form of a fluid salt or in that of air † < insertion from f 292r > † & being dropt into a red hot earthen Retort it destills in the form of common water. < text from f 291v resumes > & after all these & other changes it returns again into Mercury ‡ < insertion from f 292r > ‡ & being agitated in vacuo it shines < text from f 291v resumes > .

Now since light is the most active of all bodies known to us, & enters the composition of all natural bodies, why may it not be the chief principle of activity in them? Attraction ought to be strongest in the smallest particles in proportion to their bulk. Tis much stronger in small magnets in proportion {to} their bulk then in great ones. And considering how much the rays of ligh{t are} bent at {the}ir entrance into pellucid bodies, we may reccon that the attractive power of {the r}ay of light in proportion to its body is as much greater then the gravity of a projectile in proportion to its body as the velocity of the ray of light is greater then the velocity of the projectile & the bent of the ray greater then the bent of the line described by the projectile, supposing the inclination of the ray to refracting surface & that of the projectile to the Horizon to be alike. And by this proportion I reccon the attractive force of rays of light above ten hundred thousand thousand millions of times greater then the force whereby bodies gravitate on the surface of this earth in proportion to the matter in them. supposing that light comes from the Sun to us in about 7 minutes of an hour. And so great a force in the rays cannot but have a very great effect upon the particles of matter with which they are compounded, for causing them to attract one another. Let us therefore see if they have not such attractions

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Now attraction in bodies of the same kind & vertue is strongest in the smallest bodies in proportion to their bulk. It is found stronger in small magnets for their weight then in great ones. For the parts of small ones being close together unite their forces more easily. And therefore the rays of light being the smallest bodies known to us, we may expect to find their attraction very strong in them. And how strong it is may be gathered

by this Rule. The attraction of a ray of light in proportion to its body is to the gravity of a projectile in proportion to its body, as in a compound ratio of the velocity of the ray of light to the velocity of the projectile & of the bent of the ray to the bent of the projetile, supposing the

We have shewed that the attraction of

The smallest particles of matter may cohere by the strongest attractions & compose bigger particles of weaker vertue & many of these may cohere & compose a bigger particle whose vertue is still weaker & so on for divers successions untill the progression end in the biggest particles on which the operations in Chymistry & the colours of natural bodies depend, & which by cohering compose bodies of a sensible magnitude.

Since metals dissolve in acids attract but a smal quantity of the acid, their attractive force can reach but to a small distance from them. And as in Algebra where affirmative quantities vanish & cease, there negative ones begin so in Mechanicks where attraction ceases there a repulsive vertue ought to begin. [By this vertue the rays of light are emitted from shining substances & reflected by the bodies they fall upon & in their passage by the sides of bodies they are bent from the body. And by the same power the particles of air recede from one another, flys walk upon water without wetting their feet, & all dry things are difficultly made to touch one another, & Object glasses of long Telescopes laid upon another will scarce touch so as to make the black spot appear (as is described in the Observation the 1^{t} part of the second book) unless they be pressed together, & when the pressure ceases the glasses recede from one another.] And that there is such a vertue seems to follow from the reflection & inflexion of light. For in both these cases the rays of light are repelled without the immediate contact of the reflecting or inflecting body. It seems also to follow from the emission of light the ray so soon as it is shaken off from a shining body by the vibrating motion of the parts of the body & gets beyond the reach of attraction being driven away with exceeding great velocity. For that force which is great enough to turn it back in reflection may be great enought to give it its motion in emission. It seems to follow also from the production of air vapour the particles of bodies when shaken off from the bodies by heat or fermentation, so soon as they are beyond the reach of attraction recede from the bodies & also from one another with great strength & keepe at a distance. The particles of fluids which do not adhere too strongly to one another & are of such a smallness as renders them most susceptible of those agitations which keep liquor in a fluor, being most easily rarefied, or to use the language of the Chemists, being most volatile. These rarefy into vapor by an easy heat & condense by cold: but those which are larger & less susceptible of agitation or cohere by a stronger attraction are not seperated without a stronger heat or perhaps not without fermentation. And these last are the bodies which Chemists called fixed & which being rarefied become true permanent air; those particles receding from one another with the greatest force which upon contact cohere most strongly. And because the particles of permanent air are grosser & denser then those of vapors, thence it is that true air is more ponderous then vapour & that a moist Atmosphere is lighter then a dry one, quantity for quantity, as **{illeg}**ned by the Barometer.

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And for rejecting such a Medium we have the authority of those oldest & most celebrated Philosophers who made Atoms, Vacuum & the Gravity of Atoms the first principles of their Philosophy, understanding by atoms the least particles of matter & accounting them indivisible not by reason of their littleness but because of their being solids void of all **{**pores**}**, & attributing to every atom a gravity proportional to the quantity of its matter, without assigning the cause of such a gravity.

1 Move in right lines. 4 reflected entire at going out of glass. 5 Original properties immutable no new modifications. 3 proportion of sines. 2 act at a distance. 6 double refraction.

I have therefor proposed the Question whether the rays of light may not be small bodies emitted by shinning substances. Certainly the resemblance between them is very great. For such bodies will pass through uniform Mediums in right lines without bending into the shadow which is the property of the rays of light. Pellucid substances act upon the rays of light at a distance in **{**re**}**fracting reflecting & inflecting them, & the rays mutually agitate the parts of those substances at a distance for heating them & this action & reaction very much resembles an attractive force If refraction be performed by attraction of the rays, the sines of incidence must be to the sines of refraction in a given proportion as we shewed in our Principles: And this Rule is true by experience. If The rays of light in going out of glass into a vacuum fall too obliquely on the vacuum they

are totally reflected, which seems to an attraction of the glass Colours & refractions depend not on new modifications of light but on the original & unchangeable properties of its rays & such properties are best conserved in bodies projected. Pressions & motions are apt to receive new modifications in passing through several mediums but the properties of bodies projected will scarce be altered thereby. Nothing more is requisite for the diversity of colours & degrees of refrangibility then that the rays be bodies of different sizes, the least of which may make violet the darkest of colours , & be most easily diverted by refraction from the right course & the rest as they are bigger & bigger may make the more lucid colours blue green yellow & red, & be more & more difficultly diverted by the refracting surface. And lastly the unusual refraction of Island Crystal looks very much as if it was performed by some kind of polar vertue both in the rays & in the particles of the crystal. For were it not for some kind of polar vertue in the particles of the crystal which draws the rays towards the coast of unusual refraction the rays would not be refracted towards that coast when they fall perpendicularly on the glass. And since the crystal by this vertue does not act upon the rays unless when their sides of unusual refraction are towards that coast this argues a virtue in those two sides of the rays which answers to that vertue of the crystal as the poles of two Magnets answer one to another And as Magnetism is not found in all bodies & may be intended & remitted so this vertue of refracting the perpendicular rays is not found in all refracting substances & is greater in Island Crystal less in Crystal of the rock. But what ever this vertue be tis very difficult to conceive how the rays of light unless they be bodies can have a permanent vertue in two of their sides opposite one to another which is not in their other sides; & this without any dependance on the Medium through which they are propagated; the like sides of several rays looking towards several coasts before their incidence on the first crystal, & being turned indifferently towards any coast as the rays happen to be emitted from shining substance in several positions, & accordingly as they are turned to this or that being refracted at their incidence on the first crystal some after the unusual & some after the usual manner

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And do not hot bodies communicate their heat to contiguous cold ones by the vibrations of this Medium propagated from them into the cold ones. ⊙1 And do not the vibrations of this Medium in hot bodies contribute to the duration of their heat?

Pag. 133. lin. ult. After the word [parts?] add. And do not all bodies which abound with terrestrial parts & especially with suphureous ones, emit light as often as those parts are sufficiently agitated; whether that agitation be made by heat, or by friction or percussion or putrefaction or by any vital motion or any other cause? as for instance, Sea-water in a raging storm, quicksilver agitated in vacuo; the back of a Cat or neck of a horse obliquely struck or rubbed in a dark place; wood flesh & fish while they putrefy; Vapors arising from putrid waters usually called Ignes fatui; stacks of moist hay or corn growing hot by fermentation; glow worms & the eyes of some animals by vital motions; the vulgar Phosphorus agitated by the attrition of any body or by the acid particles of the Air; Ambar & some Diamonds by striking pressing or rubbing them; scrapings of steel struck off with a flint; iron hammered very nimbly till it becomes so hot as to kindle sulphur thrown upon it; the axe trees of chariots taking fire by the rapid rotation of the wheels; and some liquors mixed with one another whose particles come together with an impetus; as Oyl of Vitriol destilled from its weight of Nitre & then mixed with twice its weight of Oyle of Annisseeds. So also a globe of glass about 8 or 10 inches in diameter, being put into a frame where it may be turned swiftly round its axis, will in turning shine where it rubs against the palm of ones hand applied to it, & if at the same time a piece of white paper or white cloth or the end of ones finger be held at the distance of about a quarter of an inch or half an inch from that part of the glass where it is most in motion, the electric vapour which is excited by the friction of the glass against the hand, will by dashing against the white paper cloth or finger be put into such an agitation as to emit light & make the white paper, cloth or finger appear lucid like a glow worm.

Pag. 134 lin. ult. After the word [flame] add: When Gun-powder takes fire it goes away into flaming smoak. For the charcoal & sulphur easily take fire, & set fire to the Nitre, & the spirit of the Nitre being thereby rarefied into vapour, rushes out with explosion much after the manner that the vapour of water rushes out of an olipile; & the sulphur also being volatile is converted into vapor & thereby augments the explosion. Also the acid vapor of the sulphur (namely that which destills under a Bell into Oyle of Sulphur) entring violently into the fixt body of the Nitre, sets loose the spirit of the Nitre, & excites a great fermentation whereby the heat is further augmented & the fixt body of the Nitre is also rarefied into fume, & the explosion thereby

made more vehement & quick. For if Salt of Tartar be mixed with Gun pouder & that mixture be warmed till it takes fire; the explosion will be more violent & quick then that of Gunpowder alone: which cannot be from any other cause then the action of the vapor of the Gunpouder upon the salt of Tartar whereby that salt is rarefied. The explosion of Gunpowder arises therefore from the quick & violent action whereby all the mixture being quickly & vehemently heated, is rarefied & converted into fume or vapour: which vapour by the violence of that action is at the same time heated & becoming red hot appears in the form of flame.

Pag. 135 lin. 16. After the words, [arise from them?] add For if water is made warm in any pellucid vessel, & the Aer is afterwards drawn out of the vessel, that water in the vacuum will bubble & boyle as vehemently as it would in the open aer in a vessel set upon the fire till it conceives a much greater heat. For the weight of the incumbent Atmosphere keeps down the vapours & hinders the water from boyling untill it grow much hotter then is requisite to make it boyle in Vacuo. Also a mixture of Tinn & Lead being put upon a red hot iron in vacuo, emits a fume & also a <295r> flame: but the same mixture in the open air, by reason of the weight of the incumbent Atmosphere does not so much as emit any fume which can be perceived by sight. In like manner the great weight of the Atmosphere which lyes upon the globe of the Sun, may hinder bodies there from rising & going away from the Sun in the form of vapours & fumes unless by means of a far greater heat then that which in the superficies of our Earth would very easily turn them into vapours & fumes: and the same great weight may condense those vapors & exhalations as soon as they shall ascend from the Sun, & make them presently fall back again into the globe of the Sun, & by that action increase the heat of the Sun much after the manner that in our earth the Aer increases the heat of a culinary fire. And the same weight may hinder the globe of the Sun from being diminished unless perhaps by the emission of light, & a very small quantity of vapors & exhalations.

Pag. 134 lin 1 insert Qu. 18B. Do not electric bodies by friction emit a subtile exhalation or spirit by which they perform their attractions? And is not this spirit of a very active nature & capable of emitting light by its agitations? And may not all bodies abound with such a spirit & shine by the agitations of this spirit within them when sufficiently heated? For if a long cylindrical piece of Ambar be rubbed nimbly it will shine in the dark & if when it is well rubbed the finger of a man be held neare it so as almost to touch it, the electric spirit will rush out of the Ambar with a soft crackling noise like that of green leaves of trees thrown into a fire, & in rushing out it will also push against the finger so as to be felt like the ends of hairs of a fine brush touching the finger. And the like happens in glass. If a long hollow tub**{**e**}** of flint glass about an inch be rubbed nimbly with a paper held in the hand till the glass grows warm, it will in rubbing emit light & the face or any other tender part of the skin being held neare that part of the glass where it has been most rubbed, the electric spirit which is excited by the friction will rush out of the glass with a cracking noise & push against the skin so as to be felt, & in pushing emit light so as to make the skin shine like rotten wood or a glow worm. And if the glass was held neare pieces of leaf brass scattered upon a table the electric spirit which issued out of the glass would stir them at the distance of 6, 8 or 10 inches or a foot, & put them into various brisk motions, making them sometimes leap towards the glass & stick to it, sometimes leap from it with great force, sometimes move towards it & from it several times with reciprocal motion, somtimes move in lines parall to the tube, sometimes remain suspended in the air, & sometimes move in various curve lines. Which motions shew that this spirit is agitated in various manners like a wind. And if a broad plate of glass be placed between the Tube & the pieces of brass, yet the Tube will attract them , tho not so strongly as when the plate of glass is taken away. Which shews that the electrick spirit is so subtile as readily to pass through glass tho not so readily as through the Air. And whilst it pervades dense bodies so easily, why may it not be latent in them all in some measure or other, tho those only emitt it by friction in which it abounds most copiously? And since it easily emits light by agitation, why may it not emit light in all dense bodies heated red hot & thereby cause them to shine?

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And if the eye & the finger remain quiet these colours vanish in a second or two of time. But if the finger is moved forwards & backwards alternately these colours appear again while the finger is in motion. Do not — — — stroke? And when a coale of fire moved nimbly in the circumference of a circle makes the whole circumference appear like a circle of fire; is it not because the motions excited in the bottom of the eye by the rays of light are of a lasting nature & continue till the coale in going round returns to its former place? And are not these lasting motions excited in the bottom of the eye of a vibrating nature?

Qu. 17. If a stone be thrown into stagnating water the undulations excited thereby continue for some time in the place where the stone fell into the water, & are propagated thence in concentric circles to great distances. And when When light falls upon the surface of any pellucid body & is there refracted or reflected: do not the vibrations thereby excited in the refracting or reflecting Medium at the surface of the pellucid body continue as long as when they are excited in the bottom of the eye by the pressure & motion of the finger or by the light which comes from the coale of fire in the experiments above mentioned? And are not these Vibrations propagated from thence to great distances? And do they not overtake the rays of light, & by overtaking them successively do they not put the rays into the fits of easy reflexion & easy transmission described above?

Qu. 18. If 2 two little Thermometers be suspended 1 in two larg & tall cylindrical vessels of glass inverted, 3so as not to touch the vessels, & the air be drawn out of one of these vessels: When these vessels are carried into a warm place the Thermometer in vacuo will grow warm almost as soon as the other Thermometer which is not in vacuo. And when the vessels are carried into a cold place, the Thermometer in vacuo will grow cold almost as soon as the other Thermometer. Is not the heat of the warm room conveyed through the Vacuum by the vibrations of a much subtiler Medium. then air which after the Air is drawn out remains in the Vacuum. And is not this Medium the Medium by which light is refracted & reflected? And doth not light communicate heat to bodies by exciting vibrations in this Medium.

Qu. 19. Doth not the refraction of light proceed from the different density of this Medium in different places the light receding from the denser parts of the medium towards the rarer parts thereof? And is not the density thereof greater in free & open spaces void of air & other grosser bodies then within the pores of water, glass, crystal & other compact bodies? [And do not the rays of light recede from the denser parts of the Medium towards the rarer & thereby become refracted?]

Qu. 20. Doth not this Medium in passing out of water glass crystal & other compact & dense bodies into empty spaces, grow denser & denser by degrees, & by that means refract the rays of light not in a point but by bending them gradually in curve lines? And doth not the graduall condensation of this Medium extend to some distance from the bodies & thereby cause the inflexions of the rays of light which pass by the edges of compact bodies at some distance from the bodies.

Qu. 21. Is not this Medium [rarest within the densest bodies? And is it not much rarer within the Sun & Starrs & Planets then without them & in passing from them to great distances , doth it not grow denser & denser perpetually & thereby cause the gravity of those great bodies towards one another & of their parts towards the bodies, every body endeavouring to go from the denser parts of the Medium towards the rarer. For if a Medium be rarer within the suns body then at the distance of the tenth part of an inch from his body & if it be rarer at that distance from him then at the distance of Saturn from surface of the suns body then within him < insertion from f 293v > then at his surface & rarer there then at the distance of the tenth part of an inch from his body, & rarer then at the orb of Saturn: I see no reason why the increase of density should stop any where, & not rather be continued through all the distances from the Sun to Saturn & beyond. And tho this increase of density at great distances may be exceeding slow yet if the elastic force of this Medium be sufficiently great it may suffice

And in Mediums of the same density the elastic force being in a duplicate ratio of the swiftness of the vibrations the elastic force of this Medium must be 490000000000 times greater in proportion to its density then the elastic force of the Air is in proportion to its density. < text from f 295v resumes >

I can see no reason why the increase of density should stop any where & not be continued through all the distances from the Sun to Saturn & beyond. And if the elastick force of this Medium may be very great, it may suffice to impel bodies from the denser parts of the Medium towards the rarer with all that force which wee call gravity. And that the elastick force of this Medium is very great may be gathered from the swiftness of its vibrations. Sounds move about 1140 English feet in a second of time & in eight minutes they move about $103\frac{2}{3}$ English miles. Light moves from the Sun to us in eight minutes which distance is about 72000000 English miles supposing the horizont**{**a**}**ll Parallax of the Sun to be about 12″. And the vibrations of this Medium, that they may cause <293v> the alternate fits of easy transmission & easy reflexion must be swifter then & by consequence above 700000 times swifter then sounds. And therefore the elastick force of this Medium in proportion to its density must be above 700000 x 700000 times greater then the elastick force of the Air is in proportion to its density.

Qu

Qu. 22. Is not vision performed by the vibrations of this spirit excited in the bottom of the eye by the rays of light? & propagated through the uniform solid & pellucid capellamenta of the auditory nerves in the place of sensation. And is not the performed by the vibrations either of this or some other Medium, excited in the auditory nerves by the tremors of the air & propagated through their pellucid capillamenta into the place of sensation. And so of the other senses.

Qu. 23. Is not animal motion performed by the vibrations of this Medium excited in the brain by the power of the will & propagated from thence through the solid & pellucid capillamenta of the nerves into the muscles for contracting or dilating them? I suppose the capillamenta to be solid uniform & pellucid that the motion may be propagated along them uniformly without interruption.

Qu. 24. Do not electric bodies by friction emit a subtile exhalation or spirit by which they perform their attractions? And is not this Spirit – – – – – – – – – – – & thereby cause them to shine.

Qu. 25 Are there not other original properties of light – – – – –

Qu. 23. Is not electrical attraction & repulse performed by an exhalation which is raised out of the electrick body by friction & expanded to great distances & variously agitated like a turbulent wind. & which carrys light bodies along with it. & agitates them in various manners according to it own motions, making them go sometimes towards the electric body, sometimes from it & sometimes move with various other motions? And when this spirit looses its turbulent motions & begins to be recondensed & by condensation to return into the electric body doth it not carry light bodies along with it towards the electrick body & cause them to stick to it without further motion till they drop off? And is not this exhalation much more subtile then common Air or Vapour? For electric bodies attract straws & such light substances through a plate of glass interposed, tho not so vigorously. And may there not be other Exhalations & subtile invisible Mediums which may have considerable effects in the Phænomena of nature?

And the same things have been found by rubbing a long & large cylinder of glass or Ambar with a paper held in ones hand & continuing the friction till the glass grew warm.

Qu. 31. May not the mutual attraction of the small parts of bodies be sufficiently strong to make them cohere & compose very hard bodies

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Qu. 17. Are there not other original properties of the rays of light besides those already described? An instance of another original property we have in the refractions of Island-crystal described first by Erasmus Bartholin & afterwards more exactly by Hugenius in his book De la lumiere.. This crystal is a pellucid fusile stone clear as water or crystal of the rock & without colour, enduring a red heat without losing its transparency & in a very strong heat calcining without fusion. Steept a day or two in water it loses its natural polish. Being rubbed on cloth it attracts pieces of straws & other light things like Ambar or glass: & with Aqua fortis its makes an ebullition. It seems to be a sort of Talc & is found in form of an oblique Parallelopiped with six parallelogram sides & eight solid angles. The obtuse angles of the Parallelograms are each of them 101 degrees & 52 minutes, the acute ones $78^{deg.}\ 8^{min}$. Two of the solid angles opposite to one another as C & E are compossed each of them with three of these obtuse angles & each of the other six with one obtuse <297r> & two acute ones. It cleaves easily in planes parallel to any of its sides & no**{**t**}** in any other planes. It cleaves with a glossy polite surface not perfectly plane but with some little uneavenness. It is easily scratcht & by reason of its softness it takes a polish very difficultly. It polishes better upon polished looking-glass then upon metal & perhaps better upon pitch leather or parchment. Afterwards it must be rubbed with a little oyle or white of an egg to fill up its scratches: whereby it will become very transparent & polite. But for several experiments it is not necessary to polish it. If a piece of this crystalline stone be laid upon a book every letter of the book seen through it will appear double by means of a double refraction. And if any beam of light falls either perpendicularly or in any angle upon any surface of this crystal it becomes divided into two beams by means of the same double refraction. Which beams are of the same colour with the incident beam of light & seem equal to one another in the quantity of their light or very nearly equal. One of

these refractions is One of these refractions is performed by the usual Rule of Opticks, the sine of incidence out of Air into this Crystal being to the sine of refraction as five to three. The other refraction, which may be called the unusuall refraction, is performed by the following Rule.

Let ADBC represent the refracting surface of the Crystal, C the biggest solid angle at that surface, GEHF the opposite surface & CK a perpendicular on that surface. This perpendicular makes with the edge of the crystal CF an angle of $19^{\text{deg.}}$ 3′. Joyne KF & in it take KL so that the angle KCL be 6^{deg} 40′ & the angle LCF $12^{\text{deg.}}$ 23′. And if ST represent any beam of light incident at T in any angle upon the refracting surface ADBC, let TV be the refracted beam determined by the given proportion of the sines 5 to 3 according to the usual rule of Opticks. Draw VX parallel & equal to KL. Draw it the same way from V in which L lieth from K, & joyning TX this line TX shall be the other refracted beam carried from T to X by the unusual refraction.

If therefore the incident beam ST be perpendicular to the refracting surface the two beams TV & TX into which it shall become divided shall be parallel to the lines CK & CL; one of those beams going through the crystall perpendicularly as it ought to do by the usual laws of Opticks, & the other TX by an unusual refraction diverging from the perpendicular & making with it an angle VTX of about $6\frac{2}{3}$ degrees, as is found by experience. And hence the plane VTX & such like planes which are parallel to the plane CFK may be called the planes of perpendicular refraction. And the coast towards which the lines KL & VX are drawn may be called the coast of unusual refraction.

In like manner Crystal of the rock has a double refraction: but the difference of the two refractions is not so great & manifest as in Island Crystal.

When the beam ST incident on Island Crystal <298r> is divided into two beams TV & TX & these two beams arrive at the further surface of the glass, the beam TV which was refracted at the first surface after the usual manner, shall be again refracted entirely after the usual manner at the second surface & the beam TX which was refracted after the un-usual manner in the first surface shall be again refracted entirely after the unusual manner in the second surface, so that both these beams shall emerge out of the second surface in lines parallel to the first incident beam ST.

And if two pieces of Island Crystal be placed one after another in such manner that all the surfaces of the latter be parallel to all the corresponding surfaces of the former: the rays which are refracted after the usual manner in the first surface of the first crystal shall be refracted after the usual manner in all the following surfaces & the rays which are refracted after the unusual manner in the first surface shall be refracted after the unusual manner in all the following surfaces. And the same thing happens tho the surfaces of the Crystalls be any ways inclined to one another provided their planes of perpendicular refraction be parallel to one another.

And therefore there is an original difference in the rays of light by means of which some rays are in this experiment constantly refracted after the usual manner & others **{**are**}** constantly after the unusual manner. For if the difference be not original but arises from new modifications imprest on the rays at their first refraction, it would be altered by new modifications in the three following refractions: whereas it suffers no alteration but is constant & has the same effect upon the rays in all the refracti ons. The unusual refraction is therefore performed by an original property of the rays. And it remains to be enquired whether the rays have not more original properties then are yet discovered.

Qu. 18. Have not the rays of light several sides endued with several original properties? For if the planes of perpendicular refraction of the second crystal be at right angles with the planes of perpendicular refraction of the first crystal the rays which are refracted after the usual manner in passing through the first crystal will be all of them refracted after the unusuall manner in passing through the second crystal & the rays which are refracted after the unusuall manner in passing through the first crystal will all of them be refracted after the usual manner in passing through the second crystal. And therefore there are not two sorts of rays differing in their nature from one another, one of which is constantly & in all positions refracted after the usual manner & the other constantly & in all positions after the unusuall manner. The difference between the two sorts of rays in the experiment mentioned in the 19^{th} Question was only in the positions of the sides of the rays to the planes of perpendicular refraction . For one & the same ray is here refracted sometimes after the usual & sometimes after the unusual manner according to the position which its sides have to the crystalls. If the sides

of the ray are posited the same way to both crystalls it is refracted after the same manner in them both: but if that side of the ray which looks towards the coast of the unusual refraction of the first crystal <299r> be 90 degrees from that side of the same ray which looks towards the coast of the unusual refraction of the second crystal (which may be effected by varying the position of the second crystal to the first & by consequence to the rays of light) the ray shall be refracted after several manners in the several crystals. There is nothing more required to determin whether the rays which fall upon the second crystal shall be refracted after the usual or after the unusual manner but to turn about this crystall so that the coast of this crystalls unusual refraction may be on this or that side of the ray. And therefore every ray may be considered as having four sides or quarters two of which opposite to one another incline the ray to be refracted after the unusual manner as often as either of them are turned towards the coast of unusual refraction, & the other two whenever either of them are turned towards the coast of unusual refraction do not incline it to be otherwise refracted then after the usual manner. The two first may therefore be called the sides of unusual refraction, & the two last the sides of usual refraction. And since these dispositions were in th**{e}** rays before their incidence on the second third & fourth surfaces of the two crystals & suffered no alteration (so far as appears) by the refraction of the rays in their passage through those surfaces, & the rays were refracted by the same laws in all the four surfaces, it appears that those dispositions were in the the rays originally & suffered no alteration by the first refraction & that by means of those dispositions the rays were refracted at their incidence on the first surface of the first crystal some of them after the usual & some of them after the unusual manner accordingly as their sides of usual or unusual refraction were then turned towards the coast of the unusual refraction of that crystal.

† < insertion from the middle of f 298v > †Every ray of light has therefore two opposite sides originally endued with a property on which the unusual refraction depends & other two opposite sides not endued with that property. And it remains to be enquired whether there are not more properties of light by which the sides of the rays differ & are distinguished from one another

In explaining the difference of the sides of the rays above mentioned I have supposed that the rays fall perpendicularly on the first crystal. But if they fall obliquely on it the success is the same. Those rays which are refracted after the usual manner in the first crystal will be refracted after the unusual manner in the second crystal supposing the planes of perpendicular refraction to be at right angles with one another as above, & on the contrary.

If the planes of the perpendicular refraction of the two crystalls be neither parallel nor perpendicular to one another but contein an acute angle: the two beams of light which emerge out of the first crystal will be each of them divided into two more at their incidence on the second crystal. For in this case the rays in each of the two beams will some of them have their sides of usual refraction some of them their sides of unusual refraction turned towards the coast of the unusual refraction of the second crystal. < text from f 299r resumes >

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Qu. 19. Are not all Hypotheses erroneous which have hitherto been invented for explaining the phenomena of light by new modifications of the rays. For those phenomena depend not upon new modifications, as has been supposed but upon the original & unchangeable properties of the rays.

Qu. 20. Are not all Hypotheses erroneous in which light is supposed to consist in pression or motion propagated through a fluid Medium? For in all these Hypothese the phænomena of light have been hitherto explained by supposing that they arise from new modifications of the rays: which is an erroneous supposition.

If light consisted only in pression propagated without actual motionit would not be able to agitate & heat the bodies which refract & reflect it. If it consisted in motion propagated to all distances in an instant, it would require an infinite force every moment in every shining particle to generate that motion. And if it consisted in pression or motion propagated either in an instant or in time it would bend into the shadow. For pression or motion cannot be propagated in a fluid in right lines beyond an obstacle which stops part of the motion, but will bend & spread every way into the quiescent medium which lyes beyond the obstacle. Gravity tends downwards, but the pressure of water arising from Gravity tends every way with equal force & is propagated

as readily & with as much force through crooked passages as through streight ones. The waves on the surface of water passing by the sides of a broad obstacle bend & dilate themselves gradualy into the quiet water behind the obstacle. The waves pulses or vibrations of the Air wherein sounds consist bend manifestly, tho not so much as the waves of water. For a Bell or a Canon may be heard beyond a hill which intercepts the sight of the sounding body, & sounds are propagated as readily through crooked pipes as through streight ones. But light is never known to follow crooked passages nor to bend into the shadow. For the fixt stars by the interposition of any of the Planets cease to be seen, & so do the parts of the Sun by the interposition of the Moon Mercury or Venus. The rays which pass very near to the edges of any body are bent a little by the action of the body as we shewed above, but this bending is not towards but from the shadow & is performed only in the passage of the ray by the body & at a very small distance from it.. So soon as the ray is past the body, it goes right on.

To explain the unusual refraction of Island Crystal by pression or motion propagated has not hitherto been attempted (to my knowledge) except by Hugenius who for that end supposed two several vibrating Mediums within that Crystal. But when he tried the refractions in two successive pieces of that crystal & found them such as is mentioned above: he confessed himself at <301r> a loss for explaining them. For pressions or motions propagated from a shining body through an uniform Medium must be on all sides alike: whereas by those experiments it appears that the rays of light have different properties in their different sides. He suspected that the pulses of Æther in passing through the first crystal might receive certain new modifications which might determin them to be propagated in this or that Medium within the second crystal according to the position of that crystal, but what modifications those might be he could not say nor think of any thing satisfactory in that point.[2] And if had known that the unusual refraction depends not on new modifications but on the original & unchangeable dispositions of the rays, he would have found it as difficult to explain how those dispositions which he supposed to be imprest on the rays by the first Crystal could be in them before their incidence on that Crystal, & in general how all rays emitted by shining bodies can have those dispositions in them from the beginning. To me at least this seems inexplicable if light be nothing else then pression or motion propagated through Æther.

And it is as difficult to explain by these Hypotheses how rays can be alternately in fits of easy reflexion & easy transmission; unless perhaps one might suppose that there are in all space two ethereal vibrating Mediums & that the vibrations of one of them constitute light & that the vibrations of the other being swifter, as often as they overtake the vibrations of the first, put them into those fits. But to allow two æthers where we have no evidence for so much as one, to suppose that two æthers may be together in all spaces without mixing with one another so as to become one Medium & to suppose also that they may have distinct vibrations without making two sorts of light, are difficulties which I cannot get over. And that there are no such fluid Mediums I gather by the regular & very lasting motions of Planets & Comets through the heavens in all manner of positions: For hence it is manifest that the heavens are void of all sensible resistance, & by consequence of all sensible matter.

For the resisting power of fluid Mediums arises partly from the attrition of the parts of the Medium & partly from the Vis inertiæ of the matter. That part of the resistance of a spherical body which arises from the attrition of the parts of the Medium is as the factum of the diameter & the velocity of the spherical body very nearly & that part of the resistance which arises from the Vis inertiæ of the matter is as the square of that factum. And by this difference the two sorts of resistance may be distinguished from one another in any Medium & being distinguished it will be found that almost all the resistance of bodies of a competent magnitude moveing in Air Water & Quicksilver & such like fluids with a competent velocity arises from the Vis inertiæ of the parts of the fluid.

Now that part of the resisting power of any Medium which arises from the tenacity or attrition of the parts of the Medium may be diminished by dividing

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meet before they come into the brain, but the Optick Nerves of such animals as do not look the same way with both eyes (as of Fishes & the Chameleon) do not meet if I am rightly informed

Qu. 16. When a man in the dark presses either corner of his eye with his finger & turns his eye away from his finger, he will see a circle of colours like those in the feather of a Peacocks taile. Do not these colours arise from such motions excited in the bottom of the eye by the pressure of the finger, as at other times are excited there by light for causing vision?

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When I made these Observations I designed to repeat most of them with more care & exactness & to make some new ones for determining the manner how the rays of light are bent in their passage by bodies for making these fringes of colours with the dark lines between them: but I was then interrupted & cannot now think of taking these things into further consideration. And since I have not finished this part of my designe I shall conclude with proposing only some Quæres in order to a further search to be made by others. [who may take these things into consideration]

Quære 1. Do not Bodies act upon light at a distance & by their action bend its rays & is not this action strongest at the least distance. ⊙1 B. Are not &c < insertion from the bottom of f 478r > ⊙ 1 B. Are not the rays of light in passing by the edges & sides of bodies bent several times backwards, & forwards with a motion like that of an Eele. < text from f 477v resumes >

2 Do not the rays which differ in refrangibility differ also in flexibility & are they not & by their different inflexions separated from one another so as after separation to make the colours in the three fringes above described. And after what manner are they inflected to make those fringes.

3 Do not the rays of light which fall upon bodies & are reflected or refracted begin to bend before they arive at the bodies, & are they not reflected refracted & inflected by one & the same Principle acting variously in various circumstances.

4 Do not light & bodies act mutually upon one another, that is to say bodies upon light in emitting reflecting refracting & inflecting it, & light mutu <478r> ally upon bodies for heating them & putting their parts into a vibrating motion wherein heat consists. And do not black bodies conceive heat more easily from light then those ‡ < insertion from lower down f 478r > ‡ A) 4. **{**And**}** Do not black bodies conceive heat more easily from light then those of other colours do, by reason that the light falling on them is not reflected back but enters the bodies & is often reflected & refracted within them before it be stifled & lost. And is not the greatness or vigour the action between light & sulphureous bodies observed above one reason why sulphureous bodies take fire more readily & burn more vehemently then other bodies do? < text from higher up f 478r resumes >

5 Do not all fixt bodies when heated beyond a certain degree emit light by the vibrating motion of their parts.

6 Is not fire a body heated so hot as to emit light copiously. For what else is a red hot iron or a red hot stone then fire & what else is a burning coale then red hot wood whose heat is preserved by the action of an acid spirit in the air acting upon by dissolving the wood

7 Is not flame a vapour fume or exhalation heated red hot that is so hot as to shine For bodies do not flame which do not emit a copious fume.

8 Are not the sun & fixt stars great earths vehemently hot whose heat is conserved by the mutuall action & reaction between them & the light which they emit & whose parts are kept from fuming away by the vast weight of the Atmospheres incumbent upon them.

9 Do not the rays of light in falling upon the bottom of the eye excite vibrations in the Tunica retina which vibrations being propagated along the solid fibres of the Optick Nerves into the brain cause the sense of seeing. * < insertion from the bottom of f 478r > * For since dense bodies conserve their heat a long time & the densest bodies conserve their heat the longest, the vibrations of their parts are of a lasting nature & therefore may be propagated along solid fibres of uniform dense matter to a great distance for conveying into the brain the impressions made upon all the Organs of sense. For that motion which can continue long in one & the same part of a body can be propagated a long way from one part to another supposing the body homogeneal so that the motion may not be reflected refracted interrupted or disordered by any uneavenness

of the body. < text from f 478r resumes > 10 Do not several sorts of rays make vibrations of several bignesses, which according to their bignesses excite sensations of several colours much after the manner that the vibrations of the air according to their several bignesses excite sensations of several sounds? And particularly do not the most refrangible rays excite the shortest vibrations for making a sensation of deep violet, the least refrangible the largest for making a sensation of deep red & the several intermediate sorts of rays vibrations of several intermediate bignesses to make sensations of the several intermediate colours?

11 May not the harmony & discord of colours arise from the proportions of the vibrations propagated through the optic nerves into the brain as the harmony & discord of sounds arises from the proportions of the vibrations of the air. For some colours are agreable as those of gold & Indigo & others disagree.

12. Are not the species of objects seen with both eyes united where the Optick nerves meet before they come into the brain: the fibres on the right side of both Nerves uniting there & after union going thence into the brain in the nerve which is on the right side of the head & the fibres on the left side of both nerves uniting in the same place & after union going into the brain in the nerve which is on the left side of the head & these two nerves meeting in the brain in such a manner that their fibres make but one intire species half of which on the right side of the sensorium comes from the right side of both eyes & the other half of which on the left side of the sensorium comes from the left side of both eyes? For the optic nerves of such animals as look the same way with both eyes (as of Men, Doggs, Sheep, Oxen) meet before they go into the brain, but the optic nerves of such animals as do not look the same way with both eyes (as of Fishes & the Chameleon) do not meet i**{**f**}** I am rightly informed.

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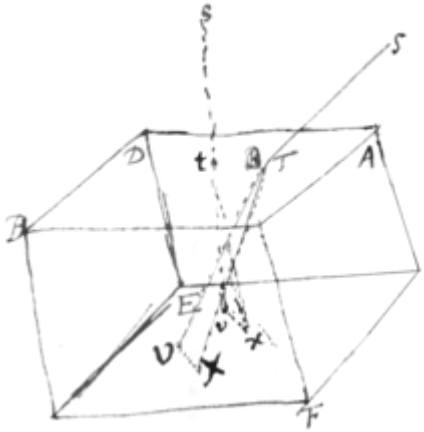
Besides the Refractions hitherto described, there is a refraction of another kind made in Island-glass, which is a sort of Talc or pellucid stone found in Island, in the form of an **{illeg}** parallelopiped, clear as crystall splitting in glossy planes parallel to any of its sides, & enduring a violent fire without fusion. The obtuse angles of its sides or surfaces being 101 degr 52′, & the acute ones 78 ^{degr} 8′ each

If a beam of light fall perpendicularly upon any surface of this glass, this beam in passing through that **{**surface**}** shall part into two beams one of which shall go perpendicularly through the glass **{illeg}** to do according to the rules of Opticks & the other beam shall start **{illeg}**varicate from the former beam in an angle of about 6° 40′ & when it arrives **{illeg}** other side of the glass falling upon it obliquely in an angle of 83° 20′ it shall **{illeg}** perpendicularly out of the glass. And if the beame of light fall upon the first surface of the glass in any oblique **{illeg} {**this**}** beame shall there divide into two beames one of which shall be refracted **{**according**}** to the known laws of Opticks the sine of incidence being to the sine of refraction **{illeg}**, & the other shall be refracted according to another law.

This **{illeg} {**instance**}** with its wonderfull refraction was first described by Erasmus Bartholine **{illeg}** more exactly by Hugenius in his Treatise of light written **{illeg}** ABCDEF represent



a p**{illeg}** bounded with six parallelogram sides or six **{illeg}** whose **{**obtuse**}** angles are each of them 101° 52′ & their acute ones 68° 8′. And let three of the obtuse angles lye about the solid angle C & other three about the opposite solid angle E the other six solid angles being composed each of them with one obtuse & two acute ones And let the two biggest solid angles C & E composed of three obtuse ones be called the principal solid angles. & the plane which is perpendicular to the refracting surfaces & bisects either of their

obtuse angles be called the principal planes. And let ST represent a beam of light falling on the first surface of the glass AB at the point T & being there refracted. This beam ST shall divide it self into two beams TV & TX some of the rays in the beam ST being refracted according to the known law of Opticks & going in the beam TV to the place V in the further surface of the glass the sine of the refraction of these rays being to the sine of their incidence as 3 to 5. And the rest of the rays in the beam ST being refracted according to another law & going in the beam TX to another place X in the further surface of the glass. which place X is thus found.

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Find the line N which is in such proportion to the thickness of the glass or distance between the two refracting surfaces as the sine of 6° 40′ is to the Radius. Then from the point V upon the further surface of the glass draw he line VK equal to the line N & parallel to the lines which bisect the obtuse angle F of the further surface which is adjacent to one of the lesser solid angles, & you will have to point X to which the beam TX shal go.

Ph. 3 When these two beams of light TV & TX arrive at the further surface of the glass the beam TV which was refracted at the first surface after the usual manner shall be again refracted entirely after the usual manner at the second surface & the beam TX which was refracted after the unusual manner in the first surface shall be again refracted entirely after the unusuall manner in the second so that both these beams shall emerge out of the second surface in lines parallel to the first incident beam ST.

Ph. 4 If two or more pieces of Island glass be placed one after another in such manner that all the surfaces of the latter be parallel to all the corresponding surfaces of the first, the rays which are refracted after the usual manner in the first surface of the first glass will be refracted after the usual manner in all the following surfaces & the rays which are refracted after the unusual manner in the first surface will be refracted after the unusual manner in all the following surfaces. And therefore there is a difference in the rays of light by means of which one sort of rays is constantly refracted after the usuall manner & the other sort constantly after the unusual manner; & this difference was in the rays before their first refraction as well as before the latter refractions because it had the same effect upon them in all the refractions.

Ph. 5 And tho the surfaces of the glasses are any ways inclined to one another yet if their planes of perpendicular refraction be parallel to one another the rays which are refracted after the usual manner in the first surface are refracted after the usual manner in all the following surfaces & the rays which are refracted after the unusual manner in the first surface are refracted after the unusuall manner in all the following surfaces.

Ph. 6. But if the planes of perpendicular refraction of the second glass be at right angles with the planes of perpendicular refraction of the first glass: the rays which are refracted after the usuall manner in passing through the first glass will all of them be refracted after the unusual manner in passing through the second glass & the rays which are refracted after the unusual manner in passing through the first glass will all of them be refracted after the usual manner in passing through the second glass. And therefore there are not two sorts of rays differing in nature from one another one of which is refracted constantly & in all positions after the usual manner & the other constantly & in all positions after the unusual manner The difference in the foregoing experiment was only in the position of the sides of the ray to the coast of unusual refraction For by this experiment it appears that one & the same way is refracted sometimes in the usual & sometimes in the unsual manner according to the position which its sides have to the glass. not according to the position or bigness of the angle of incidence but according to the position of the sides of the ray to the planes of perpendicular refraction of the glass. Let every ray be conceived to have four sides or quadrants two of them opposite to one another which incline the ray to be refracted unusually & other two opposits which do not incline it to

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And let the planes which are perpendicular to the refracting surfaces of the glass & parallel to the lines which bisect the other **{illeg}**angles of that parallelogram surface be called the planes of perpendicular refraction. For if a **{**beam**}** of light fall perpendicularly upon any surface of this glass it shall at the point of incide**{**nce**}** divide into two beames one of which shall go perpendicularly into the glass as it ought to do by the usual

rules of Opticks, the other shall start aside & diaricate from the perpendicular ray making with it an angle of 6° 40′, & going through the glass in the plane of perpendicular refraction & bending from the perpendicular towards the sides of the glass which with the refracting plane comprehend one of the two begger solid angles. Let ST represent the beam incident at T perpendicularly on the surface ACBD, & this beam at the point of incidence T shall become divided into **{**the**}** beame TV & TX one of which TV shall go perpendicularly into the glass, the other TX shall shall go into it obliquely making with the perpendicular an angle VTX of 6° 40′ [who**{**se**}** plane VTX is parallel to the planes of perpendicular refraction] & **{illeg}** from it in the plane of perpendicular refraction VTX towards th**{**e**} {illeg}** of the glass AF & BF which with the refracting surface AB **{**conteine**}** the solid angle C which is one of the two biggest solid angles. let the two rays TV & TX fall upon the further side of the glass EF at the points V & X & draw the line VX [& this line VX will be to the thickness of the glass or distance between the planes AB & EF as the tangent of 6 40 to the radius & be parallel to the lines which bisect the obtuse angles E & F of that further side of the glass]

Now let ST represent any other beam of light incident obliquely on **{**AB**}** the first surface of the glass AB & let the point of incidence be T & this beam shall also be divided at the point of incidence T into two beams TV & TX one of which TV shal be refracted after the usual manner, the sine of incidence being to the sine of refraction as five to three, Let this beame fall upon the further surface of the glass EF at the point V. Draw the line VX equal & parallel to the line VX. Draw it the same way from V which the line VX lies from V & joyning TX this line TX shall be the other beam of light carried by the unusual refraction from T to V.

When these two beams &c

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Qu. 23. By what means do bodies act on one another at a distance. The ancient Philosophers who held Atoms & Vacuum attributed gravity to Atoms without telling us the means unless perhaps in figures: as by calling God Harmony & representing him & matter by the God Pan & his Pipe, or by calling the Sun the prison of Jupiter because he keeps the Planets in their orbs. Whence it seems to have been an ancient opinion that matter depends upon a Deity for its laws of motion as well as for its existence. The Cartesians make God the author of all motion & its as reasonable to make him the author of the laws of motion. Matter is a passive principle & cannot move it self. It continues in its state of moving or resting unless disturbed. It receives motion proportional to the force impressing it. And resists as much as it is resisted. These are passive laws & to affirm that there are no other is to speak against experience. For we find in our selves a power of moving our bodies by our thought Life & will are active Principles by which we move our bodies, & thence arise other laws of motion unknown to us.

And since all matter duly formed is attended with signes of life & all things are framed with perfect art & wisdom & Nature does nothing in vain; if there be an universal life & all space be the sensorium of a thinking being who by immediate presence perceives all things in it as that which thinks in us $_{\text{perceives}}$ | $^{\text{see}}$ their pictures in the brain: the laws of motion arising from life or will may be of universal extent.

— those laws. To some such laws the ancient Philosophers seem to have elluded when they called God H**{**arm**}**ony, & signified his actuating matter harmonicaly by the God Pan's playing upon a Pipe & attribute musick to the spheres made the distances & motions of the heavenly bodies to be harmonical, & represented the Planets by the seven strings of Apollo's Harp.

——— If you think that the Vis inertia is sufficient for conserving motion, pray tell me the Experiments from whence you gather this conclusion. Do you learn by any experiment that the beating of the heart give no new motion to the blood, that the explosion of Gunpouder gives no new motion to **{**a**}** bullet or that a man by his will can give no new motion to his body? Or do you learn by experiment that the beating of the heart takes away as much motion from something else as it gives to the blood or that explosion takes away as much motion rom something else as it gives to a bullet or that a man by his will takes away as much motion from something else as he gives to his body? If so, tell me your experiments **{**;**}** if not, your opinion is Reasoning without experience is very slippery. A man may puzzle me by arguments against local**{**ized**}** motion but I'le beleive my eyes. A man may may bring plausible arguments against the power of the will but I'le beleive experience. A man may argue plausibly for blind fate against final causes but I find by experience that I am constantly aiming at something. Were it not for experience I should not know that matter is heavy or

impenetrable or moveable or that I think or am or that there is matter or any thing else. And therefore to affirm any thing more then I know by experience & good reasoning upon it is precarious. Even arguments for a Being if not taken from Phænomena are slippery & serve only for ostentation. An Atheist will allow that there is a Being absolutely perfect, necessarily existing & the author of mankind & call it Nature: & if you talk of infinite wisdom or of any perfection more then he allows to **{**say**}** in **{**natur**}** heel reccon at a chemæra & tell you that you have the notion of finite or limited wisdom from what you find in your self & are able of your self to **{**prefin**}** the word no**{**t**}** or more then to any verb or adjective & without the existence of wisdome not limited or wisdome more then finite to understand the meaning of the phrase as easily as Mathematicians understand what is meant by an infinite line or an infinite area. And heel may tell you further that the

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And While these powers are of so large extent, I do not see but that they may be numbred among the general laws of motion. The Vis inertiæ is a passive principle by which bodies persist in their motion or rest, receive motion in proportion to the force impressing it & resist as much as they are resisted: By this principle alone there could never have been any motion in the world. Thinking is an active principle by which we move our bodies according to our will, & thence arise other laws of motion unknown to us, which if **{**all**}** the Universe be the sensorium of a thinking Being, may be of greater entent. Gravity was recconed among the laws of motion by the ancient Philosphers who attributed gravity to their Atoms in vacuo, & the forces above mentioned by which smal bodies act on one another at small distances may have a good a title as gravity to be recconed among those laws.

But while I call those forces attraction & repulse I would not be understood to define the cause or manner of the action. That which I call attraction may be done by impulse or by some other meane unknown to me. I only use that word to signify a force by which bodies tend towards one another whatever perfect Art & be the cause duly formed is attended with signes of life: & if since all things are framed with wisdome & Nature does nothing in vain all matter if there be an universal life & all space be the sensorium of a thinking Being & finite things **{illeg}** be instead of their sensible pictures formed by motion in our Brain; those laws may be of Universal extent.

I have hitherto been arguing from the effects to their causes & carried the argument up to certain forces by which little bodies act on one another at small distances. These forces may be recconed among the laws of motion, but whether they depend on Bodies alone considered only a long broad & thick bodies alone may be a question For are passive. By their vis inertiæ they continue in their state of moving or resting & receive motion proportional to the force impressing it & resiste as much as they are resisted, but they cannot move themselves; & without some other principle then the vis inertiæ there could be no motion in the world. And if there be another Principle of motion there must be other laws of motion depending on that Principle. And the first thing to be done in Philosophy is to find out all the general laws of motion on which the frame of nature depends. We find in our selves a power of moving our bodies by our thoughts] & see the same power in other living creatures but how this is done & by what laws we do not know. We cannot say that all Nature is not alive. not know her laws or powers any further then we gather them from Phænomena.

If the body is compact & bends or yealds inward to pression without any sliding of its parts, it is hard & elastic returning to its figure with a force arising from the mutual attraction of its parts. If the parts slide upon one another the body is maleable and soft. If they slip easily & are of a size most apt to be agitated by heat & the heat is big enough to keep its parts in agitation the body is fluid, & if it be apt to stick to things it is humid; & the drops of every fluid affect a round figure by the mutual attraction of its parts as the globe of the earth & sea affects a round figure by the mutual attraction of its parts by gravity.

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But how two Æthers can be diffused through all space one of which acts upon the other & by consequence is reacted upon, without retarding slackening shattering & confounding one anothers motions, is inconceivable. And against filling the heavens with fluid Medium unless they be exceeding rare a great objection arises from the regular & very lasting motions of the Planets & Comets through the heavens in all — — —

By a vacuum I do not mean a space void of all substances. Glass cannot attract light without a Medium. I mean only such a Vacuum as may be made by drawing Aer out of a vessel of glass.

What I mean in this Question by a Vacuum, & the attractions of the rays of light towards the glass or crystall, may be understood by what was said in the 18th Question.

Now in bodies — — — — — forces more easily. And for the like reason Gravity in the surfaces of small globes is greater in proportion to the globes then in the surfaces of great globes of equal density. And therefore since the rays of light are the smallest bodies yet known to us (For I do not here consider the particles of æther) we may expect to find their attractions very strong. And how strong they are may be gatherred by this Rule — — — — — — —; — to be above an hundred million of millions of millions of times greater in proportion to the matter in them then the gravity of the Earth towards the Sunn in proportion to the matter in it.

As attraction is stronger in small magnets then in great ones in proportion to their bulk, & gravity is greater in the surfaces of small Planets then in those of great ones in proportion to their bulk so the smallness of the rays of light may very much contribute to the force by which they are refracted. And so if any one should suppose that Ether (like our aer) may **{**containe**}** particles which endeavour to recede from one another (for I do not know what the Ether is) & that its particles are exceedingly smaller then those of aer, or even the**{**ir**}** those of light, the the exceeding smalness of its particles may contribute to the greatness of the force by which those particles recede from one another & thereby make that medium exceedingly more rare & elastick then Aer.

And that the gravity of the Planets towards the Sun may not be thought too great to be produced by the cause of gravity here suggested: upon a fair computation it will found that the gravity of our earth towards the Sun in proportion to the quantity of its matter is above ten hundred millions of millions of millions of millions of times less then the force by which a ray of light in entring into glass or crystall is drawn or f**{**orced**}** impelled towards the refracting body. And therefore the gravity of the earth towards the Sun requires a variation of the density of the Ether at the Orb of the Earth an hundred millions of millions of millions of millions of times slower then the variation of the density of the Ether at the surface of glass or crystal requisite to refract light. For the velocity of light is to the velocity of the Earth in the Orbis magnus as 58 days the time in the Earth describes the ; that is an earth equal to the radius of its orb to about 7 minutes, the time in which light comes fro ⊙ to **{**as**}** as about 12000 to 1. And the the curvity of a ray of light during it refraction at the surface of glass on which it falls very obliquely, is to the curvity of the earths Orb, as the radius of that Orb to the radius of the curvity of the ray or as above 1000000000000000000 to 1. And the force which bends the ray is to the force which keeps the earth or any Projectile in its orb or line of Projection in a ratio compounded of the duplicate ratio of the velocities & this ratio of the curvities of the lines of projection.

The Atmosphere by its weight presses the Quicksilver into the glass to the height of 29 or 30 inches. And some other Agent raises it higher, not by pressing it into the glass but by making its parts stick to the glass & to one another. For upon any discontinuation of parts made either by bubbles or by shaking the glass, the whole liquor falls down.

<621v>

And if it were not for these Principles the Bodies of the Earth Planets Comets Sun & all things in them would grow cold, & freeze & become inactive masses, & putrefaction generation vegetation & life would cease, & the Planets & Comets would not remain in their Orbs.

— causes be not yet explained. For these are manifest qualities & their causes only are occult. [Occult qualities are not manifest qualities but are specific qualities which do not yet appear but are only supposed to be in the species for producing manifest effects whose causes are unko] To tell — — extent & leave their causes to be enquired into.

of any third thing. The Organs of sense are not for enabling the soul to perceive the species of things in its Sensorium, but only for conveying them thither & God has no need of such Organs, . he being every where present to the things themselves.

& in arguing from them by Induction & admitting of no objections but from Experiments this sort of argument is not demonstrative but yet it is the best which the nature of things admits off, & may be looked

upon as so much the stronger by how much the induction is more general. And if no exception occur from Phenomena, the Conclusion may be pronounced generally. But if at any time afterwards any exception occur from Experiments, it may then begin to be pronounced with such exceptions as occurr.

— & admitting of no objections against the conclusions but such as are taken from Experiments. For Hypotheses are not to be regarded in Experimental Philosophy. Nor are we here to regard Metaphysical Principles unless so far as they are founded upon experience. For all Metaphysicks not founded upon experience is Hypothetical: And so far as Metaphysical Propositions are founded upon experience they are a part of experimental Philosophy. Even that celebrated Proposition Ego cogito ergo sum is known to us by experience. We know that we think by an inward sensation of our thoughts. And therefore from that Proposition we cannot conclude that any thing more is true then what we deduce from experience † < insertion from lower down f 622r > †

†And even in proving a Deity all aguments not taken from Phænomena are little better then dreams. Now {altho} the arguing from experiments & observations by Induction be no demonstration of general Propositions, yet it is the best way of

Even in Metaphy < text from f 621v resumes > . Now altho the arguing from experiments & observations by Induction is not fully demonstrative yet it is the best way of arguing which the nature of things admits of, & may be looked — — — as ocean. By this way of arguing we may proceed from compositions to ingredients & from motions to the forces producing them & in general from effects — — — the most general. This is the Analysis & the Synthesis consists in assuming

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If two plane polished plates of glass three or four inches broad & about twenty long be laid one of them parallel to the horizon the other upon the first so as to touch it & make an angle with it. of about 10 or 15 minutes at one of their ends & the same be first moistened on their inward sides with a cleane cloth dipt into oyle of Oranges, & rubbed upon it & a drop or two of the oyle be let fall upon he lower glass at the other end: so soon as the upper glass is laid down upon the lower so as to touch it at one end & to touch the drop at the other end making with the lower glass an angle of about 10 or 15 as above; the drop will begin to move towards the concourse of the glasses & will continue to move with an accelerated motion till it arrives at that concourse of the glasses. [And if you then open the glasses where they met & touched & make them meet & touch at their other end in the same acute angle as before; the drop will run back to that end of the glasses where they now touch, & where it was at first.] For the two glasses attract the drop, & by the attraction make it run that way towards which the attractions incline. And if when the drop is in motion you lift up that end of the glasses where they meet & towards which the drop moves: the drop will ascend between the glasses, & therefore is attracted. And as you lift up the glasses, more & more the drop will ascend slower & slower & at length rest. And when you see it rest you may reccon that it then carried downward by its weight as much as upwards by the attraction. And thereby you may know the force by which the drop is attracted at all distances from the contact of the glasses. And by some experiments, the attraction is almost reciprocally as in a duplicate proportion of the distance of the {middle} of the drop from the concours of the glasses. viz reciprocally in a simple proportion by reason of the spreading of the drop & its touching the glasses in alarger surface; & again reciprocally in a simple proportion by reason of the attractions growing stronger within the same quantity of attracting surface. The attraction therefore within the same quantity of surface is reciprocally as the distance between the glasses. And therefore where the distance is very small, suppose the ten-thousand-thousandth part of an inch, the attraction must be exceeding great; so great perhaps as within in a circle of an inch in diameter to suffice to hold up a weight equal to a cylinder of water of an inch in diameter, & above a mile in length. There are therefore Agents in Nature able to to make the particles of bodies attract one another very strongly & to stick together strongly those by attractions. One of those Agents may be the Æther above mentioned whereby light is refracted. Another may be the Agent or Spirit which causes electrical attraction. For tho this Agent acts not at great distances except when it is excited by the friction of electrick bodies: yet it may act perpetually at very small distances without friction, & that not only in bodies accounted electric, but also in some others. And there are still other mediums which may cause attractions, (such as are the Magnetick effluvia; it is the business of experimental Philosophy to find out all these Mediums with their properties.

Now the smallest particles of matter may cohere

By the Table in the second part of the second Book wherein the thicknesses of coloured plates of water between two glasses are set down, the thickness of the plate where it appears very black is three eighths of the thousand-thousandth part of an inch. And where the Oyle of Oranges between the glasses is of this thickness, the attraction seems to be so strong as within a circle of an inch in diameter to suffice to hold up a weight equal to that of a cylinder of water of an inch in diameter & two or three furlongs in lenghth And where it is of a less thickness the attraction may be proportionally greater. & increase untill the thickness be no bigger then that of a single particle of water.

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For the Velocitys of the pulses of Elastick mediums are a subduplicate ratio of the elasticityes directly & densities inversely. For the squares of the velocities of the pulses of Elastick Mediums are as the elasticities & the rarities of the Mediums taken together

The parts — — — — any sensible effect. All bodies — — — — difficult to conceive The same thing — — — — cohesion of its parts. It is not therefore by the pressure of the Æther upon the outside of the Marbles or Mercury (tho such a pressure may contribute to the effect) but by the action of either that or some other Medium or Mediums upon the inward parts of those bodies by which the contiguous parts of the Marbles & those of the glass & Mercury stick to one another. The like Experiment hath been tried with water — — — — amongst themselves.

And of the same kind with these Experiments are those that follow. If two plane polished plates of glass (suppose two pieces of a broken looking-glass) bee laid together so that their sides be parallel & at a very small distance from one another; & then their lower edges be dipped into water; the water will rise up between them. And the less the distance of the glasses is the greater will be the height to which the water will rise. If the distance be about the hundreth part of an inch, the water will rise to the light of about an inch & if the distance be greater or less in any proportion, the height will be reciprocally proportional to the distance very nearly. For the attractive force of the glasses is the same whether the distance between them be greater or less & the weight of the water drawn up is the same if the height of it be reciprocally proportional to the distance between the glasses. [And in like manner water ascends between two Marbles polished plane, when their polished sides are parallel , & at a very little distance from one another.] And if slender pipes of glass be dipt at one end into stagnating water the water will rise up within the pipe & the hight to which it rises will be reciprocally proportional to the diameter of the cavity of the pipe & will equall the height to which it rises between two planes of glass if the semidiameter of the cavity of the Pipe be equal to the distance between the planes, or thereabouts. And these experiments suceed after the same manner in vacuo as in the open air, & therefore are not influenced by the weight or pressure of the Atmosphere.

And if a wide pipe of glass be filled with sifted ashes well pressed together in the glass & one end of the pipe be dipped into stagnating water; the water will rise up slowly in the glass so as in the space of a week or afortnight to reach up to 30 or 40 inches above the surface of the stagnating water. And the water is raised to this height by the attraction of those particles of the ashes only which are upon the surface of the elevated water; the particles which are within the water, attracting it as much downwards as upwards. And therefore the attraction is very strong but it would be much stronger if the ashes upon the surface of the attracted water were one continued body, as the glass is which keeps quicksilver suspended to the hight of above 60 or 70 inches, & therefore attracts with a force which would keep water suspended to the height of above fifty feet. And the particles of glass, which lie closer to one another then they do or the quicksilver **{**mor**}** attracts one another with a force much stronger.

By the same principle a sponge sucks in water, & the glands in the bodies of animals according their several natures & dispositions suck in various juices from the blood

[1] Mais pour dire comment cela se fait, je n'ay rien trove jusqu' ici qui me sati fasse. C.H. de la lumiere. c. 5. p 91.

[2] Mais pour dire comment cela se fait, je n'ay rien trouvé jusqu'ici qui me satisfasse. C.H. De la lumiere. c. 5. p 91.