THE WORKS

OF

FRANCIS BACON.

W M Spalding

THE

WORKS

OF

FRANCIS BACON,

BARON OF VERULAM, VISCOUNT ST. ALBANS, AND
LORD HIGH CHANCELLOR OF ENGLAND.

Collected and Edited

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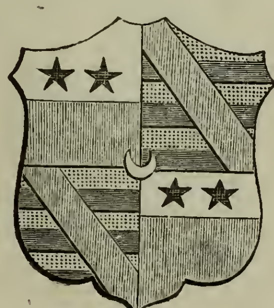
VOLUME IV.



NEW YORK:
HURD AND HOUGHTON, 401 BROADWAY.
BOSTON: TAGGARD AND THOMPSON.
MDCCCLXIV.

RIVERSIDE, CAMBRIDGE:
STEREOTYPED AND PRINTED BY
H. O HOUGHTON.

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OF

THE FOURTH VOLUME.

PHILOSOPHICAL WORKS.

PART I. — CONTINUED.

WORKS PUBLISHED, OR DESIGNED FOR PUBLICATION, AS PARTS OF THE INSTAURATIO MAGNA.

HISTORIA DENSI ET RARI.

PREFACE

TO THE

HISTORIA DENSI ET RARI.

BY ROBERT LESLIE ELLIS.

The following treatise, which is one of the five histories mentioned in the *Historia Naturalis*, was published in 1658 by Dr. Rawley. A good deal of its contents occur in an imperfect and fragmentary state in the *Phænomena Universi*.[1]

It has somewhat the appearance of having been left unfinished, and excepting a table of specific gravities and an account of the way in which this table was constructed, contains little that is now of interest. The table occurs also in the *Phænomena Universi:* in the *Historia Densi et Rari* one substance is omitted and six added, so that the whole number of substances men-

[1] One of the fragments published by Gruter in 1651, which will be printed in Part III. of this edition. My own impression is that much of the first portion of the present treatise — from the first *tabula* down to the *monitum*, p. 53. — is of earlier date than Gruter's copy, and less perfect; and that the remainder only — extending from the first *connexio* to the end — is to be regarded as the *Historia Densi et Rari* which Rawley mentions as having been composed by Bacon during his last *quinquennium;* the previous part being made up of notes and loose papers written at various times, many of them long before, and never digested into order. See my note at the end of this preface. — *J. S.*

tioned, which is seventy-three in the former, is seventy-eight in the latter work.

This table of specific gravities is the only collection of quantitative experimental results that we find in Bacon's works. Few experiments of the same kind had previously been made. The method which Bacon employed enables us to form some opinion as to the amount of his acquaintance with mathematical physics.

The first table of specific gravities was constructed by Marinus Ghetaldus,[1] whose *Archimedes Promotus* was published in 1603. It contains only twelve substances, and is therefore, so far as the number of experiments is concerned, much inferior to Bacon's. But on the other hand Ghetaldus is the author of the method of finding specific gravities which, with certain modifications and corrections, has remained in use to the present day, whereas no one, probably, has attempted to find specific gravities by Bacon's process. The principle of Ghetaldus's method consists in weighing the substance which is to be examined in air and in water, and thus ascertaining the weight of the water which it displaces. By this method the comparison of the densities of different substances is made to depend on the first principles of hydrostatics. The often-told story of Archimedes and Hiero's crown contains the germ of the same method; and it is probably from this that Ghetaldus took the title of his book. It contains

[1] It appears from Harriot's papers, now in the British Museum, that before the publication of the *Archimedes Promotus*, he knew how to determine specific gravities by weighing in air and water. We are not however entitled to assert, as Baron Zach has done, that his experiments preceded those of Ghetaldi. See the supplement to Dr. Bradley's Miscellaneous Works, by Prof. Rigaud, pp. 43 and 51.

however, beside the tables of specific gravities, certain corollaries from propositions in Archimedes's treatise on the equilibrium of floating bodies, enough to show that Ghetaldus was entitled to profess himself a follower of Archimedes.[1] Towards the end of his treatise he tells the story of Archimedes and Hiero, and remarks on the practical defects of the method which Archimedes employed. The chief inaccuracy arises from the effect of capillary attraction on the surface of the water, which makes it difficult to know when the vessel, into which the crown or other substance to be examined is introduced, is only just full. Ghetaldus's remark, that the water which overflows cannot be collected and measured without loss, is no doubt correct; but it does not seem that this way of trying the experiment was employed by Archimedes. After putting the crown into a vessel full of water and thus making a part of the water overflow, he filled the vessel again, measuring the quantity of water poured in. Repeating this experiment with a mass of gold equal in weight to the crown, and then again with a mass of silver also of equal weight, he found that the crown displaced more water than the gold and less than the silver, and thereby showed that the crown was not of pure gold. It does not seem, from what Vitruvius says, that Archimedes calculated the amount of alloy which it contained. In truth he had not sufficient data for the purpose, unless it was clear that the gold was alloyed only with silver.

After pointing out the defects of Archimedes's method, Ghetaldus remarks that they are effectually avoided

[1] "Isti vero opusculo nomen ab Archimede, quem ducem sequor, imposui"

by weighing the body in air and water, in the manner which he has already described. In this manner it is not necessary to take masses of equal weight in air, in order to compare the specific gravities; any particle of each is sufficient for the required experiments.

The simplicity and modesty of Ghetaldus's style — he says of himself, "is enim ego sum, qui malim scire quam nosci; discere quam docere:"[1] — make us unwilling to believe that he was aware that the method of weighing in air and water, in order to compare specific gravities, was not new. Yet it had been given in a slightly different form in one of the most popular books of the time, — the *Natural Magic* of Porta. The error however which Porta has made in applying it seems to be good evidence in favor of Ghetaldus, who would scarcely have omitted an opportunity of pointing it out.

Porta, like Ghetaldus, tells the story of Hiero's crown, and after saying something of the practical objections to the method which Archimedes employed, goes on to remark that the method he is about to describe is so much better than the old one, "ut dicere possimus ὑπερεύρηκα ὑπερεύρηκα."[2] Take, he says, the metal whose purity is to be examined, and an equal weight of the same metal known to be free from all alloy. Place them in the scales of an accurate balance, and when they are in equilibrium, immerse both scales in water. It will be seen that the impure metal will rise, and that the other will sink. Thus, in the case

[1] "I had rather know than be known," is one of the sentences in Bacon's *Promus*. — *J. S.*

[2] There is, of course, no such word as ὑπερευρίσκω, nor would it mean what Porta wishes to express. But his meaning is obvious.

of gold alloyed with silver, if we would know how much silver it contains, we must put it in the one scale, and in the other as much pure gold as will produce equilibrium under water. Then lift both scales out of the water, and determine the excess of weight which was necessary to produce equilibrium in the water. This excess is the weight of the alloy. Again, if you would know how much gold there is in the gilding of a silver vessel: Put the vessel in one scale, and balance it in air with pure silver: put both scales into water; and the weight of the gold which must be added to the pure silver in order to restore the balance is the weight of the gilding. Both these methods are entirely wrong.[1] But Porta goes on, after remarking that they are applicable to other alloys beside that of gold and silver, to give certain statements of the weight of iron and other metals as weighed in air and in water, which constitute in effect a table of specific gravities. For some reason or other, they almost all err in the same direction, making the substances to which they relate appear lighter than they really are. Probably Porta forgot that the scale in which the body was placed, was itself buoyed up by the water. However that may be, he says that an iron ball weighing

[1] If, in the case of the first, ρ and σ are respectively the densities of gold and silver, and v, u, and V the volumes of the gold in the debased metal, of the silver, and of the pure gold respectively; then, as they balance in water,

$$\rho v + \sigma u - (v + u) = (\rho - 1) V:$$

and if the excess of weight in air is w, then

$$\frac{w}{g} = \rho v + \sigma u - \rho V = v + u - V = u - \frac{\sigma - 1}{\rho - 1} u,$$

$$\text{or} \quad w = g \frac{\rho - \sigma}{\rho - 1} u, \text{ instead of } = g \sigma u.$$

And similarly in the second case.

nineteen ounces in air weighs fifteen in water, which would make the specific gravity of iron only four and three quarters. Similarly a ball of lead of thirty-one ounces in air loses four ounces in water: so that the specific gravity of lead is less than eight. He states similar results for six kinds of gold; the highest specific gravity being seventeen. The error in this case may have been caused by the alloy; which is the more probable, as in the case of silver his result is almost absolutely accurate. Silver weighing a hundred and twenty-five grains in air weighs a hundred and thirteen in water. This gives a specific gravity of 10·41. For the precious metals he probably used greater care in making the experiment. Porta manifestly but half understood what he was doing: still he had got possession of the idea that specific weights were to be compared by weighing in air and water; and this idea once got, any person who had read Archimedes's treatise on floating bodies, might easily have done what Ghetaldus did.

I have thought this digression allowable, as the most recent account of the progress of science in Italy, namely M. Libri's, contains nothing on the subject. M. Libri remarks, that it is difficult to enumerate Porta's speculations, and still more so to ascertain how much of them he is entitled to claim as his own. In the present case however he is, I think, entitled to at least the credit due to an ingenious mistake.

Porta's method, like that of Archimedes, requires us to have a mass of pure gold equal in weight to the crown or other portion of alloyed metal which is to be examined. Ghetaldus's, on the contrary, is free from this condition, which would in many cases make the other methods wholly useless. But Bacon's, so far from being an improvement on any of those which had preceded it, is the most unmanageable of all. His experiments must have been carefully made in order to give him the degree of accuracy which he has in most cases attained ; for nothing can be more inartificial than the process employed. He formed a hollow prism, of which the height is a little greater than the side of the base — the base being a square, and just equal to a side of a cube of gold weighing one ounce. Any substance to be compared with gold is to be formed into a cube of dimensions equal to the ounce cube of gold, which is ascertained by its just fitting into the prism : the weight of the prism being known both when it is empty, and when it carries a cube of the given substance, that of the latter is also known, and its gravity compared to that of gold is thence determined. Consequently this method requires it to be possible to give a cubical form to the substance to be examined ; a condition in many cases wholly impracticable, and which in all cases will give rise to many sources of error. In the original problem of Hiero's crown, for instance, Bacon could not have been permitted to cut a piece out in order to mould it into a cube. His method must have been changed, and he could only have advised the king to have another crown made on the same pattern, and of gold known to be unalloyed, and then to see whether the two crowns were of equal weight. It is tolerably certain that he had formed no distinct notion of the problem proposed to Archimedes, — namely, to compare the specific weights of bodies of given forms ; because, after remarking that a table of specific gravities may be usefully employed in determining the composition of alloys, he goes on to say, "Arbitror hoc esse εὕρηκα illud Archimedis; sed utcunque ita res est." As in the *Sylva Sylvarum* he has copied largely from the *Natural Magic*, and even from the neighbourhood of the passage of which I have been speaking, it may appear odd that he had not learnt from Porta what was the real difficulty which Archimedes had to overcome. The most obvious explanation is, that the *Historia Densi et Rari* was written before he had become acquainted with Porta's work.[1]

The use of making the height of the prism greater than the side of the base was this: when fluids were examined, the prism was filled up to a mark placed inside, at the height of the top of the cube, and the depth of the prism being somewhat greater than this height prevented the fluid from overflowing. In a small prism the surface of the fluid will be perceptibly convex; but this source of error was disregarded, or not observed. But, probably, the most remarkable error which Bacon has committed is chiefly owing to this circumstance. Both in the *Phænomena Universi* and the *Historia Densi et Rari*, the weight of the cube of mercury is stated at nineteen pennyweights and nine grains, that of the cube of gold being, as we know, one ounce. The specific gravity of gold is therefore to that of mercury as twenty to nineteen and three eighths; whereas the real ratio is less than twenty to fourteen and a half. Of this large error, a considerable part is accounted for by the convexity of the surface of the mercury. In the other specific gravities of fluids, which admit of an

[1] His attention seems to have been drawn to the point in question afterwards. See "Certain Experiments made by the Lord Bacon about Weight in Air and Water," Part III. of this edition near the end, and Mr. Ellis's note. — *J. S.*

accurate comparison with modern results, there will be found an error in the same direction, though, as we should expect, of a much smaller amount.

Beside solids and fluids, Bacon also made experiments on substances reduced to powder; not however distinguishing between merely mechanical pulverization, and that which is the result of some chemical process. Thus he compares lead "in corpore" and in ceruss, mercury and corrosive sublimate, &c. It was not however to be expected that he should make this distinction.

With respect to the philosophical inferences which he proposes to deduce from the quantitative theory of Density and Rarity, he seems, as usual, to bear somewhat too hardly on Aristotle. It was a received opinion among the disciples of Aristotle that one measure of earth is transmutable into ten of water, and one of water into ten of air. This opinion was no doubt founded on a passage in which Aristotle arguing against the doctrine of Empedocles, who recognising four elements did not admit that they could be transmuted into one another, remarks that if this be denied, we cannot compare them κατὰ ποσὸν ᾗ ποσόν, according to quantity as such. If we say that one measure of water becomes ten of air, then we may also assert that one measure of water is in point of quantity equal to ten of air; and conversely, in order that the latter statement may have a definite meaning, we must admit that water may be changed into air, or *vice versâ*. Therefore, Aristotle says, we may well be surprised that any of those who compare the elements according to quantity deny their mutual transmutability. In this *argumentum per incommodum* there are two points worthy of notice: in the first place, the complete absence of any notion that the quantity of matter was to be measured by the weight; and in the second, the recognition of the possibility of definite quantitative comparisons among the elements. So clearly is this fixed in Aristotle's mind, that he uses it to show that the elements must be transmutable. There is however no foundation for Bacon's censure,[1] that under the sanction of the doctrine that matter is wholly indifferent to differences of form, the schoolmen in effect maintained that any given portion of water might possibly become any quantity of air. He remarks, that if any one asserts that one measure of water can be transmuted into an equal measure of air, he in reality asserts that something which previously existed can be absolutely annihilated; since, taking for argument's sake the common opinion as to the relation between water and air, the single measure of water might have been made into ten of air; so that in order to arrive at the single measure of air nine must have been annihilated. No one, he says, can be so bewildered with abstract subtleties as to believe that there is as much matter in one measure of air as in ten. Certainly not; and the follower of Aristotle would simply remark, that the phrase "as much matter" is, in his sense of the word matter, a phrase without meaning. For to him matter apart from form has no actual existence; it is not *ens actu*, and therefore does not admit of any determination either in the category of quantity or any other. Whatever may be thought of the value of the Aristotelian antithesis of form and matter, we are not at liberty to charge it with

[1] This censure is implied throughout the *Aditus*. I have expressed his argument rather more fully than he has done himself.

difficulties which only arise when we forget that, in this antithesis, matter does not mean any actually existing thing. We must not replace the merely negative notion of the Aristotelian ὕλη by the positive idea of substance, and then interpret the dictum that matter is indifferently susceptible of all forms, so as to make it mean that the quantity of a given portion of substance can be conceived to vary. That this transition from matter to substance has been often made, may readily be admitted; it is only one instance of the tendency of the mind to replace highly abstract notions by others which are less so, — a tendency which, in the history of philosophy, is as the ὁδὸς εἰς τὸ κάτω of Heraclitus.

In commending those who deny that primitive matter is "quanto plane spoliata, licet ad alias formas æqua," Bacon refers to the Averroists, who ascribed to matter, considered apart from any form, extension in three dimensions — interminate extension, as it was usually expressed. Any attempt to give metes and bounds to this interminate extension would have been in the opinion of Averroes, as well as in that of the other followers of Aristotle, to introduce an εἶδος or form. This doctrine was however regarded by the orthodox schoolmen as little less of a heresy than that which Averroes had promulgated touching the soul of man. Another and a somewhat earlier doctrine ascribed to all matter a form of corporeity, prior to the introduction of any special or particular form. Both these doctrines are of Arab origin, the last-mentioned being that of Avicenna: they seem to spring from the same character of mind, though Avicenna's opinion is strongly condemned by Averroes. It does not seem to have ever been received with much assent, though the phrase "form of corporeity" became long afterwards famous, when Duns Scotus introduced it into his psychological theory.

Bacon is scarcely justified in asserting that Aristotle reduced the whole question of density and rarity to "the frigid distinction of act and power." He said, on the contrary, that density and rarity, instead of being, as at first they seem to be, purely qualitative conceptions, pass into another category than that of quality, when they are more narrowly examined. His expressions are sufficiently remarkable to be quoted: — ἔοικε .. ἀλλότρια τὰ τοιαῦτα (namely the rare and the dense, the smooth and the rough) εἶναι τῆς περὶ τὸ ποιὸν διαιρέσεως· θέσιν γὰρ μᾶλλόν τινα φαίνεται τῶν μορίων ἑκάτερον δηλοῦν· πυκνὸν μὲν γὰρ τῷ τὰ μόρια σύνεγγυς εἶναι ἀλλήλοις, μανὸν δὲ τῷ διεστάναι ἀπ' ἀλλήλων, καὶ λεῖον μὲν τῷ ἐπ' εὐθείας πως τὰ μόρια κεῖσθαι, τραχὺ δὲ τῷ τὸ μὲν ὑπερέχειν τὸ δὲ ἐλλείπειν. "The dense and the rare, the smooth and the rough, seem to be foreign from the classification of qualities. For each of them seems rather to denote a mode of disposition of the particles: the dense consists in their being near one another, and the rare in their standing apart; the smooth in their lying somehow in a straight line, and the rough in this — that one particle projects and another comes short."

This explanation is precisely the same as Bacon's; and on the other hand Aristotle would have adopted Bacon's caveat "Neque propterea res deducitur ad atomum, qui præsupponit vacuum et materiam non fluxam (quorum utrunque falsum est), sed ad particulas veras quales inveniuntur."[1]

In this as in some other instances, Bacon speaks of Aristotle with needless disrespect. Yet even now

[1] Nov. Org. ii. 8.

Aristotle has not lost his claim to be accounted "il maestro di coloro che sanno."

One of the applications which Bacon makes of his table of specific gravities is to the common doctrine of the elements, to which he esteems it a fatal objection, that many bodies, as gold for instance, are much heavier than the densest of the elements. The objection would be conclusive if it were more difficult to believe that any mixture of the elements could by condensation become of the same specific gravity as gold, than to believe that it could possess the qualities by which gold is distinguished from other substances.

From comparing the densities of tangible bodies "quæ pondere dotantur," Bacon proceeds to speak of aeriform or pneumatical bodies, whose density cannot be judged of by their weight. In classifying aeriform bodies, he distinguishes, as in the *Historia Vitæ et Mortis*, between the crude spirits which are present in every tangible substance, and the animal spirits which are peculiar to living creatures. The latter are much the rarer, and possess positive levity; which appears in the difference of weight of the same animal before and after death. Between these two kinds of spirits stands, in the scale of rarity, the ambient air, which is devoid of levity; a bladder filled with air not being lighter than when empty. It is scarcely necessary to remark that this observation proves nothing. Whether the air was in its own nature light or heavy, a portion of it separated from the rest by being enclosed either in a bladder or in any other envelope would clearly not tend either upwards or downwards. The principle of sufficient reason seems enough to show that any given portion of air must, in relation to the general mass, remain at rest. It is on this account that [J. B. Benedetti], of whom M. Libri gives an account, greatly condemns Aristotle for not having perceived that in its own place air has no weight.[1]

In order to connect the density of tangible bodies with that of air, Bacon tried to ascertain what quantity of spirits of wine would, when converted into vapour, completely fill a bladder of a known size. His result is, that the vapour occupied more than three hundred and twenty times as much space as the spirits themselves.

The remainder of the *Historia Densi et Rari* consists of a miscellaneous collection of remarks on dilatations and condensations, and on the different causes by which these changes are brought about. There is not much of interest in this part of the treatise. The whole concludes, like the *Historia Vitæ et Mortis* and the *Historia Ventorum*, with a number of Canones Mobiles, followed, as in the *Historia Ventorum*, by a list of things yet to be accomplished. The most remarkable circumstance connected with the Canones is the emphatic rejection of the doctrine of a vacuum. In this respect the *Historia Densi et Rari* is completely in accordance with the *Novum Organum*, and both show that Bacon's opinions must have undergone a decided change after the time of his writing the *Cogitationes de Rerum Naturâ*, or the essay on the fable of Cupid.

[1] Libri, Histoire des Sciences Mathém. liv. ii. p. 125.

NOTE.

Dr. Rawley, whose copy of this treatise, as printed in the *Opuscula*, is our only authority for the text, does not tell us in what state he found the manuscript. I apprehend however that it came into his hands either unfinished or mutilated.

It was evidently meant to correspond in form with the two preceding *tituli*, namely the *Historia Ventorum* and the *Historia Vitæ et Mortis*, and to be set forth according to the plan described in the *Norma historiæ præsentis*, vol. iii. p. 211.; and had Bacon prepared it for the press himself, he would certainly not have omitted the *Topica Particularia sive articuli inquisitionis*. This, being a particular description of the order of inquiry, would have followed the *aditus*. Each section of the *historia* would have been assigned by a marginal reference to its proper article, would have been introduced by a *connexio*, and followed by *observationes majores* or *commentationes;* the *monita* and *mandata* being inserted in their places immediately after the paragraphs to which they had reference, and distinguished from the *historia* by italics or some other typographical difference.

Now in Dr. Rawley's edition we find no *Topica Particularia;* consequently no references to the several *articuli inquisitionis* to which the successive portions of the *historia* relate. In the earlier part of the inquiry, which treats *de exporrectione materiæ in corporibus, secundum consistentias suas diversas, dum quiescunt*, we find no *connexiones*, nor anything to indicate the particular relation which the several *tabulæ*, *monita*, *mandata*, *observationes*, *commentationes*, &c., bear to each other, or to the subject of inquiry. These are all printed in separate groups; each group having its separate heading (*monita*, *mandata*, &c., as the case may be); and the paragraphs into which they are divided are separately numbered; except towards the end, where the numbers are omitted. Thus the various *monita* which are dispersed through this part of the work are numbered from 1 to 6, after which occur three single ones without any numbers; the various *observationes* from 1 to 9, and afterwards one without any number; the *mandata* from 1 to 4; and so on. The paragraphs however to which the several series of numbers apply are not kept together, but intermingled. After the first *tabula*, for instance, we have *monita* 1, 2, 3, 4; then *observationes* 1, 2, 3; then *mandata* 1, 2; then *observationes* 4, 5, 6; then *mandatum* 3; then *vellicationes de practicâ*, 1, 2, 3, 4; then *observatio* 7; then *historia* 1; and so on. From all which I am inclined to suspect that the arrangement of this part had not been completed by Bacon; that Rawley found the *monita*, *mandata*, &c., set down in numbered paragraphs on separate sheets, and that the distribution of them into their places in the order of inquiry was his own work; a work which, without the help of the *articuli inquisitionis*, which should have given the directions, it would not have been easy to accomplish successfully, even if the materials had been themselves complete, which I can hardly think they were.

However that may be, the result is certainly not satisfactory. As the text stands, the relation which the several paragraphs bear to each other is far from clear, and the typographical arrangement (which differs materially from that adopted by Bacon in the two histories edited by himself) is perplexing from the absence of all distinction between the major and minor divisions; not always consistent with itself; and in some places positively incorrect. That it has not been reproduced in its original form by any subsequent editor, is not therefore a matter of regret; but the changes which have been introduced by modern editors (following, with some variations, the example of Blackbourne) do not appear to me to be exactly of the right kind; the object which they had in view being apparently to make the printed page neater and more compact, rather than to exhibit more clearly the order of inquiry and the divisions of subject.

My own object in arranging the text of this third *titulus*, has been to bring the typographical form more into symmetry with that of the two others. In them, it will be observed, the whole inquiry is distributed into several *articuli;* each article having its separate *connexio*, which marks and explains the transition from the article preceding; its separate *historia*, with *monita*, *mandata*, &c., interspersed; and its separate *observationes* or *commentationes* (as the case may be), generally coming in at the end, and always distinguished (as stepping beyond the region of pure history into that of *interpretation*) by being printed in a larger type. That a similar logical arrangement was meant to be followed in the present history is evident enough even from the text as edited by Rawley. But in order to make this arrangement apparent to the eye, so far as that could be attempted without altering the words or the order of paragraphs, I have found it necessary to introduce some headings which are not in the original, and to alter the places of others. I have not however added anything except within brackets, nor altered or omitted anything without mentioning it in the notes. — *J. S.*

HISTORIA DENSI ET RARI,

[SIVE

TITULUS TERTIUS

IN HISTORIA NATURALI ET EXPERIMENTALI

AD CONDENDAM PHILOSOPHIAM:

QUÆ EST INSTAURATIONIS MAGNÆ PARS TERTIA.][1]

[1] The words within brackets are not in the title as printed by Rawley. But had Bacon himself brought out the work in the same form with the *Historia Vitæ et Mortis*, they would no doubt have been added. — *J. S.*

HISTORIA DENSI ET RARI;

NECNON

COITIONIS ET EXPANSIONIS MATERIÆ PER SPATIA.

ADITUS.

Nil mirum, si natura philosophiæ et scientiis debitrix sit, cum ad reddendas rationes nunquam adhuc sit interpellata. Neque enim de *quanto materiæ*, et *quomodo* illud per corpora sit distributum (in aliis copiose, in aliis parce), instituta est inquisitio diligens et dispensatoria, secundum veros aut proximos veris calculos. Illud recte receptum est, Nil deperdi aut addi summæ universali: etiam tractatus est a nonnullis ille locus, Quomodo corpora laxari possint et contrahi, absque vacuo intermisto, secundum plus et minus. Densi autem et Rari naturas alius ad copiam et paucitatem materiæ retulit; alius hoc ipsum elusit; plerique, authorem suum secuti, rem totam per frigidam illam distinctionem actus et potentiæ discutiunt et componunt. Etiam qui illa materiæ rationibus attribuunt (quæ vera est sententia), neque materiam primam Quanto plane spoliatam, licet ad alias formas æquam, volunt, tamen in hoc ipso inquisitionem terminant, ulterius nihil quærunt, neque quid inde sequatur perspiciunt; remque, quæ ad infinita spectat, et naturalis philosophiæ veluti basis est, aut non attingunt, aut non urgent.

Primo igitur, quod bene positum est, non movendum: Non scilicet fieri in aliqua transmutatione corporum transactionem aut a nihilo, aut ad nihilum; sed opera esse ejusdem omnipotentiæ, creare ex nihilo, et redigere in nihilum; ex cursu naturæ vero hoc nunquam fieri. Itaque summa materiæ totalis semper constat; nil additur, nil minuitur. At istam summam inter corpora per portiones dividi, nemini dubium esse possit. Neque enim quisquam subtilitatibus abstractis tam dementatus esse queat, ut existimet tantum materiæ inesse dolio aquæ, quantum decem doliis aquæ; neque similiter dolio aëris, quantum decem doliis aëris. At in corpore eodem non dubitatur quin copia materiæ multiplicetur pro mensura corporis: in corporibus diversis ambigitur. Quod si demonstretur, unum dolium aquæ in aërem versum, decem dare dolia aëris (istam enim computationem propter opinionem receptam sumimus, licet centupla verior sit), bene habet: etenim jam non amplius sunt diversa corpora, aqua et aër, sed idem corpus aëris in decem doliis. At unum dolium aëris (ut modo concessum est) decima tantum pars est decem doliorum. Itaque resisti jam non potest, quin in uno dolio aquæ decuplo plus sit materiæ, quam in uno dolio aëris. Itaque, si quis asserat dolium aquæ totum in dolium aëris unicum verti posse, idem prorsus est ac si asserat aliquid posse redigi ad nihilum. Etenim una decima aquæ ad hoc sufficiet, reliquæ novem partes necesse est ut annihilentur. Contra, si quis asserat dolium aëris in dolium aquæ verti posse, idem est ac si asserat aliquid posse creari ex nihilo. Etenim dolium aëris, nisi[1] ad decimam partem dolii aquæ attinget, reliquæ novem partes necesse est ut fiant ex nihilo. Illud

[1] So in the original. Qu. *non* nisi; and omit the comma? — *J. S.*

interim plane confitemur, de rationibus et calculis et quota parte quanti materiæ quæ diversis corporibus subest, et qua industria et sagacitate de illis informatio vera capi possit, arduam inquisitionem esse; quam tamen ingens et latissime fusa utilitas compenset. Nam et densitates et raritates corporum nosse, et multo magis condensationes et rarefactiones procurare et efficere, maxime interest et contemplativæ et practicæ. Cum igitur sit res (si qua alia) plane fundamentalis et catholica, accincti debemus ad eam accedere; quandoquidem omnis philosophia absque ea penitus discincta et dissoluta sit.[1]

[1] Here, if the work had been completed, would no doubt have followed the *Topica Particularia, sive Articuli Inquisitionis de Denso et Raro*, and the order of the subsequent inquiry would have been particularly explained. The *Tabula* which follows is the commencement of the *Historia.* — *J. S.*

[*Historia.*]

TABULA COITIONIS ET EXPANSIONIS MATERIÆ PER SPATIA IN TANGIBILIBUS (QUÆ SCILICET DOTANTUR PONDERE)[1] CUM SUPPUTATIONE RATIONUM IN CORPORIBUS DIVERSIS.

Idem spatium occupant, sive æque exporriguntur,

	Den.	Gr.		Den.	Gr.	
Auri puri uncia una, sive	20	0	Terræ communis	2	1½	
Argenti vivi . .	19	9	Vitrioli albi	1	22	
Plumbi . . .	12	1½	Eboris .	1	21½	
Argenti puri . .	10	21	Aluminis .	1	21	
Plumbi cinericei; anglice Tynglas	10	12	Olei vitrioli	1	21	
			Arenæ albæ	1	20	
Cupri . . .	9	8	Cretæ .	1	18½	
Aurichalci. . .	9	5	Olei sulphuris	1	18	
Chalybis . . .	8	10	Pulveris salis communis	1	10	
Æris communis . .	8	9				
Ferri. . . .	8	6				
Stanni . . .	7	22	Ligni vitæ.	1	10	
Magnetis . . .	5	12	Carnis ovillæ	1	10	
Lapidis Lydii . .	3	1	Aquæ fortis	1	7	
Marmoris . . .	2	22¾	Cornu bovis	1	6	
Silicis . . .	2	22½	Balsami Indi	1	6	
Vitri. . . .	2	20½	Cerebri vitulini crudi	1	5	paul. min.
Crystalli . . .	2	18				
Alabastri . . .	2	12	Sanguinis ovilli	1	5	
Salis gemmæ . .	2	10				
Luti communis . .	2	8½	Ligni santali rubei	1	5	
Luti albi . . .	2	5½				
Nitri. . . .	2	5	Gagatis .	1	5	
Ossis bovis . .	2	5	Cepæ recentis	1	5	
Pulveris margaritarum	2	2	Lactis vaccini	1	4½	
Sulphuris . . .	2	2	Caphuræ .	1	4	

[1] In the heading of the corresponding title in the *Phænomena Universi*, the clause "quæ scilicet dotantur pondere" does not occur.

	Den.	Gr.	
Succi menthæ expressi	1	4	
Succi boraginis expressi	1	3½	
Cervisiæ lupulatæ fortis	1	3½	
Ligni ebeni .	1	3½	
Pulveris seminis fænicúli dulcis	1	3½	
Aceti . .	1	3½	
Agrestæ, ex pomis acerbis	1	3	
Succini lucidi	1	3	
Urinæ . .	1	3	
Aquæ communis	1	3	paul. min.
Olei caryophyllorum chymici	1	3	paul. min.
Vini clareti .	1	2¾	
Pulveris sacchari albi	1	2½	

	Den.	Gr.
Ceræ flavæ . .	1	2
Radicis Chinæ . .	1	2
Carnis pyri brumalis crudi	1	2
Aceti distillati . .	1	1
Aquæ rosaceæ distillatæ	1	1
Cineris communis .	1	0½
Myrrhæ . . .	1	0
Benjovin . . .	1	0
Butyri . . .	1	0
Adipis . . .	1	0
Olei amygdalini dulcis	0	23½
Olei maceris viridis expressi	0	23½
Pulveris herbæ sampsuci	0	23
Petrolei . . .	0	23
Pulveris florum rosæ .	0	22
Spiritus vini . .	0	22
Ligni quercus . .	0	19½
Pulveris fuliginis communis e camino	0	17
Ligni abietis . .	0	15[1]

Modus experimenti circa tabulam suprascriptam.

Intelligantur pondera, quibus usi sumus, ejus generis et computationis quibus aurifabri utuntur; ut libra capiat uncias 12, uncia 20 denarios, denarius grana 24. Delegimus autem corpus auri puri, ad cujus exporrectionis mensuram reliquorum corporum rationes applicaremus, non tantum

[1] Seventy-eight substances are mentioned in this table, and only seventy-three in that in the *Phænomena*, which contains only one not contained here, namely, "radix caricæ recens." The six which it omits are cerebrum vitulinum crudum, sanguis ovilis, lac vaccinum, succus menthæ expressus, succus boraginis expressus, and cervisia lupulata fortis.

quia gravissimum, sed quia maxime unum et sui simile, nihil habens ex volatili. Experimentum fuit tale: unciam auri puri in figuram aleæ sive cubi efformavimus; dein situlam parvam, quadratam, ex argento paravimus, quæ cubum illum auri caperet, atque ei exacte conveniret; nisi quod situla esset nonnihil altior; ita tamen ut locus intra situlam, quo cubus ille auri ascenderat, linea conspicua signaretur. Id fecimus liquorum et pulverum gratia; ut cum liquor aliquis intra eandem situlam immittendus esset, non difflueret, sed paulo interius se contineret. Simul autem aliam situlam fieri fecimus, quæ cum altera illa, pondere et contento, prorsus par esset; ut in pari situla corporis contenti tantum ratio appareret. Tum cubos ejusdem magnitudinis sive dimensi fieri fecimus, in omnibus materiis in Tabula specificatis quæ sectionem pati possent; liquoribus vero ex tempore usi sumus, implendo scilicet situlam, quousque liquor ad locum illum linea signatum ascenderet. Pulveribus eodem modo. Sed intelligantur pulveres maxime et fortiter compressi. Hoc enim potissimum ad æquationem pertinet, nec casum recipit. Itaque non alia fuit probatio, quam ut una ex situlis vacua in una lance, altera cum corpore in altera lance poneretur; et ratio ponderis corporis contenti per se exciperetur. Quanto vero pondus corporis pondere auri est minus, tanto exporrectio corporis est exporrectione auri major. Exempli gratia, cum auri ille cubus det unciam unam, myrrhæ vero denarium unum; liquet, exporrectionem myrrhæ ad exporrectionem auri habere rationem vicecuplam: ut vicies plus materiæ sit in auro quam in myrrha, in simili spatio; rursus, vicies plus exporrectionis sit in myrrha quam in auro, in simili pondere.

Monita. 1. Parvitas vasis quo usi sumus et forma etiam (licet ad cubos illos recipiendos habilis et apta), ad rationes exquisitas verificandas minus propria fuit. Nam nec minutias infra grani quadrantem facile excipere licebat; nec quadrata illa superficies, in parvo nec sensibili ascensu sive altitudine, notabilem ponderis differentiam trahere potuit: contra quam fit in vasis in acutum surgentibus.

2. Minime dubium est, etiam complura corpora, quæ in Tabula ponuntur, intra suam speciem magis et minus recipere, quoad pondera et spatia; nam et vina, et ligna ejusdem speciei, et nonnulla e reliquis, sunt certe alia aliis graviora. Itaque quoad calculationem exquisitam, casum quendam ista res recipit; neque ea individua in quæ experimentum nostrum incidit, naturam speciei exacte referre, neque cum aliorum experimentis fortasse omnino in minimis consentire possunt.

3. In Tabulam superiorem conjecimus ea corpora, quæ spatium sive mensuram commode implere, corpore integro et tanquam similari, possent; quæque etiam pondus habeant; ex cujus rationibus de materiæ coacervatione judicium fecimus. Itaque tria genera corporum huc retrahi non poterant: primo, ea quæ dimensioni cubicæ satisfacere non poterant; ut folia, flores, pelliculæ, membranæ; secundo, corpora inæqualiter cava et porosa, ut spongia, suber, vellera: tertio, pneumatica, quia pondere non dotantur; ut aër, flamma.

4. Videndum, num forte contractio corporis arctior ex vi unita nanciscatur majorem rationem ponderis, quam pro quantitate materiæ. Id, utrum fiat necne, ex Historia propria Ponderis inquiratur.

Quod si fiat, fallit certe supputatio: et quo corpora sunt tenuiora, eo paulo plus habent materiæ in simili exporrectione, quam pro calculo ponderis et mensuræ quæ ex eo pendet.

Hanc Tabulam multis abhinc annis confeci, atque (ut memini) bona usus diligentia.[1] Verum possit proculdubio Tabula multo exactior componi; videlicet, tum ex pluribus, tum ampliore quapiam mensura; id quod ad exactas rationes plurimum facit; et omnino paranda est, cum res sit ex fundamentalibus.

Observationes.

1. Licet, atque adeo juvat, animo prospicere, quam finita et comprehensibilis sit natura rerum in tangibilibus. Tabula enim naturam claudit tanquam in pugno. Nemo itaque expatietur, nemo fingat aut somniet. Non invenitur in Tabula ens, quod aliud ens in copia materiæ superet, ultra proportionem tricesimam duplam: tanto enim superat aurum lignum abietis. De interioribus autem terræ nihil decernimus; cum nec sensui nec experimento subjiciantur. Illa, cum a calore cœlestium primo longius, deinde penitus, semota sint, possint esse corporibus nobis notis densiora.

2. Opinio de compositione sublunarium ex quatuor elementis non bene cedit. Aurum enim in situla illa tabulari est ponderis Den. 20; terra communis Den. 2, paulo plus; aqua Den. 1, Gran. 3;[2]

[1] Probably at the time when he wrote the *Phænomena Universi.* If so, the present *tabula*, with the *mandata* belonging to it, must be presumed to be the later copy. — *J. S.*

[2] 33 in the original. — *J. S.*

aër, ignes, longe tenuiora et minus materiata; ponderis vero nullius. At forma materiam non auget. Videndum igitur, quomodo ex corpore 2 Den. et corporibus longe tenuioribus, educatur per formam, in pari dimenso, corpus 20 Den. Duo sunt effugia: unum, quod elementa tenuiora compingant densiorem in majorem densitatem quam simplicis elementi; alterum, quod non intelligant Peripatetici hoc de terra communi, sed de terra elementari, omni ente composito graviore. At ignis et aër non condensant, nisi per accidens, ut suo loco dicetur. Terra autem illa, quæ foret auro et omnibus gravior, ita sita est, ut vix adsit ad mistionem. Melius igitur foret, ut plane nugari desinant, et cesset dictatura.

3. Diligenter notanda est series sive scala coacervationis materiæ; et quomodo ascendat a coacervatione majore ad minorem: idque interdum per gradus, interdum per saltum. Siquidem utilis est hæc contemplatio, et ad judicium et ad practicam. Coagmentatio metallica et subterranea maxima est; ita ut ex 32 illis partibus occupet 12: tantum enim distat aurum a stanno. In illo descensu ab auro et argento vivo magnus saltus ad plumbum. A plumbo ad stannum gradatio. Rursus magnus saltus a metallis ad lapides: nisi quod se interponat magnes, qui inde convincitur esse lapis metallicus. A lapidibus vero ad reliqua usque ad levissimum, continui et pusilli gradus.

Mandata. 1. Cum fons densitatis videatur esse in profundo terræ, adeo ut versus superficiem ejus corpora eximie extenuentur; illud notatu dignum est, quod aurum (quod est ex metallis gravissimum) nihilominus reperiatur quandoque in arenulis et ramentis fluviorum; etiam fere purum. Itaque inquirendum diligenter de situ ejusmodi locorum: utrum non sint ad pedes montium, quorum fundi et radices æquiparari possint mineris profundissimis, et aurum inde eluatur; aut quid tandem sit, quod pariat tantam condensationem versus summitates terræ.

2. De mineris in genere quærendum, quæ ex iis soleant esse depressiores, et quæ propius ad superficiem terræ; et in quali situ regionum, et in qua gleba nascantur; et quomodo se habeant ad aquas; et maxime, in quibus cubilibus decumbant et jaceant; et quomodo circundentur aut misceantur lapide, aut aliquo alio fossili: denique omnes circumstantiæ examinandæ, ut per istas explorari possit, qua ratione succi et spiritus terræ in condensationem istam metallicam (quæ reliquas longe superat) coëant aut compingantur.

Observationes.

4. Dubium minime est, quin et in vegetabilibus, atque etiam in partibus animalium, se ostendant corpora complura ligno abietis longe leviora. Nam et lanugines nonnullarum plantarum, alæ muscarum, et spolia serpentum; atque artificialia quoque diversa, ut lineus pannus extinctus (quali utimur ad fomites flammarum), et folia rosarum quæ supersunt a distillatione, et hujusmodi, superant levitate (ut putamus) ligna levissima.

5. Cohibenda et corrigenda est illa cogitatio, in quam intellectus humanus propendet, nempe, Dura esse maxime Densa. Nam argentum vivum fluit, aurum molle est, et plumbum. Illa vero durissimis metallis (ferro et ære) sunt densiora et graviora; lapidibus vero adhuc multo magis.

6. In Tabula multa cadunt præter opinionem: veluti quod metalla lapidibus tanto graviora; quod vitrum (corpus scilicet excoctum) crystallo (corpore conglaciato) gravius; quod terra communis tam parum ponderosa; quod olea aqua distillata vitrioli et sulphuris, ad pondus crudorum tam prope accedant; quod tam parum intersit inter pondus aquæ et vini; quod olea chymica (quæ subtiliora videri possint) oleis expressis ponderosiora; quod os sit dente et cornu tanto gravius; et alia similiter haud pauca.

Mandatum. 3. Natura Densi et Rari, licet cæteras naturas fere percurrat, neque secundum earum normas regatur, videtur solummodo magnum habere consensum cum Gravi et Levi. At suspicamur etiam eam posse habere consensum cum tarda et celeri exceptione et depositione Calidi et Frigidi. Fiat igitur experimentum, si rarius corpus non admittat et amittat calorem aut frigus celerius, densius vero tardius. Idque probetur in auro, plumbo, lapide, ligno, &c. Fiat autem in simili gradu caloris, simili quanto et figura corporis.

Vellicationes de Practica.

1. Mistura omnis corporum per Tabulam et Pondera

revelari et deprehendi potest. Si enim quæratur quantum aquæ sit admistum vino, vel quantum plumbi auro, et sic de reliquis; ponderato compositum, et consule Tabulam de pondere simplicium; et mediæ rationes compositi, comparatæ ad simplicia, dabunt quantum misturæ. Arbitror hoc esse εὕρηκα illud Archimedis; sed utcunque ita res est.[1]

2. Confectio auri, aut transmutatio metallorum in illud, omnino pro suspecta habenda est. Aurum enim omnium corporum ponderosissimum et densissimum. Igitur, ut aliud quippiam vertatur in aurum, prorsus condensatione opus est. Condensatio autem (præsertim in corporibus valde materiatis, qualia sunt metalla) apud nos homines in superficie terræ degentes vix superinducitur: pleræque enim ignis densationes *pseudo-densationes* sunt, si totum respicias (ut postea videbimus); hoc est, corpora in partibus aliquibus suis condensant, totum minime.

3. Verum versio argenti vivi aut plumbi in argentum (cum argentum sit illis rarius) habenda est pro sperabili; cum tantum fixationem et alia quædam innuat, non densationem.

4. Attamen si argentum vivum, aut plumbum, aut aliud metallum, verti posset in aurum quatenus ad cæteras auri proprietates, dempto pondere; ut, scilicet, fierent magis quam sunt fixa, magis malleabilia, magis sequacia, magis durabilia, et minus exposita rubigini, magis splendida, etiam flava, et hujusmodi; esset proculdubio res utilis et lucrativa, licet pondus auri non explerent.

[1] See for the story of Archimedes, Vitruvius, ix. 3. But I am inclined to believe that Bacon took it from Porta's *Nat. Magic*, xviii. 8. See the Preface.

Observatio.

7. Neque auro est ponderosius quicquam; neque ipsum aurum purum per artem (quatenus adhuc innotuit) redditur sese ponderosius.[1]

Plumbum tamen notatum est et mole et pondere augeri; præsertim si condatur in cellis subterraneis, ubi res situm facile colligunt. Id quod maxime deprehensum est in statuis lapideis, quarum pedes plumbeis vinculis erant alligati; quæ vincula invênta sunt intumuisse, ut portiones illorum ex lapidibus penderent, quasi verrucæ. Utrum vero hoc fuerit auctio plumbi, an pullulatio vitrioli, inquiratur plenius.

[1] In the original the *observatio* ends here, and the next paragraph is printed in a different type, numbered 1. and separated from the rest by a new heading, viz. *Historia;* as if it were the commencement of a new section and the introduction to the *tabula* which follows. It can hardly be doubted however that the paragraph beginning *plumbum tamen* was meant to belong to the *observatio*, and that the *Historia* is resumed with the *tabula*. The mistake may have arisen in this way: as the MS. originally stood, the *observatio* probably ended with *ponderosius*, and with it ended the discussion of the first article of inquiry, viz. the specific gravity of *different* bodies; then followed the second *tabula*, which, being the commencement of the history upon the second article of inquiry, viz. the specific gravity of the *same* bodies in different conditions, would naturally be headed *Historia* 1.: afterwards a sentence was added to the *observatio*, but being inserted in the margin, looked as if it were meant to follow the new heading, instead of preceding it. This, of course, is merely a conjecture, no part of the original MS. having been preserved. But, however the error may have arisen, it is impossible to believe that the paragraph in question was meant for an introduction to the new table, and therefore I have treated it as part of the preceding *observatio*, and printed it accordingly. — *J. S.*

[*Historia.*][1]

TABULA EXPORRECTIONIS MATERIÆ PER IDEM SPATIUM SIVE DIMENSUM, IN CORPORIBUS IISDEM INTEGRIS ET COMMINUTIS.

	Den.	Gr.		Den	Gr.
Mercurius in corpore, quantus impleat mensuram tabularem, ponderat	19	9	sublimatus vero in pulvere presso	3	22
Plumbum in corpore .	12	$1\frac{1}{2}$	in cerussa vero in pulvere presso	4	$8\frac{1}{2}$
Chalybs in corpore .	8	10	in pulvere præparato (quali ad medicinas utuntur) et presso	2	9
Crystallum[2] in corpore	2	18	in pulvere presso[3] .	2	20
Santalum rubeum in corpore	1	5	in pulvere presso . .	0	$16\frac{1}{2}$
Lignum quercus in corpore	0	$19\frac{1}{2}$	in cinere	1	2

TABULA EXPORRECTIONIS MATERIÆ PER IDEM SPATIUM SIVE DIMENSUM, IN CORPORIBUS CRUDIS ET DISTILLATIS.

	Den.	Gr.		Den.	Gr.
Sulphur in corpore .	2	2	in oleo chymico . .	1	18
Vitriolum in corpore .	1	22	in oleo	1	21
Vinum in corpore .	1	$2\frac{3}{4}$	in distillato . . .	0	22
Acetum in corpore[4] .	1	$3\frac{1}{2}$	in distillato . . .	1	1

[1] In the fragment published by Gruter under the title *Phænomena Universi*, which will be printed in its place in Part III. of this edition, a table of specific gravities corresponding with that which follows is introduced thus: " *Continuatio Historiæ Coitionis et Expansionis Materiæ in Corpore eodem.* Rationes pulverum majore cum utilitate inquiri, si fiat collatio

[2] *Crystallus* in orig. — *J. S.*

[3] The table in the *Phænomena Universi* gives *denar.* 1 *gran.* 20 as the weight of *crystallum in pulvere.* — *J. S.*

[4] The table in the *Phænomena Universi* gives *denar.* 1. *gran.* 2 *d.* as the weight of *acetum in corpore.* — *J. S.*

Monitum.[1] Modus versionis corporis in pulverem ad apertionem sive expansionem corporis multum facit. Alia enim est ratio pulveris qui fit per simplicem contusionem, sive limaturam ; alia ejus qui per sublimationem, ut in mercurio ; alia ejus qui per aquas fortes et erosionem (vertendo ea tanquam in rubiginem), ut in croco martis, et nonnihil in chalybe præparato ; alia ejus qui per exustionem, ut cinis, calx. Itaque ista æquiparari nullo modo debent.

Mandatum. Indigentissimæ sunt illæ duæ tabulæ priores. Ea demum foret tabula exacta corporum cum suis aperturis, quæ corporum singulorum integrorum pondera primo, dein pulverum suorum crudorum, dein cinerum, calcium, et rubiginum suarum, dein malagmatum suorum, dein vitrificationum suarum (in iis quæ vitrificantur), dein distillationum suarum (subtracto pondere aquæ, in qua dissolvuntur), nec non aliarum eorundem corporum alterationum, pondera exhiberet : ut hoc modo de corporum aperturis, et arctissimis naturæ integralis nexibus, judicium fieri posset.

eorum cum corporibus ipsorum integris, quam si ponerentur per se et simpliciter, judicavimus. Hoc enim modo et de corporum diversitate et de arctissimis illis naturæ integralis nexibus et vinculis judicium fieri et rationes iniri posse animum advertimus. Intelligimus autem in rationibus pulverum pulveres fortiter et maxime pressos. Hoc enim facit ad æquationem nec recipit casum. Mercurius in corpore habet, &c." The fragment published by Gruter is fuller in this part, and apparently of later date. See note p. 50. — *J. S.*

[1] This *monitum* is numbered (6.) in the original. But if I am right in supposing that we are now dealing with a new article of inquiry, the numbers ought (according to the plan followed by Bacon in the *Historia Ventorum* and the *Historia Vitæ et Mortis*) to begin afresh. The same remark applies to the *monitum* which stands next, and which is numbered (4.) in the original, and to the two following *observationes*, which are marked in the original (8.) and (9.). — *J. S.*

Observationes.

1. Pulveres non sunt proprie corporum aperturæ, quia augmentum spatii fit non ex dilatatione corporis, sed ex interpositione aëris; attamen per hoc optime capitur æstimatio de corporum unione interiore, aut porositate. Nam quo corpora sunt magis unita, eo major intercedit differentia inter pulverem suum et corpus integrum. Igitur ratio argenti vivi crudi ad sublimatum in pulvere est quintupla, et amplius. Rationes chalybis et plumbi non ascendunt ad quadruplam. At in corporibus levioribus et porosis, laxior quandoque est positura partium in integris, quam in pulveribus pressis; ut in ligno quercus, gravior est cinis quam corpus ipsum: etiam in pulveribus ipsis, quo corpus est gravius, eo pressus pulvis minus habet dimensum ad non pressum. Nam in levioribus, pulverum partes ita se sustentare possunt (utpote qui aërem intermistum minus premant et secent), ut pulvis non pressus triplicem impleat mensuram ad pulverem pressum.

2. Distillata plerunque attenuantur, et pondere decrescunt; sed hoc facit vinum duplo plus quam acetum.[1]

Commentatio.

1. Atque Tangibilia per familias jam censa sunt,

[1] Here ends the inquiry (as much at least as we have of it) upon the second article, viz. *Exporrectio materiæ in corporibus tangibilibus iisdem, integris et comminutis et crudis et distillatis.* We now enter upon a third article, viz. *Exporrectio materiæ in corporibus pneumaticis.* The first paragraph of the following *Commentatio* would probably have been described, had the work been finished, as Ad Art. 3. *Connexio.* — *J. S.*

tanquam Divites et Inopes. Restat altera classis, videlicet Pneumaticorum. Ea vero pondere non dotantur, per cujus incubitum de exporrectione materiæ in ipsis contentæ judicium fieri possit. Opus est igitur alio quopiam interprete. At primum, species pneumaticorum proponendæ sunt; deinde comparatio facienda.

Quemadmodum in tangibilibus interiora terræ, ita in pneumaticis ætherea, ad tempus seponimus.

Sunt pneumatica apud nos triplicis naturæ; inchoata, devincta, pura. Inchoata sunt fumi omnigeni, atque ex materiis diversis. Eorum ordo esse possit; primo, volatilium, quæ expirant ex metallis et ex nonnullis fossilium; quæ sunt (prout nomen significat) potius alata quam pneumatica; quia facile admodum coagulantur, vel sublimando, vel cadendo aut præcipitando. Secundo, vaporum; qui expirant ex aqua et aqueis. Tertio, fumorum (nomine generali retento); qui expirant ex corporibus siccis. Quarto, halituum; qui expirant ex corporibus oleosis. Quinto, aurarum; quæ expirant ex corporibus mole aqueis, spiritu inflammabilibus; qualia sunt vina, et liquores exaltati, sive potus fortes.

Est et aliud genus fumorum: illi scilicet in quos flamma desinit. Ii vero non possunt expirare nisi ex inflammabilibus, cum flammam subsequantur. Hos *post-fumos*, seu *fumos secundos*, appellamus. Itaque non possunt esse *post-vapores*, quia aquea non inflammantur; sed *post-fumi* (nomine speciali), *post-halitus*, *post-auræ;* etiam, ut arbitror, *post-volatilia*, in nonnullis.

At pneumatica devincta ea sunt, quæ ipsa solitaria aut soluta non reperiuntur, sed tantum corporibus tangibilibus inclusa; quos spiritus etiam vulgo vocant. Participant autem et ex aqueo, et ex oleoso, et ex iisdem nutriuntur; quæ in pneumaticum versa, constituunt corpus veluti ex aëre et flamma; unde utriusque mysteria sunt. Accedunt autem spiritus isti (si ad pneumatica soluta spectes) proxime ad naturam aurarum, quales ex vino aut sale surgunt. Horum spirituum natura duplex; alia crudorum, alia vivorum. Crudi insunt omni tangibili; vivi animatis tantum, sive vegetabilibus sive sensibilibus. At pneumatica pura duo tantum inveniuntur, aër et flamma; licet illa quoque magnas diversitates sortiantur, et gradus exporrectionis inæquales.

Tabula Pneumaticorum, secundum Commentationem supradictam, prout ordine ascendunt ad Exporrectionem majorem.

Volatilia metallorum et fossilium.	Auræ.
Post-volatilia ipsorum.	Post-auræ.
Vapores.	Spiritus crudi devincti in tangibilibus.
Fumi.	Aër.
Post-fumi.	Spiritus vivi, sive incensi, devincti in tangibilibus.
Halitus.	Flamma.
Post-halitus.	

De exporrectionibus horum, tum ad invicem tum ad tangibilia collatis, jam videndum. Atque si natura levis, per ascensum sursum, posset liquidare[1] raritatem corporum, quemadmodum natura gravis, per descensum deorsum, liquidat eorum densitatem, res bene posset succedere. Sed multa obsunt. Primo, quod differentiæ motuum in iis quæ aspectum fugiunt non percipiantur immediate per sensum: deinde, quod non reperiatur in aëre, et similibus, tam fortis appetitus petendi superiora, quam putatur: denique, si aër moveretur sursum, tamen cum continuetur plerunque cum alio aëre, motus ille ægre percipi posset. Nam sicut aqua non ponderat super aquam; ita aër non insurgit subter aërem. Itaque alii modi excogitandi sunt.

Atque de exporrectione pneumaticorum ad invicem, quodque ordo et series raritatis, qualis in Tabula ponitur, non leviter fundata sit, offerunt se quædam probationes non malæ: verum de certis gradibus hujusmodi exporrectionis, et rursus de exporrectione pneumatici comparati ad tangibile, difficilior certe est inquisitio.

Primo igitur fumos omnes, tam secundos quam primos, aëris raritatem non æquare consentaneum est; cum illi conspicui sint, aër minime; neque ipsi conspicui maneant paulo post, cum se aëri miscuerint.

Post-fumos præ-fumis esse tenuiores et rariores, satis liquet; cum sint flammæ (corporis tam subtilis) cadavera et solutiones: experimento quoque manifestissimum est, in nocturnis spectaculis, intra cœnacula quæ tot lychnis et facibus collucent, etiam post plurium horarum moram, sufficere aërem respirationi, licet tot post-fumis in eum receptis. Quod si fuissent illi fumi præ-fumi (quales sunt ex lychnis et facibus extinctis, absque flamma) nemo, vel ad longe minorem moram, eos sustinere posset.

[1] That is, could make clear.

Spiritus crudos quoscunque in tangibilibus devinctos, etiam aëre densiores judicamus. Etenim spiritus vegetabilium, aut animalium mortuorum, aut hujusmodi, cum exhalaverint, manifesto retinent quiddam ex crasso, sive tangibili: ut cerni datur in odoribus; qui cum sint fumi parce exeuntes, nec conferti, ut in fumis conspicuis et vaporibus, tamen si nacti fuerint aliquid tangibile, præsertim ex mollioribus, applicant se ad illud, et plane adhærent, illudque odore inficiunt; ut manifestum sit, illos cum crassa natura affinitatem ægre dirimere.

At spiritus vivos aëre ipso aliquanto rariores existimamus: tum quia inflammantur nonnihil; tum quia diligenter experti sumus, aërem ad minuendum aut sublevandum pondus nihil conferre. Nam vesica inflata non est vacua et compressa levior, cum sit illa tamen repleta aëre; nec similiter spongia aut vellus lanæ, aëre referta, illis ipsis vacuis leviora sunt, aëre excluso. At corpus animale vivum et mortuum gravitate manifesto differunt; licet haud tantum quantum putantur. Quare videtur aër pondus non minuere; spiritus autem vivus hoc facere. Atque cum pondus densitates dijudicet, etiam levatio ponderis raritates dijudicare debet.

Supremo ordine collocatur flamma; tum quia illa manifestissime petit superiora; tum quia verisimile est, rationes pneumaticorum minime differre a rationibus fomitum suorum; ideoque, quemadmodum oleum est rarius aqua, similiter flammam rariorem esse aëre et spiritu. Etiam videtur flamma corpus tenuius et mollius et magis cedens, quam aër. Nam levissima quæpiam aura, commota juxta flammam lychni, eam reddit tremulam.[1]

[1] Here, I think, should have followed the *Historia*, properly so called (for

Historia.

1. Quantam vero expansionem assequatur Pneumaticum collatum ad Tangibile, licet sit res ardua inventu, tamen curam de ejus inquisitione non abjecimus. Certissima autem visa est nobis fore probatio, si corpus aliquod tangibile (exporrectione ejus prius capta et mensurata) verti posset plane in pneumaticum, et deinde pneumatici illius exporrectio itidem notaretur; ut pensitatis utriusque rationibus, de multiplicatione dimensi evidens demonstratio fieri posset.

2. Accepimus igitur phialam vitream parvam, quæ unciam fortasse unam capere posset. In eam spiritus vini (quia ex liquoribus proxime accedebat ad pneumaticum, cum esset levissimus) unciam dimidiam infudimus. Deinde vesicam accepimus admodum grandem, utpote quæ octo pintas vinarias (*galonium* scilicet, ut nostrates appellant) capere posset. Vesica autem erat non vetus; et propterea non sicca et renitens, sed recens et mollis. Ex illa vesica aërem omnem, quoad fieri potuit, expressimus; ut latera ejus essent quasi contigua et cohærentia. Vesicam insuper per exterius oleo parum oblevimus, et molliter fricavimus; ut poros-

the preceding observations are but preparatory considerations), of the expansion of pneumatical bodies compared with one another. But it seems to have been lost or never written, for all that relates to the *Exporrectiones pneumaticorum ad invicem collatæ* ends here, and the *Historia* which follows relates to the *pneumaticum collatum ad tangibile.*

The two next paragraphs are printed in italic in the original, headed *Historia*, and numbered (2.) and (3.). These numbers are connected probably with the portion of *Historia* in the preceding section, which is numbered (1.). The paragraphs which follow, to the end of this part, are not numbered at all, though distinguished by headings. As they all appear to belong properly to the present article of inquiry, I have numbered them consecutively from this place, and omitted the separate headings, which under the arrangement which I have adopted are unnecessary; the general heading which I have inserted within brackets applying to them all. — *J. S.*

itas vesicæ oleo obturaretur, atque etiam ut inde fieret magis cedens et tensibilis. Hanc circa os phialæ (ore scilicet phialæ intra os vesicæ recepto) applicuimus; eamque filo cerato arcte ligavimus. Tum demum phialam supra prunas ardentes in foculo collocavimus. Non ita multo post ascendebat aura spiritus vini in vesicam, eamque paulatim undequaque fortiter admodum inflavit. Quo facto, continuo vitrum ab igne removimus; et in summitate vesicæ foramen acu fecimus, ut aura potius expiraret, quam relaberetur in guttas. Deinde vesicam a phiala sustulimus, et per lances quantum de illa semiuncia spiritus vini diminutum fuisset, et in auram versum, probavimus. Erat autem deperditum non plus (pondere) denariis sex. Adeo ut sex illi denarii in corpore spiritus vini, qui quadragesimam partem pintæ (ut memini) non implebant, in auram versi spatium octo pintarum adæquarent.

Monitum. Memini etiam vesicam ab igne remotam paulum flaccescere incepisse; ut, non obstante tam insigni expansione, non videretur tamen aura versa fuisse in pneumaticum purum et fixum, cum ad se restituendam inclinaret. Attamen fallere possit hoc experimentum, si ex eo conjiciamus aërem communem esse adhuc hujusmodi aura rariorem; quoniam arbitramur spiritum vini in pneumaticum versum (licet minime purum) tamen propter calorem, superare raritatem aëris frigidi; cum et ipse aër per calorem majorem in modum dilatetur, et exporrectionem aëris frigidi haud paulum superet. Itaque arbitramur, si experimentum fiat in aqua,[1] multo minorem

[1] In the *Phænomena Universi* we have a very exact account of this same experiment tried with water. The result of a comparison of the two experiments was, that the expansion of the vapour of spirits of wine was a

futuram expansionem; licet corpus aquæ plus materiæ contineat quam spiritus vini.

3. Si advertas fumum ex cereo recenter extincto exeuntem, et oculis metiaris crassitudinem ejus, et rursus intuearis corpus ipsius fumi postea inflammati; videbis expansionem flammæ, collatæ ad fumum, ampliatam quasi ad duplam.

Monitum. Si accipias pauca grana pulveris pyrii, eaque inflammes, magna prorsus fit expansio respectu corporis pulveris. Sed rursus, extincta illa flamma, multo amplius adhuc se extendit corpus fumi. Id verò non te fallat, ac si corpus tangibile plus expanderetur in fumo, quam in flamma; nam id secus se habet. Sed ratio apparentiæ est, quod corpus flammæ sit corpus integrum, corpus fumi corpus commistum, ex longe majore parte, cum aëre; itaque, sicut parum croci multum aquæ colorat, similiter parum fumi in multum aërem se spargit. Nam fumus spissus (ut antea dictum est) non sparsus, minor cernitur corpore flammæ.

4. Si accipias frustulum corticis arantii exterioris (qui aromaticus est, et oleosus), ipsumque subito comprimas juxta lychnum, exilit aliquid roris in guttulis; quod tamen constituit corpus flammæ (respectu guttularum) insigniter amplum.

little more than five times as great as that of vapour of water. I have thought this the rather worth mentioning, because the fact that Bacon, when he wrote the tract printed by Gruter, had tried this experiment with water as well as with spirits of wine, whereas when he wrote this *monitum* he had clearly not tried it with water, seems to prove that Gruter's copy of *this part* of the treatise is the later of the two; and therefore, if any one wishes to ascertain the exact worth of Bacon's labours in this matter, he must take both the writings together. — *J. S.*

Observatio.

Commentum illud Peripateticorum de decupla proportione elementorum ad invicem in raritate, res fictitia est, et ad placitum; cum certum sit, aërem centuplo (ad minimum) rariorem esse aqua, flammamque oleo; at flammam ipsum aërem decupla minime superare.[1]

Monitum. Non est cur ista inquisitio et commentatio circa pneumatica videatur cuipiam nimis subtilis aut curiosa. Certum enim est, omissionem et inobservantiam circa illa obstupefecisse philosophiam et medicinam, easque tanquam siderasse; ut fuerint ad veram causarum investigationem attonitæ et quasi inutiles, qualitatibus tribuendo quæ spiritibus debentur: ut in titulo proprio de pneumatico ipso fusius apparebit.[2]

Connexio.

Atque de exporrectione materiæ in corporibus secundum consistentias suas diversas, dum quiescunt, hæc inquisita sint. De appetitu autem et motu corporum, unde tumescunt, residunt, rarefiunt, condensantur, dilatantur, contrahuntur, majorem, minorem locum occupant, accuratius, si fieri possit, inquirendum; quia fructuosior est inquisitio, naturam simul et revelans et regens. Attamen

[1] See the note on *Nov. Org.* i. 45.

[2] Here ends the first part of the treatise, relating to the specific gravities of different bodies, or the same bodies in different conditions, *when at rest;* which I take to be altogether imperfect and fragmentary. The rest is much more complete, and set forth more orderly. It seems however that it ought to have been divided from what goes before by a separate title, *De Dilatationibus et Contractionibus Corporum.* — *J. S.*

carptim facienda est inquisitio ista, et cursim. Iste enim titulus, de Denso et Raro, tam generalis est, ut si plenarie deductus foret, multa ex sequentibus titulis anticipaturus esset, quod fieri non oportet.

Monitum. Non difficile nobis foret Historiam (quam jam subjungemus) Sparsam in ordinem meliorem quam qua usi sumus redigere, instantias quæ inter se affines sunt simul collocando. Id consulto evitavimus, duplici ratione moti. Primo, quod multæ ex instantiis ancipitis naturæ sint, et ad plura spectent; itaque ordo accuratus in ejusmodi rebus aut iterat aut fallit. Deinde (id quod præcipue in causa fuit cur a methodo aliqua exacta abhorremus) hoc quod agimus omnium industriæ ad imitationem patere volumus. Quod si methodo aliqua artificiali et illustri collectio ista instantiarum connexa fuisset, desperassent proculdubio complures se ejusmodi inquisitionem facere potuisse. Quare et exemplo et monito cavemus, ut quisque in instantiis comparandis et proponendis suo judicio, suæ memoriæ, suæ copiæ inserviat. Satis sit si de scripto et non memoriter (id enim in tantis instantiarum fluctibus ludicrum quiddam esset) semper procedat inventio; ut veræ inductionis lumine postea absolvi possit. Atque illud perpetuo memoria tenendum, nos in hoc opere stipem tantummodo et tributum a sensu ad ærarium scientiarum exigere; neque exempla ad illustranda axiomata, sed experimenta ad ea constituenda, proponere. Neque tamen dispositionem instantiarum prorsus negligemus, neque discincti hoc aggrediemur; sed ita instantias collocabimus, ut sibi invicem lucem præbeant nonnullam.

Historia Sparsa.

1. Ex introceptione corporis alieni nil mirum si sequatur dilatatio corporis alicujus; quandoquidem hoc sit plane augmentum sive additio, non rarefactio vera. Attamen cum corpus quod introcipitur fuerit pneumaticum (veluti aër, aut spiritus), aut etiam cum corpus introceptum, licet fuerit tangibile, tamen sensim illabatur et se insinuet; vulgo habetur magis pro tumore quodam quam accessione.

DILATATIONES PER INTROCEPTIONEM SIMPLICEM, SIVE ADMISSIONEM CORPORIS NOVI.[1]

2. Vesica, aut alia tensilia (ut folles), inflantur aëre integro, atque extenduntur; adeo ut indurentur, et ictum, jactum, pati possint: etiam bulla aquæ est instar vesicæ, nisi quod est tam fragilis.

3. Liquores de vase in vas de alto fusi, aut cochlearibus et spatulis aut ventis fortiter agitati, committuntur et commiscentur cum aëre; unde se attollunt in spumam. Illi paulo post residunt, et minorem locum occupant, aëre (fractis spumæ bullulis) exeunte.

4. Extruunt pueri ex aqua saponi admista (unde fit paulo tenacior) turres bullatas; adeo ut parum admodum aquæ (aëre introcepto) magnum locum occupet.

5. At non invenitur quod flamma, per inflationem follium aut agitationem aliam exteriorem, cum aëre misceatur et spumescat, in eum modum ut possit con-

[1] I am inclined to think that this heading and the last, ought properly to change places, the preceding paragraph being rather a *monitum* than an article of the *Historia Sparsa.* I have not ventured to make so great an alteration in the order of the text as it stands in the original. But I have little doubt that the arrangement which will be found a little further on in a similar case (see p. 63.) is that which ought to be adopted here. — *J. S.*

stitui corpus commistum ex flamma et aëre, instar spumæ, quæ commista est ex aëre et liquore.

6. At contra, certum est, per mistionem interiorem in corpore antequam inflammetur, fieri posse corpus commistum ex aëre et flamma. Nam pulvis pyrius habet partes non inflammabiles ex nitro, alias inflammabiles præcipue ex sulphure: unde etiam magis albicat et pallescit quam cæteræ flammæ (licet flamma ipsa sulphuris vergat ad cæruleum): adeo ut possit illa flamma recte comparari spumæ potentissimæ, ex flamma et aëre coagmentatæ, sive vento cuidam igneo.

7. Quemadmodum autem spuma est corpus compositum ex aëre et liquore; ita etiam pulveres omnes sunt compositi ex aëre et minutiis corporis pulverizati; ut non aliter differant a spumis, quam contiguum differt a continuo: nam magna moles ipsorum consistit ex aëre, qui partes corporis sublevat; ut ex Tabula secunda et tertia liquet.

8. Fiunt tumores in ventre animalium et aliis partibus, ex flatu et humore aqueo introcepto et admisso; ut in hydrope, tympanite, et similibus.

9. Est genus columbarum, quod, capite intra collum recepto, inflatur et tumet.

10. Respiratio per pulmones (follium instar) aërem attrahit et reddit; dilatante se per vices pulmone, et residente.

11. Fœmellæ prægnantes tument mammillas, lacteo scilicet humore turgentes.

12. Glans virgæ in masculis, cum arrigitur in venerem, multum dilatatur mole.

13. Inspice in speculum, et nota latitudinem utriusque oculi pupillæ; dein claude alterum oculum; et videbis pupillam oculi aperti manifeste dilatatam, spi-

ritibus qui utrique oculo inserviebant in unum confluentibus.

14. Rimæ globorum lusoriorum, et similiter lignorum aliorum, a siccitate contractæ, per immissionem et moram nonnullam in aqua, et imbibitionem ipsius aquæ, implentur et consolidantur.

15. Est genus quoddam fungi qui excrescit ex arbore, quem vocant *Auriculam Judæi*, qui immissus in aquam magnopere intumescit: quod non facit spongia aut lana.

Connexio.

Atque de introceptionibus corporis alieni (quæ sunt pseudo-rarefactiones) hæc inquisita sint. Transeundum ad dilatationes et tumores quæ fiunt in corporibus ex spiritu innato (sive illi sunt naturales, ut loquuntur, sive præternaturales) absque igne aut calore manifesto externo: licet in his quoque sequatur quandoque accessio sive introceptio humoris, præter ipsam dilatationem simplicem.

DILATATIONES PER SPIRITUM INNATUM SE EXPANDENTEM.

[*Historia.*] [1]

1. Mustum, aut cervisia nova, et similia, in doliis reposita, intumescunt et insurgunt admodum; adeo

[1] The thirty-two paragraphs which follow are numbered in the original 16—47.; the last paragraph of the *Historia* in the previous section being numbered 15. As they clearly belong to a fresh division of the inquiry, I have followed modern editors in giving them a fresh series of numbers. It will be seen as we proceed, that the numeration of these paragraphs in the original is not conducted upon any consistent or intelligible plan. —*J. S.*

ut, nisi detur spiraculum, dolia infringant; sin detur, se attollant, et exundent cum spuma, et quasi ebulliant.

2. Liquores spirituosi arctius conclusi (ut in utribus fortiter obturatis) magno impetu sæpe erumpunt, et opercula sua quandoque ejiciunt, tanquam e tormento.

3. Audivi mustum nuper calcatum, et quasi fervens, in vitro crasso et forti repositum (ore vitri bene lutato et clauso, ut mustum nec erumpere nec perfringere posset) non reperiente exitum spiritu, se per continuas circulationes et vexationes vertisse plane in tartarum; ut nihil restaret in vitro, præter auram et fæces: verum de hoc mihi parum constat.

4. Semina plantarum, ut pisorum, fabarum, et ejusmodi, turgescunt nonnihil, antequam emittant radicem aut caulem.

5. Arbores quandoque, spiritu et succo nativo tumescentes, corticem rumpunt, et emittunt gummi et lacrymas.

6. Etiam gemmæ complures videntur esse eruptiones succorum puriorum ex rupibus; cum tam gummi quam gemmæ rupium deprehendantur (ex splendore) esse succi percolati et depurati; adeo ut etiam saxa et lapides videantur ex spiritu innato tumescere.

7. Neque dubium est, quin in spermate animalium primus actus ad vivificandum sit quædam expansio massæ.

8. Vitriolum erumpendo tanquam germinat, et fere arborescit.

9. Lapides tempore et senio (præsertim in locis humidioribus) emittunt salem, qui est ex natura nitri.

10. Omnis gleba terræ tumet nitro: itaque si terra quævis sit cooperta et accumulata, ita ut succus ejus

non exhauriatur per solem et aërem, nec se consumat in emittendo vegetabili, colligit nitrum, ut internum tumorem. Ideo in aliquibus Europæ partibus struunt mineras artificiales nitri, accumulata terra, in domibus ad hoc paratis, prohibito aditu solis.[1]

11. Sudores in animalibus, per motum dilatatis spiritibus, atque humoribus veluti liquefactis, proveniunt.

12. Pulsus cordis et arteriarum in animalibus fit per irrequietam dilatationem spirituum, et receptum ipsorum, per vices.

13. Quin et motus voluntarius in animalibus, qui expeditur (in perfectioribus) per nervos, videtur radicem habere in compressione primum, deinde relaxatione, spirituum.

14. In omni contusione membri alicujus in animalibus sequitur tumor: idem evenit in plerisque doloribus.

15. Aculei vesparum et apum majorem inducunt tumorem, quam pro inflictu: id multo magis faciunt punctiones serpentum.

16. Etiam urtica, bryonia, et alia nonnulla, levant cutem, et vesicas in illa causant.

17. Habetur pro evidenti signo veneni (præsertim ejus generis quod operatur ex qualitate maligna, non per erosionem) si facies aut corpus intumescat.

18. In vesicationibus colli aut alterius alicujus partis, quæ adhibentur ad curationes morborum, assurgit humor aqueus, sive ichor, qui postea, cute scissa aut puncta, effluit.

19. Omnes pustulæ ex causa interna, et hujusmodi efflorescentiæ et apostemata, inducunt tumores apparentes, et sublevant cutem.

[1] See Beckmann's Hist. of Inventions, ii. p. 479.

20. Iracundia subito effervescens (in nonnullis) inflat buccas: similiter et fastus.

21. Ranæ et bufones tument; et complura animalia per ferociam erigunt cristas, et pilos, et plumas: quod fit ex contractione cutis per tumorem spirituum.

22. Galli, quos Indicos, alii Turcicos vocant, irati magnopere tument, et pennas tanquam jubas erigunt. Aves cum dormitant, dilatato spiritu per receptum caloris ad interiora, nonnihil tument.

23. In omni carie et putredine tumescere incipiunt spiritus corporis innati; cumque ad exitum properant, solvunt et alterant rei compagem; et, si compages rei sit paulo tenacior et viscosior, ut exire non possint, novas formas moliuntur, ut in vermibus e putredine natis; sed exordium actionis est a dilatatione spirituum.

24. Neque spiritus in putredine cohibitus tantum molitur animalcula, verum et rudimenta plantarum: ut conspicitur in musco, et hirsutie arborum nonnullarum. Memini me expertum esse, casu quodam non de industria, quod cum æstivo tempore malum citrium, ex parte sectum, in conclavi reliquissem, post duos menses inveni in parte secta putredinem quandam germinantem; adeo ut in capillis quibusdam exurgeret ad altitudinem pollicis, ad minus, atque in summitate capillorum singulorum adscivisset caput quoddam, instar capitis pusilli clavi; plane incipiens imitari plantam.[1]

25. Similiter, rubigines fiunt in metallis et vitro et similibus, ex dilatatione spiritus innati, qui tumescit, et urget partes crassiores, easque ante se agit, et extrudit, ut exeat.

[1] Compare *Sylva Sylvarum*, 606., where it is said that the lemon was left for three months.

26. Utrum terra in superficie tumescat, præsertim ubi glebæ sunt spongiosæ et cavæ, inquirendum. Certe inveniuntur quandoque in ejusmodi glebis arbores instar malorum navium, quæ sub terra, nonnullos pedes in altum, jacent demersæ et sepultæ: ut verisimile sit arbores illas per tempestates fuisse olim dejectas; postea vero, attollente se paulatim terra, coopertas fuisse et sepultas.

27. At subito et manifeste intumescit terra in terræ motibus, unde sæpenumero erumpunt scaturigines aquarum, vortices, et globi flammarum, venti vehementes et peregrini, atque ejiciuntur saxa, cineres.

28. Neque tamen terræ motus omnes prorsus subito fiunt; nam evenit nonnunquam ut terra contremuerit per plures dies: et nostro tempore apud nos in agro Herefordiensi fuit terræ motus, admodum pusillus et lentus, sed rarus; in quo aliqua jugera terræ per diem integrum paulatim se moverunt, et in alium locum paulo decliviorem, nec multo distantem, se transtulerunt, et ita quieverunt.

29. Utrum moles aquarum in maribus aliquando tumescant, inquirendum. Nam in ipsis fluxibus maris, necesse est ut illi fiant vel ex motu progressivo, vel ex sublatione aquarum in sursum per virtutem et consensum aliquem magneticum, vel denique per tumorem sive relaxationem aliquam in ipsis aquis. Atque postremus iste modus (si modo talis aliquis sit inter causas fluxus alicujus) pertinet ad inquisitionem præsentem.

30. Aqua in fontibus et puteis nonnullis tumescit et residit; adeo ut æstus quosdam videatur pati.

31. Etiam erumpunt quandoque in quibusdam locis scaturigines aquarum, absque aliquo terræ motu, intra

aliquos annos, ex causis incertis. Fitque ista eruptio plerunque in magnis siccitatibus.

32. Etiam notatum est, intumescere quandoque maria absque fluxu aut vento aliquo exteriore; idque fere tempestatem aliquam magnam præcedere.

Mandata. Non foret indignum experimento, ut probetur utrum fiat interdum aliqua relaxatio in corpore aquæ, etiam in minore quanto. Atqui si exponatur aqua soli vel aëri, fiet potius consumptio: itaque experimentum faciendum in vitro clauso. Accipe itaque vitrum, quod habeat ventrem amplum, collum vero longum et angustum, atque infundatur aqua, donec venter et pars inferior colli impleatur. Fiat autem hoc per tempestatem aëris borealem et siccam; atque ita permittatur, donec succedat tempestas australis et pluviosa; et vide, si aqua insurgat aliqualiter in collo vitri. Etiam de tumoribus aquæ in puteis facienda est diligentior inquisitio; utrum fiant magis noctu quam interdiu, et quali tempestate anni.

33.[1] In pinnis fidium ligneis fit, tempore pluvioso, ut illæ tumescentes difficilius torqueantur. Similiter pyxides ligneæ difficilius extrahuntur ex thecis suis, et ostia lignea difficilius aperiuntur.

34. Chordæ fidium extentæ paulo rigidius temporibus pluviosis rumpuntur.

35. Humores in corporibus animalium, tempestatibus australibus et pluviosis, deprehenduntur laxari et tumescere, et fluere, et incumbere magis, et meatus obstruere.

[1] The seven paragraphs which follow are headed *Historia* in the original, and numbered 1—7. As they are obviously a continuation of the same inquiry, I have followed Mr. Montagu in continuing the numbers and omitting the heading. — *J. S.*

36. Recepta est opinio, humores et succos, non in animalibus tantum sed et in plantis, sub pleniluniis magis turgescere, et cava implere.[1]

37. Sales in locis humidis se solvunt, aperiunt, et dilatant: id quod faciunt (aliqua ex parte) saccharum et condita; quæ, nisi reponantur in cameris ubi aliquando accenditur ignis, situm colligunt.

38. Etiam omnia quæ per ignem cocta et majorem in modum contracta sunt, tractu temporis nonnihil laxantur.

39. De tumoribus et relaxationibus aëris diligentius videndum; et quatenus in his militent (magna ex parte) causæ ventorum; cum vapores nec colliguntur commode in pluviam, nec dissipantur in aërem limpidum, sed inducunt tumores in corpore aëris.

Connexio.

Atque de dilatationibus corporum per spiritum innatum, sive in maturationibus, sive in rudimentis generationum, sive in excitatione per motum, sive in irritationibus naturalibus aut præternaturalibus, sive in putrefactionibus, sive in relaxationibus, hæc pauca ex cumulo naturæ inquisita sunto. Transeundum jam ad aperturas et dilatationes quæ fiunt per ignem et calorem externum actualem.

[1] Thus Rattray says, "omnia bulbosa inter herbas et cucumeracea lunæ incrementum et decrementum servant accrescendo et decrescendo, item ostracea, et pupilla oculi cati." — *Theatrum Sympathet.* p. 28.

DILATATIONES ET APERTURÆ CORPORUM, QUÆ FIUNT PER IGNEM ET CALOREM ACTUALEM, SIMPLICEM, EXTERNUM.

Monitum. Aperturæ corporum per calorem sive ignem (de quibus jam inquiremus) proprie spectant ad titulos de Calido et Frigido, et de Motu Hyles, et de Separationibus et Alterationibus. Attamen carpendum et prægustandum est aliquid ex ipsis in præsenti titulo, cum absque aliqua notitia ipsorum non possit inquiri recte de Denso et Raro.

Historia.

1. Aer per calorem dilatatur simpliciter. Neque enim separatur quippiam aut emittitur, ut in tangibilibus; sed simpliciter fit expansio.

2. In ventosis, vitro et aëre intra ipsum contento calefactis et ventosis carni applicatis, quando paulo post aër, qui per calorem dilatatus fuerit, remittente calore se recipiat paulatim et contrahat, attrahitur per motum nexus caro. Quod si ventosas fortius attrahere cupias, accipe spongiam frigida madefactam, et pone eam super ventrem ventosæ; ut, per refrigerationem amplius contracto aëre, ventosa fortius attrahat.

3. Accipe vitrum, et calefacias illud: mitte illud post in aquam: attrahet aquam pro minimo ad tertias contenti; unde liquet, aërem a calore rarefactum fuisse pariter ad tertias contenti. Sed hoc parum est. Nam cum vitrum quo usi sumus tenue esset, majorem calefactionem absque periculo rupturæ non facile patiebatur. Quod si fuisset phiala ferrea aut ænea, et majorem in modum calefacta, arbitror aërem posse dilatari ad duplum aut triplum: quod experimento dignissimum est;

etiam ad quousque; ut inde melius de raritate aëris superne, atque adeo ætheris ipsius, judicium facere possimus.

4. In *vitro* quod appellamus *calendare* (quod tempestatum, quatenus ad calorem et frigus, tam accurate demonstret varietates et gradus), evidentissime patet quam parva accessio caloris expandat aërem notabiliter; adeo ut manus vitro superposita, radii aliqui solis, ipse anhelitus astantium operetur: quin et ipsius aëris externi inclinationes ad calorem et frigus (tactui ipsi imperceptibiles) aërem nihilominus in vitro sensim et perpetuo dilatent et contrahant.

5. Hero describit altaris fabricam, eo artificio, ut superimposito holocausto et incenso, subito aqua descenderet, quæ ignem extingueret. Id non aliam poscebat industriam, quam ut sub altare esset locus concavus et conclusus, aëre repletus; qui aër ab igne calefactus et propterea dilatatus nullum reperiret exitum, nisi in canali ad parietem altaris erecto et curvato, ore super altare inverso. In canali erecto infusa erat aqua (facto etiam ventre in canali, ut largior copia aquæ reciperetur); ea aqua obice impediebatur, ne descenderet, foraminato; qui obex postquam erat versus, dabat locum aëri dilatato, ut aquam eveheret et ejiceret.[1]

6. Inventum fuit Fracastorii ad excitandos apoplecticos, ut poneretur sartago fervens circa caput ad nonnullam distantiam; unde spiritus in cellis cerebri suffocati et congelati, et ab humoribus obsessi, dilatarentur, excitarentur, et vivificarentur.[2]

7. Etiam papiliones, quæ hieme jacent emortuæ, ad-

[1] Hero, Spiritalia, c. 11. See Commandine's translation (1583), p. 44.

[2] See the note on *Nov. Org.* ii. § 35., Vol. I. p. 432.

motæ ad ignem aut radios solis, motum et vitam recipiunt. Ægroti quoque in deliquiis, tam aquis fortibus et calidis intro sumptis, quam calore exteriore, et fricationibus, et motu excitantur.

8. Apertura aquæ talis est. Sub primo calore emittit vaporem paucum et rarum : neque intra corpus alia conspicitur mutatio. Continuato calore, corpore integro non insurgit, nec etiam bullis minutis in modum spumæ; sed per bullas majores et rariores ascendit, et in copiosum vaporem se solvit. Ille vapor, si non impediatur aut repercutiatur, aëri se immiscet; primo conspicuus, dein insensibilis et se deperdens.

9. Apertura olei talis est. A primo calore ascendunt guttulæ quædam aut granula per corpus olei sparsa; idque cum crepitatione quadam. Interim nec bullæ in superficie ludunt (ut in aqua), nec corpus integrum tumet, nec quicquam fere halitus evolat. At post moram nonnullam, tum demum corpus integrum insurgit, et dilatatur expansione notabili, tanquam ad duplum; et copiosissimus et spissus admodum evolat halitus. Is halitus, si flammam interea non conceperit, miscet se tandem cum aëre, quemadmodum et vapor aquæ. Majorem autem calorem desiderat, ad hoc ut bulliat, oleum quam aqua, et tardius multo bullire incipit.

10. Apertura spiritus vini ea est, ut aquam potius referat quam oleum. Nam ebullit, magnis utique bullis, absque spuma aut totius corporis elevatione; longe autem minore calore, et multo celerius expanditur et evolat, quam aqua. Utriusque vero naturæ particeps (tam aqueæ scilicet quam oleosæ), et facile se immiscet aëri, et cito concipit flammam.

11. Acetum et agresta et vinum in hoc differunt in processu suæ aperturæ: quod acetum insurgat in mi-

noribus bullis, et magis circa latera vasis; agresta et vinum in majoribus bullis, et magis in medio vasis.

12. Generaliter in liquidis hoc fit, ut pinguia, sicut oleum, lac, adeps, et hujusmodi, insurgant et tumeant simul toto corpore; succi maturi (et magis adhuc immaturi) bullis majoribus; succi effœti et vapidi bullis minoribus.

13. Omnibus liquoribus commune est, etiam oleo ipsi, ut antequam bulliant, paucas et raras semibullas circa latera vasis jaciant.

14. Omnibus liquoribus commune est, ut in parva quantitate citius aperiantur, bulliant, atque consumantur, quam in magna.

Monitum. Experimentum de aperturis liquorum faciendum est in vasis vitreis, ut motus in corpore liquorum melius conspici possint; atque super foculos cum calore æquali, ut differentia verius excipiatur; atque igne lento, quia ignis vehemens præcipitat et confundit actiones.

15.[1] Sunt vero complura corpora, quæ non sunt liquida, sed consistentia et determinata; attamen per calorem nanciscuntur eam aperturam, ut liquescant sive deveniant liquida, quamdiu calor ea vellicet et expandat; qualia sunt cera, adeps, butyrum, pix, resina, gummi, saccharum, mel; et plurima ex metallis, veluti plumbum, aurum, argentum, æs, cuprum. Ita tamen, ut ad aperturam requirantur non solum gradus caloris longe diversi, sed et modificationes ignis et flammæ dissimiles. Nam alia metalla colliquantur per ignem simpliciter, ut plumbum; alia per ignem motum et follibus

[1] Here again we find in the original a fresh heading and a fresh series of numbers. I have again followed the example of Mr. Montagu in continuing the series. — *J. S.*

excitatum, ut aurum et argentum; alia non sine admistione, ut chalybs; qui non nisi admisto sulphure aut simili quopiam colliquatur.

16. At ista omnia, si continuetur ignis et urgeat, non solum sortiuntur aperturam colliquationis, sed pertranseunt, et adipiscuntur secundam aperturam (volatilis scilicet, sive pneumatici, sive consumptionis); omnia, inquam, præter aurum: nam quatenus ad argentum vivum, cum in natura sua sit liquidum, incipit illud ab apertura secunda, et facile vertitur in volatile. De auro adhuc dubium est, utrum possit fieri volatile aut pneumaticum, (aut etiam potabile, ut loquuntur); hoc est, non dissolubile quidem (id enim facile est et tritum per aquas fortes), sed digestibile aut alterabile per ventriculum humanum. Hujus autem rei legitima videtur probatio, minime illa, ut vi ignis ascendat aut trudatur sursum, sed ut ita attenuetur et subigatur, ut restitui in metallum non possit.

17. Inquiratur etiam ulterius de vitro et vitrificatis, utrum per ignem consumantur et vertantur in pneumaticum. Habetur enim vitrum pro corpore fixo et exucco; et vitrificatio pro morte metallorum.

18. Quæ colliquantur omnia, in via et processu suo incipiunt ab infimo illo gradu aperturæ, qui est emollitio et inteneratio, antequam colliquentur et fundantur; ut cera, gummi, metalla colliquabilia, vitrum, et similia.

19. At ferrum et chalybs, postquam fuerint perfecta et repurgata (nisi fuerit admistio) quatenus ad ignem simplicem, persistunt, et non procedunt ultra illum gradum emollitionis, ut reddantur scilicet malleabilia et flexibilia, et exuant fragilitatem suam; minime autem pertingunt ad colliquationem sive fusionem.

20. Videntur ferrum et vitrum, cum aperiuntur ad illam mollitiem de qua diximus, dilatari sane in spiritu suo incluso; unde fit illa subactio partium tangibilium, ut duritiem et obstinationem suam deponant; neque tamen corpus ipsum integrum localiter dilatari aut intumescere cernitur. Attamen attentius paulo inquirenti, deprehenditur plane in ipsis invisibilis quidam tumor et partium pulsatio; licet cohibeatur ab arcta compage suu. Nam si accipias vitrum ignitum, et majorem in modum calefactum, et ponas illud supra tabulam lapideam aut simile aliquod corpus durum, (licet et ipsa tabula illa seu corpus bene calefactum fuerit, ut frigori causa imputari non possit) rumpetur prorsus vitrum, duritie lapidis scilicet tumorem illum occultum vitri repercutiente. Itaque solent in hujusmodi casu, quando vitrum fervens summovetur ab igne, substernere ipsi pulverem aliquem aut arenam mollem, quæ suaviter cedens tumorem in partibus vitri non retundat.

21. Etiam pilæ e bombardis emissæ, postquam non solum vehi, sed et gliscere aut labi omnino desierint, adeo ut ad aspectum sint prorsus immobiles, tamen diu post, magnum deprehenduntur habere tumultum et pulsationem in minimis; adeo ut, si aliquid superponatur, magnam vim patiatur: neque id tam a calore comburente, quam a palpitatione percussiva.

22. Bacula lignea recentia, sub cineribus calidis detenta et versata, induunt mollitudinem, ut melius flectantur ad arbitrium. Experire quid fiat in baculis antiquioribus et in cannis.

23. Apertura combustibilium ea est, ut per ignem primo emittant fumum, dein concipiant flammam, postremo deponant cinerem.

24. In corporibus quæ continent humorem aqueum et a flamma abhorrentem in compage clausa et compacta (qualia sunt folia lauri, et alia non porosa, sales et similia), ea est apertura per ignem, ut spiritus in iis contentus (aqueus et crudus), per calorem dilatatus, cum sonitu emittatur antequam flamma concipiatur: si vero in aliquo corpore (quod raro fit) insimul fiant et eruptio flatus et conceptio flammæ, ingens tumultus excitatur, et potentissima dilatatio; flatu, tanquam internis follibus, flammam undiquaque exufflante et expandente, ut in pulvere pyrio.

25. Panis in furno nonnihil tumescit, licet fiat minoris ponderis quam ante: etiam in summo panis quandoque colligitur tanquam bulla aut vesica crustæ; ut cavum quiddam aëre impletum maneat inter pelliculam illam crustæ (quæ exscindi solet) et massam panis.

26. Etiam carnes assatæ nonnihil tument, præsertim si maneat epidermis, ut in porcellis.

27. At fructus assati quandoque exiliunt, ut castaneæ; quandoque effringunt corticem, et emittunt pulpam, ut poma; quod si ab igne magis torrefiant, asciscunt crustam carbonariam, ut cavum sit quiddam (ut in pane) inter crustam et carnem fructus; quod et fit in ovis.

28. Si vero calor sit lenis et cæcus, nec detur spiraculum facile ad emittendum vaporem, ut fit in pyris sub cinere assatis, et multo magis in iis quæ reponuntur in ollis, atque deinde sub cinere sepeliuntur, atque similiter in carnibus suffocatis, vel inter crustas panis vel patinas; tum tumor ille et dilatatio per calorem repellitur et in se vertitur, atque tanquam in distillatione restituitur, et reddit corpora magis humectata, et tanquam mersa in succis suis.

29. At in aridis, si flamma fuerit suffocata nec facilem reperiat exitum, rarefiunt corpora, et redduntur cava et porosa, ut in carbonibus e ligno, et pumicibus quæ ejiciuntur ex montibus flammantibus.

Connexio.

Transeundum jam esset ad dilatationes et aperturas corporum quæ fiunt per calorem in distillationibus; in quibus magis accurate datur cernere hujusmodi aperturas, quam in coctionibus et ustionibus. Verum cum in illis immorari haud parum oporteat, cumque proprie pertineat inquisitio ipsarum ad titulos de Calido et Frigido, et de Motu Hyles, et de Separationibus, exiguum quiddam est quod proponi debet in hoc titulo.

DILATATIONES PER CALOREM EXTERNUM IN DISTILLATIONIBUS.

1. Duplex est dilatatio, sive apertura, sive attenuatio corporum in distillationibus. Altera in transitu, cum corpus vertitur in vaporem aut fumum (qui postea restituitur); altera in corpore restituto, quod semper tenuius est et magis subtile et expansum et minus materiatum, quam corpus crudum ex quo distillatum emanavit. Aqua enim rosacea (exempli gratia) est succo rosarum tenuius et minus ponderosum.

2. Distillationes omnes fiunt ex æstu quodam sive reciprocatione rarefactionis primo, et versionis in pneumaticum; dein condensationis et restitu-

tionis in corpus tangibile, remittente se calore et vapore repercusso.

3. In distillationibus actiones dilatationis et condensationis non sunt sinceræ; sed intervenit actio illa (quæ maxime est intentionalis in practica) separationis partium heterogenearum; ut succi veri, phlegmatis, aquæ, olei, partis tenuioris, partis crassioris.

4. In distillationibus optime inquiritur et decernitur de gradibus et diversitatibus calorum; ut carbonum, furni calefacti, balnei, cinerum, arenæ calidæ, fimi, solis, ignis quiescentis, ignis follibus excitati, ignis conclusi et reverberati, caloris ascendentis, coloris descendentis, et hujusmodi; quæ omnia ad aperturas corporum, et præcipue ad complicatas actiones dilatandi et contrahendi (de quibus postea dicemus) insigniter faciunt. Neque tamen ullo modo videntur calores illi imitatores caloris solis et cœlestium; cum nec satis lenes sint et temperati, nec satis lenti et continuati, nec satis refracti et modificati per corpora media, nec satis inæqualiter accedentes et recedentes. De quibus omnibus, sub titulo Calidi et Frigidi, et titulis aliis ad hoc propriis, diligenter inquiremus.

5. Distillationes et dilatationes per eas fiunt in clauso, ubi concluduntur simul corpus distillandum, et vapores qui ex eo emittuntur, et aër. Neque tamen in stillatoriis et alembicis communibus diligenter arcetur aër exterior; quin per rostrum

stillatorii, per quod liquor effluit, ille subintrare aliquatenus possit. At in retortis, ubi majore vehementia caloris opus est, non datur aëri exteriori ingressus; sed os receptaculi ori vasis (ubi corpus imponitur) per lutationes ita continuatur, ut universus processus rarefactionis et restitutionis intus transigatur. Quod si corpus sit plenum spiritu vigoroso (ut vitriolum), opus est receptaculo vasto et amplo, ut vapores liberius ludant, nec vas infringant.

Mandata. 1. Utcunque tamen distillationes tanquam intra cellam undiquaque clausam transigantur; datur tamen spatium, ut corporis aliæ partes se expandere in vapores, aliæ subsidere in fæcibus, vapores rursus se glomerare et restituere, atque (si heterogenei fuerint) alii ab aliis se separare possint. Quod sequitur igitur, pro mandato magno habendum; cum ad naturam in imis concutiendam et ad novas transformationes aditum præbere possit. Vulcanus enim chymicorum et medicorum (licet multa utilia genuerit) tamen virtutes veriores caloris fortassis minus complexus est, ob divortia et separationes partium quæ in operationibus ipsorum semper interveniunt. Itaque summa rei quam mandamus huc spectat; ut illa separatio et reciprocatio rarefactionis et condensationis omnino prohibeatur, atque opus caloris intra corpus ipsum atque ejus claustra vertatur: hoc enim fortasse Proteum Materiæ per manicas constrictum tenebit, et se versiones suas experiri et expedire compellet. De hoc complura nobis in mentem veniunt, et alia reperiri possunt. Proponemus exemplum unum aut alterum ex facillimis, ad hoc tantum, ut percipi possit quid velimus.

2. Accipe vas quadratum ferri, in figura cubi, habeatque latera bene fortia et crassa. Impone cubum ligni ad mensuram vasis ad amussim factum, quique illud prorsus impleat. Superponatur operculum ferri non minus forte quam latera vasis; et lutetur optime, more chymicorum, ita ut sit clausissimum, et ignem tolerare possit. Deinde ponatur vas intra prunas, atque ita permittatur ad horas aliquas. Post amoveatur operculum; et vide quid factum sit de ligno. Nobis quidem videtur (cum prohibita plane fuerint inflammatio et fumus, quo minus pneumaticum et humidum ligni emitti potuerint) alterum ex his eventurum; vel ut corpus ligni vertatur in quoddam amalagma; vel ut solvatur in aërem, sive pneumaticum purum, simul cum fæcibus (magis crassis quam sunt cineres) in fundo, et incrustatione nonnulla in lateribus vasis.

3. In simili vase ferreo fiat experimentum de aqua pura; qua repleatur ad summum. Sed adhibeatur ignis lenior: mora vero sit amplior. Quinetiam amoveatur ab igne certis horis, et refrigescat; dein iteretur operatio aliquoties. Hoc experimentum de aqua pura delegimus hanc ob causam; quod aqua corpus simplicissimum sit, expers coloris, odoris, saporis, et aliarum qualitatum. Quamobrem si per calorem temperatum et lenem, et alternationem calefactionis et refrigerationis, et prohibitionem omnis evaporationis, spiritus aquæ non emissus, et nihilominus per hujusmodi calorem sollicitatus et attenuatus, se verterit in partes aquæ crassiores, easque ita digerere et in novum schematismum mutare possit

(minus scilicet simplicem et magis inæqualem) eo usque, ut vel colorem alium nanciscatur, vel odorem, vel saporem, vel oleositatem quandam, vel aliam alterationem notabilem (qualis invenitur in corporibus compositis); proculdubio res magna confecta foret, et ad plurima aditum patefaciens.

4. Circa distillationem clausam (ita enim eam appellare licet, ubi non datur spatium ad evaporationem) quivis multa alia poterit comminisci. Pro certo enim habemus, calorem analogum, operantem in corpus absque separatione aut consumptione partium, mirabiles metaschematismos effingere et producere posse.

5. Attamen illud addi possit, ut mandati hujus appendix; ut excogitetur etiam aliquis modus (quod certe difficile non est) per quem calor operetur non solum in clauso, sed in tensili: id quod fit in omni matrice naturali, sive vegetabilium, sive animalium. Hoc enim operationem ad multa extendit, quæ per clausuram simplicem effici non possunt. Neque hoc pertinet ad Pygmæum Paracelsi,[1] aut hujusmodi prodigiosas ineptias: sed ad solida et sana. Exempli gratia; non efficiet unquam distillatio clausa, ut aqua tota vertatur in oleum; quia oleum et pinguia majus occupant dimensum quam aqua. At si operatio fiat in tensili, hoc fortasse fieri possit: quæ esset res immensæ utilitatis, cum omnis alimentatio maxime consistat in pingui.

6. Bonum esset, et ad multa utile, ut in distillationibus natura ad rationes reddendas quandoque

[1] The Pygmæi of Paracelsus are the same as the gnomes or earth spirits. See his *Philosophical Works*, ii. p. 487. But perhaps for "pygmæum" we ought to read "archæum."

compelleretur; atque ut poneretur in certo quantum per distillationem consumptum fuerit, id est, versum in pneumaticum; et quid maneret, sive fixum, sive restitutum in corpore. Id fiere potest, si ante distillationem corpus distillandum ponderes, et vasa ipsa intra quæ distillatio perficitur. At post distillationem ponderabis liquorem; ponderabis item fæces; denique ponderabis iterum vasa. Ex istis enim tribus ponderationibus cognosces quantum fuerit restitutum, quantum manserit in fæcibus, quantum adhæserit vasibus; atque a decessione ponderis in illis tribus, comparati ad pondus corporis integri, cognosces quantum versum fuerit in pneumaticum.

Connexio.

Transeundum a dilatationibus et rarefactionibus quæ fiunt per calorem actualem, ad dilatationes et relaxationes quæ fiunt per remissionem frigoris vehementis et intensi; quæ ipsa remissio censeri debet pro calore comparato.

Historia.

DILATATIONES ET RELAXATIONES CORPORUM PER REMISSIONEM FRIGORIS.

1. Quæ per frigus vehemens concreverunt, neque tamen eo usque ut per moram frigoris in densatione sua fixa sint, ea absque calore manifesto, et per remissionem tantum frigoris, se aperiunt et restituunt; ut fit in glacie, grandine, nive: sed hoc faciunt per calorem manifestum admotum multo celerius.

2. Verum delicatiora, quorum vigor consistit in spiritu nativo subtili, ut poma, pyra, granata, et similia,

si semel fuerint congelata, suffocato spiritu, non recipiunt postea pristinum vigorem.

3. At vinum et cervisia per gelu ad gustum languescunt, nec vigent; attamen succedentibus regelationibus et tempestatibus australibus, reviviscunt et relaxantur, et quasi denuo fervescunt.

Connexio.

TRANSEUNDUM a dilatationibus quæ fiunt per calorem externum actualem, atque etiam per remissionem frigoris (quæ, ut jam diximus, est calor comparatus), ad dilatationes corporum quæ fiunt per calores potentiales, sive spiritus auxiliares alterius corporis applicati et admoti.

[*Historia.*]

DILATATIONES CORPORUM, QUÆ FIUNT PER CALOREM POTENTIALEM, SIVE PER SPIRITUS AUXILIARES ALTERIUS CORPORIS.

De caloribus potentialibus consule Tabulas Medicinales qualitatum secundarum; et ex his poteris excerpere ea quæ operantur super corpus humanum per dilatationem: quæ sunt fere illa quæ sequuntur.

Confortantia, quæ dilatant spiritus oppressos.
Abstergentia, quæ roborant virtutem expulsivam.
Aperientia, quoad orificia venarum et vasorum.
Aperientia, quoad poros et meatus partium.
Digerentia cum maturatione.
Digerentia cum discussione.
Caustica.

Hæc præcipue (sunt et alia) habent radicem in dilatatione spirituum et humorum et succorum et substantiæ, in corpore, per spiritus auxiliares; necnon per complexionem tangibilem, quæ inest medicinis illis, vel interius vel exterius sumptis.

Commentatio.

Patet in vitro calendari, quam exquisito sensu sive perceptione præditus sit aër communis calidi et frigidi: utpote quæ tam subtiles ejus differentias et gradus statim dijudicare possit. Nec dubito, quin perceptio spiritus in animalibus vivis versus calorem et frigus sit adhuc longe acutior: nisi quod aër sit pneumaticum purum et sincerum, et nihil habeat tangibilis admisti; at spirituum perceptio retundatur et hebetetur corpore tangibili in quo sunt devincti. Attamen, non obstante hoc impedimento, videntur adhuc spiritus vivorum potiores ipso aëre, quoad hanc perceptionem. Neque enim hactenus nobis constat, quod calor potentialis (de quo jam loquimur) aërem possit dilatare; cum certum sit, quod hoc faciat super spiritus in animalium membris contentos; ut in qualitatibus (quas diximus) secundis medicinarum liquet. Sed de hoc inquiratur paulo accuratius, ex mandato proxime sequente.

Mandata. 1. Accipe duo vitra calendaria ejusdem magnitudinis. Impone in altero aquam, in altero spiritum vini, fortem et acrem; atque ita calefiant vitra, ut aqua et spiritus vini ad parem altitudinem ascendant. Colloca ea simul, et dimitte per spatium aliquod; et nota, si aqua deveniat altior quam spiritus vini. Nam si hoc fit, palam est, calorem spiritus vini potentialem aërem dilatasse, ita ut spiritum vini depresserit.

2. Possit esse res varii usus, si operationes secundarum qualitatum medicinalium probentur interdum, et exerceantur in corporibus vitæ expertibus. Licet enim dubium non sit, plerasque earum nullius prorsus effectus fore, quoniam requiritur plane spiritus vivus ad eas actuandas, ob operationis subtilitatem; aliæ tamen proculdubio super nonnulla corpora inanimata operabuntur. Videmus enim quid possit sal in carnibus, aromata in cadaveribus, coagulum in lacte, fermentum in pane, et hujusmodi. Inserviet igitur diligentia medicorum circa qualitates secundas, ad instruendas complures alias operationes, si animum advertas cum judicio; id semper supponens, quod virtus fortior requiritur ad operandum super corpus mortuum, quam vivum.

Connexio.

Transeundum ad dilatationes corporum quæ fiunt per liberationem spirituum, refractis nimirum ergastulis partium crassiorum, quæ illos arcte detinuerant, ut se dilatare non possent. In corporibus enim quæ habent arctam compagem atque naturæ integralis nexibus fortiter devincta sunt, non exequuntur spiritus opus suum dilatationis, nisi fiat prius solutio continui in partibus crassioribus; vel per liquores fortes erodentes et stimulantes tantum, vel per eosdem cum calore. Atque hoc cernitur in aperturis et dissolutionibus metallorum, de quibus nunc (ut in reliquis) pauca proponemus.

Historia.

DILATATIONES CORPORUM PER LIBERATIONEM SPIRITUUM SUORUM.

1. Accipe pondus auri puri ad denarium 1, in parvas bracteolas redacti, quæ etiam manu lacerari possint.

2. Accipe etiam pondus 4 den. aquæ regis; et mittantur simul in vitrum. Tum ponatur vitrum super foculum, in quo sit ignis prunarum modicus et lenis. Paulo post insurgunt arenulæ quædam, aut grana; quæ deinde post parvam moram se diffundunt et incorporantur cum aqua; ut aqua efficiatur, aqua tanquam electrica, et splendida, et veluti croco tincta. Dissolutio autem auri per aquam in quantitatibus prædictis fit tantum ad tertias. Neque enim aqua oneratur ulterius; adeo ut, si dissolvere cupis totum pondus illud auri den. 1, opus sit effundere portionem in qua solutio facta est, et superinfundere de novo pondus simile 4 den. aquæ regis, et sic tertio. Ista dissolutio fit leniter et placide modico igne, absque fumis, et sine calefactione vitri, alia quam per ignem.

3. Accipe argenti vivi in corpore pondus ad placitum, duplum aquæ fortis: ponito simul in vitro, neque ea ad ignem omnino admove. Attamen paulo post insurget intra corpus aquæ instar pulveris tenuissimi, et intra spatium horæ, absque igne, absque fumis, absque tumultu, vertetur corpus commistum in aquam bene claram.

4. Accipe plumbum in lamellis ad pond. den. 1, aquæ fortis ad pond. den. 9. Non fit bona incorporatio, ut in aliis metallis; sed aqua demittit majorem partem plumbi in calce ad fundum vitri, manente aqua perturbata, sed vergente ad diaphanum.

5. Accipe argenti in lamellis, sive bracteolis, pondus den. 1, aquæ fortis pond. den. 4; pone super foculum in vitro, cum igne lento. Insurgit argentum in arenis, aut bullulis, intra corpus aquæ, majoribus paulo quam aurum; deinde incorporatur cum aqua, et vertuntur simul in liquorem tenuem, sed album et quasi lacteum. Sed postquam paulisper resederit liquor et refrixerit, ejaculantur (sive hoc emanet ex metallo, sive ex aqua, sive ex utroque) fragmina glacialia intra corpus aquæ: postquam autem per moram longiorem penitus resederit, clarificat se liquor, et devenit clarus et crystallinus, demissa glacie in fundum. Sustinet aqua onerationem, qualem in auro, et fit dissolutio simili fere calore, nec colligit calorem per motum magis quam aurum.

6. Accipe cuprum in bracteolis ad pondus den. 1, aquæ fortis ad pondus den. 6. Mitte super foculum. Insurget cuprum in bullulis sive arenulis majoribus adhuc quam argentum. Paulo post incorporatur cum aqua, et corpus commistum vertitur in liquorem cœruleum, turbidum; sed postquam resederit, clarificat se ætheris instar in cœruleum, pulchrum, et splendidum, demissis in fundum fæcibus instar pulveris, quæ tamen ipsæ per moram imminuuntur, et ascendunt, et incorporantur. At den. illi 6 aquæ fortis solvunt den. totum cupri, ut sustineat se onerari aqua duplo plus quam in auro et argento. Concipit autem dissolutio cupri calorem manifestum per tumultum interiorem, etiam antequam admoveatur ad ignem.

7. Accipe stannum in bracteolis ad pondus den. 1, aquæ fortis ad pond. den. 3; et vertitur totum metallum in corpus simile flori lactis aut coagulo; nec facile se clarificat; et concipit sine igne calorem manifestum.

8. Accipe ferri in laminis pond. den. 1, aquæ fortis pond. den. 9; et sine igne surgit ferrum in magnis bullis, non tantum intra corpus aquæ, sed supra, adeo ut ebulliat extra os vitri, atque insuper emittat copiosum et densum fumum croceum; idque cum maximo tumultu, et calore vehementissimo, et qualem manus non sustineat.

Monitum. Dubium non est quin vires variæ aquarum fortium diversorum generum, et modi ignis sive caloris qui adhibetur, istas aperturas etiam variare possint.

Mandata. Qualis sit ista dilatatio metallorum per aperturas, videndum: utrum sit instar dilatationis auri foliati, quæ est pseudo-rarefactio (ut mox dicemus) quia corpus dilatatur potius loco quam substantia, qualis itidem est dilatatio pulverum; an revera corpus ipsum metallorum dilatetur in substantia. Hoc hujusmodi experimento probari potest. Pondera argentum vivum; excipe etiam modulum ejus in situla: pondera similiter aquam fortem, et excipe modulum ejus in altera situla: deinde dissolve et incorpora ea modo supradicto; postea pondera incorporatum, et immitte illud etiam in duas illas situlas, et nota, si pondus et mensura compositi ad pondus et mensuram simplicium juste respondeat. Delegimus autem argentum vivum ad experimentum, quia minor est suspicio alicujus consumptionis, cum fiat dissolutio sine igne.

Videndum (obiter) utrum dissolutio argenti vivi lapides ponderosissimos, aut fortasse stannum, sustineat, ut innatent. Etenim ex rationibus ponderum hoc colligi potest. Neque hoc pertinet ad miraculum et imposturam, sed ad investigandam naturam misturarum, ut suo titulo apparebit.

Observatio.

Notatu etiam dignum est (licet non sit præsentis inquisitionis) omnia metalla, licet sint aquis in quibus dissolvuntur insigniter graviora, tamen in actu primo dissolutionis ascendere in arenulis vel bullis. Atque eo magis hoc notandum est, quod ubi non admovetur ignis, ut in argento vivo, idem faciant.

Commentatio.

Tumultus intra partes corporis inter dissolvendum, istam ascensionem causat. Nam in vehementi erosione corpora impelluntur nonnihil motu locali; ut videre est in lapide parvo glareoso, qui positus in aceto forti ad latera patellæ (ut facilius labatur) per vices gliscit, ut pisciculus. Est et genus lapidis aut fossilis, quod immissum in acetum irrequiete se agitat, et huc illuc currit. At quæ sine impetu isto miscentur, (ut arbitror) nisi quassata, non ascendunt; velut saccharum in fundo aquæ non dulcificat in summo; nec crocus colorat, nisi moveatur et agitetur.

Connexio.

Transeundum ad aliud genus dilatationum, quod etiam communi vocabulo *dissolutionum* (in aliquibus) nuncupatur. Fit autem ubi corpora versus alia corpora amica ruunt in amplexum; et, si datur copia, aperiunt se ut illa introcipiant. Neque fit hæc apertura tumultuose, aut per penetrationem corporis ingredientis, (ut in aquis fortibus), sed placide, et per relaxationem corporis recipientis.

Historia.

DILATATIONES PER AMPLEXUM ET OCCURSUM CORPORIS AMICI.

1. Saccharum et gummi nonnulla, ut tragacanthum, in liquoribus infusa, solvuntur; laxant enim libenter (instar spongiarum) partes suas ad recipiendum liquorem.

2. Papyrus, seta, lana, et hujusmodi porosa, liquoribus immersa, aut alias humectata, ita se aperiunt, ut deveniant magis mollia, lacerabilia, et quasi putria.

3. Gaudia subita, ut ob nuntium bonum, aspectus[1] ejus quod fuit in desiderio, et similia, licet non corpus amplectantur sed phantasiam aliquam, nihilominus spiritus animalium insigniter dilatant; idque interdum cum periculo repentini deliquii aut mortis. Simile facit imaginatio in venereis.

Mandatum. Cogitandum de inveniendis menstruis substantiarum specialium: videntur enim posse esse liquores et pulpæ, tantæ cum corporibus determinatis sympathiæ, ut, illis admotis, partes suas facile laxent, easque libenter imbibant; seque per hoc in succis suis intenerent et renovent. Hoc enim pertinet ad unum ex magnalibus naturæ; nempe, ut rerum humores maxime radicales refocillari et nutritio ab extra fieri possint, ut in carnibus, ossibus, membranis, lignis, &c. Etiam in iis quæ operantur per divulsionem et penetrationem, est sympathia sive conformitas: aqua fortis siquidem non

[1] *Aspectum* in the original. — *J. S.*

solvit aurum, ut nec aqua regia communis argentum.

Connexio.

TRANSEUNDUM ad dilatationes per assimilationem aut versionem; quando scilicet corpus imperans et magis activum subigit corpus accommodum et obsequiosum et magis passivum, ita ut illud in se plane vertat, seque ex eo multiplicet et renovet. Quod si corpus assimilans sit tenuius et rarius quam corpus assimilatum, manifestum est assimilationem fieri non posse absque dilatatione.

Historia.

DILATATIONES QUÆ FIUNT PER ASSIMILATIONEM, SIVE VERSIONEM IN TENUIUS.

1. Aër, et maxime cum commotus est (ut in ventis), lambit humiditatem terræ, eamque deprædatur et in se vertit.

2. Processus desiccationis in lignis, herbis, et hujusmodi tangibilibus, non admodum duris aut obstinatis, fit per deprædationem aëris, qui spiritum in corpore evocat et exugit, et in se transubstantiat: itaque tarde hoc fit in oleosis et pinguibus, quia spiritus et humidum ipsorum non sunt tam consubstantialia aëri.

3. Spiritus in tangibilibus (qualia diximus) deprædantur partes ipsas crassiores corporis in quo includuntur. Nam spiritus qui proximi sunt aëri, ipsi aëri obediunt, et exeunt cito: at qui in magis profundo corporis siti sunt, illi partes interiores adjacentes deprædantur, et novum inde spiritum gignunt et secum copulant, ut una tandem exeant: unde fit in istis cor-

poribus per ætatem et moram diminutio ponderis; quod fieri non posset, nisi pars aliqua non pneumatica in pneumaticum sensim verteretur. Nam spiritus jam factus in corpore non ponderat, sed levat pondus potius.

4. Multi tumores in corporibus animalium discutiuntur absque suppuratione aut sanie, per insensilem transpirationem, versi plane in pneumaticum, et evolantes.

5. Esculenta flatuosa gignunt ventositates, succis suis versis in flatum, et exeunt per ructus et crepitus; etiam partes internas extendunt et torquent: quod faciunt etiam alimenta proba et laudata quandoque, ob debilitatem functionum.

6. In omni alimentato, cum pars alimentata tenuior est alimento (ut spiritus atque sanguis per arterias in animalibus leviores sunt quam cibus et potus), necesse est ut alimentatio inducat dilatationem.

7. Omnium aperturarum, dilatationum, et expansionum maxima, quatenus ad analogiam inter corpus ante dilatationem et post, omniumque pernicissima, et quæ minima mora et brevissimo actu transigitur, est dilatatio oleosorum et inflammabilium in flammam; quod fit quasi affatim et sine gradibus. Estque (quoad flammam successivam) plane ex genere assimilationum; multiplicante se flamma super fomitem suum.

8. At quod potentissimum in hoc genere est, non ad velocitatem primæ inflammationis (nam pulvis pyrius non tam cito inflammatur quam sulphur aut caphura aut naphtha), sed ad successionem flammæ semel conceptæ et ad superandum ea quæ resistunt, est commistio illa expansionum in aërem simul et in flammam (de

qua supra diximus), quæ invenitur in pulvere pyrio (ut liquet in bombardis et cuniculis).

9. Notant autem chymistæ, etiam argenti vivi expansionem per ignem esse admodum violentam; quin et aurum, vexatum et occlusum, quandoque potenter erumpere, cum periculo operantium.

Connexio.

Transeundum ad eas dilatationes, vel distractiones et divulsiones, quæ fiunt, non ab appetitu aliquo in corpore ipso quod dilatatur, sed per violentiam corporum externorum, quæ, cum suis motibus prævaleant, necessitatem imponunt corpori alicui ut dilatetur et distrahatur. Atque ista inquisitio pertinet ad titulum de Motu Libertatis; sed (ut in reliquis) aliquid de hoc, sed parce et paucis, jam inquiremus. Iste autem motus est plerunque geminus: primo, motus distractionis a vi externa; deinde motus contractionis vel restitutionis a motu corporis proprio: qui posterior motus licet ad condensationes spectet, tamen ita conjunctus est cum priore ut hic commodius tractari debeat.

[*Historia.*]

DILATATIONES SIVE DISTRACTIONES A VIOLENTIA EXTERNA.

1. Bacula lignea et similia flexionem nonnullam patiuntur, sed per vim; illa autem vis distrahit partes exteriores ligni in loco ubi arcuatur, et comprimit partes interiores: quod si vis illa paulo post remittatur, restit-

uit se baculum, et resilit; sed si diutius in ea positura detineatur, figitur in ea, nec resilit amplius.

2. Similis est ratio horologiorum (eorum scilicet quæ moventur per torturam laminarum), in quibus videre est continuum et graduatum nixum laminarum ad se restituendum.

3. Pannus, et similia filacea, extenduntur majorem in modum, et resiliunt citius dimissa; non resiliunt longius detenta.

4. Caro quæ surgit in ventosis, non est tumor, sed violenta extensio carnis integralis per attractionem.

5. Qualem rarefactionem tolleret aër (pro modo scilicet violentiæ) tali experimento elicere possis. Accipe ovum vitreum, in quo sit foramen minutum: exuge aërem anhelitu quantum potes; deinde affatim obtura foramen digito, et merge ovum in aquam ita obturatum. Post tolle digitum, et videbis ovum attrahere aquam, tantum scilicet quantum exuctum fuerit aëris; ut aër qui remansit possit recuperare exporrectionem suam veterem, a qua fuerat vi distractus et extensus. Memini autem intrasse aquam, quasi ad decimam partem contenti ovi. Etiam memini me reliquisse ovum (post exuctionem) cera obturatum per diem integrum, ut experirer, si per moram illam (quæ certe nimis brevis erat ad experimentum justum) aër dilatatus figi posset, nec curaret de restitutione, ut fit in baculis et pannis. Sed cum tolleretur cera, aqua intrabat ut prius; etiam si ovum appositum fuisset ad aurem, aër novus intrarat cum sibilo.[1]

6. At qualem rarefactionem aqua sustineat, possit forte hoc modo deprehendi. Accipe folles: attrahe aquam, quantum impleat cavum follium: neque ta-

[1] Compare Nov. Org. ii. 45.

men eleva folles ad summum, sed quasi ad dimidium. Deinde obstrue folles, et nihilominus eleva eos paulatim; et videbis, quatenus ista aqua recepta se dilatari patiatur. Aut etiam per fistulam, aut syringam, attrahe nonnihil aquæ; deinde foramen obtura, et embolum adhuc paulatim attrahe.

Commentatio.

Suspicor etiam fieri distractionem spiritus aquæ in conglaciatione; sed subtilis est hujus rei ratio. Primo, pro certo poni possit, in omni excoctione (puta luti, cum fiunt lateres et tegulæ, crustæ panis, et similium) multum ex pneumatico corporis exhalare et evolare (ut paulo post monstrabimus), atque inde necessario sequi, ut partes crassiores per motum nexus magna ex parte (nam est et alius motus, de quo nunc sermo non est) se contrahant. Nam sublato spiritu nec alio corpore facile subintrante, *ne detur vacuum* (ut loquuntur), in locum illum quem occupabant spiritus succedunt partes; unde fit illa durities et contractio. Eadem prorsus ratione, sed modo contrario, videtur necessario sequi, ut spiritus in conglaciatione distrahantur. Etenim partes crassiores per frigus contrahuntur; itaque relinquitur aliquod spatium (intra claustra corporis) occupandum; unde sequitur si aliud corpus non succedat, ut spiritus præinexistens per motum nexus distrahatur tantum, quantum partes crassiores contrahantur. Sane id conspicitur in glacie, quod corpus interius reddatur rimosum, crustulatum, et parum tumescat: quodque ipsa glacies, non obstante insigni partium contractione, sit (in toto) levior quam ipsa aqua: idque dilatationi pneumatici merito attribui possit.

Connexio.

TRANSEUNDUM ad dilatationes per deacervationem; quando, scilicet, quod erat cumulatum et acervatum, fit applanatum. Istæ autem dilatationes pro pseudo-dilatationibus habendæ sunt; dilatatio enim fit in positura partium, non in substantia corporis. Siquidem corpus manet in eadem densitate substantiæ; sed figuram nanciscitur ampliorem in superficie, minorem in profunditate.

[*Historia.*]

DILATATIONES PER DEACERVATIONEM.

1. Aurum per malleationem in immensum dilatatur, ut in auro foliato; item per distractionem, ut in argenteis filis inauratis: inauratio enim fit in massa antequam distrahatur.

2. Argentum etiam fit foliatum, licet non ad tam exquisitam tenuitatem quam aurum. Reliqua quoque metalla per malleationem dilatantur in bracteolas et lamellas tenues.

3. Cera, et hujusmodi, premuntur et finguntur in oblinimenta tenuia.

4. Gutta atramenti in calamo dilatatur ad exarationem multarum literarum: quod et fit per penicillum in pigmentis, et vernice.

5. Crocus in parva quantitate magnam inficit quantitatem aquæ.

Connexio.

Atque de dilatationibus, et rarefactionibus, et aperturis corporum, hæc inquisita sunto. Superest jam ut de contrariis actionibus simili diligentia inquiramus; id est, de contractionibus, et condensationibus, et clausuris corporum. Quam partem visum est seorsum tractare, eo magis quod non omnes actiones ex hac parte sint reciprocæ; sed nonnullæ earum propriæ, et per se explicandæ. Etiam, quamvis contraria ratione consentiant, tamen in experimentis valde diversis investigantur et se conspicienda præbent.

Actioni dilatationis per introceptionem corporis alieni, reciproca est actio contractionis per emissionem aut expressionem corporis alieni: itaque de eo primo est inquirendum.

[*Historia.*]

CONTRACTIONES PER EMISSIONEM AUT DEPOSITIONEM CORPORIS INTROCEPTI.

1. Consule instantias de dilatationibus per introceptionem, et oppone illis easdem instantias postquam dilatationes resederint: in his intelligimus, ubi datur residere.

2. Metalla pura et perfecta, licet variis modis vexentur et alterentur, ut in sublimationibus, præcipitationibus, malagmatibus, dissolutionibus, calcinationibus, et hujusmodi; tamen (natura metallica cum aliis cor-

poribus non bene conveniente) per ignem et conflationem plerunque restituuntur, et vertuntur in corpus quale prius. Est autem condensatio ista minus vera, quia videtur esse nihil aliud quam emissio et exclusio aëris qui se miscuerat, aut aquarum in quibus dissoluta erant, ad hoc, ut partes genuinæ corporis metalli rursus coire possint. Neque tamen dubium est, quin corpus longe minus spatium occupet quam prius, sed minime videtur densari substantia. Atque hæc *potestas clavium*, quæ aperit et claudit, viget maxime in metallis. Etiam metalla impura, et marcasitæ, atque mineræ metallorum, eodem modo (per ignem congregatis partibus homogeneis, et emissa et exclusa scoria et purgamentis) depurantur. Etenim omne metallum purum densius est et ponderosius impuro.

3. Ad magis arctam autem condensationem metallorum facit, si metalla sæpius fusa, sæpius in aquis extincta sint; unde magis obstinata fiunt, et indurescunt. Utrum vero pondere ipso augeantur, pro ratione dimensi, hactenus non constat. De eo fiat experimentum. Atque ista induratio magis adhuc potenter fit per crebras solutiones et restitutiones, quam per fusiones et extinctiones. Inquirendum etiam est, in quali genere aut mixtura aquarum indurescant magis.

4. Reperiuntur tamen modi mortificationum metallorum, id est, prohibitionum ne cum soluta et aperta fuerint restituantur. Id maxime cernitur in argento vivo; quod, si strenue tundatur, et inter tundendum injiciatur parum terebinthinæ, aut salivæ hominis, aut butyri, mortificatur argentum vivum, et nanciscitur aversationem et fastidium ad se restituendum.

Mandatum. Diligenter inquirendum de mortificationibus, hoc est, de impedimentis restitutionum omnium metallorum. Magna enim debet esse antipathia eorum quæ prohibent ne ea coeant. Cumque omnis restitutio ipsorum sit genus quoddam condensationis, pertinebit scilicet cognitio privationis ad cognitionem formæ.

Historia.[1]

1. Dilatationibus per spiritum innatum se expandentem non opponitur proprie actio aliqua reciproca: cum contractio res aliena sit a spiritu, qui non contrahitur, nisi cum aut suffocatur, aut patitur, aut colligit se (arietis instar) ut fortius se dilatet. Attamen commode hoc loco substituemus actionem illam quæ est propria partium crassiorum, sed per accidens imputari debet spiritui innato; ea est, ubi per evolationem sive emissionem spiritus, contrahuntur et indurantur partes. Spiritus autem emittitur vel ex agitatione sua propria, vel sollicitatus ab aëre ambiente, vel provocatus et irritatus ab igne seu calore.

Commentatio.

Idem faciunt quoad attenuationem et emissionem spiritus, et actiones quæ ex ea sequuntur, ignis sive calor, et tempus sive ætas. Verum ætas per se curriculum est solummodo aut mensura motus. Igitur

[1] Though this paragraph is headed *Historia* in the original, and numbered 1., and printed in the smaller type, it corresponds to that class of paragraphs which are in other places distinguished by the title *Connexio*. I have therefore divided it from what goes before by the same marks which I have used elsewhere to denote the transition to a new article of inquiry, and printed it in the larger type; and though I have not ventured otherwise to alter the text, I have no doubt that for *Historia*, *Connexio* ought to be substituted. — *J. S.*

cum de ætate loquimur, intelligimus de virtute et operatione composita ex agitatione spiritus innati, et aëre ambiente, atque radiis cœlestium. Sed illud interest, quod ignis et calor vehemens dilatet corpora confertim, et fortiter, et visibiliter; ætas autem, instar caloris lenissimi, paulatim, et leniter, et occulto: fumi enim et vapores scilicet spissi sunt et conspicui, perspirationes vero neutiquam; ut manifestum est in odoribus. Attamen magis subtilis et exquisita est ea corporum attenuatio et rarefactio quæ fit per ætatem, quam quæ fit per ignem.[1] Nam ignis præcipitans actionem, pneumaticum quod in corpore est rapide evolare facit; humidum quoque quod præparatum est in pneumaticum subinde vertit, atque tale factum emittit: unde partes tangibiles sedulo se interim et gnaviter constipant, et non parum spiritus (tanquam manu injecta) morantur et detinent. At ætas pneumaticum jam factum ad evolationem non urget subito; unde fit ut illud diutius manens in corpore, quicquid in tenue digeri possit sensim et seriatim præparet, parum ex pneumatico jam facto placide et successive interim evolante; adeo ut anticipet fere et tanquam fallat constipationem partium tangibilium. Quamobrem in dissolutione per ætatem, sub finem negotii, parum admodum tangibilis figitur et manet. Etenim pulvis ille putris, qui per longos annorum circuitus manet, tanquam consumptionis reliquiæ, (qualis in sepulchris et monumentis

[1] Compare Nov. Org. ii. 20.

vetustis nonnunquam invenitur), res quasi nihili est, et omni incineratione quæ fit per ignem minutior, et magis destitutus. Nam cineres etiam succum habent, qui possit elici et verti in sales: hujusmodi pulvis minime. Verum, quod ad inquisitionem præsentem pertinet, et cujus causa hæc dicta sunt, certum est spiritum, quamdiu detinetur in corpore, partes tangibiles colliquare, intenerare, conficere, subruere; verum ab ejus emissione partes tangibiles continuo se contrahere et constipare.

Historia.

CONTRACTIONES PER ANGUSTATIONEM PARTIUM CRASSIORUM POST SPIRITUM EMISSUM.

1. In senectute cutes animalium corrugantur, et membra arescunt.

2. Pyra et poma diu servata rugas colligunt; nuces autem ita contrahuntur, ut non impleant testam.

3. Casei veteres in cortice exteriore efficiuntur rugosi. Ligna in trabibus, postibus, et palis, tractu temporis (præsertim si ponantur viridia) contrahuntur in arctum, ut disjungantur et hient. Simile fit in globis lusoriis.

4. Terra in magnis siccitatibus divellitur, et in superficie sua plena rimarum efficitur: etiam quandoque rimæ tam in profundum penetrant, ut ad eruptionem aquarum causam præbeant.

Monitum. Nemo nugetur, aiens istam contractionem in desiccationibus nihil aliud esse, quam absumptionem humidi. Nam si id tantum ageretur ut humidum in spiritum versum evolaret, deberent corpora manere in priore exporrectione et dimenso suo, et solummodo cava fieri, ut pumices aut suber; non autem localiter contrahi et minui dimenso suo.

5.[1] Lutum per fornaces cogitur in lateres et tegulas: at si instet calor vehemens, ut in medio fornacis, vertitur etiam nonnulla pars luti et funditur in vitrum.

6. Ligna, si suffocetur flamma, vertuntur in carbones; materiam scilicet magis spongiosam et levem quam ligna cruda.

7. Metalla pleraque sepulta in crucibulis inter prunas ardentes, et multo magis per fornaces reverberatorias, vertuntur in materiam friabilem, et calcinantur.

8. Complura fossilia et metalla, et ex vegetabilibus nonnulla, vitrificantur per ignes fortes.

9. Omnia quæ assantur, si ignem plus æquo tolerent, incarbonantur, et recipiunt se in angustius dimensum.

10. Papyrus, membrana, lintea, pelles, et similia, per ignem non solum corrugantur in partibus, sed etiam se complicant et convolvunt, et tanquam rotulantur in toto.

11. Lintea, a flamma primo concepta, paulo post suffocata, vertuntur in substantias raras, quæ vix inflammantur, sed facile ignescunt: quibus utimur ad fomites flammarum.

12. Pinguia, ut cera, butyrum, lardum, oleum, et similia, per ignem deveniunt frixa et fæculenta, et tanquam fuliginosa.

13. Ova contrahuntur ab igne, et quatenus ad albumen ipsorum, colorem mutant a claro in candidum.

14. Quinetiam si ovum testa exutum injiciatur in

[1] The ten following paragraphs have in the original a fresh heading and a fresh series of numbers. I have again followed Mr. Montagu's example in continuing the series. — *J. S.*

spiritum vini bonum et fortem, elixatur, et fit candidum; similiter et offa panis injecta in ipsum devenit quasi tosta.

Observationes.

1. Quamdiu (ut paulo ante innuimus) spiritus in corpore detinetur, si per ignem aut calorem excitatus et dilatatus fuerit, tamdiu agitat se, molitur exitum, partes tangibiles emollit, intenerat, colliquat: atque hoc est proprium opus spiritus, qui digerit et subigit partes. Sed postquam spiritus sibi exitum invenerit et emissus fuerit, tum prævalet opus partium, quæ a spiritu vexatæ conspirant, et se stringunt; tam ex desiderio nexus et mutui contactus, quam ex odio motus et vexationis. Atque inde sequitur coarctatio, induratio, obstinatio.

2. Est in processu contractionis partium ab igne, finis et ultimitas: nam si minor sit copia materiæ per violentam deprædationem ignis, quam ut cohærere possint; tum demum se deserunt, et incinerantur et calcinantur.

Connexio.

Atque de contractionibus quæ fiunt ab emissione spiritus e corporibus, sive is emittatur per ætatem sive per ignem sive per calorem potentialem, hæc inquisita sunto. Actioni vero dilatationis per calorem actualem externum reciproca est actio contractionis per frigus actuale externum. Atque hæc condensatio est omnium maxime propria et genuina; maxime potens etiam foret, nisi quod non habemus hic apud nos in superficie terræ frigus aliquod intensum. Frigus autem et caloris remissio (nam utrunque hoc loco conjungere visum est) alia simpliciter, manente natura sua, condensat; alia rarefacta (sed imperfecte) restituit; alia per condensationem plane vertit et transformat de natura in naturam. De his omnibus jam pauca sunt proponenda.

CONTRACTIONES CORPORUM PER FRIGUS ACTUALE EXTERNUM.

1.[1] Aër in vitro calendari percipit gradus tam frigidi quam calidi. Atque temporibus nivalibus super caput vitri quasi pileum ex nive posuimus; qui, licet aër ipse illo tempore fuisset hiemalis et asper, tamen frigus in tantum auxit, ut aqua per paucos gradus, aëre contracto, insurgeret.

2. Superius posuimus, aërem in vitro ad tertias per calorem dilatatum fuisse, atque tantundem, remittente calore, se contraxisse.

Mandata. 1. Experimento plane dignum est, ut probetur utrum aër per calorem dilatatus figi in eadem exporrectione possit, ut se restituere et contrahere non laboret. Itaque accipe vitrum calendare robustum, idemque vehementer calfacito; deinde os bene obturato, ne aër se contrahere possit; et per aliquot dies obturatum dimittito: deinde in aquam ita obturatum mergito; et postquam in aqua fuerit, aperito, et videto quantum aquæ trahat, atque utrum sit

[1] I am inclined to think that the *historia* upon the article properly begins here, and not after the *mandata*, as in the original. But as the process of inquiry is clear enough as it stands, I have not thought it necessary to make any alteration. — *J. S.*

ad eam proportionem quam alias tracturum fuisset si vitrum statim in aquam fuisset missum.

2. Etiam obiter nota (etsi ad titulum de Calido et Frigido potius pertineat) utrum aër, ita fortiter dilatatus et per vim detentus, retineat calorem suum multo diutius quam si os vitri apertum fuisset.

Historia.

1. Stellæ tempore hiemali, noctibus valde serenis et gelidis, apparent grandiores quam noctibus æstivis serenis: quod fit præcipue ex universali condensatione aëris, qui tum vergit magis ad naturam aquæ: nam sub aqua omnia apparent longe grandiora.

2. Rores matutini sunt proculdubio vapores, qui in aërem purum non erant plene dissipati et versi, sed hærebant imperfecte misti, donec per frigora noctis, præsertim in regione media quam vocant aëris, fuerint repercussi, et in aquam condensati.

3. Condensatio pluviæ et nivis et grandinis fit similiter per frigus mediæ regionis, quod vapores coagulat magis (ut plurimum) in alto, quam rores. Occurrunt vero dubitationes duæ, circa quas diligens fieri debet inquisitio. Altera, utrum guttæ ipsorum congelentur et condensentur in ipso casu; an fuerint illæ primo collectæ et congregatæ in moles majores aquarum, in aëre (propter distantiam a terra) pensiles, quæ postea, per violentiam aliquam conquassatæ, frangunt se et comminuunt in guttas; ut in nonnullis cataractis Indiæ Occidentalis, quæ tam subito et confertim descendunt, ut videantur quasi ex vasibus fusæ et dejectæ. Altera, utrum non solum vapores (qui olim fuerunt humores et aquæ, et solummodo restituuntur), sed etiam pars magna aëris puri et perfecti, per frigus (in illis regionibus

vehemens et intensum) non fuerit coagulata, et mutata plane, et versa in pluviam, et reliqua ; de quo paulo post inquiremus.

4. In distillationibus, humores primo vertuntur in vapores ; illi, per remotionem ab igne destituti, per latera stillatorii contrusi, et nonnunquam per frigidam ab extra infusam accelerati, restituunt se in aquas et liquores. Imago prorsus familiaris rorum et pluviæ.

5. Argentum vivum præcipue, necnon metallica alia, cum volatilia facta fuerint, properant tamen ad se restituendum, et occursu alicujus solidi et materiati magnopere gaudent. Itaque facile hærent, facile decidunt ; adeo ut quandoque sit necesse vapores ipsorum igne persequi, et de igne in ignem transmittere, factis tanquam scalis receptaculorum ignis, ad nonnullam distantiam inter se, circa vas ; ne vapor, postquam per ascensionem paulo fuerit remotior ab igne, citius quam expedit se restituat.

6. Quæ ab igne colliquata fuerint, post remissionem caloris densantur et consistunt ut prius ; ut metalla, cera, adeps, gummi, &c.

7. Vellus laneum, super terram diutius jacens, colligit pondus ; quod fieri non posset, nisi aliquid pneumaticum densaretur in ponderosum.

8. Solebant antiquitus nautæ, velleribus lanæ, tanquam tapetibus aut aulæis, vestire latera navium noctu, ita ut non attingerent aquam ; atque inde mane exprimere aquam dulcem, ad usum navigantium.[1]

9. Etiam expertus sum de industria, quod alligando quatuor uncias lanæ ad funem, qui demittebatur in puteum 28 orgyarum, ita tamen ut aquam per sex orgyas

[1] Pliny, xxxi. 37. The same thing is mentioned in the *Sylva Sylvarum* (76.), as also the experiment detailed in the next paragraph.

non attingeret, ex mora unius noctis crevisset pondus lanæ ad quinque uncias et drachmam unam; et hæsissent per exterius lanæ plane guttæ aquæ, ut ex iis tanquam lavare aut madefacere manus quis possit: idque iterum atque iterum expertus sum, variante quantitate ponderis, sed semper multum aucta.

10. Lapides, ut marmora et silices, atque etiam trabes ligneæ (præsertim pictæ et oblitæ oleo), manifesto madefiunt sub regelationibus aut tempestatibus australibus; ut tanquam exudare videantur, et guttæ inde detergi possint.

11. In gelu madido (quod Anglice *Rynes* vocant) fit irroratio in ædibus super vitra fenestrarum; idque magis interius versus cubiculum, quam exterius ad aërem apertum.

12. Anhelitus, qui est aër primo attractus ac deinde intra cavum pulmonum brevi mora parum humefactus, super specula aut corpora polita (qualia sunt gemmæ, laminæ ensium, et similia) vertitur in quiddam roscidum, quod paulo post instar nubeculæ dissipatur.

13. Lintea, etiam in ædibus (ubi ignis non accenditur), colligunt humiditatem, ita ut foco appropinquata fument.

14. Pulveres omnes in repositoriis conclusi colligunt humiditatem, ut hæreant et quasi glebefiant.

15. Existimatur origo fontium et aquarum dulcium, quæ ex terra scaturiunt, fieri ex aëre concluso in cavis terræ (præsertim montium) coagulato et condensato.

16. Nebulæ sunt condensationes aëris imperfectæ, commistæ ex longe majore parte aëris et parum aquei vaporis; et fiunt, hieme quidem, sub mutatione tempestatis a gelu ad regelationem, aut e contra; æstate vero et vere, ex expansione roris.

Mandatum. 1. Quia versio aëris in aquam utilissima res esset, idcirco omnes instantiæ quæ ad hoc innuunt diligenter pensitandæ: atque inter alia in certo ponendum, utrum exudationes marmorum, et similium, in tempestatibus australibus et pluviosis sint meræ condensationes aëris a duritie et lævore lapidum repercussi, instar anhelitus in speculo; an participent nonnihil ex succo et pneumatico intrinseco lapidis.

2. Probatio fieri possit per pannum lineum aut lanam supra lapidem positam: nam si tunc quoque exudat lapis, participat exudatio ex causa interiore.

Commentatio.

Quod ipse aër vertatur in aquam in regionibus supernis, omnino necessario concluditur ex conservatione rerum. Nam certissimum est humores maris et terræ verti in aërem purum, postquam vaporum naturam, tempore et consortio et rarefactione plenaria, penitus exuerint. Itaque si non esset reciprocatio, ut aër vicissim quandoque verteretur in aquam, quemadmodum aqua vertitur in aërem, non sufficerent plane vapores, qui remanent novelli et imperfecte misti, ad pluvias et imbres et re-integrationes specierum; sed secutæ forent siccitates intolerabiles, et conflagratio, et venti impetuosi, et tumores aëris, ex aëre perpetuo multiplicato.

17.[1] In conglaciatione aquæ, moles corporis integri

[1] In the original the heading *Historia* is repeated here, and the series of numbers begins afresh. But as it is obviously a continuation of the inquiry upon the same article, I have continued the numbers; and the repetition

non decrescit, sed intumescit potius. Fit tamen manifesta densatio in partibus; adeo ut conspiciantur rimæ et divulsiones intra corpus glaciei. Etiam quandoque (si aër subintret) cernuntur sensim capillitia et fila et flosculi. Glacies autem innatat aquæ; ut manifestum sit, non fieri densationem integralem.

18. Vinum tardius congelascit quam aqua; spiritus vini non omnino.

19. Aquæ fortes et argentum vivum (arbitror) non gelascunt.

20. Oleum et adeps gelascunt et densantur, sed non ad indurationem.

21.[1] Gelu terram facit concrescere, eamque reddit siccam et duram.

22. Poëta ait de regionibus hyperboreis:

> Æraque dissiliunt vulgo, vestesque rigescunt.[2]

23. Id quod faciunt tabulæ ligneæ, præsertim in juncturis glutinatis.

24. Etiam clavi, per contractionem frigoris, decidunt (ut referunt) e parietibus.

25. Ossa animalium per gelu deveniunt magis crispa; adeo ut fractura ipsorum per hujusmodi tempora et facilius fiat, et ægrius curetur. Denique omnia dura redduntur per frigus magis fragilia.

26. Condensantur manifesto aquæ aut succi in lapides splendentes sive crystallinos; ut videre est in cavernis subterraneis intra rupes; ubi cernuntur stillæ multiformes (instar stillarum conglaciatarum) sed fixæ et saxeæ, pensiles, quæ in ipso decasu (lento scilicet et

of the heading is superfluous according to the typographical arrangement which I have adopted. — *J. S.*

[1] This paragraph is not numbered in the original. — *J. S.*

[2] Virgil, Georg. iii. 363.

tardo) congelatæ fuerunt. Utrum vero materia ipsarum sit prorsus aqua, an succus nativus lapidis (saltem commistus) in dubio est; præsertim cum gemmæ et crystalla in rupibus apertis exurgant sæpe et excrescant (quod non potest imputari aquæ adhærenti) in sursum, et non decidant aut pendeant.

27. Lutum manifesto condensatur in lapides; ut videre est in aliquibus lapidibus magnis compositis ex parvis calculis, qui materia lapidea satis polita, et æque dura ac ipsi calculi, in interstitiis calculorum conglutinantur. Sed videtur hæc condensatio fieri non solum ex frigore terræ, sed per assimilationem, de qua paulo post.

28. Sunt quædam aquæ, quæ lignum, etiam paleas (ut aiunt) et hujusmodi, condensant in materiam lapideam; adeo ut pars ligni adhuc integri, quæ fuerit sub aqua, sit saxea; quæ emineat, maneat lignea; quod etiam vidi. De eo diligentius inquirendum, cum multum lucis præbere possit ad operativam condensationis.[1]

Mandatum. Probabile est aquas metallicas, ob densitatem quam contraxerint a metallis, posse habere naturam insaxantem. Fiat probatio per stipulam, folia crassiora, lignum, et similia. Sed arbitror deligendas esse aquas metallicas quæ fiunt per ablutionem aut crebram extinctionem, potius quam per dissolutionem; ne forte aquæ illæ fortes et corrosivæ impediant condensationem.

29.[2] In China habent mineras porcellanæ artificiales, defodiendo (nonnullas orgyas subter terram) massam quandam cæmenti ad hoc præparati et proprii; quæ

[1] Compare Gilbert, Physiol. v. 22.

[2] The original repeats the heading (*historia*) here.

post quadraginta aut circiter annos sepulta vertitur in porcellanam; ita ut transmittant homines hujusmodi mineras de hærede in hæredem.[1]

30. Accepi rem fidei probatæ, de ovo quod diu jacuerat in fundo aquæ, quæ circuibat ædes; quod inventum versum erat manifesto in lapidem, manentibus coloribus et distinctionibus vitelli, albuminis, testæ; sed testa erat fracta hic illic, et splendescebat in crustulis.[2]

31. Audivi sæpius de versione albuminis ovi in materiam lapideam; sed nec veritatem rei nec modum novi.

32. Flamma proculdubio, cum extinguitur, vertitur in aliquid; videlicet in post-fumum; qui et ipse vertitur in fuliginem. De flammis vero spiritus vini, et hujusmodi aurarum, diligentior facienda est inquisitio, in quale corpus densentur, et qualis sit post-aura ipsarum. Neque enim apparet fuliginosum aliquod, ut in flammis ex oleosis.

Connexio.

Atque de contractionibus corporum per frigus actuale, sive hoc fiat in aëre, sive in aquis et liquoribus, sive in flamma; ac rursus, sive illa sit contractio simplex, sive restitutio, sive coagulatio et versio, hæc inquisita sint. Sequitur actio quæ opponitur dilatationi per calorem potentialem, scilicet contractio per frigus potentiale.

[1] This account seems to be taken from Marco Polo, ii. 77.
[2] Compare Sylv. Sylvar. 85.

[*Historia.*][1]

CONTRACTIONES CORPORUM PER FRIGUS POTENTIALE.

1. Quemadmodum consulendæ sunt tabulæ medicinales qualitatum secundarum ad inquisitionem de calore potentiali, similiter consulendæ sunt ad inquisitionem de frigore potentiali: in quibus excerpi debent potissimum astrictio, repercussio, oppilatio, inspissatio, stupefactio.

2. Opium, hyoscyamus, cicuta, solanum, mandragora, et hujusmodi narcotica, spiritus animalium manifesto densant, in se vertunt, suffocant, et motu privant. Utrum vero super corpora mortua aliquid possint, fiat experimentum macerando carnes in succis ipsorum (ad experiendum si succedat denigratio et gangræna); vel macerando semina et nucleos (ad experiendum utrum mortificent ipsa, ut non crescant); vel linendo summitatem vitri calendaris per interius succis ipsorum, (ad experiendum utrum aliqualiter contrahant aërem).

3. Apud Indias Occidentales reperiuntur, etiam per deserta arenosa et valde arida, cannæ magnæ, quæ super singulas juncturas, sive genicula, bonam copiam præbent aquæ dulcis, magno commodo itinerantium.[2]

4. Referunt esse in quadam insula, aut ex Terceris aut ex Canariis, arborem quæ perpetuo stillet; imo quæ nubeculam quandam roscidam semper habeat impendentem.[3] Digna autem res cognitu esset, utrum inveniatur in vegetabili aliquo potentiale frigus, quod denset aërem in aquam. Itaque de hoc diligenter in-

[1] Though the heading (*Historia*) is omitted here in the original, it is introduced between the *mandatum* and the paragraph numbered 7., and therefore must have been omitted here by oversight. — *J. S.*

[2] See Purchas's Pilgrims, v. p. 913.

[3] Ibid. iv. 1359. The island is Ferro.

quiratur. Sed magis existimo, has esse cannas geniculatas, de quibus diximus.

5. Inveniuntur super folia nonnullarum arborum (veluti quercus) quæ unita sunt, nec humorem sugunt aut condunt, præcipue mense Maii apud nos, rores dulces, instar mannæ, et quasi melliti: utrum vero sit vis aliqua in foliis coagulans, an tantum illa rores commode excipiant et custodiant, non constat.

6. Vix invenitur corpus, in quo emineat tantum potentiale frigus quantum in nitro. Nam ut aromata, et alia, (licet ad tactum minime) tamen ad linguam aut palatum habent calorem perceptibilem; ita etiam nitrum ad linguam vel palatum habet frigus perceptibile, magis quam sempervivum, aut aliqua herba ex maxime frigidis. Itaque videtur subjectum accommodum ad experiendum virtutem potentialis frigidi in nitro. Poterit autem esse mandatum tale:

Mandatum. Accipe minutam vesicam ex pellicula, quantum fieri potest, tenui. Infla et liga; et merge eam intra nitrum per aliquos dies, et exime; et nota, si vesica aliqualiter flaccescat: quod si facit, scias frigus nitri aërem contraxisse. Fiat idem experimentum mergendo vesicam intra argentum vivum. Sed debet suspendi vesica per filum, ut mergi possit, et minus opprimi.

7. Accipe unguentum rosarum, aut hujusmodi; infunde aceti nonnihil: tantum abest ut liquor aceti reddat unguentum magis liquidum, ut contra illud reddat magis induratum et solidum.

Connexio.

Actioni dilatationis per amplexum opponitur [actio] contractionis per fugam et antiperistasin.

Quemadmodum enim corpora versus grata et amica se laxant undiquaque, atque eunt in occursum; ita cum incidunt in odiosa et inimica, fugiunt undiquaque, et se contrudunt et constringunt.

[*Historia.*]

CONTRACTIONES CORPORUM PER FUGAM ET ANTIPERISTASIN.

1. Calor ignis per antiperistasin videtur nonnihil densari, et fieri acrior, ut sub gelu.

2. Contra, in regionibus torridis, videtur densari frigus per antiperistasin ; adeo ut, si quis se recipiat ex campo aperto et radiis solaribus sub arbore patula, statim cohorreat.

3. Attribuitur, nec prorsus male, ista operatio contractionis per antiperistasin mediæ regioni aëris, ubi colligit se et unit natura frigidi, fugiens radios solis directos sparsos a cœlo, et reflexos resilientes a terra; unde fiunt magnæ condensationes in illis partibus pluviarum, nivis, grandinis, et aliorum.[1]

4. Merito dubitari possit, utrum opium et narcotica stupefaciant a potentiali frigido, vel a fuga spirituum. Nam videtur opium partes habere calidas, ex fortitudine odoris, ex amaritudine, et provocatione sudoris, et aliis signis. Verum cum emittat vaporem inimicum et horribilem spiritibus, fugat illos undiquaque ; unde se coagulant, et suffocantur.

Connexio.

Actioni dilatationis quæ fit per assimilationem et versionem in tenuius, opponitur actio contractionis

[1] Arist. Meteor. i. 12.

quæ fit per assimilationem et versionem in densius. Intelligimus autem, quando hoc fit non per frigidum, vel actuale vel potentiale, sed per imperium corporis magis activi, quod se multiplicat ex corpore magis passivo. Assimilatio autem ad densum magis rara est, et minus potens multo, quam assimilatio ad rarum; quia corpora densa magis sunt ignava et inertia ad opus assimilationis quam tenuia.

[*Historia.*]

CONTRACTIONES CORPORUM PER ASSIMILATIONEM, SIVE VERSIONEM IN DENSIUS.

1. Supra notavimus, lutum inter lapides parvos densari in materiam lapideam.

2. Latera doliorum densant fæces vini in tartarum.

3. Dentes densant ea quæ ex manducatione cibi et humoribus oris adhærent, in squamas, quæ purgari et abscindi possint; verum æque duras ac ipsum os dentium.

4. Omnia dura et solida aliquid ex liquoribus et in fundo (maxime) et per latera adhærentibus condensant.

5. Quæcunque alimenta vertuntur in corpus alimentatum magis densum quam corpus ipsius alimenti (sicut cibus et potus in animalibus vertuntur in ossa, calvariam, et cornua), in assimilando (ut manifestum est) condensantur.

Connexio.

Actioni dilatationis per violentiam externam, sive ex appetitu sive contra appetitum corporis dilatati, opponitur actio contractionis per violentiam similiter externam; cum corpora ponuntur in necessitate, ab illis quæ in ipsum agunt, cedendi et se comprimendi.

[*Historia.*]

CONTRACTIONES CORPORUM, QUÆ FIUNT PER VIOLENTIAM EXTERNAM.

1. Aër per violentiam sive compressionem externam aliquam condensationem facile patitur; majorem vero non tolerat: ut in violento impetu ventorum et terræmotibus liquet.

2. Accipe catinum ligneum, inverte concavum ejus, et dimitte in aquam perpendiculariter, et facito illum descendere, impellens manu. Portabit secum aërem usque in fundum vasis, nec recipiet aquam interius, nisi parum infra summa labra; id ex colore ligni madefacti apparebit. Tanta autem fuerat condensatio aut compressio aëris, non amplior. Hoc ipsum insigniter apparebat, invento instrumento ad usum operariorum sub aqua.[1] Illud tale erat. Deprimebatur dolium magnum et concavum aëre impletum. Illud stabat supra tres pedes metallicos, crassos, ut mergi posset. Pedes erant breviores statura hominis. Urinatores, cum respiratione iis opus esset, flectebant se, et inserebant capita ipsorum in dolium, et respirabant: et hoc repetebant, et opus continuabant ad moram nonnullam; quousque scilicet aër, qui per insertionem capitis semper in quantitate nonnulla e dolio exibat, ad minimum diminutus esset.

3. At quantum ipsum condensationis, quod libenter toleraturus sit aër, cognoscere et supputare possis hoc modo. Accipe pelvem aquæ plenam: mitte in eam

[1] Compare Nov. Org. ii. 50.

globulum ex metallo, aut lapidem, qui resideat in fundo. Superimpone catinum, vel impellens manu, vel ex metallo ita fabricatum, ut fundum sponte petat. Si globulus fuerit talis magnitudinis, ut aër condensationem (qualis ad globulum intra catinum recipiendum sufficiat) libenter pati possit, condensabit se aër placide, et nullus erit alius motus: sin majoris fuerit magnitudinis, quam aër bene ferre possit, resistet aër, et levabit latus aliquod ipsius catini, et exibit in bullis.

4. Etiam ex compressione vesicæ videbis quousque comprimi possit sine ruptura; aut etiam ex follibus levatis, et denuo obturatis, (prius foraminibus compressis). De condensatione aquæ tale a nobis factum est experimentum.[1] Globum fieri fecimus plumbeum, cum lateribus bene crassis, et foramine in summo non magno. Globum aqua replevimus, et foramen metallo (ut meminimus) optime solidavimus. Tum globum illum, tanquam ad duos polos contrarios, primo malleis, deinde per pressorium robustum, fortiter compressimus. Cum autem ea applanatio multum sustulisset ex capacitate globi, adeo ut ad octavam quasi diminuta fuisset, tamdiu et non amplius sustinuit se aqua condensari. Sed ulterius vexata et compressa non tolerabat, sed exibat aqua ex multis partibus solidi metalli, ad modum parvi imbris.

5. At omnis motus, quem vocant, violentus, veluti pilarum e tormentis, sagittarum, spiculorum, machinarum, et aliorum infinitorum, expeditur per compressionem præternaturalem corporum, et nixum ipsorum ad se restituendum; quod cum commode ad tempus facere non possint, loco moventur. Nam solida, præsertim dura, ulteriorem compressionem ægre admodum

[1] See the note on *Nov. Org.* ii. 45.

tolerant. Verum hujusce rei inquisitionem ad titulum de Motu Libertatis rejicimus. Etenim, ut sæpius diximus, titulus præsens de Denso et Raro spicas tantum legit, non demetit.

6. Quo corpora sunt rariora, eo ab initio se contrahunt facilius; quod si ultra terminos suos compressa fuerint, eo se vindicant potentius; ut in flamma et aëre clauso manifestatur.

7. Flamma simpliciter compressa (licet sine flatu, ut in pulvere pyrio) tamen magis furit; ut conspici datur in fornacibus reverberatoriis, ubi flamma impeditur, arctatur, repercutitur, sinuat.

Monitum. Dilatationi per deacervationem non opponitur actio reciproca: quia corpora deacervata non coacervantur rursus, nisi per conflationem: ut in restitutione metallorum, de qua supra.

Commentatio.

Est et aliud genus fortasse contractionis corporum, non ex reciprocis sed positivum et per se. Arbitramur enim, in dissolutione corporum quæ fit in liquoribus, ut in dissolutione metallorum, etiam gummi, sacchari, et similium, recipi corpus aliquatenus intra liquorem; neque tamen liquorem pro rata parte corporis recepti dilatari aut exporrigi. Quod si fit, sequitur ut sit condensatio; cum idem spatium contineat plus corporis. Certe in dissolutione metallorum, si aqua semel exceperit onus suum, non dissolvit amplius, nec operatur. Hanc autem condensationem (si talis quæpiam sit) contractionem corporum per onerationem appellare possumus.

Mandatum. Immitte aquam in cineres pressos ad summum; et nota diligenter quantum decrescat de exporrectione cinerum, postquam receperint aquam, ab ea quam habuerunt prius intermisto aëre.

Observationes.

Efficientia dilatationis corporum, quæ ex inquisitione priore in lucem prodeunt, sunt novem. 1. Introceptio sive admissio corporis alieni. 2. Expansio naturalis, sive præternaturalis, spiritus innati. 3. Ignis, sive calor externus actualis; aut etiam remissio frigoris. 4. Calor externus potentialis, sive spiritus auxiliares. 5. Liberatio spirituum a vinculis partium. 6. Assimilatio ex imperio corporis rarioris magis activi. 7. Amplexus, sive itio in occursum corporis amici. 8. Distractio a violentia externa. 9. Deacervatio, sive applanatio partium.

Efficientia vero contractionis corporum sunt octo. 1. Exclusio aut depositio corporis introcepti. 2. Angustatio sive contractio partium post spiritum emissum. 3. Frigus externum actuale; aut etiam remissio caloris. 4. Frigus externum potentiale. 5. Fuga et antiperistasis. 6. Assimilatio ex imperio corporis densioris magis activi. 7. Compressio per violentiam externam. 8. Oneratio, si modo aliqua sit.

Actiones dilatationis per spiritum innatum, et per liberationem spirituum, et per deacervationem; atque rursus, actiones contractionis per constrictionem, sunt actiones sine reciproco. Reliquæ actiones sunt reciprocæ.

Dilatationes per introceptionem et per deacervationem sunt pseudo-dilatationes; sicut et contractiones per exclusionem, sunt pseudo-condensationes; sunt enim locales, non substantiales.

Expansio per ignem sive calorem sine separatione est omnium simplicissima: ea fit in pneumatico puro, sicut aëre; ubi nihil exhalat, nihil residet, sed mera fit dilatatio, eaque ad ampliationem spatii sive exporrectionis insignem. Utrum simile quippiam fiat in flamma, videlicet, utrum flamma post expansionem primæ accensionis (quæ est magna) jam facta flamma (ubi magnus est ambientium ardor) se adhuc magis expandat, difficile cognitu est, propter celerem et momentaneam extinctionem flammæ: verum de hoc in titulo de Flamma inquiremus. Proxima huic dilatationi (quatenus ad simplicitatem) est expansio quæ fit in colliquatione metallorum, aut in emollitione ferri et ceræ, et similium, ad tempus, antequam aliquid fiat volatile et emittatur. Verum hæc dilatatio occulta est, et fit intra claustra corporis integralis, nec visibiliter exporrectionem mutat aut ampliat. At simul ac incipiat in corpore aliquo quippiam evolare, tum actiones fiunt complicatæ, partim rarefacientes, partim contrahentes: adeo ut contrariæ illæ actiones ignis, quæ vulgo notantur,

> Limus ut hic durescit, et hæc ut cera liquescit,
> Uno eodemque igni,[1]

[1] Virg. Eclog. viii. 80.

in hoc fundentur, quod in altera spiritus emittitur, in altera detinetur.

Condensatio quæ fit per ignem, licet non sit pseudo-densatio (est enim substantialis), tamen est condensatio potius secundum partes, quam secundum totum. Nam contrahuntur certe partes crassiores; ita tamen ut corpus integrum reddatur magis cavum et porosum, et minus ponderosum.

Canones mobiles.

1. Summa materiæ in universo eadem manet; neque fit transactio, aut a nihilo, aut ad nihilum.

2. Ex summa in aliquibus corporibus est plus, in aliquibus minus, sub eodem spatio.

3. Copia et paucitas materiæ constituunt notiones densi et rari, recte acceptas.

4. Est terminus, sive *non ultra*, densi et rari, sed non in ente aliquo nobis noto.

5. Non est vacuum in natura, nec congregatum nec intermistum.

6. Inter terminos densi et rari est plica materiæ, per quam se complicat et replicat absque vacuo.

7. Differentiæ densi et rari in tangibilibus nobis notis parum excedunt rationes 32 partium.

8. Differentia a rarissimo tangibili ad densissimum pneumaticum habet rationem centuplam et amplius.

9. Flamma est aëre rarior, ut et oleum aqua.

10. Flamma non est aër rarefactus, ut nec oleum est aqua rarefacta; sed sunt plane corpora heterogenea, et non nimis amica.

11. Spiritus vegetabilium et animalium sunt auræ compositæ ex pneumatico aëreo et flammeo; quemadmodum et succi eorum ex aqueo et oleoso.

12. Omne tangibile apud nos habet pneumaticum, sive spiritum, copulatum et inclusum.

13. Spiritus, quales sunt vegetabilium et animalium, non inveniuntur apud nos soluti, sed in tangibili devincti et conclusi.

14. Densum et rarum sunt propria opificia calidi et frigidi; densum frigidi, rarum calidi.

15. Calor super pneumatica operatur per expansionem simplicem.

16. Calor in tangibili exercet duplicem operationem; semper dilatando pneumaticum, sed crassum interdum contrahendo, interdum laxando.

17. Norma autem ejus rei talis est: spiritus emissus corpus contrahit et indurat; detentus intenerat et colliquat.

18. Colliquatio incipit a pneumatico in corpore expandendo; aliæ dissolutiones a crasso, liberando operationem pneumatici.

19. Post calorem et frigus, potentissima sunt ad rarefactionem et condensationem corporum consensus et fuga.

20. Restitutio a violentia et dilatat et condensat, in adversum violentiæ.

21. Assimilatio et dilatat et condensat, prout est assimilans assimilato rarius aut densius.

22. Quo corpora sunt rariora, eo majorem sustinent et dilatationem et contractionem per externam violentiam, ad certos terminos.

23. Si tensura aut pressura in corpore raro transgrediatur terminos sustinentiæ, tum corpora rariora potentius se vindicant in libertatem quam densiora, quia sunt magis activa.

24. Potentissima omnium expansio est expansio aëris et flammæ conjunctim.

25. Imperfectæ sunt dilatationes et contractiones, ubi facilis et proclivis est restitutio.

26. Densum et rarum magnum habent consensum cum gravi et levi.

27. Parce suppeditatur homini facultas ad condensationem, ob defectum potentis frigidi.

28. Ætas est instar ignis lambentis, et exequitur opera caloris, sed accuratius.

29. Ætas deducit corpora vel ad putrefactionem vel ad arefactionem.

Optativa cum proximis.

1. Versio aëris in aquam.

Proximi. Fontes in cavis montium. Exudatio lapidum. Roratio anhelitus. Vellus super latera navium, qu.[1] Meteora aquea, &c.

2. Augmentum ponderis in metallis.

[1] See p. 99. § 7. —*J. S.*

Proxima. Versio ferri in cuprum, qu. Incrementum plumbi in cellis, qu. Versio argenti vivi in aurum, qu.

3. Insaxatio terræ, et materiarum ex vegetabilibus aut animalibus.

Proxima. Aqua insaxans. Lapis compositus ex lapidibus parvis incrustatis. Stillicidia crystallina in speluncis. Calculi in renibus et vesica et cyste fellis. Squamæ dentium.

4. Varii usus motus dilatantis et contrahentis in aëre per calorem.

Proxima. Vitrum calendare. Altare Heronis. Organum musicum splendentibus radiis solis. Impostura de imitatione fluxus et refluxus maris et amnium.

5. Inteneratio membrorum in animalibus per calorem proportionatum et spiritum detentum.

Proxima. Emollitio ferri. Emollitio ceræ. Omnia amalagmata. Pertinet ad instaurationem juventutis: nam omnis humectatio, præter eam quæ fit ex spiritu nativo detento, videtur esse pseudo-inteneratio, et parum juvat; ut in proprio titulo videbimus.

Monitum. Parce proponimus sub isto titulo Optativa et Vellicationes de Praxi: quia cum sit tam generalis et late patens, magis idoneus est ad informandum judicium quam ad instruendam praxin.

INQUISITIO DE MAGNETE.

PREFACE

TO THE

INQUISITIO DE MAGNETE.

In Dr. Rawley's list of works composed by Bacon during the last five years of his life, the *Inquisitio de Magnete* stands last but two. The following fragment, first published by Dr. Rawley himself in 1658, and bearing that title, may be presumed to be the work in question. Though it seems to be only a sheet of notes, the place which it holds in the list implies that it was meant to be preserved; and therefore I place it here rather than in the third part, to which otherwise it might seem more properly to belong. It may be regarded as a loose leaf belonging to the third part of the Instauratio.

J. S.

INQUISITIO DE MAGNETE.

Magnes trahit pulverem chalybis præparati, quali utuntur ad medicinam, etiam chalybem calcinatum in tenuissimum pulverem nigrum, æque fortiter ac limaturam ferri crudam: crocum autem Martis, qui est rubigo ferri artificiosa, hebetius et debilius. Si vero ferrum dissolvatur in aqua forti, et guttæ aliquæ dissolutionis ponantur super vitrum planum, non extrahit magnes ferrum, nec trahit aquam ipsam ferratam.

Magnes scobem suum trahit, quemadmodum limaturam ferri: parvaque admodum magnetis frustula, alterum alterum trahit, ut pensilia fiant, et capillata, quemadmodum acus.

Pone magnetem in tali distantia a ferro, ut non trahat: interpone pileum ferri, servata distantia, et trahet; virtute magnetis per ferrum melius diffusa, quam per medium aëris solius.

Magnes immissus intra aquam fortem, ibique per plures horas manens, virtute non minuitur.

Magnes fricatione contra pannum (ut utimur in electro), aut contra alium magnetem, aut calefactus ad ignem, virtute non augetur.

Magnes alius alio est longe virtuosior: quinetiam virtutem suam, pro modo ejus, ferro tactum transmittit: virtutem, inquam, non solum verticitatis, sed etiam attractionis simplicis. Nam si accipias magnetem fortiorem, eoque ferrum (puta cultellum) tangas, deinde magnete debiliore similiter alium cultellum, videbis cultellum fortiore magnete tactum majus trahere pondus ferri, quam qui debiliore tactus est.

Magnes ad æque distans ferrum trahit per aërem, aquam, vinum, oleum.

Magnete, aut pulvere ejus, in aqua forti immerso, nihil omnino dissolvitur, sicut in ferro fit; licet magnes videatur esse corpus ferro consubstantiale.

Pulvis magnetis ferrum intactum non trahit, nec tactum etiam: attamen ipse pulvis a ferro tacto trahitur, et adhæret; ab intacto autem minime: adeo ut pulvis magnetis videatur passivam virtutem aliquo modo retinere, activam autem non omnino.

Acus super planum posita, quæ magnete non trahitur propter pondus, eadem superimposita fundo vitri elevato, ut utrinque propendeat, trahetur; quod eo magis relatu dignum puto, quia hujusmodi quiddam fortasse occasionem dedit frivolæ illi narrationi, quod adamas magnetis virtutem impediat. Pone enim acum super adamantem parvum, in tabulam sectum, magnete præsente ad distans majus quam in quo trahere posset, tamen trepidabit: illa autem trepidatio, non prohibitio motus est, sed motus ipse.

Magnes ferrum tactum longe vivacius trahit, quam intactum; adeo ut ferrum, quod intactum in data distantia non trahit, id in triplici distantia tactum trahat.

Nihil extrahitur ferri aut metallicæ materiæ ex magnete per ignem, et nota separationis.

Magnes non solvitur in aqua regis plus quam in aqua forti.

Magnes in crucibulo positus, citra tamen quam ut flammam immittat, minuitur multum pondere, et immensum virtute, ut vix ferrum attrahat.

Magnes ægre liquefit, sed tamen figuram nonnihil immutat, et rubescit ut ferrum.

Magnes combustus integer, virtutem passivam, ut se applicet alteri magneti, retinet; activam ad ferrum trahendum fere perdit.

Magnes in crucibulo combustus emittit fumum, vix tamen visibilem, qui laminam æris superimpositam nonnihil albicare facit: ut solent etiam metalla.

Magnes in comburendo penetrat per crucibulum, idque tam extra quam intra fracto, quod a splendore splendescere facit.

Consentiunt omnes, magnetem, si comburatur, ita ut flammam quandam luridam et sulphuream jaciat, prorsus fieri virtute evanidum; eamque nunquam postea recuperare; licet refrigeretur in positura australi, et septentrionali: id quod lateribus virtutem indit, et in magnetibus non prorsus combustis vires renovat.

Experimentum factum est, de ferro magnete tacto, ac etiam de magnete ipso, collocatis super fastigium templi S. Pauli Londini, quod est ex altissimis templis Europæ; annon minuerentur virtute attractiva, propter distantiam a terra? sed nihil prorsus variatum est.

TOPICA INQUISITIONIS

DE

LUCE ET LUMINE.

PREFACE

TO

TOPICA INQUISITIONIS DE LUCE ET LUMINE.

The following paper of directions for an experimental inquiry concerning Light was first published by Gruter in 1653, among the pieces which he entitles *Impetus Philosophici;* afterwards (from another copy) by Dr. Rawley in 1658; and since a work with the same title is mentioned in Rawley's list of Bacon's later writings, where it stands last but one,[1] I presume that this is it, and that it was meant to be preserved. If so, this is its proper place.

In my preface to the *Parasceve*, I have noticed Bacon's intention to draw up, with reference to the Natural and Experimental History which was to be the basis of the new philosophy, certain heads of inquiry showing what points in each subject were more particularly to be observed; and I have pointed out the importance of this part of his scheme, as bearing upon the question whether it were possible or not to procure a collection of the facts of nature in the manner he proposed. One example of the thing we have

[1] See Vol. I. p. 46. Mr. Ellis however infers from the allusion (infra, p. 135.) to *specula perspectiva*, that this tract must have been written before 1612. See his note. — *J. S.*

already seen, in the *Topica Particularis sive Articuli Inquisitionis de Gravi et Levi*, given in the fifth book of the *De Augmentis*. This is another; and though it does not profess to contain more than a few instances by way of example, it serves to show how he proposed to set about the work. If the enclosure transmitted in his letter to Father Baranzan, which related to a history of Comets (*de qua conficienda ecce tibi articulos quosdam et quasi topica particularia*), had been preserved, it would have supplied us with a third. It may be thought strange perhaps that he did no more during the last five years of his life towards the performance of a task, which in 1620 he talked of setting about as soon as he could find leisure,[1] and which in 1623 he was still meditating.[2] But the sufficient explanation of the matter is, that he never had the offer of any help in making the proposed collections, and therefore the proposed directions would have been useless.

That the suggestions contained in the paper before us, which was probably drawn up with a view to the *Historia Visûs et Visibilium*, should retain any substantial value at the present day, was of course not to be expected. What value they may have had in Bacon's time, I do not know. But they remain to prove (if proof were wanting) that the system of observations and experiments from which he hoped to procure a collection of the facts of nature sufficient for the purposes of philosophy, was not to be carried on altogether

[1] Enimvero cum primum huic rei vacare possimus, consilium est in singulis veluti interrogando docere, &c. — *Parasceve*, § 10.

[2] Nos autem Topicis Particularibus tantum tribuimus ut proprium opus de ipsis, in subjectis naturalibus dignioribus et obscurioribus, conficere in animo habemus. Domini enim quæstionum sumus, rerum non item. — *De Aug.* v. 3.

without help from theory. They show also in what particular way he conceived that a communication between Theory and Observation might be established; and if the points upon which in this case he asks for information were not the most critical which might have been selected, it must have been owing to his imperfect acquaintance with what was then known about Light, not from any inherent impracticability in determining what next to ask, when one has a clear idea of what one wants next to know.

In the original, the numbers are placed before the first paragraph of each section, not before the headings. But as they belong properly to the sections, and not to the paragraphs, I have in this respect preferred the arrangement of Gruter's copy, where they are prefixed to the headings.

The notes to this fragment (except those marked with my initials) are Mr. Ellis's.

J. S.

TOPICA INQUISITIONIS

DE

LUCE ET LUMINE.

I. *Tabula Præsentiæ.*

Videndum primo, quæ sint ea, cujuscunque generis, quæ progignunt lucem: ut stellæ, meteora ignita, flamma, ligna, metalla et alia ignita, saccharum inter scalpendum et frangendum, cicendula, rores aquæ salsæ percussæ et sparsæ, oculi quorundam animalium, ligna nonnulla putria, magna vis nivis. Aër fortasse ipse tenuem possit habere lucem, animalium visui, quæ noctu cernunt, conformem. Ferrum et stannum, cum in aquam fortem immittuntur resolvenda, ebulliunt, et sine igne ullo acrem calorem concipiunt; utrum vero lucem aliquam edant, inquiratur. Oleum lampadum magnis frigoribus scintillat: nocte suda, circa equum sudantem, conspicitur nonnunquam lux quædam tenuis: circa capillos quorundam hominum accidit, sed raro, lux etiam tenuis, tanquam flammula lambens; ut factum est Lucio Martio in Hispania.[1] Ventrale cujusdam fœminæ nuper inventum est quod micaret, minime immotum, sed inter fricandum. Erat autem intinctum in viridi, atque tincturam illam ingreditur alumen, et

[1] Livy, xxv. 39.

crepabat nonnihil cum micabat. Utrum alumen inter scalpendum aut frangendum micet, inquiratur ; sed fortiore (ut puto) indiget fractione quam saccharum, quia magis contumax est. Tibialia nonnulla inter exuendum nituerunt, sive ex sudore, sive ex tinctura aluminis. Alia.

II. *Tabula Absentiæ in proximo.*

Videndum etiam, quæ sint ea quæ nullam lucem edant, quæ tamen cum iis quæ edant magnam habent similitudinem. Aqua bulliens non edit lucem. Aër licet violenter fervefactus non edit lucem. Specula et diamantes, quæ lucem tam insigniter reflectunt, nullam edunt lucem originalem. Alia.

Videndum est etiam accurate, in hoc genere instantiarum, de instantiis *migrantibus*, ubi scilicet adest et abest lux, quasi transiens. Carbo ignitus lucet, sed fortiter compressus statim lucem deponit. Humor ille crystallinus cicendulæ, morte vermis, etiam fractus et in partes divisus, lucem ad parvum tempus retinet, sed quæ paulo post evanescat. Alia.

III. *Tabula Graduum.*

Videndum quæ lux sit magis intensa et vibrans, quæ minus. Flamma lignorum fortem edit lucem ; flamma spiritus vini debiliorem ; flamma carbonum penitus accensorum, fuscam admodum et vix visibilem. Alia.

IV. *Colores Lucis.*

Videndum est de coloribus lucis, quales sint, quales non. Stellarum aliæ candidæ sunt, aliæ splendidæ, aliæ rubeæ, aliæ plumbeæ. Flammæ ordinariæ fere croceæ sunt,[1] et inter eas coruscationes cœlitus, et flammæ pulveris pyrii maxime albicant. Flamma sulphuris cœrulea est et pulchra. In aliquibus autem corporibus sunt purpureæ flammæ. Non inveniuntur flammæ virides.[2] Quæ maxime ad viriditatem inclinat, est lux cicendulæ. Nec inveniuntur coccineæ flammæ. Ferrum ignitum rubicundum est, et paulo intensius ignitum quasi candescit. Alia.

V. *Reflexiones Lucis.*

Videndum quæ corpora lucem reflectunt; ut specula, aquæ, metalla polita, luna, gemmæ. Omnia liquida, et superficie valde æquata et levi, splendent nonnihil. Splendor autem est gradus quidam pusillus luminis.

Videndum attente, utrum lux corporis lucidi ab alio corpore lucido reflecti possit: ut si sumatur ferrum ignitum, et opponatur radiis Solis. Nam reflexiones lucis omnino super-reflectuntur (elanguentes[3] tamen paulatim) de speculo in speculum. Alia.

VI. *Multiplicationes Lucis.*

Videndum de multiplicatione lucis, ut per specula perspectiva et similia,[4] quibus acui potest lux et in longinquum projici, aut etiam reddi ad distinguendas

[1] So Gruter's copy. In Rawley's the words *fere croceæ sunt* are omitted, probably by mistake. — *J. S.*

[2] Green flames for fireworks are produced by means of copper, which is sometimes employed in a metallic state, and sometimes in verdigris or in vitriol.

[3] *Elanguentia* in Rawley's copy. — *J. S.*

[4] This does not appear to refer to telescopes, but merely to bringing to a focus light incident on a convex lens. Consequently this tract seems to have been written before Bacon was acquainted with the invention of the telescope, and consequently before 1612. See the Preface to the *Descriptio Globi intellectualis.*

res visibiles subtilius et melius;[1] ut videre est apud pictores, qui phialam aqua plenam ad candelam adhibent.

Videndum etiam, num omnia in majore quanto lucem non reflectant. Lux enim (ut credi possit) aut pertransit aut reflectitur. Qua de causa luna, etiamsi fuerit corpus opacum, tamen ob magnitudinem lucem reflectere possit.

Videndum etiam, utrum aggregatio corporum lucidorum lucem multiplicet. Atque de æqualiter lucidis, dubitandum non est. Utrum vero lux quæ majore luce plane obruitur, ut videri per se non possit, adjiciat tamen aliquid lucis, inquiratur. Etiam splendida quæque nonnihil lucis contribuunt. Magis enim lucidum erit cubiculum serico quam lana ornatum. Multiplicatur etiam lux per refractionem: nam gemmæ angulis intercisæ, et vitrum fractum, magis splendent quam si plana fuerint. Alia.

VII. *Modi obruendi lucem.*

Videndum de modis obruendi lucem; veluti per exuperantiam majoris lucis, mediorum crassitudines et opacitates. Radii solis certe, in flammam foci immissi, flammam veluti fumum quendam albiorem apparere faciunt. Alia.

VIII. *Operationes sive Effectus Lucis.*

Videndum de operationibus sive effectibus lucis, qui pauci sunt; et ad corpora, præsertim solida, alteranda parum possunt. Lux enim præ omnibus se generat, alias qualitates parce.

Lux certe aërem nonnihil attenuat; spiritibus ani-

[1] *Mollius* in Gruter's copy. — *J. S.*

malium grata est, eosque exhilarat; colorum omnium et visibilium radios submortuos excitat. Omnis enim color, lucis imago fracta est. Alia.

IX. *Mora Lucis.*

Videndum est de mora lucis; quæ, ut videtur, momentanea est. Neque enim lux, si per multas horas in cubiculo duraverit, magis illud illuminat, quam si per momentum aliquod; cum in calore et aliis contra fiat. Etenim et prior calor manet, et novus superadditur. Attamen crepuscula nonnihil a reliquiis lucis[1] provenire ab aliquibus putantur.

X. *Viæ et Processus Lucis.*

Videndum attente de viis et processibus lucis. Lux circumfunditur; utrum vero una ascendat paululum, an æqualiter deorsum et sursum circumfundatur, inquiratur. Lux ipsa lucem undique circa se parit; ut cum corpus lucis, umbraculo scilicet interposito, non cernatur, lux ipsa tamen omnia circum illuminat, præter ea quæ sub umbram umbraculi cadunt; quæ tamen ipsa nonnihil lucis accipiunt a luce circumjecta; nam multo melius aliquid intra umbram umbraculi situm cerni potest, quam si nulla omnino adesset lux. Itaque corpus visibile corporis alicujus lucidi, et ipsa lux, res discrepantes esse videntur. Lux corpora fibrosa et inæqualis posituræ non penetrat; sed tamen a soliditate duritiæ corporis non impeditur, ut fit in vitro et similibus. Itaque recta linea, et pori non transversi, videntur lucem tantum perferre.

Delatio lucis fit optime per aërem; qui quo purior fuerit, eo melius lucem transmittit. Utrum lux per

[1] *Solis* in Gruter's copy. — *J. S.*

corpus aëris vehatur, inquiratur. Sonos certe videmus a ventis vehi, ut[1] longius secundo vento quam adverso audiri possint. Utrum vero simile aliquid fiat in luce, inquiratur. Alia.

XI. *Diaphaneitas lucidorum.*

Videndum est etiam de diaphaneitate lucidorum. Filum candelæ intra flammam cernitur: at per majores flammas objecta ad visum non perveniunt. At contra, omnis diaphaneitas ex corpore aliquo ignito perit; ut in vitro videre est, quod ignitum non amplius manet diaphanum. Corpus aëris diaphanum est; item aquæ: at illa duo diaphana commista, in nive aut spuma, non amplius diaphana sunt, sed acquirunt lucem quandam originalem.

XII. *Cognationes et Hostilitates Lucis.*

Videndum de cognationibus atque etiam hostilitatibus lucis. Cognationem maxime habet lux cum tribus rebus, quatenus ad generationem lucis; calore, tenuitate, et motu.[2] Videndum igitur de conjugiis et divortiis eorum erga lucem, atque eorundem conjugiorum et divortiorum gradibus. Flamma spiritus vini, aut ignis fatui, longe ferro ignito calore lenior est, verum lumine fortior. Cicendulæ et rores aquæ salsæ, et multa ex illis quæ enumeravimus, lucem jaciunt, calida ad tactum non sunt. Etiam metalla ignita tenuia non sunt, at calore tamen ardente prædita. At contra aër est inter tenuissima corpora, sed luce vacat. Rursus idem

[1] So Gruter's copy. Rawley's has *et*. — *J. S.*

[2] This quaternion of qualities, light, heat, tenuity, and motion, is a fundamental part of the philosophy of Telesius. See his *De Rer. Nat.* i. passim.

aër, atque etiam venti, motu rapidi sunt, lucem tamen non præbent. At contra, metalla ignita motum suum hebetem non exuunt, lucem nihilominus vibrant.

In cognationibus autem lucis, quæ non ad generationem ejus, sed ad processum tantum spectant, nihil tam conjunctum est quam sonus. Itaque de eorum sympathiis et dissidiis accurate videndum. In his conveniunt. Lux et sonus in ambitum circumfunduntur. Lux et sonus per longissima spatia feruntur, sed lux pernicius; ut in tormentis videmus, ubi lux citius cernitur quam auditur sonus, cum tamen flamma pone sequatur. Lux et sonus subtilissimas distinctiones patiuntur; ut in verbis articulatis soni, in omnibus visibilium imaginibus lux. Lux et sonus nihil fere producunt aut generant, præterquam in sensibus et spiritibus animalium. Lux et sonus facile generantur et brevi evanescunt. Nam non est quod quis putet sonum illum qui ad tempus aliquod a campana aut chorda percussa durat, a prima percussione fieri. Nam si campana vel chorda tangatur, et sistatur, sonus statim perit. Unde manifestum est, durationem soni[1] per successionem creari. Lux a majore luce, sicut sonus a majore sono, obruitur; et cætera.

Differunt autem, quod lux (ut diximus) sono velocior sit. Lux majora spatia vincat quam sonus. Lux utrum in corpore aëris deferatur, quemadmodum sonus, incertum sit. Lux in linea recta tantum, sonus in linea obliqua et undiquaque, feratur: etenim cum quid in umbra umbraculi cernitur, non est quod quis putet quod lux ipsa penetret umbraculum, sed aërem tantum circumfusum illuminat; qui etiam aërem pone umbra-

[1] So Gruter's copy: the words *durationem soni* are omitted in Rawley's. — *J. S.*

culum vicinitate nonnihil illustrat: at sonus ab uno latere parietis redditus, ex altera parte parietis auditur, non multum debilitatus. Etiam sonus intra septa corporum solidorum auditur, licet exilior factus; ut fit in sonis infra lapides hæmatites, aut in corporibus percussis infra aquam; at lux in corpore solido et non[1] diaphano, undique obstructo, omnino non cernitur. Ultimo, quod[2] omnis sonus generetur in motu, et elisione corporum manifesta; lux non item.

At hostilitates lucis, nisi quis privationes pro hostilitatibus habere velit, non occurrunt; verum quod maxime credibile est, torpor corporum in partibus suis maxime est luci inimicus. Nam fere nihil lucet, quod non aut propria natura insigniter mobile est; aut excitatum vel calore vel motu vel spiritu vitali. Alia.

Intelligo autem semper, quod non tantum aliæ instantiæ investigandæ sint (istas enim paucas exempli loco solummodo adduximus) sed etiam ut novi topici articuli, prout rerum natura fert, adjiciantur.

[1] So Gruter's copy: the words *solido et non* are omitted in Rawley's. — *J. S.*

[2] Gruter's copy has *Lux magis in profundum penetrat quam sonus; ut in fundo aquarum. Omnis sonus generatur, &c.* — *J. S.*

SYLVA SYLVARUM.

PREFACE

TO

THE SYLVA SYLVARUM.

BY ROBERT LESLIE ELLIS.

In 1627, the year after that in which Bacon died, his chaplain Dr. Rawley published the *Sylva Sylvarum*. The preface is Rawley's own, and was written in Bacon's lifetime; it gives some account of Bacon's views touching the kind of natural history required as the foundation of the instauration of the sciences, but contains little or nothing which is not found elsewhere. Although Rawley says that in the present work the materials for the building are collected, yet it cannot be doubted but that Bacon was fully conscious that, even taken in conjunction with the treatises *De Ventis* and *De Vitâ et Morte*, &c., the *Sylva Sylvarum* falls far short of his own idea of a just and perfect Natural History. We should do him injustice if we were to suppose that he was satisfied with the collection of facts here published, of which much the greater part are taken from a few popular writers. We ought rather to regard it as a proof that Bacon's thoughts were busied, up to the close of life, with his plan for the reform of philosophy, and as the work of a man who, knowing that he could not accomplish his own designs, was yet resolved, in spite of worldly troubles and of increasing infirmities, to labour on in the good cause which he had so long had in hand. That it was Bacon's last work gives it a peculiar interest, though the habits of thought which in the seventeenth century made it a popular book have long since passed away. Curiosity about isolated or slightly connected facts seems gradually to decline, as scientific notions become more generally diffused; the interest which we feel in any phenomenon is much impaired, when we know that however marvellous it may seem to us it can nevertheless be intelligibly explained. Men learn by degrees to leave off wondering, and to seek for causes, or trust for information to those who do. At present, popular books on science attempt for the most part to make abstract theories intelligible, or at least to give an account of what these theories are about. But in Bacon's time, and still more at an earlier period, men delighted in nothing more than in collections of remarkable facts; the more marvellous, so they did not become altogether incredible, the better. In those days men were much more nearly on a level in scientific matters than they are now; and the reader of Mizaldus or of John Baptist Porta was not mortified by the reflection that his wonder was only the result of his own ignorance. All men were, as it seemed, equally ignorant of the occult causes of phenomena, and if any explanation was offered it was such as all men could equally understand. For at best these explanations involved only loose and popular notions of force and motion, and for the most part they merely referred the phenomena to sympathy and antipathy, the influence of the stars, specific forms, and the like, of which principles the modus operandi was, by the consent of all men, held undiscoverable. To this class of writings the *Sylva Sylvarum* seems naturally to belong, and, in truth, a considerable part of it is copied from the most celebrated book of the kind, namely Porta's *Natural Magic*. It has doubtless a more scientific character than the average of similar works, but there are some to which in this and in other respects it is decidedly inferior. I refer particularly to Cardan's *De Subtilitate*, and to his *De Rerum Varietate*. Both of them supplied some of the facts mentioned in the *Sylva Sylvarum*.

I may be allowed to digress for a moment from the *Sylva Sylvarum* to a subject of considerable interest, namely the facility with which miraculous stories were received in the middle ages. We are apt to regard this as a proof of the prevalence of gross superstition; whereas in reality miracles were simply believed like other marvels. The habit of asking *how* effects are produced had then no existence, and consequently the *à priori* difficulty which hinders men from believing in wonderful stories, except on commensurate evidence, was never felt. Every one believed, for instance, that bleeding might be stopped by touching the wounded man with a blood-stone, — why might not the same effect be produced by the relic of a saint? And so in all similar cases. The *à priori* conceivability of any assertion is one of the circumstances by which men are decided in believing or disbelieving it; but this operates differently according to the mental habits of different men. The subject cannot here be pursued farther, though, from its connexion with the application of the theory of probabilities to questions of evidence, it is by no means unimportant.

The *Sylva Sylvarum* consists of one thousand paragraphs, and is divided into ten centuries. Each of these paragraphs contains a statement of one or more facts, accompanied generally by some remarks tending more or less to explain the causes of the observed phenomena. The facts themselves are derived from a variety of sources; some from Bacon's own observation, some perhaps from oral report, and the remainder from books. In many places they seem to have been noted down as the book from which they are taken was read; at least they occur in the same order as in the original work. The principal sources are Aristotle's *Problems*, his *De mirabilibus auscultationibus* (not genuine), and his *Meteorologics;* Pliny's *Natural History*, Porta's *Natural Magic*, and Sandys's *Travels.* To these are to be added Cardan *De Subtilitate*, Scaliger *Adversus Cardanum*, and one or two others. The *Natural Magic* contributes more than any other book, and next to it, I think, Aristotle's *Problems.*

The route which Sandys, whose book was published in 1615, followed in his travels may almost be traced in Bacon's extracts. Thus, in (701) he is at Lemnos, from whence he proceeds in the next two paragraphs up the Dardanelles to Constantinople. In (704) and (705) we find some mention of what he saw there; a subject resumed in (738) and continued to (741). In (743) he has reached Egypt, where he is found again in (767) and the next paragraph. The succeeding sixteen paragraphs follow him, with some admixture of extraneous matter, through Syria and Palestine to Sicily and the neighbourhood of Naples.

From Cardan is taken the great mass of what is said in the tenth century touching sympathy and antipathy. One or two curious stories Bacon adds from his own experience, and he also mentions two remarkable cases of instinctive divination. Of these the first is the story told in the life of Angelo Caltho, prefixed to some editions of Comines's *Memoirs*, namely that he announced the death of Charles the Bold at the very time at which it took place: the other is mentioned in Catena's *Life of Pius V.*, — that he knew of the victory at Lepanto as soon as it was won. For the first story Bacon refers to Comines, who says nothing about it, and whose silence is all but conclusive against its truth;[1] for the second he gives no authority, but there is no doubt but that he derived it from Catena, with whose book he was in all probability acquainted, as what he says of Pius V. in the beginning of the *Advancement of Learning* is taken from it.

Porta's *Natural Magic* supplied Bacon with almost all he says of the changes which may be produced in fruits and other vegetable products by peculiar modes of cultivation. In some of the paragraphs taken from Porta he refers to "one of the ancients," the reason of which is that almost all Porta's statements are supported by reference to a Greek or Latin author. If we did not know the channel through which his information is derived, we might give him credit for much cu-

[1] The misfortunes of the Duke of Burgundy are recorded in four curious lines, written apparently by a contemporary. They are manifestly corrupt, but may perhaps be thus restored: —

Nix Burgundo nocuit
Sed Gransen grande gravavit
Morat momordit
Quem lancea Nancy necavit.

KELLER'S *Romvart*, p. 157.

rious research. Thus in (458) he observes that it is reported by one of the ancients that artichokes will be less prickly if their tops have been grated off upon a stone. The writer referred to is Varro, but the statement is only preserved in the *Geoponica;* it does not occur in any part of his works now extant. As the *Geoponica* are certainly not often read or even quoted, it would have been interesting to know that Bacon was acquainted with them. Unfortunately, on looking into the *Natural Magic*, we find that Bacon was in this case simply a transcriber.

The statements taken from Aristotle's *Problems* relate, like the problems themselves, to a great variety of subjects. Bacon does not adopt Aristotle's solutions, at least not generally, but after stating affirmatively the fact of which Aristotle inquires the cause, he gives his own explanation of it, often introducing it by the formula, "the reason is, &c.," which is, I think, not employed except in paragraphs taken from or suggested by something in the *Problems*. The paragraphs from (837) to (846) are evidently the result of Bacon's having been reading the fourth book of the *Meteorologics*, but they consist less of statements of facts than of speculations relating to familiarly known phenomena.

Pliny's *Natural History* supplied Bacon with many remarks on agriculture and kindred subjects.

The description of the chameleon in (360) is clearly taken from Scaliger's *Exercitationes adversus Cardanum*, and in another paragraph (694) he mentions Scaliger by name, and approves of something which is said in the same work. Scaliger and Comines are, I think, the only two modern writers mentioned in the *Sylva Sylvarum*.

In the paragraphs of the second century, which relate to music, Bacon refers to the controversy as to whether the interval of the fourth ought to be considered a harmony. There are a number of books by which this question may have been suggested to him, but it is impossible to know which of them he had read. His opinion in favour of the fourth is quoted with great approbation by [Charles Butler, of Magdalen College, Oxford, in his *Principles of Music* (1636). See note on Exp. 107.]

In concluding these desultory remarks it may be well to observe that the name Sylva Sylvarum seems to be a Hebraism for optima sylva;[1] sylva being used as ὕλη in Greek for the materials out of which anything is to be constructed. The name therefore accords with Bacon's notion of natural history; namely that it ought to supply the materials with which the new philosophy is to be built up.

[1] I should rather take it to mean *a collection of collections*; that is, a variety of Sylvæ (or collections of facts relating to particular subjects) gathered together. Almost all the experiments concerning sound, which extend from 100 to 290, are to be found in a Latin fragment which has *Sylva Soni et Auditus* for one of its titles. That is one of the *Sylvæ* of which this *Sylva Sylvarum* is made up. — *J. S.*

SYLVA SYLVARUM:

OR

A NATURAL HISTORY.

IN TEN CENTURIES.

WRITTEN BY THE RIGHT HONOURABLE

FRANCIS LORD VERULAM, VISCOUNT ST. ALBAN.

PUBLISHED AFTER THE AUTHOR'S DEATH

BY

WILLIAM RAWLEY, DOCTOR OF DIVINITY,

LATE HIS LORDSHIP'S CHAPLAIN.

LONDON:
Printed by J. H. for William Lee at the Turk's Head in Fleet Street,
next to the Mitre.

1627.

TO

THE MOST HIGH AND MIGHTY

PRINCE CHARLES,

BY THE GRACE OF GOD,

KING OF GREAT BRITAIN, FRANCE, AND IRELAND,

DEFENDER OF THE FAITH, ETC.

May it please Your Most Excellent Majesty,

THE whole body of the *Natural History*, either designed or written by the late Lord Viscount St. Alban, was dedicated to Your Majesty, in his book *De Ventis*, about four years past, when Your Majesty was Prince: so as there needed no new dedication to this work, but only in all humbleness to let Your Majesty know it is yours. It is true, if that Lord had lived, Your Majesty ere long had been invoked to the protection of another History; whereof, not Nature's kingdom, as in this, but these of Your Majesty's (during the time and reign of King Henry the Eighth) had been the subject; which since it died under the designation merely, there is nothing left but Your Majesty's princely goodness, graciously to accept of the undertaker's heart and intentions; who was willing to have parted for a while with his darling philosophy, that he might have attended your royal commandment in that other work. Thus much I have been bold in all lowliness to represent unto Your Majesty, as one that was trusted with his Lordship's writings even to the last. And as this work affecteth the stamp of Your Majesty's royal protection, to make it more current to the world; so under the protection of this work, I presume in all humbleness to approach Your Majesty's presence, and to offer it up into your sacred hands.

Your Majesty's most loyal
and devoted subject,

W. RAWLEY.

TO THE READER.

Having had the honour to be continually with my lord in compiling of this work, and to be employed therein, I have thought it not amiss (with his lordship's good leave and liking), for the better satisfaction of those that shall read it, to make known somewhat of his lordship's intentions touching the ordering and publishing of the same. I have heard his lordship often say, that if he should have served the glory of his own name, he had been better not to have published this Natural History: for it may seem an indigested heap of particulars, and cannot have that lustre which books cast into methods have; but that he resolved to prefer the good of men, and that which might best secure it, before anything that might have relation to himself. And he knew well that there was no other way open to unloose men's minds, being bound and, as it were, maleficiate by the charms of deceiving notions and theories, and thereby made impotent for generation of works, but only nowhere to depart from the sense and clear experience; but to keep close to it, especially in the beginning: besides, this Natural History was a debt of his, being designed and set down for a third part of the Instauration. I have also heard his lordship discourse that men (no doubt) will think many of the experiments contained in this collection to be vulgar and trivial, mean and sordid, curious and fruitless: and therefore, he wisheth that they would have perpetually before their eyes what is now in doing, and the difference between this Natural History and others. For those Natural Histories which are extant, being gathered for delight and use, are full of pleasant descriptions and pictures, and affect and seek after admiration, rarities, and secrets. But, contrariwise, the scope which his lordship intendeth, is to write such a Natural History as may be fundamental to the erecting and building of a true philosophy; for the illumination of the understanding, the extracting of axioms, and the producing of many noble works and effects. For he hopeth by this means to acquit himself of that for which he taketh himself in a sort bound, and that is, the advancement of all learning and sciences. For, having in this present work collected the materials for the building, and in his Novum Organum (of which his lordship is yet to publish a second part) set down the instruments and directions for the work; men shall now be wanting to themselves, if they raise not knowledge to that perfection whereof the nature of mortal men is capable. And in this behalf, I have heard his lordship speak complainingly, that his lordship (who thinketh he deserveth to be an architect in this building) should be forced to be a workman and a labourer, and to dig the clay and burn the brick; and more than that, (according to the hard condition of the Israelites at the latter end) to gather the straw and stubble over all the fields to burn the bricks withal. For he knoweth, that except he do it, nothing will be done: men are so set to despise the means of their own good.

And as for the baseness of many of the experiments; as long as they be God's works, they are honourable enough. And for the vulgarness of them, true axioms must be drawn from plain experience and not from doubtful; and his lordship's course is to make wonders plain, and not plain things wonders; and that experience likewise must be broken and grinded, and not whole, or as it groweth. And for use; his lordship hath often in his mouth the two kinds of experiments, *experimenta fructifera* and *experimenta lucifera:* experiments of Use, and experiments of Light: and he reporteth himself, whether he were not a strange man, that should think that light hath no use, because it hath no matter. Further, his lordship thought good also to add unto many of the experiments themselves some gloss of the causes: that in the succeeding work of interpreting nature and framing axioms, all things may be in more readiness. And for the causes herein by him assigned; his lordship persuadeth himself, they are far more certain than those that are rendered by others; not for any excellency of his own wit (as his lordship is wont to say), but in respect of his continual conversation with nature and experience. He did consider likewise, that by this addition of causes, men's minds (which make so much haste to find out the causes of things) would not think themselves utterly lost in a vast wood of experience, but stay upon these causes (such as they are) a little, till true axioms may be more fully discovered. I have heard his lordship say also, that one great reason why he would not put these particulars into any exact method (though he that looketh attentively into them shall find that they have a secret order) was because he conceived that other men would now think that they could do the like, and so go on with a further collection; which, if the method had been exact, many would have despaired to attain by imitation. As for his lordship's love of order, I can refer any man to his lordship's Latin book, *De Augmentis Scientiarum;* which (if my judgment be anything) is written in the exactest order that I know any writing to be. I will conclude with an usual speech of his lordship's; That this work of his Natural History is the world as God made it, and not as men have made it; for that it hath nothing of imagination.

W. RAWLEY.

This epistle is the same that should have been prefixed to this book if his lordship had lived.

NATURAL HISTORY.

CENTURY I.

Experiments in consort touching the straining and passing of bodies one through another; which they call Percolation.

1. Dig a pit upon the sea-shore, somewhat above the high-water mark, and sink it as deep as the low-water mark; and as the tide cometh in, it will fill with water, fresh and potable. This is commonly practised upon the coast of Barbary, where other fresh water is wanting. And Cæsar knew this well when he was besieged in Alexandria: for by digging of pits in the sea-shore, he did frustrate the laborious works of the enemies, which had turned the sea-water upon the wells of Alexandria; and so saved his army, being then in desperation.[1] But Cæsar mistook the cause, for he thought that all sea-sands had natural springs of fresh water. But it is plain that it is the sea-water; because the pit filleth according to the measure of the tide;[2]

[1] Hirtius, De Bello Alexandrino, c. 8. and 9.; and see Aristot. Prob. sect. xxiii. 21. and 37.

[2] Wells of fresh water close upon the sea shore sometimes ebb and flow with the tide. But this arises from the comparative levity of the fresh water, in consequence of which it is, so to speak, floated up when the tide comes in. Or it may arise from the presence of compressed air in the in-

and the sea-water passing or straining through the sands leaveth the saltness.

2. I remember to have read that trial hath been made of salt water passed through earth, through ten vessels one within another, and yet it hath not lost his saltness, as to become potable: but the same man saith, that (by the relation of another) salt water drained through twenty vessels hath become fresh.[1] This experiment seemeth to cross that other of pits made by the sea-side; and yet but in part, if it be true that twenty repetitions do the effect. But it is worth the note, how poor the imitations of nature are in common course of experiments, except they be led by great judgment, and some good light of axioms. For first, there is no small difference between a passage of water through twenty small vessels, and through such a distance as between the low-water and high-water mark. Secondly, there is a great difference between earth and sand; for all earth hath in it a kind of nitrous salt, from which sand is more free; and besides earth doth not strain the water so finely as sand doth. But there is a third point that I suspect as much or more than the other two; and that is, that in the experiment of transmission of the sea-water into the pits the water riseth; but in the experiment of transmission of the water through the

terstices of the soil which lies between the fresh and the salt water; an explanation which appears to be confirmed by recent experiments on the subject of drainage.

[1] This statement is taken from J. B. Porta. See his *Natural Magic*, xx. 1. Aristotle, in support of the opinion that fish are nourished by the fresh water present in the sea, states that a closed vessel of thin wax immersed for a certain time in the sea is found to contain fresh water. If this is true, the explanation probably is, that the temperature of the sea at the depth to which the vessel is sunk happens to be below the dew point of the air at the surface.

vessels it falleth. Now, certain it is that the salter part of water (once salted throughout) goeth to the bottom. And therefore no marvel if the draining of water by descent doth not make it fresh. Besides, I do somewhat doubt that the very dashing of the water that cometh from the sea is more proper to strike off the salt part, than where the water slideth of her own motion.

3. It seemeth percolation, or transmission, (which is commonly called *straining*) is a good kind of separation; not only of thick from thin, and gross from fine, but of more subtile natures; and varieth according to the body through which the transmission is made: as if through a woollen bag, the liquor leaveth the fatness; if through sand, the saltness, &c. They speak of severing wine from water, passing it through ivy wood, or through other the like porous body; but *non constat.*[1]

4. The gum of trees (which we see to be commonly shining and clear) is but a fine passage or straining of the juice of the tree through the wood and bark. And in like manner, Cornish diamonds and rock rubies (which are yet more resplendent than gums) are the fine exudations of stone.

5. Aristotle giveth the cause, vainly, why the feathers of birds are of more lively colours than the hairs of beasts; for no beast hath any fine azure, or carnation, or green hair. He saith, it is because birds are more in the beams of the sun than beasts;[2] but that

[1] Pliny, xvi. 63.; and Cato, De Re Rusticâ, cxi.

[2] Rather that hair is not susceptible of the action of the sun's rays as feathers are. See Aristot. De Coloribus, 6. It is remarkable that almost, if not absolutely, the only case in which hair exhibits something of the iridescent lustre of which the feathers of birds and the scales of fishes offer so

is manifestly untrue; for cattle are more in the sun than birds, that live commonly in the woods, or in some covert. The true cause is, that the excrementitious moisture of living creatures, which maketh as well the feathers in birds as the hair in beasts, passeth in birds through a finer and more delicate strainer than it doth in beasts: for feathers pass through quills; and hair through skin.

6. The clarifying of liquors by adhesion is an inward percolation; and is effected when some cleaving body is mixed and agitated with the liquors; whereby the grosser part of the liquor sticks to that cleaving body, and so the finer parts are freed from the grosser. So the apothecaries clarify their syrups by whites of eggs, beaten with the juices which they would clarify; which whites of eggs gather all the dregs and grosser parts of the juice to them; and after the syrup being set on the fire, the whites of eggs themselves harden, and are taken forth. So hippocras[1] is clarified by mixing with milk, and stirring it about, and then passing it through a woollen bag, which they call Hippocrates Sleeve; and the cleaving nature of the milk draweth the powder of the spices and grosser parts of the liquor to it; and in the passage they stick upon the woollen bag.

7. The clarifying of water is an experiment tending to health; besides the pleasure of the eye, when water is crystalline. It is effected by casting in and placing

many examples, is that of an animal of burrowing habits; the chrysochloris or cape mole, of which several species are known.

[1] Hippocras was made by boiling together red wine and spice. Its name is of course derived from its being strained in the manner described in the text. See Strutt, Manners and Customs, iii. 74. and compare Hippocrates, De Affectionibus, ii. p. 420. of Kuhn's edition.

pebbles at the head of a current, that the water may strain through them.

8. It may be, percolation doth not only cause clearness and splendour, but sweetness of savour; for that also followeth as well as clearness, when the finer parts are severed from the grosser. So it is found, that the sweats of men that have much heat, and exercise much, and have clean bodies and fine skins, do smell sweet; as was said of Alexander;[1] and we see commonly that gums have sweet odours.

Experiments in consort touching motion of bodies upon their pressure.

9. Take a glass, and put water into it, and wet your finger, and draw it round about the lip of the glass, pressing it somewhat hard; and after you have drawn it some few times about, it will make the water frisk and sprinkle up in a fine dew. This instance doth excellently demonstrate the force of compression in a solid body. For whensoever a solid body (as wood, stone, metal, &c.) is pressed, there is an inward tumult in the parts thereof, seeking to deliver themselves from the compression. And this is the cause of all violent motion. Wherein it is strange in the highest degree, that this motion hath never been observed nor inquired; it being of all motions the most common, and the chief root of all mechanical operations. This motion worketh in round at first, by way of proof and search which way to deliver itself; and then worketh in progress, where it findeth the deliverance easiest. In liquors this motion is visible; for all liquors

[1] Plutarch in Alexandr. p. 666. Lord Herbert of Cherbury affirms that his personal attendants could testify that he possessed this advantage.

strucken make round circles, and withal dash; but in solids (which break not) it is so subtile, as it is invisible; but nevertheless bewrayeth itself by many effects; as in this instance whereof we speak.[1] For the pressure of the finger, furthered by the wetting (because it sticketh so much the better unto the lip of the glass) after some continuance, putteth all the small parts of the glass into work, that they strike the water sharply; from which percussion that sprinkling cometh.

10. If you strike or pierce a solid body that is brittle, as glass or sugar, it breaketh not only where the immediate force is; but breaketh all about into shivers and fitters; the motion, upon the pressure, searching all ways, and breaking where it findeth the body weakest.

11. The powder in shot, being dilated into such a flame as endureth not compression, moveth likewise in round, (the flame being in the nature of a liquid body) sometimes recoiling, sometimes breaking the piece, but generally discharging the bullet, because there it findeth easiest deliverance.

12. This motion upon pressure, and the reciprocal thereof, which is motion upon tensure, we use to call (by one common name) *motion of liberty;* which is, when any body, being forced to a preternatural extent or dimension, delivereth and restoreth itself to the natural: as when a blown bladder (pressed) riseth again; or when leather or cloth tentured spring back. These two motions (of which there be infinite instances) we shall handle in due place.

[1] The solution of continuity of the earth's surface, observed in violent earthquakes, has been referred by Humboldt to this class of phenomena; the earthquake being in fact, as Æschylus might have called it, a *κῦμα χερσαῖον*.

13. This motion upon pressure is excellently also demonstrated in sounds; as when one chimeth upon a bell, it soundeth; but as soon as he layeth his hand upon it, the sound ceaseth. And so the sound of a virginal string, as soon as the quill of the jack falleth from it, stoppeth. For these sounds are produced by the subtile percussion of the minute parts of the bell or string upon the air; all one, as the water is caused to leap by the subtile percussion of the minute parts of the glass upon the water, whereof we spake a little before in the ninth experiment. For you must not take it to be the local shaking of the bell or string that doth it: as we shall fully declare when we come hereafter to handle sounds.

Experiments in consort touching separations of bodies by weight.[1]

14. Take a glass with a belly and a long neb; fill the belly (in part) with water: take also another glass, whereinto put claret wine and water mingled; reverse the first glass, with the belly upwards, stopping the neb with your finger; then dip the mouth of it within the second glass, and remove your finger: continue it in that posture for a time; and it will unmingle the wine from the water: the wine ascending and settling in the top of the upper glass; and the water descending and settling in the bottom of the lower glass.[2] The passage is apparent to the eye; for you shall see the wine, as it

[1] These experiments are taken from Porta's *Natural Magic*, xviii. 1. and 3.

[2] The wine and water are not separated from one another; all that takes place is that the water contained in the upper glass descends through the wine and water without perceptibly mixing with it, and settles at the bottom. The case is one of unstable equilibrium gradually becoming stable.

were in a small vein, rising through the water. For handsomeness sake (because the working requireth some small time) it were good you hang the upper glass upon a nail. But as soon as there is gathered so much pure and unmixed water in the bottom of the lower glass as that the mouth of the upper glass dippeth into it, the motion ceaseth.

15. Let the upper glass be wine, and the lower water; there followeth no motion at all. Let the upper glass be water pure, the lower water coloured; or contrariwise; there followeth no motion at all. But it hath been tried, that though the mixture of wine and water in the lower glass be three parts water and but one wine, yet it doth not dead the motion. This separation of water and wine appeareth to be made by weight; for it must be of bodies of unequal weight, or else it worketh not; and the heavier body must ever be in the upper glass.[1] But then note withal, that the water being made pensile, and there being a great weight of water in the belly of the glass, sustained by a small pillar of water in the neck of the glass, it is that which setteth the motion on work: for water and wine in one glass, with long standing, will hardly sever.

16. This experiment would be extended from mixtures of several liquors, to simple bodies which consist of several similar parts. Try it therefore with brine or salt water, and fresh water; placing the salt water (which is the heavier) in the upper glass; and see whether the fresh will come above. Try it also with water thick sugared, and pure water; and see whether the water which cometh above will lose his sweetness:

[1] Of course; as in the contrary case the equilibrium is stable.

for which purpose it were good there were a little cock made in the belly of the upper glass.

Experiments in consort touching judicious and accurate infusions, both in liquors and air.

17. In bodies containing fine spirits which do easily dissipate, when you make infusions, the rule is, A short stay of the body in the liquor receiveth the spirit ; and a longer stay confoundeth it ; because it draweth forth the earthy part withal, which embaseth the finer. And therefore it is an error in physicians to rest simply upon the length of stay, for increasing the virtue. But if you will have the infusion strong, in those kinds of bodies which have fine spirits, your way is not to give longer time, but to repeat the infusion of the body oftener. Take violets, and infuse a good pugil of them in a quart of vinegar ; let them stay three quarters of an hour, and take them forth ; and refresh the infusion with like quantity of new violets, seven times ; and it will make a vinegar so fresh of the flower, as if a twelvemonth after it be brought you in a saucer, you shall smell it before it come at you. Note, that it smelleth more perfectly of the flower a good while after than at first.

18. This rule which we have given, is of singular use for the preparations of medicines and other infusions. As for example : the leaf of burrage hath an excellent spirit to repress the fuliginous vapour of dusky melancholy, and so to cure madness : but nevertheless, if the leaf be infused long, it yieldeth forth but a raw substance, of no virtue : therefore I suppose that if in the must of wine or wort of beer, while it worketh, before it be tunned, the burrage stay a small time,

and be often changed with fresh; it will make a sovereign drink for melancholy passions. And the like I conceive of orange flowers.

19. Rhubarb hath manifestly in it parts of contrary operations: parts that purge, and parts that bind the body: and the first lie[1] looser, and the latter lie deeper: so that if you infuse rhubarb for an hour and crush it well, it will purge better, and bind the body less after the purging, than if it stood twenty-four hours. This is tried. But I conceive likewise, that by repeating the infusion of rhubarb several times, (as was said of violets,) letting each stay in but a small time, you may make it as strong a purging medicine as scammony. And it is not a small thing won in physic, if you can make rhubarb, and other medicines that are benedict, as strong purgers as those that are not without some malignity.

20. Purging medicines, for the most part, have their purgative virtue in a fine spirit; as appeareth by that they endure not boiling without much loss of virtue. And therefore it is of good use in physic, if you can retain the purging virtue, and take away the unpleasant taste of the purger; which it is like you may do, by this course of infusing oft, with little stay. For it is probable that the horrible and odious taste is the grosser part.[2]

21. Generally, the working by infusions is gross and blind, except you first try the issuing of the several parts of the body, which of them issue more speedily, and which more slowly; and so by apportioning the time, can take and leave that quality which you desire.

[1] *Lay* in the original, in both places. — *J. S.*

[2] *Is in the grosser part.* Ed. 1635. — *J. S.*

This to know, there be two ways; the one to try what long stay and what short stay worketh, as hath been said; the other to try in order the succeeding infusions of one and the same body, successively, in several liquors. As for example; take orange-pills, or rosemary, or cinnamon, or what you will; and let them infuse half an hour in water; then take them out, and infuse them again in other water; and so the third time: and then taste and consider the first water, the second, and the third; and you will find them differing, not only in strength and weakness, but otherwise in taste or odour; for it may be the first water will have more of the scent, as more fragrant; and the second more of the taste, as more bitter or biting, &c.

22. Infusions in air (for so we may well call odours) have the same diversities with infusions in water; in that the several odours (which are in one flower or other body) issue at several times; some earlier, some later. So we find that violets, woodbines, strawberries, yield a pleasing scent, that cometh forth first; but soon after an ill scent, quite differing from the former; which is caused not so much by mellowing, as by the late issuing of the grosser spirit.

23. As we may desire to extract the finest spirits in some cases, so we may desire also to discharge them (as hurtful) in some other. So wine burnt, by reason of the evaporating of the finer spirit, inflameth less, and is best in agues: opium leeseth some of his poisonous quality, if it be vapoured out, mingled with spirit of wine, or the like: sean loseth somewhat of his windiness by decocting; and (generally) subtile or windy spirits are taken off by incension or evaporation. And even in infusions in things that are of too

high a spirit, you were better pour off the first infusion, after a small time, and use the latter.

Experiment solitary touching the appetite of continuation in liquids.

24. Bubbles are in the form of an hemisphere; air within, and a little skin of water without: and it seemeth somewhat strange, that the air should rise so swiftly while it is in the water; and when it cometh to the top, should be stayed by so weak a cover as that of the bubble is. But as for the swift ascent of the air, while it is under the water, that is a motion of percussion from the water; which itself descending driveth up the air; and no motion of levity in the air. And this Democritus called *motus plagæ*.[1] In this common experiment, the cause of the inclosure of the bubble is, for that the appetite to resist separation or discontinuance (which in solid bodies is strong) is also in liquors, though fainter and weaker; as we see in this of the bubble: we see it also in little glasses of spittle that children make of rushes; and in castles of bubbles, which they make by blowing into water, having obtained a little degree of tenacity by mixture of soap: we see it also in the stillicides of water, which, if there be water enough to follow, will draw themselves into a small thread, because they will not discontinue; but if there be no remedy, then they cast themselves into round drops; which is the figure that saveth the body most from discontinuance: the same reason is of the

[1] "Declinat, inquit, atomus. Primum cur? aliam quandam vim motus habebunt a Democrito impulsionis, quam plagam ille appellat." — *Cicero, De Fato*, c. 20. It is difficult to determine whether this notion of "plaga" involved the conception of a mutual action between the atoms. See Mullach. *Democrit. Abder. Oper. Frag.* p. 384.

roundness of the bubble, as well for the skin of water, as for the air within; for the air likewise avoideth discontinuance; and therefore casteth itself into a round figure. And for the stop and arrest of the air a little while, it sheweth that the air of itself hath little or no appetite of ascending.

Experiment solitary touching the making of artificial springs.

25. The rejection which I continually use of experiments (though it appeareth not) is infinite; but yet if an experiment be probable in the work, and of great use, I receive it, but deliver it as doubtful. It was reported by a sober man, that an artificial spring may be made thus. Find out a hanging ground, where there is a good quick fall of rain-water. Lay a half-trough of stone, of a good length, three or four foot deep within the same ground; with one end upon the high ground, the other upon the low. Cover the trough with brakes a good thickness, and cast sand upon the top of the brakes. You shall see (saith he) that after some showers are past, the lower end of the trough will run like a spring of water: which is no marvel, if it hold while the rain-water lasteth; but he said it would continue long time after the rain is past: as if the water did multiply itself upon the air, by the help of the coldness and condensation of the earth, and the consort of the first water.

Experiment solitary touching the venomous quality of man's flesh.

26. The French (which put off the name of the French disease unto the name of the disease of Naples)

do report, that at the siege of Naples there were certain wicked merchants that barrelled up man's flesh (of some that had been lately slain in Barbary) and sold it for tunney; and that upon that foul and high nourishment was the original of that disease.[1] Which may well be; for that it is certain that the cannibals in the West Indies eat man's flesh; and the West Indies were full of the pocks when they were first discovered; and at this day the mortalest poisons practised by the West Indians have some mixture of the blood or fat or flesh of man; and divers witches and sorceresses, as well amongst the heathen as amongst the christians, have fed upon man's flesh, to aid (as it seemeth) their imagination with high and foul vapours.

Experiment solitary touching the version and transmutation of air into water.

27. It seemeth that there be these ways (in likelihood) of version of vapours or air into water and moisture. The first is cold; which doth manifestly condense; as we see in the contracting of the air in the weather-glass; whereby it is a degree nearer to water. We see it also in the generation of springs, which the ancients thought (very probably) to be made by the version of air into water, holpen by the rest which the air hath in those parts; whereby it cannot dissipate;[2] and by the coldness of rocks; for there springs are chiefly generated. We see it also in the effects of the cold of the middle region (as they call it) of the air;

[1] This story is told in Sandys's *Travels*, p. 186. (7th edition). Monardes, quoted by Kapmannis, ascribes the disease to the bad food to which the army was reduced; but does not mention the use of human flesh. See Kapmannis, Ensáyos.

[2] Arist. Meteor. i. 13.

which produceth dews and rains. And the experiment of turning water into ice, by snow, nitre, and salt (whereof we shall speak hereafter) would be transferred to the turning of air into water. The second way is by compression; as in stillatories, where the vapour is turned back upon itself by the encounter of the sides of the stillatory; and in the dew upon the covers of boiling pots; and in the dew towards rain, upon marble and wainscot. But this is like to do no great effect; except it be upon vapours and gross air, that are already very near in degree to water. The third is that which may be searched into, but doth not yet appear; which is, by mingling of moist vapours with air, and trying if they will not bring a return of more water than the water was at first: for if so, that increase is a version of the air. Therefore put water into the bottom of a stillatory, with the neb stopped; weigh the water first; hang in the middle of the stillatory a large sponge; and see what quantity of water you can crush out of it; and what it is more or less, compared with the water spent: for you must understand, that if any version can be wrought, it will be easiliest done in small pores: and that is the reason why we prescribe a sponge. The fourth way is probable also, though not appearing; which is, by receiving the air into the small pores of bodies: for (as hath been said) every thing in small quantity is more easy for version; and tangible bodies have no pleasure in the consort of air, but endeavour to subact it into a more dense body; but in entire bodies it is checked; because if the air should condense, there is nothing to succeed: therefore it must be in loose bodies, as sand and powder; which we see, if they lie close, of themselves gather moisture.

Experiment solitary touching the helps towards the beauty and good features of persons.

28. It is reported by some of the ancients,[1] that whelps, or other creatures, if they be put young into such a cage or box as they cannot rise to their stature, but may increase in breadth or length, will grow accordingly as they can get room; which if it be true and feasible, and that the young creature so pressed and straitened[2] doth not thereupon die, it is a means to produce dwarf creatures, and in a very strange figure. This is certain, and noted long since, that the pressure or forming of parts of creatures, when they are very young, doth alter the shape not a little: as the stroking of the heads of infants between the hands was noted of old to make *Macrocephali;* which shape of the head at that time was esteemed.[3] And the raising gently of the bridge of the nose, doth prevent the deformity of a saddle nose. Which observation well weighed, may teach a means to make the persons of men and women, in many kinds, more comely and better featured than otherwise they would be, by the forming and shaping of them in their infancy: as by stroking up the calves of the legs, to keep them from falling down too low; and by stroking up the forehead, to keep them from being low-foreheaded. And it is a common practice to swathe infants, that they may grow more straight and better shaped: and we see young women, by wearing straight bodies, keep themselves from being gross and corpulent.

[1] Namely by Aristotle, *Problem.* x. 14.

[2] *Straightened* in the original. — *J. S.*

[3] Hippocrates, De Aere Aquis et Locis. The same practice existed among many American tribes.

Experiment solitary touching the condensing of air, in such sort as it may put on weight and yield nourishment.

29. Onions, as they hang, will many of them shoot forth; and so will penny-royal; and so will an herb called orpin,[1] with which they use in the country to trim their houses, binding it to a lath or stick, and setting it against a wall. We see it likewise, more especially, in the greater semper-vive, which will put out branches, two or three years: but it is true, that commonly they wrap the root in a cloth besmeared with oil, and renew it once in half a year. The like is reported by some of the ancients, of the stalks of lilies.[2] The cause is; for that these plants have a strong, dense, and succulent moisture, which is not apt to exhale; and so is able, from the old store, without drawing help from the earth, to suffice the sprouting of the plant: and this sprouting is chiefly in the late spring or early summer; which are the times of putting forth. We see also, that stumps of trees lying out of the ground, will put forth sprouts for a time. But it is a noble trial, and of very great consequence, to try whether these things, in the sprouting, do increase weight; which must be tried by weighing them before they be hanged up, and afterwards again when they are sprouted.[3] For if they in-

[1] Sedum Telephium. The greater Sempervive, mentioned a little further on, is the great house-leek, or perhaps tree house-leek. See Gerard's Herbal. p. 510. (1636.)

[2] Pliny, xxi. 13.

[3] Bacon has here in a remarkable manner anticipated a celebrated experiment of Decandolle's, who showed that the cactus, which exhibits the phenomenon in question, actually loses in weight after severance from its root, though it will put out shoots of very considerable length. Compare Aristot. Prob. sect. xx. 21. and 26.

crease not in weight, then it is no more but this; that what they send forth in the sprout they leese in some other part: but if they gather weight, then it is *magnale naturæ;* for it showeth that air may be made so to be condensed as to be converted into a dense body; whereas the race and period of all things, here above the earth, is to extenuate and turn things to be more pneumatical and rare; and not to be retrograde, from pneumatical to that which is dense. It sheweth also that air can nourish: which is another great matter of consequence. Note, that to try this, the experiment of the semper-vive must be made without oiling the cloth; for else, it may be the plant receiveth nourishment from the oil.[1]

Experiment solitary touching the commixture of flame and air, and the great force thereof.

30. Flame and air do not mingle, except it be in an instant; or in the vital spirits of vegetables and living creatures. In gunpowder, the force of it hath been ascribed to rarefaction of the earthy substance into flame; and thus far it is true: and then (forsooth) it is become another element, the form[2] whereof occupieth more place; and so of necessity followeth a dilatation; and therefore, lest two bodies should be in one place, there must needs also follow an expulsion of the pellet, or blowing up of the mine. But these are crude and ignorant speculations. For flame, if there were

[1] The suggestions contained in this paragraph touching the nutrition of plants are exceedingly curious. In reality however the plant, though it loses by exhalation more in point of weight than it receives from the air, does actually assimilate the carbon existing in the carbonic acid of the latter; so that the test proposed is inconclusive.

[2] The word is used in its scholastic sense.

nothing else, except it were in a very great quantity, will be suffocate with any hard body, such as a pellet is, or the barrel of a gun; so as the flame would not expel the hard body, but the hard body would kill the flame, and not suffer it to kindle or spread. But the cause of this so potent a motion is the nitre (which we call otherwise saltpetre) which having in it a notable crude and windy spirit, first by the heat of the fire suddenly dilateth itself; (and we know that simple air, being preternaturally attenuated by heat, will make itself room, and break and blow up that which resisteth it); and secondly, when the nitre hath dilated itself, it bloweth abroad the flame, as an inward bellows. And therefore we see that brimstone, pitch, camphire, wild-fire, and divers other inflammable matters, though they burn cruelly and are hard to quench, yet they make no such fiery wind as gunpowder doth: and on the other side, we see that quicksilver (which is a most crude and watery body) heated and pent in, hath the like force with gunpowder. As for living creatures, it is certain their vital spirits are a substance compounded of an airy and flamy matter; and though air and flame being free will not well mingle; yet bound in by a body that hath some fixing, they will. For that you may best see in those two bodies (which are their aliments) water and oil; for they likewise will not well mingle of themselves, but in the bodies of plants and living creatures they will. It is no marvel therefore, that a small quantity of spirits, in the cells of the brain and canals of the sinews, are able to move the whole body (which is of so great mass), both with so great force, as in wrestling, leaping, and with so great swiftness, as in playing division upon the lute. Such is the force of these two natures, air and flame, when they incorporate.

Experiment solitary touching the secret nature of flame.[1]

31. Take a small wax candle, and put it in a socket of brass or iron ; then set it upright in a porringer full of spirit of wine heated ; then set both the candle and spirit of wine on fire, and you shall see the flame of the candle open itself, and become four or five times bigger than otherwise it would have been ; and appear in figure globular, and not in pyramis. You shall see also, that the inward flame of the candle keepeth colour, and doth not wax any whit blüe towards the colour of the outward flame of the spirit of wine. This is a noble instance; wherein two things are most remarkable: the one, that one flame within another quencheth not; but is a fixed body, and continueth as air or water do. And therefore flame would still ascend upwards in one greatness, if it were not quenched on the sides: and the greater the flame is at the bottom, the higher is the rise. The other, that flame doth not mingle with flame, as air doth with air, or water with water, but only remaineth contiguous ; as it cometh to pass betwixt consisting bodies. It appeareth also that the form of a pyramis in flame, which we usually see, is merely by accident, and that the air about, by quenching the sides of the flame, crusheth it, and extenuateth it into that form ; for of itself it would be round ; and therefore smoke is in the figure of a pyramis reversed ;

[1] The explanation of this experiment is simply that in impure air flames increase in size because the heated vapour of which they are composed diffuses itself before it meets with sufficient oxygen for complete combustion.

for the air quencheth the flame and receiveth the smoke. Note also, that the flame of the candle, within the flame of the spirit of wine, is troubled; and doth not only open and move upwards, but moveth waving, and to and fro; as if flame of his own nature (if it were not quenched) would roll and turn, as well as move upwards. By all which it should seem that the celestial bodies (most of them) are true fires or flames, as the Stoics held; more fine (perhaps) and rarified than our flame is. For they are all globular and determinate; they have rotation; and they have the colour and splendour of flame: so that flame above is durable, and consistent, and in his natural place; but with us it is a stranger, and momentany, and impure; like Vulcan that halted with his fall.

Experiment solitary touching the different force of flame in the midst and on the sides.

32. Take an arrow, and hold it in flame for the space of ten pulses; and when it cometh forth, you shall find those parts of the arrow which were on the outsides of the flame more burned, blacked, and turned almost into a coal, whereas that in the midst of the flame will be as if the fire had scarce touched it.[1] This is an instance of great consequence for the discovery of the nature of flame; and sheweth manifestly that flame burneth more violently towards the sides than in the midst; and, which is more, that heat or fire is not violent or furious but where it is checked and pent. And therefore the Peripatetics (howsoever their opinion of an element of fire above

[1] The real reason is, that the air has freer access to the external parts of the wood.

the air is justly exploded) in that point they acquit themselves well: for being opposed, that if there were a sphere of fire that encompassed the earth so near hand, it were impossible but all things should be burnt up; they answer, that the pure elemental fire, in his own place and not irritate, is but of a moderate heat.

Experiment solitary touching the decrease of the natural motion of gravity in great distance from the earth, or within some depth of the earth.

33. It is affirmed constantly by many, as an usual experiment, that a lump of ore in the bottom of a mine will be tumbled and stirred by two men's strength, which if you bring it to the top of the earth, will ask six men's strength at the least to stir it. It is a noble instance, and is fit to be tried to the full. For it is very probable that the motion of gravity worketh weakly both far from the earth and also within the earth: the former, because the appetite of union of dense bodies with the earth, in respect of the distance, is more dull: the latter, because the body hath in part attained his nature when it is some depth in the earth. For as for the moving to a *point* or place (which was the opinion of the ancients) it is a mere vanity.[1]

[1] Bodies weigh less at the bottom of a mine than on the earth's surface, though of course the difference is not so great as Bacon supposed. The explanation is, that the shell external to the body exerts no attraction on it, and the body may therefore be conceived of, as lying on the surface of a smaller ellipsoid. This at least would be the case if the shell were perfectly homogeneous.

Experiment solitary touching the contraction of bodies in bulk, by the mixture of the more liquid body with the more solid.

34. It is strange how the ancients took up experiments upon credit, and yet did build great matters upon them. The observation of some of the best of them, delivered confidently, is, that a vessel filled with ashes will receive the like quantity of water that it would have done if it had been empty.[1] But this is utterly untrue; for the water will not go in by a fifth part. And I suppose that that fifth part is the difference of the lying close or open of the ashes; as we see that ashes alone, if they be hard pressed, will lie in less room; and so the ashes with air between lie looser, and with water closer. For I have not yet found certainly, that the water itself, by mixture of ashes or dust, will shrink or draw into less room.

Experiment solitary touching the making vines more fruitful.

35. It is reported of credit, that if you lay good store of kernels of grapes about the root of a vine, it will make the vine come earlier and prosper better. It may be tried with other kernels laid about the root of a plant of the same kind; as figs, kernels of apples, &c. The cause may be, for that the kernels draw out of the earth juice fit to nourish the tree, as those that would be trees of themselves, though there were no root; but the root being of greater strength, robbeth

[1] Arist. Prob. xxv. 8. It has been found by Messrs. Playfair and Joule that the solution of many salts in water, *e. g.* of alum, increases the volume of the water simply by that of the water of crystallisation they contain; which is a curious approximation to Aristotle's notion.

and devoureth the nourishment, when they have drawn it; as great fishes devour little.

Experiments in consort touching purging medicines.

36. The operation of purging medicines, and the causes thereof, have been thought to be a great secret; and so according to the slothful manner of men, it is referred to a hidden propriety, a specifical virtue, and a fourth quality,[1] and the like shifts of ignorance. The causes of purging are divers: all plain and perspicuous, and throughly maintained by experience. The first is, that whatsoever cannot be overcome and digested by the stomach, is by the stomach either put up by vomit, or put down to the guts; and by that motion of expulsion in the stomach and guts, other parts of the body (as the orifices of the veins, and the like) are moved to expel by consent. For nothing is more frequent than motion of consent in the body of man. This surcharge of the stomach is caused either by the quality of the medicine, or by the quantity. The qualities are three: extreme bitter, as in aloes, coloquintida, &c.; loathsome and of horrible taste, as in agaric, black hellebore, &c.; and of secret malignity and disagreement towards man's body, many times not appearing much in the taste; as in scammony, mechoacham,[2] an-

[1] That is, an occult quality not explicable by the combination of the primary qualities of the elements of which the body is composed. Occult qualities are often called tertiary, but Bacon apparently supposes that tertiary qualities are those which result from combinations of the secondary, and therefore ultimately from the four primary or elementary qualities, namely hot, cold, moist, and dry.

[2] Mechoachan is the root of an American plant; it takes its name from the district of Mexico from which it is brought. See Frampton's *Joyful News out of the new found World*, (1577) p. 23. Frampton's work is only

timony, &c. And note well, that if there be any medicine that purgeth, and hath neither of the first two manifest qualities, it is to be held suspected as a kind of poison; for that it worketh either by corrosion, or by a secret malignity and enmity to nature; and therefore such medicines are warily to be prepared and used. The quantity of that which is taken doth also cause purging; as we see in a great quantity of new milk from the cow; yea, and a great quantity of meat; for surfeits many times turn to purges, both upwards and downwards. Therefore we see generally, that the working of purging medicines cometh two or three hours after the medicines taken; for that the stomach first maketh a proof whether it can concoct them. And the like happeneth after surfeits, or milk in too great quantity.

37. A second cause is mordication of the orifices of the parts; especially of the mesentery veins; as it is seen that salt, or any such thing that is sharp and biting, put into the fundament, doth provoke the part to expel; and mustard provoketh sneezing; and any sharp thing to the eyes provoketh tears. And therefore we see that almost all purgers have a kind of twitching and vellication, besides the griping which cometh of wind. And if this mordication be in an over-high degree, it is little better than the corrosion of poison; and it cometh to pass sometimes in antimony, especially if it be given to bodies not replete with humours; for where humours abound, the humours save the parts.

a translation of that of Nicolas Monardes, of which a Latin translation by Clusius was published in 1574. I have not seen the original work, which is in Spanish. The title of Clusius's translation is *De simplicibus medicam. ex occident. India delatis.*

38. The third cause is attraction: for I do not deny, but that purging medicines have in them a direct force of attraction; as drawing plaisters have in surgery: and we see sage or bettony bruised, sneezing-powder, and other powders or liquors (which the physicians call *errhines*) put into the nose, draw phlegm and water from the head; and so it is in apophlegmatisms and gargarisms, that draw the rheum down by the palate. And by this virtue, no doubt, some purgers draw more one humour, and some another, according to the opinion received: as rhubarb draweth choler; sean melancholy; agaric phlegm, &c. But yet (more or less) they draw promiscuously. And note also, that besides sympathy between the purger and the humour, there is also another cause why some medicines draw some humour more than another. And it is, for that some medicines work quicker than others: and they that draw quick, draw only the lighter and more fluid humours; they that draw slow, work upon the more tough and viscous humours. And therefore men must beware how they take rhubarb and the like, alone, familiarly; for it taketh only the lightest part of the humour away, and leaveth the mass of humours more obstinate. And the like may be said of wormwood, which is so much magnified.

39. The fourth cause is flatuosity: for wind stirred moveth to expel: and we find that (in effect) all purgers have in them a raw spirit or wind; which is the principal cause of tortion in the stomach and belly. And therefore purgers leese (most of them) the virtue, by decoction upon the fire; and for that cause are given chiefly in infusion, juice, or powder.

40. The fifth cause is compression or crushing; as

when water is crushed out of a sponge ; so we see that taking cold moveth looseness by contraction of the skin and outward parts; and so doth cold likewise cause rheums and defluxions from the head ; and some astringent plaisters crush out purulent matter. This kind of operation is not found in many medicines. Myrobalanes have it ; and it may be the barks of peaches : for this virtue requireth an astriction ; but such an astriction as is not grateful to the body ; (for a pleasing astriction doth rather bind in the humours than expel them) : and therefore such astriction is found in things of an harsh[1] taste.

41. The sixth cause is lubrefaction and relaxation. As we see in medicines emollient ; such as are milk, honey, mallows, lettuce, mercurial, pellitory of the wall, and others. There is also a secret virtue of relaxation in cold ; for the heat of the body bindeth the parts and humours together, which cold relaxeth ; as it is seen in urine, blood, pottage, or the like ; which, if they be cold, break and dissolve. And by this kind of relaxation, fear looseneth the belly : because the heat retiring inwards towards the heart, the guts and other parts are relaxed ; in the same manner as fear also causeth trembling in the sinews. And of this kind of purgers are some medicines made of mercury.

42. The seventh cause is abstersion ; which is plainly a scouring off, or incision of the more viscous humours, and making the humours more fluid ; and cutting between them and the part. As is found in nitrous water, which scoureth linen cloth (speedily) from the

[1] *Harrish* in the original, both here and in several other places; though not always. But I suppose it is only another way of spelling *harsh*. — *J. S.*

foulness. But this incision must be by a sharpness without astriction: which we find in salt, wormwood, oxymel, and the like.

43. There be medicines that move stools, and not urine; some other, urine and not stools. Those that purge by stool, are such as enter not at all, or little, into the mesentery veins; but either at the first are not digestible by the stomach, and therefore move immediately downwards to the guts; or else are afterwards rejected by the mesentery veins, and so turn likewise downwards to the guts; and of these two kinds are most purgers. But those that move urine, are such as are well digested of the stomach, and well received also of the mesentery veins; so they come as far as the liver, which sendeth urine to the bladder, as the whey of blood; and those medicines being opening and piercing, do fortify the operation of the liver, in sending down the wheyey part of the blood to the reins. For medicines urinative do not work by rejection and indigestion, as solutive do.

44. There be divers medicines which in greater quantity move stool, and in smaller urine: and so contrariwise, some that in greater quantity move urine, and in smaller stool. Of the former sort is rhubarb, and some others. The cause is, for that rhubarb is a medicine which the stomach in a small quantity doth digest and overcome (being not flatuous nor loathsome) and so sendeth it to the mesentery veins; and so being opening, it helpeth down urine: but in a greater quantity, the stomach cannot overcome it, and so it goeth to the guts. Pepper by some of the ancients is noted to be of the second sort; which being in small quantity, moveth wind in the stomach or guts,

and so expelleth by stool; but being in greater quantity, dissipateth the wind; and itself getteth to the mesentery veins, and so to the liver and reins; where, by heating and opening, it sendeth down urine more plentifully.

Experiments in consort touching meats and drinks that are most nourishing.

45. We have spoken of evacuating of the body; we will now speak something of the filling of it by restoratives in consumptions and emaciating diseases. In vegetables, there is one part that is more nourishing than another; as grains and roots nourish more than the leaves; insomuch as the order of the Foliatanes was put down by the pope, as finding leaves unable to nourish man's body.[1] Whether there be that difference in the flesh of living creatures, is not well inquired: as whether livers, and other entrails be not more nourishing than the outward flesh. We find that amongst the Romans, a goose's liver was a great delicacy; insomuch as they had artificial means to make it fair and great;[2]

[1] Some account of the austerities of the Feuillans has been given in a note on the *Novum Organum*, vol. i. p. 532. The notion that they attempted to live on leaves arose probably from a mistaken etymology. The Abbey of Feuillans existed as a Cistercian monastery long before the reform which made it the seat of a new order. The reason why human beings cannot live upon grass or leaves appears to be the proportion in which vegetable fibre (cellulose and lignose) is present in those parts of vegetables. Animals, as the solipedes and the ruminants, to whom such a diet is natural, are adapted by the organisation either of the stomach or of the intestines for the separation and rejection of the large proportion of innutritious matter contained in their food.

[2] Pliny, x. 27. The goose was fed on figs. Hence the phrase *jecur ficatum*, or simply *ficatum*, for liver so prepared; and hence, according to Diez and other etymologists, the French word *foie* for liver in general. The presence of sugar in the liver even of carnivorous animals is one of the most curious of recent physiological discoveries.

but whether it were more nourishing appeareth not. It is certain that marrow is more nourishing than fat. And I conceive that some decoction of bones and sinews, stamped and well strained, would be a very nourishing broth: we find also that Scotch skinck, (which is a pottage of strong nourishment) is made with the knees and sinews of beef, but long boiled: jelly also, which they use for a restorative, is chiefly made of knuckles of veal. The pulp that is within the crafish or crab, which they spice and butter, is more nourishing than the flesh of the crab or crafish. The yolks of eggs are clearly more nourishing than the whites. So that it should seem that the parts of living creatures that lie more inwards, nourish more than the outward flesh; except it be the brain: which the spirits prey too much upon, to leave it any great virtue of nourishing. It seemeth for the nourishing of aged men, or men in consumptions, some such thing should be devised as should be half chylus, before it be put into the stomach.

46. Take two large capons; parboil them upon a soft fire, by the space of an hour or more, till in effect all the blood be gone. Add in the decoction the pill of a sweet lemon, or a good part of the pill of a citron, and a little mace. Cut off the shanks and throw them away. Then with a good strong chopping-knife mince the two capons, bones and all, as small as ordinary minced meat; put them into a large neat boulter; then take a kilderkin, sweet and well seasoned, of four gallons of beer, of 8*s.* strength,[1] new as it cometh from the tunning: make in the kilderkin a great bung-hole

[1] Perhaps the eight-shilling strength means that the barrel, *i. e.* thirty-six gallons, cost eight shillings.

of purpose: then thrust into it the boulter (in which the capons are) drawn out in length; let it steep in it three days and three nights, the bung-hole open, to work; then close the bung-hole, and so let it continue a day and a half; then draw it into bottles, and you may drink it well after three days' bottling; and it will last six weeks (approved). It drinketh fresh, flowereth and mantleth exceedingly; it drinketh not newish at all. It is an excellent drink for a consumption, to be drunk either alone or carded with some other beer. It quencheth thirst, and hath no whit of windiness. Note, that it is not possible that meat and bread, either in broths, or taken with drink, as is used, should get forth into the veins and outward parts so finely and easily, as when it is thus incorporate, and made almost a chylus aforehand.

47. Trial would be made of the like brew with potado roots, or burr roots, or the pith of artichokes,[1] which are nourishing meats: it may be tried also with other flesh; as pheasant, partridge, young pork, pig, venison, especially of young deer, &c.

48. A mortress made with the brawn of capons, stamped and strained, and mingled, (after it is made) with like quantity (at the least) of almond butter, is an excellent meat to nourish those that are weak; better than blanc-manger, or jelly; and so is the cullice of cocks, boiled thick with the like mixture of almond butter; for the mortress or cullice, of itself, is more savoury and strong, and not so fit for nourishing of

[1] Compare *Hist. Vitæ et Mortis*, vol. iii. p. 450. § 24.; where *pulpæ artiplicis* are mentioned in conjunction with *radices potado* and *radices bardanæ*. The coincidence favours Mr. Ellis's conjecture that by *artiplex* Bacon meant *artichoke*. — *J. S.*

weak bodies; but the almonds, that are not of so high a taste as flesh, do excellently qualify it.

49. Indian maiz hath (of certain) an excellent spirit of nourishment; but it must be thoroughly boiled, and made into a maiz-cream like a barley-cream. I judge the same of rice, made into a cream; for rice is in Turkey, and other countries of the east, most fed upon; but it must be thoroughly boiled, in respect of the hardness of it; and also because otherwise it bindeth the body too much.[1]

50. Pistachoes, so they be good, and not musty, joined with almonds in almond milk, or made into a milk of themselves, like unto almond milk, but more green, are an excellent nourisher; but you shall do well to add a little ginger, scraped, because they are not without some subtile windiness.

51. Milk warm from the cow, is found to be a great nourisher, and a good remedy in consumptions: but then you must put into it, when you milk the cow, two little bags; the one of powder of mint, the other of powder of red roses; for they keep the milk somewhat from turning or crudling in the stomach; and put in sugar also, for the same cause, and partly for the taste's sake; but you must drink a good draught, that it may stay less time in the stomach, lest it crudle: and let the cup into which you milk the cow, be set in a greater

[1] It seems to be clear that both maize and rice, and especially the latter, are inferior with respect to nutritive power to most of the cerealia. Maize is said to be indigenous in America, and to have been brought from thence to Europe. Yet the culture of it in Italy is said to be older than the discovery of America. The introduction of it is ascribed to a brother of Conrad of Montferrat. V. Michaud's *Hist. des Croisades.* The principal value of maize as an article of diet consists in its being richer in oil than any other grain. Rice, on the other hand, is remarkably deficient in this respect.

cup of hot water, that you may take it warm. And cow-milk thus prepared, I judge to be better for a consumption than ass-milk, which (it is true) turneth not so easily, but it is a little harsh;[1] marry it is more proper for sharpness of urine, and exulceration of the bladder, and all manner of lenifying. Woman's milk likewise is prescribed, when all fail; but I commend it not; as being a little too near the juice of man's body, to be a good nourisher; except it be in infants, to whom it is natural.

52. Oil of sweet almonds, newly drawn, with sugar and a little spice, spread upon bread toasted, is an excellent nourisher; but then to keep the oil from frying in the stomach, you must drink a good draught of mild beer after it; and to keep it from relaxing the stomach too much, you must put in a little powder of cinnamon.

53. The yolks of eggs are of themselves so well prepared by nature for nourishment, as (so they be poached, or rear boiled) they need no other preparation or mixture; yet they may be taken also raw, when they are new laid, with Malmsey or sweet wine: you shall do well to put in some few slices of eryngium roots, and a little ambergrice; for by this means, besides the immediate faculty of nourishment, such drink will strengthen the back; so that it will not draw down the urine too fast; for too much urine doth always hinder nourishment.

54. Mincing of meat, as in pies and buttered minced meat, saveth the grinding of the teeth; and therefore (no doubt) it is more nourishing: especially in age, or to them that have weak teeth; but the butter is not so proper for weak bodies; and therefore it were good to

[1] *Harrish* in the original. — *J. S.*

moisten it with a little claret wine, pill of lemon or orange, cut small, sugar, and a very little cinnámon or nutmeg. As for chuets, which are likewise mincèd meat, instead of butter and fat, it were good to moisten them partly with cream or almond or pistacho milk, or barley or maiz cream; adding a little coriander seed and caraway seed, and a very little saffron. The more full handling of alimentation we reserve to the due place.

We have hitherto handled the *particulars* which yield best and easiest and plentifullest nourishment; and now we will speak of the best *means* of conveying and converting the nourishment.

55. The first means is to procure that the nourishment may not be robbed and drawn away; wherein that which we have already said is very material; to provide that the reins draw not too strongly an over-great part of the blood into urine. To this add that precept of Aristotle, that wine be forborne in all consumptions;[1] for that the spirits of the wine do prey upon the roscide juice of the body, and inter-common with the spirits of the body, and so deceive and rob them of their nourishment. And therefore if the consumption, growing from the weakness of the stomach, do force you to use wine, let it always be burnt, that the quicker spirits may evaporate; or, at the least, quenched with two little wedges of gold, six or seven times repeated. Add also this provision, that there be

[1] Aristotle does not give any precept on the subject; but that he thought wine hurtful in consumptions may be inferred from the *Problems*, iii. 5. and 23.

not too much expence of the nourishment, by exhaling and sweating; and therefore if the patient be apt to sweat, it must be gently restrained. But chiefly Hippocrates' rule is to be followed; who adviseth quite contrary to that which is in use: namely, that the linen or garment next the flesh be, in winter, dry and oft changed; and in summer seldom changed, and smeared over with oil;[1] for certain it is, that any substance that is fat, doth a little fill the pores of the body, and stay sweat in some degree. But the more cleanly way is, to have the linen smeared lightly over with oil of sweet almonds; and not to forbear shifting as oft as is fit.

56. The second means is, to send forth the nourishment into the parts more strongly; for which the working must be by strengthening of the stomach; and in this, because the stomach is chiefly comforted by wine and hot things, which otherwise hurt, it is good to resort to outward applications to the stomach: wherein it hath been tried, that the quilts of roses, spices, mastic, wormwood, mint, &c., are not so helpful, as to take a cake of new bread and to bedew it with a little sack or alegant; and to dry it; and after it be dried a little before the fire, to put it within a clean napkin, and to lay it to the stomach; for it is certain, that all flour hath a potent virtue of astriction; insomuch as it hardeneth a piece of flesh or a flower that is laid in it: and therefore a bag quilted with bran is likewise very good; but it drieth somewhat too much, and therefore it must not lie long.

[1] See Hippocrates, *De Salubri Diætâ*, but it does not seem clear that the rule of wearing in summer ἐλαιοπίνεα ἱμάτια is given as a general precept. Hippocrates seems to refer particularly to persons of a gross habit.

57. The third means (which may be a branch of the former) is to send forth the nourishment the better by sleep. For we see that bears, and other creatures that sleep in the winter, wax exceeding fat: and certain it is, (as it is commonly believed) that sleep doth nourish much; both for that the spirits do less spend the nourishment in sleep, than when living creatures are awake; and because (that which is to the present purpose) it helpeth to thrust out the nourishment into the parts. Therefore in aged men, and weak bodies, and such as abound not with choler, a short sleep after dinner doth help to nourish; for in such bodies there is no fear of an over-hasty digestion, which is the inconvenience of postmeridian sleeps. Sleep also in the morning, after the taking of somewhat of easy digestion, as milk from the cow, nourishing broth, or the like, doth further nourishment: but this would be done sitting upright, that the milk or broth may pass the more speedily to the bottom of the stomach.

58. The fourth means is, to provide that the parts themselves may draw to them the nourishment strongly. There is an excellent observation of Aristotle: that a great reason why plants (some of them) are of greater age than living creatures is, for that they yearly put forth new leaves and boughs: whereas living creatures put forth (after their period of growth) nothing that is young but hair and nails, which are excrements, and no parts.[1] And it is most certain, that whatsoever is young, doth draw nourishment better

[1] Aristot. De Long. et Brev. Vitæ, 6. It may be said that in vegetables the seat of vitality is constantly shifting, and that in this respect they differ from all but the lower forms of animal life.

than that which is old; and then (that which is the mystery of that observation) young boughs and leaves calling the sap up to them, the same nourisheth the body in the passage. And this we see notably proved also, in that the oft cutting or polling of hedges, trees, and herbs, doth conduce much to their lasting. Transfer therefore this observation to the helping of nourishment in living creatures: the noblest and principal use whereof is, for the prolongation of life; restoration of some degree of youth; and inteneration of the parts; for certain it is, that there are in living creatures parts that nourish and repair easily, and parts that nourish and repair hardly; and you must refresh and renew those that are easy to nourish, that the other may be refreshed and (as it were) drink in nourishment in the passage. Now we see that draught oxen, put into good pasture, recover the flesh of young beef; and men, after long emaciating diets, wax plump and fat, and almost new: so that you may surely conclude, that the frequent and wise use of those emaciating diets, and of purgings, and perhaps of some kind of bleeding, is a principal means of prolongation of life, and restoring some degree of youth: for as we have often said, death cometh upon living creatures like the torment of Mezentius:

> Mortua quinetiam jungebat corpora vivis,
> Componens manibusque manus, atque oribus ora.[1]

For the parts in man's body easily reparable (as spirits, blood, and flesh) die in the embracement of the parts hardly reparable (as bones, nerves, and membranes); and likewise some entrails (which they reckon amongst the spermatical parts) are hard to repair: though that

[1] Æn. viii. 485.

division of spermatical and menstrual parts be but a conceit.[1] And this same observation also may be drawn to the present purpose of nourishing emaciated bodies: and therefore gentle frication draweth forth the nourishment, by making the parts a little hungry, and heating them; whereby they call forth nourishment the better. This frication I wish to be done in the morning. It is also best done by the hand, or a piece of scarlet wool, wet a little with oil of almonds, mingled with a small quantity of bay-salt or saffron. We see that the very currying of horses doth make them fat and in good liking.

59. The fifth means is, to further the very act of assimilation of nourishment; which is done by some outward emollients, that make the parts more apt to assimilate. For which I have compounded an ointment of excellent odour, which I call Roman ointment; vide the receipt.[2] The use of it would be between sleeps; for in the latter sleep the parts assimilate chiefly.

Experiment solitary touching Filum Medicinale.

60. There be many medicines, which by themselves would do no cure, but perhaps hurt; but being applied in a certain order, one after another, do great cures. I have tried (myself) a remedy for the gout, which hath seldom failed, but driven it away in twenty-four hours'

[1] See Telesius, De Rer. Nat. vi. 1. His doctrine is "albas exsanguesque animalis partes prius quam sanguineas efformari, et illas e masculino fœmineoque semine, has e fœmineo sanguine, ab uteri calore immutatis." In this as elsewhere he follows Galen. See the *De fœtuum formatione*, c. 2., of the latter, and compare his *De usu partium*, xiv. 11.

[2] This receipt is not given in any edition of the *Sylva Sylvarum* which I have seen, but there is one answering the description in Tenison's *Baconiana*, p. 173.; for which see the *Medical Remains* in the seventh volume. — *J. S.*

space; it is first to apply a poultice, of which vide the receipt; and then a bath or fomentation, of which vide the receipt; and then a plaister, vide the receipt.[1] The poultice relaxeth the pores, and maketh the humour apt to exhale. The fomentation calleth forth the humour by vapours; but yet, in regard of the way made by the poultice, draweth gently; and therefore draweth the humour out, and doth not draw more to it; for it is a gentle fomentation, and hath withal a mixture (though very little) of some stupefactive. The plaister is a moderate astringent plaister, which repelleth new humour from falling. The poultice alone would make the part more soft and weak, and apter to take the defluxion and impression of the humour. The fomen-

[1] These receipts do not appear to have been given in the original edition. They were inserted on a separate leaf at the end of the edition of 1635; but may be most conveniently introduced here. — *J. S.*

His Lordship's usual receipt for the gout, to which the sixtieth experiment hath reference, was this.

To be taken in this order.

1. *The poultice.*

R. Of manchet about three ounces, the crumb only, thin cut. Let it be boiled in milk till it grow to a pulp. Add in the end a dram and a half of the powder of red roses.

Of saffron ten grains. Of oil of roses an ounce. Let it be spread upon a linen cloth, and applied luke-warm; and continued for three hours space.

2. *The bath or fomentation.*

R. Of sage-leaves half an handful. Of the root of hemlock sliced six drams. Of briony-roots half an ounce. Of the leaves of red roses two pugils. Let them be boiled in a pottle of water, wherein steel hath been quenched, till the liquor come to a quart. After the straining, put in half an handful of bay-salt. Let it be used with scarlet cloth, or scarlet wool, dipped in the liquor hot, and so renewed seven times; all in the space of a quarter of an hour, or little more.

3. *The plaister.*

R. *Emplastrum diacalciteos*, as much as is sufficient for the part you mean to cover. Let it be dissolved with oil of roses, in such a consistence as will stick; and spread upon a piece of holland, and applied.

tation alone, if it were too weak, without way made by the poultice, would draw forth little ; if too strong, it would draw to the part, as well as draw from it. The plaister alone, would pen the humour already contained in the part, and so exasperate it, as well as forbid new humour. Therefore they must be all taken in order, as is said. The poultice is to be laid to for two or three hours: the fomentation for a quarter of an hour, or somewhat better, being used hot, and seven or eight times repeated: the plaister to continue on still, till the part be well confirmed.

Experiment solitary touching cure by custom.

61. There is a secret way of cure (unpractised) by assuetude of that which in itself hurteth. Poisons have been made, by some, familiar, as hath been said.[1] Ordinary keepers of the sick of the plague are seldom infected. Enduring of tortures, by custom, hath been made more easy. The brooking of enormous quantity of meats, and so of wine or strong drink, hath been, by custom, made to be without surfeit or drunkenness. And generally diseases that are chronical, as coughs, phthisics, some kinds of palsies, lunacies, &c., are more dangerous at the first. Therefore a wise physician will consider whether a disease be incurable ; or whether the just cure of it be not full of peril ; and if he find it to be such, let him resort to palliation ; and alleviate the symptom, without busying himself too much with the perfect cure: and many times (if the patient be indeed patient) that course will exceed all expectation. Likewise the patient himself may strive, by little and

[1] As in the case of Mithridates, and in that of the attempt made to poison Alexander.

little, to overcome the symptom in the exacerbation, and so, by time, turn suffering into nature.

Experiment solitary touching cure by excess.[1]

62. Divers diseases, especially chronical (such as quartan agues), are sometimes cured by surfeit and excesses: as excess of meat, excess of drink, extraordinary fasting, extraordinary stirring, or lassitude, and the like. The cause is, for that diseases of continuance get an adventitious strength from custom, besides their material cause from the humours; so that the breaking of the custom doth leave them only to their first cause; which if it be anything weak will fall off. Besides such excesses do excite and spur nature, which thereupon rises more forcibly against the disease.

Experiment solitary touching cure by motion of consent.

63. There is in the body of man a great consent in the motion of the several parts. We see it is children's sport to prove whether they can rub upon their breast with one hand, and pat upon their forehead with another; and straightways they shall sometimes rub with both hands, or pat with both hands. We see that when the spirits that come to the nostrils expel a bad scent, the stomach is ready to expel by vomit. We find that in consumptions of the lungs, when nature cannot expel by cough, men fall into fluxes of the belly, and then they die. So in pestilent diseases, if they cannot be expelled by sweat, they fall likewise into looseness; and that is commonly mortal. Therefore physicians should ingeniously contrive, how by motions that are in their power, they may excite in-

[1] Compare Aristot. Prob. i. 2.

ward motions that are not in their power, by consent: as by the stench of feathers, or the like, they cure the rising of the mother.

Experiment solitary touching cure of diseases which are contrary to predisposition.

64. Hippocrates' aphorism, *in morbis minus*, is a good profound aphorism.[1] It importeth, that diseases contrary to the complexion, age, sex, season of the year, diet, &c., are more dangerous than those that are concurrent. A man would think it should be otherwise; for that when the accident of sickness and the natural disposition do second the one the other, the disease should be more forcible: and so (no doubt) it is, if you suppose like quantity of matter. But that which maketh good the aphorism is, because such diseases do shew a greater collection of matter, by that they are able to overcome those natural inclinations to the contrary. And therefore in diseases of that kind, let the physician apply himself more to purgation than to alteration; because the offence is in the quantity; and the qualities are rectified of themselves.

Experiment solitary touching preparations before purging, and settling of the body afterward.

65. Physicians do wisely prescribe, that there be preparatives used before just purgations; for certain it is that purgers do many times great hurt, if the body be not accommodated both before and after the purging. The hurt that they do for want of preparation

[1] "In morbis minus periclitantur quorum naturæ et ætati et habitui et tempori morbus magis affinis fuerit, quam hi quibus non affinis in aliquo horum existit." — *Hippocrates*, *Aph.* ii. 34.

before purging, is by the sticking of the humours, and their not coming fair away; which causeth in the body great perturbations and ill accidents during the purging; and also the diminishing and dulling of the working of the medicine itself, that it purgeth not sufficiently. Therefore the work of preparation is double; to make the humours fluid and mature, and to make the passages more open: for those both help to make the humours pass readily. And for the former of these, syrups are most profitable; and for the latter, apozumes, or preparing broths; clysters also help, lest the medicine stop in the guts, and work gripingly. But it is true that bodies abounding with humours, and fat bodies, and open weather, are preparatives in themselves; because they make the humours more fluid. But let a physician beware how he purge after hard frosty weather, and in a lean body, without preparation. For the hurt that they may do after purging, it is caused by the lodging of some humours in ill places: for it is certain that there be humours, which somewhere placed in the body, are quiet and do little hurt; in other places (especially passages) do much mischief. Therefore it is good, after purging, to use apozumes and broths not so much opening as those used before purging; but abstersive and mundifying clysters also are good to conclude with, to draw away the reliques of the humours that may have descended to the lower region of the body.

Experiment solitary touching stanching of blood.

66. Blood is stanched divers ways. First, by astringents and repercussive medicines. Secondly, by drawing of the spirits and blood inwards; which is done by

cold ; as iron or a stone laid to the neck doth stanch the bleeding of the nose ; also it hath been tried, that the testicles being put into sharp vinegar, hath made a sudden recess of the spirits, and stanched blood. Thirdly, by the recess of the blood by sympathy. So it hath been tried, that the part that bleedeth being thrust into the body of a capon or sheep, new ript and bleeding, hath stanched blood : the blood, as it seemeth, sucking and drawing up, by similitude of substance, the blood it meeteth with, and so itself going back. Fourthly, by custom and time ; so the Prince of Orange, in his first hurt by the Spanish boy, could find no means to stanch the blood either by medicine or ligament ; but was fain to have the orifice of the wound stopped by men's thumbs, succeeding one another, for the space at the least of two days ; and at the last the blood by custom only retired.[1] There is a fifth way also in use, to let blood in an adverse part, for a revulsion.

Experiment solitary touching change of aliments and medicines.

67. It helpeth, both in medicine and aliment, to change, and not to continue the same medicine and aliment still. The cause is, for that nature, by continual use of any thing, groweth to a satiety and dullness, either of appetite or working. And we see that assuetude of things hurtful doth make them leese their force to hurt ; as poison, which with use some have brought themselves to brook. And therefore it is no marvel

[1] The Prince of Orange was shot through both cheeks at Antwerp in 1582. Bacon calls this his first hurt, because two years afterwards he was killed by Baltazar Gerard.

though things helpful, by custom, leese their force to help. I count intermission almost the same thing with change; for that that hath been intermitted is after a sort new.

Experiment solitary touching diets.

68. It is found by experience, that in diets of guaiacum, sarza, and the like, (especially if they be strict,) the patient is more troubled in the beginning than after continuance; which hath made some of the more delicate sort of patients give them over in the midst; supposing that if those diets trouble them so much at first, they shall not be able to endure them to the end. But the cause is, for that all those diets do dry up humours, rheums, and the like: and they cannot dry up until they have first attenuated; and while the humour is attenuated, it is more fluid than it was before, and troubleth the body a great deal more, until it be dried up and consumed. And therefore patients must expect a due time, and not check at them at the first.

Experiments in consort touching the production of cold.

The producing of cold is a thing very worthy the inquisition; both for use and disclosure of causes. For heat and cold are nature's two hands, whereby she chiefly worketh; and heat we have in readiness, in respect of the fire; but for cold we must stay till it cometh, or seek it in deep caves or high mountains: and when all is done, we cannot obtain it in any great degree: for furnaces of fire are far hotter than a summer's sun; but vaults or hills are not much colder than a winter's frost.

69. The first means of producing cold is that which nature presenteth us withal: namely, the expiring of cold out of the inward parts of the earth in winter, when the sun hath no power to overcome it; the earth being (as hath been noted by some) *primum frigidum*. This hath been asserted as well by ancient as by modern philosophers. It was the tenet of Parmenides. It was the opinion of the author of the discourse in Plutarch (for I take it that book was not Plutarch's own) *De primo frigido*. It was the opinion of Telesius, who hath renewed the philosophy of Parmenides, and is the best of the novellists.

70. The second cause of cold is the contact of cold bodies; for cold is active and transitive into bodies adjacent, as well as heat: which is seen in those things that are touched with snow or cold water. And therefore, whosoever will be an inquirer into nature, let him resort to a conservatory of snow and ice, such as they use for delicacy to cool wine in summer: which is a poor and contemptible use, in respect of other uses that may be made of such conservatories.

71. The third cause is the primary nature of all tangible bodies; for it is well to be noted, that all things whatsoever (tangible) are of themselves cold; except they have an accessory heat by fire, life, or motion: for even the spirit of wine, or chemical oils, which are so hot in operation, are to the first touch cold; and air itself compressed and condensed a little by blowing is cold.

72. The fourth cause is the density of the body; for all dense bodies are colder than most other bodies; as metals, stone, glass; and they are longer in heating than softer bodies. And it is certain, that Earth,

Dense, Tangible, hold all of the nature of cold. The cause is, for that all matters tangible being cold, it must needs follow, that where the matter is most congregate the cold is the greater.

73. The fifth cause of cold, or rather of increase and vehemence of cold, is a quick spirit inclosed in a cold body: as will appear to any that shall attentively consider of nature in many instances. We see nitre (which hath a quick spirit) is cold; more cold to the tongue than a stone. So water is colder than oil, because it hath a quicker spirit; for all oil, though it hath the tangible parts better digested than water, yet hath it a duller spirit. So snow is colder than water, because it hath more spirit within it. So we see that salt put to ice (as in the producing of the artificial ice) increaseth the activity of cold. So some *insecta* which have spirit of life, as snakes and silkworms, are to the touch cold. So quicksilver is the coldest of metals, because it is fullest of spirit.

74. The sixth cause of cold is the chasing and driving away of spirits, such as have some degree of heat: for the banishing of the heat must needs leave any body cold. This we see in the operation of opium and stupefactives upon the spirits of living creatures. And it were not amiss to try opium, by laying it upon the top of a weather-glass, to see whether it will contract the air. But I doubt it will not succeed; for besides that the virtue of opium will hardly penetrate through such a body as glass, I conceive that opium, and the like, make the spirits fly rather by malignity than by cold.

75. Seventhly, the same effect must follow upon the exhaling or drawing out of the warm spirits, that doth

upon the flight of the spirits. There is an opinion, that the moon is magnetical of heat, as the sun is of cold and moisture: it were not amiss therefore to try it with warm waters; the one exposed to the beams of the moon; the other with some skreen betwixt the beams of the moon and the water; as we use to the sun for shade: and to see whether the former will cool sooner. And it were also good to inquire, what other means there may be to draw forth the exile heat which is in the air; for that may be a secret of great power to produce cold weather.[1]

Experiments in consort touching the version and transmutation of air into water.

We have formerly set down the means of turning air into water, in the experiment 27. But because it is *magnale naturæ*, and tendeth to the subduing of a very great effect, and is also of manifold use, we will add some instances in consort that give light thereunto.

76. It is reported by some of the ancients, that sailors have used, every night, to hang fleeces of wool on the sides of their ships, the wool towards the water; and that they have crushed fresh water out of them in the morning, for their use.[2] And thus much we have tried, that a quantity of wool tied loose together, being let down into a deep well, and

[1] The most intense cold yet known is produced in Thillorier's experiment, by the sudden conversion into the gaseous state of liquid carbonic acid. It is so intense as to solidify a portion of the acid in a form resembling snow.

[2] Pliny, xxxi. 37.

hanging in the middle some three fathom from the water for a night in the winter time, increased in weight (as I now remember) to a fifth part.

77. It is reported by one of the ancients, that in Lydia, near Pergamus, there were certain workmen in time of wars fled into caves; and the mouth of the caves being stopped by the enemies, they were famished. But long time after the dead bones were found; and some vessels which they had carried with them; and the vessels full of water; and that water thicker, and more towards ice, than common water:[1] which is a notable instance of condensation and induration by burial under earth (in caves) for long time; and of version also (as it should seem) of the air into water; if any of those vessels were empty. Try therefore a small bladder hung in snow, and the like in nitre, and the like in quicksilver; and if you find the bladders fallen or shrunk, you may be sure the air is condensed by the cold of those bodies; as it would be in a cave under earth.

78. It is reported of very good credit, that in the East Indies, if you set a tub of water open in a room where cloves are kept, it will be drawn dry in twenty-four hours; though it stand at some distance from the cloves. In the country, they use many times, in deceit, when their wool is new shorn, to set some pails of water by in the same room, to increase the weight of the wool. But it may be, that the heat of the wool remaining from the body of the sheep, or the heat gathered by the lying close

[1] Aristot. De Mirab. 52. But Aristotle, or rather the author of the treatise *De Mirab.*, does not speak of any change in the water, but only that the vessels and the bones of the workmen were petrified.

of the wool, helpeth to draw the watery vapour; but that is nothing to the version.

79. It is reported also credibly, that wool new shorn, being laid casually upon a vessel of verjuice, after some time, hath drunk up a great part of the verjuice, though the vessel were whole without any flaw, and had not the bung-hole open. In this instance there is (upon the by) to be noted, the percolation or suing of the verjuice through the wood; for verjuice of itself would never have passed through the wood; so as it seemeth it must be first in a kind of vapour, before it pass.

80. It is especially to be noted, that the cause that doth facilitate the version of air into water, when the air is not in gross, but subtilly mingled with tangible bodies, is (as hath been partly touched before) for that tangible bodies have an antipathy with air; and if they find any liquid body that is more dense near them, they will draw it; and after they have drawn it, they will condense it more, and in effect incorporate it; for we see that a sponge, or wool, or sugar, or a woollen cloth, being put but in part in water or wine, will draw the liquor higher, and beyond the place where the water or wine cometh. We see also, that wood, lute-strings, and the like, do swell in moist seasons; as appeareth by the breaking of the strings, the hard turning of the pegs, and the hard drawing forth of boxes, and opening of wainscot doors: which is a kind of infusion; and is much like to an infusion in water, which will make wood to swell; as we see in the filling of the chops of bowls, by laying them in water. But for that part of these experiments which concerneth

attraction, we will reserve it to the proper title of attraction.

81. There is also a version of air into water seen in the sweating of marbles and other stones; and of wainscot before and in moist weather. This must be, either by some moisture the body yieldeth, or else by the moist air thickened against the hard body. But it is plain that it is the latter; for that we see wood painted with oil-colour will sooner gather drops in a moist night, than wood alone, which is caused by the smoothness and closeness, which letteth in no part of the vapour, and so turneth it back, and thickeneth it into dew. We see also, that breathing upon a glass or smooth body giveth a dew; and in frosty mornings (such as we call rime frosts) you shall find drops of dew upon the inside of glass-windows; and the frost itself upon the ground is but a version or condensation of the moist vapours of the night into a watery substance: dews likewise, and rain, are but the returns of moist vapours condensed; the dew, by the cold only of the sun's departure, which is the gentler cold; rains, by the cold of that which they call the middle region of the air; which is the more violent cold.

82. It is very probable (as hath been touched) that that which will turn water into ice, will likewise turn air some degree nearer unto water. Therefore try the experiment of the artificial turning water into ice[1] (whereof we shall speak in another place) with air in place of water, and the ice about it. And although it be a greater alteration to turn air into water, than water into ice; yet there is this hope, that by con-

[1] Bacon here, as elsewhere, refers to the experiment performed by Drebbel in the presence of James I.

tinuing the air longer time, the effect will follow; for that artificial conversion of water into ice, is the work of a few hours; and this of air may be tried by a month's space, or the like.

Experiments in consort touching induration of bodies.

Induration, or lapidification, of substances more soft, is likewise another degree of condensation, and is a great alteration in nature. The effecting and accelerating thereof is very worthy to be inquired. It is effected by three means. The first is by cold, whose property is to condense and constipate, as hath been said. The second is by heat; which is not proper, but by consequence; for the heat doth attenuate; and by attenuation doth send forth the spirit and moister part of a body; and upon that, the more gross of the tangible parts do contract and serre themselves together; both to avoid *vacuum* (as they call it); and also to munite themselves against the force of the fire which they have suffered. And the third is by assimilation; when a hard body assimilateth a soft, being contiguous to it.

The examples of induration, taking them promiscuously, are many: as the generation of stones within the earth, which at the first are but rude earth or clay; and so of minerals, which come (no doubt) at first of juices concrete, which afterwards indurate: and so of porcelain, which is an artificial cement, buried in the earth a long time; and so the making of brick and tile; also the making of glass of a certain sand and brake-roots, and some other matters; also the exudations of rock-diamonds and crystal, which harden with time; also the induration of bead-amber, which at first is a soft substance; as appeareth by the flies and spiders which are found in it; and many more; but we will speak of them distinctly.

83. For indurations by cold, there be few trials of it; for we have no strong or intense cold here on the surface of the earth, so near the beams of the sun and the heavens. The likeliest trial is by snow and ice; for as snow and ice, especially being holpen and their cold activated by nitre or salt, will turn water into ice, and that in a few hours; so it may be, it will turn wood or stiff clay into stone, in longer time. Put therefore into a conserving pit of snow and ice (adding some quantity of salt and nitre) a piece of wood, or a piece of tough clay, and let it lie a month or more.

84. Another trial is by metalline waters, which have virtual cold in them. Put therefore wood or clay into smith's water, or other metalline water; and try whether it will not harden in some reasonable time. But I understand it of metalline waters that come by washing or quenching, and not of strong waters that come by dissolution; for they are too corrosive to consolidate.

85. It is already found that there are some natural spring-waters, that will inlapidate wood; so as you shall see one piece of wood, whereof the part above

the water shall continue wood, and the part under the water shall be turned into a kind of gravelly stone. It is likely those waters are of some metalline mixture; but there would be more particular inquiry made of them. It is certain, that an egg was found, having lien many years in the bottom of a moat, where the earth had somewhat overgrown it; and this egg was come to the hardness of a stone, and had the colours of the white and yolk perfect, and the shell shining in small grains like sugar or alabaster.

86. Another experience there is of induration by cold, which is already found; which is, that metals themselves are hardened by often heating and quenching in cold water: for cold ever worketh most potently upon heat precedent.

87. For induration by heat, it must be considered, that heat, by the exhaling of the moister parts, doth either harden the body; as in bricks, tiles, &c.; or if the heat be more fierce, maketh the grosser part itself run and melt; as in the making of ordinary glass; and in the vitrification of earth (as we see in the inner parts of furnaces), and in the vitrification of brick, and of metals. And in the former of these, which is the hardening by baking without melting, the heat hath these degrees; first, it indurateth, and then maketh fragile, and lastly it doth incinerate and calcinate.

88. But if you desire to make an induration with toughness and less fragility, a middle way would be taken, which is that which Aristotle hath well noted,[1] but would be thoroughly verified. It is to decoct bodies in water for two or three days. But they must be such bodies into which the water will not enter; as

[1] I have not been able to find the passage here referred to.

stone and metal. For if they be bodies into which the water will enter, then long seething will rather soften than indurate them; as hath been tried in eggs, &c. Therefore softer bodies must be put into bottles; and the bottles hung into water seething, with the mouths open, above the water, that no water may get in: for by this means the virtual heat of the water will enter; and such a heat as will not make the body adust or fragile; but the substance of the water will be shut out. This experiment we made; and it sorted thus. It was tried with a piece of free-stone, and with pewter, put into the water at large. The free-stone, we found, received in some water; for it was softer and easier to scrape than a piece of the same stone kept dry. But the pewter, into which no water could enter, became more white, and liker to silver, and less flexible by much. There were also put into an earthen bottle, placed as before, a good pellet of clay, a piece of cheese, a piece of chalk, and a piece of free-stone. The clay came forth almost of the hardness of stone: the cheese likewise very hard, and not well to be cut; the chalk and the free-stone much harder than they were. The colour of the clay inclined not a whit to the colour of brick, but rather to white, as in ordinary drying by the sun. Note, that all the former trials were made by a boiling upon a good hot fire, renewing the water as it consumed with other hot water; but the boiling was but for twelve hours only: and it is like that the experiment would have been more effectual, if the boiling had been for two or three days, as we prescribed before.

89. As touching assimilation (for there is a degree of assimilation even in inanimate bodies), we see ex-

amples of it in some stones in clay-grounds, lying near to the top of the earth, where pebble is; in which you may manifestly see divers pebbles gathered together, and a crust of cement or stone between them as hard as the pebbles themselves; and it were good to make a trial of purpose, by taking clay, and putting in it divers pebble-stones, thick set, to see whether in continuance of time it will not be harder than other clay of the same lump, in which no pebbles are set.[1] We see also in ruins of old walls, especially towards the bottom, the mortar will become as hard as the brick; we see also, that the wood on the sides of vessels of wine, gathereth a crust of tartar, harder than the wood itself; and scales likewise grow to the teeth, harder than the teeth themselves.

90. Most of all, induration by assimilation appeareth in the bodies of trees and living creatures: for no nourishment that the tree receiveth, or that the living creature receiveth, is so hard as wood, bone, or horn, &c., but is indurated after by assimilation.

Experiment solitary touching the version of water into air.

91. The eye of the understanding is like the eye of the sense; for as you may see great objects through small crannies or levels, so you may see great axioms of nature through small and contemptible instances. The speedy depredation of air upon watery moisture, and version of the same into air, appeareth in nothing

[1] In the museum of the University of Liége I was shown a cannon ball, originally (it was affirmed) iron, which had been converted into stone by the influence of the sandstone in which it was imbedded. It appeared to me that the ball was stone *ab origine*, and that the sandstone in which it lay being ferruginous had suggested the idea of the metamorphosis.

more visible than in the sudden discharge or vanishing of a little cloud of breath or vapour from glass, or the blade of a sword, or any such polished body; such as doth not at all detain or imbibe the moisture; for the mistiness scattereth and breaketh up suddenly. But the like cloud, if it were oily or fatty, will not discharge; not because it sticketh faster, but because air preyeth upon water, and flame and fire upon oil; and therefore to take out a spot of grease, they use a coal upon brown paper; because fire worketh upon grease or oil, as air doth upon water. And we see paper oiled, or wood oiled, or the like, last long moist; but wet with water, dry or putrify sooner. The cause is, for that air meddleth little with the moisture of oil.

Experiment solitary touching the force of union.

92. There is an admirable demonstration in the same trifling instance of the little cloud upon glass or gems or blades of swords, of the force of union, even in the least quantities and weakest bodies, how much it conduceth to preservation of the present form, and the resisting of a new. For mark well the discharge of that cloud; and you shall see it ever break up, first in the skirts, and last in the midst. We see likewise, that much water draweth forth the juice of the body infused; but little water is imbibed by the body: and this is a principal cause why, in operation upon bodies for their version or alteration, the trial in great quantities doth not answer the trial in small, and so deceiveth many; for that (I say) the greater body resisteth more any alteration of form, and requireth far greater strength in the active body that should subdue it.

Experiment solitary touching the producing of feathers and hairs of divers colours.

93. We have spoken before, in the fifth instance, of the cause of orient colours in birds; which is by the fineness of the strainer; we will now endeavour to reduce the same axiom to a work. For this writing of our *Sylva Sylvarum* is (to speak properly) not natural history, but a high kind of natural magic. For it is not a description only of nature, but a breaking of nature into great and strange works. Try therefore the anointing over of pigeons, or other birds, when they are but in their down; or of whelps, cutting their hair as short as may be; or of some other beast; with some ointment that is not hurtful to the flesh, and that will harden and stick very close; and see whether it will not alter the colours of the feathers or hair. It is received, that the pulling off the first feathers of birds clean, will make the new come forth white: and it is certain that white is a penurious colour, and where moisture is scant. So blue violets and other flowers, if they be starved, turn pale and white; birds and horses, by age or scars, turn white; and the hoar hairs of men come by the same reason. And therefore in birds, it is very likely that the feathers that come first will be many times of divers colours, according to the nature of the bird; for that the skin is more porous; but when the skin is more shut and close, the feathers will come white. This is a good experiment, not only for the producing of birds and beasts of strange colours, but also for the disclosure of the nature of colours themselves: which of them require a finer porosity, and which a grosser.

Experiment solitary touching the nourishment of living creatures before they be brought forth.

94. It is a work of providence, that hath been truly observed by some, that the yolk of the egg conduceth little to the generation of the bird, but only to the nourishment of the same;[1] for if a chicken be opened when it is new hatched, you shall find much of the yolk remaining.[2] And it is needful that birds, that are shaped without the female's womb, have in the egg as well matter of nourishment as matter of generation for the body. For after the egg is laid, and severed from the body of the hen, it hath no more nourishment from the hen, but only a quickening heat when she sitteth. But beasts and men need not the matter of nourishment within themselves, because they are shaped within the womb of the female, and are nourished continually from her body.

Experiments in consort touching sympathy and antipathy for medicinal use.

95. It is an inveterate and received opinion, that cantharides applied to any part of the body touch the bladder and exulcerate it, if they stay on long. It is likewise received, that a kind of stone, which they bring out of the West Indies, hath a peculiar force to move gravel, and to dissolve the stone; insomuch as laid but to the wrist, it hath so forcibly sent down

[1] See Aristot. De Gen. Animal. iii. 2.

[2] According to Vicq d'Azyr, the pedicule of the yolk remains permanently, and something of the yolk itself may be traced until the 12th or 13th day after the chicken is hatched. The opinion that the yolk contributes to the nutriment of the chicken appears to be well founded, as chickens from which it had been removed died with symptoms of atrophy.

gravel, as men have been glad to remove it, it was so violent.[1]

96. It is received and confirmed by daily experience, that the soles of the feet have great affinity with the head and the mouth of the stomach; as we see, going wet-shod, to those that use it not, affecteth both: applications of hot powders to the feet attenuate first, and after dry the rheum; and therefore a physician that would be mystical, prescribeth for the cure of the rheum, that a man should walk continually upon a camomile alley; meaning, that he should put camomile within his socks. Likewise pigeons bleeding, applied to the soles of the feet, ease the head; and soporiferous medicines applied unto them, provoke sleep.

97. It seemeth that as the feet have a sympathy with the head, so the wrists and hands have a sympathy with the heart; we see the affects and passions of the heart and spirits are notably disclosed by the pulse: and it is often tried, that juices of stock-gillyflowers, rose-campion, garlick, and other things, applied to the wrists and renewed, have cured long agues. And I conceive that washing with certain liquors the palms of the hands doth much good: and they do well in heats of agues, to hold in the hands eggs of alabaster and balls of crystal.

Of these things we shall speak more, when we handle the title of sympathy and antipathy in the proper place.

[1] Monardes in Frampton's translation speaks thus of the efficacy of this stone. "A gentleman whiche had one of them here, the best of them that I have seen, hauying put it to his arme, he dooeth make hym to expell and caste out much sande, that many tymes he doeth take it awaie, for that he thinketh that it dooeth hurte hym for to put out so muche, and in takyng it awaie he ceaseth to caste any from hym," &c. — *Joyfull Newes out of the newe founde Worlde*, fol. 19.

Experiment solitary touching the secret processes of nature.

98. The knowledge of man (hitherto) hath been determined by the view or sight; so that whatsoever is invisible, either in respect of the fineness of the body itself, or the smallness of the parts, or of the subtilty of the motion, is little inquired. And yet these be the things that govern nature principally; and without which you cannot make any true analysis and indication of the proceedings of nature. The spirits or pneumaticals, that are in all tangible bodies, are scarce known. Sometimes they take them for *vacuum;* whereas they are the most active of bodies. Sometimes they take them for air; from which they differ exceedingly, as much as wine from water, and as wood from earth. Sometimes they will have them to be natural heat, or a portion of the element of fire; whereas some of them are crude and cold. And sometimes they will have them to be the virtues and qualities of the tangible parts which they see; whereas they are things by themselves. And then, when they come to plants and living creatures, they call them souls. And such superficial speculations they have; like prospectives, that shew things inward, when they are but paintings. Neither is this a question of words, but infinitely material in nature. For spirits are nothing else but a natural body, rarified to a proportion, and included in the tangible parts of bodies, as in an integument. And they be no less differing one from the other than the dense or tangible parts; and they are in all tangible bodies whatsoever, more or less; and they are never (almost) at rest; and from them and their

motions principally proceed arefaction, colliquation, concoction, maturation, putrefaction, vivification, and most of the effects of nature; for, as we have figured them in our *Sapientia Veterum*, in the fable of Proserpina, you shall in the infernal regiment hear little doings of Pluto, but most of Proserpina: for tangible parts in bodies are stupid things; and the spirits do (in effect) all. As for the differences of tangible parts in bodies, the industry of the chemists hath given some light, in discerning by their separations the oily, crude, pure, impure, fine, gross parts of bodies, and the like. And the physicians are content to acknowledge that herbs and drugs have divers parts; as that opium hath a stupefacting part, and a heating part; the one moving sleep, the other a sweat following; and that rhubarb hath purging parts, and astringent parts, &c. But this whole inquisition is weakly and negligently handled. And for the more subtile differences of the minute parts, and the posture of them in the body, (which also hath great effects,) they are not at all touched: as for the motions of the minute parts of bodies, which do so great effects, they have not been observed at all; because they are invisible, and incur not to the eye; but yet they are to be deprehended by experience: as Democritus said well, when they charged him to hold that the world was made of such little motes as were seen in the sun: *Atomus*, saith he, *necessitate rationis et experientiæ esse convincitur; atomum enim nemo unquam vidit.*[1] And therefore the

[1] There is no doubt but that Democritus affirmed that the atom is cognisable by the mind only, and nowise by the senses. See among other passages Sextus Empiricus *Adver. Logicos*, ii. 6. On the other hand, he certainly compared his atoms to motes seen in the sunbeams, probably be-

tumult in the parts of solid bodies when they are compressed, which is the cause of all flight of bodies through the air, and of other mechanical motions, (as hath been partly touched before, and shall be thoroughly handled in due place,) is not seen at all. But nevertheless, if you know it not, or inquire it not attentively and diligently, you shall never be able to discern, and much less to produce, a number of mechanical motions. Again, as to the motions corporal within the inclosures of bodies, whereby the effects (which were mentioned before) pass between the spirits and the tangible parts, (which are arefaction, colliquation, concoction, maturation, &c.,) they are not at all handled. But they are put off by the names of virtues, and natures, and actions, and passions, and such other logical words.

Experiment solitary touching the power of heat.

99. It is certain that of all powers in nature heat is the chief; both in the frame of nature, and in the works of art. Certain it is likewise that the effects of heat are most advanced, when it worketh upon a body without loss or dissipation of the matter; for that ever betrayeth the account. And therefore it is true that the power of heat is best perceived in distillations which are performed in close vessels and receptacles. But yet there is a higher degree; for howsoever distillations do keep the body in cells and cloisters, without going abroad, yet they give space unto bodies to turn into vapour, to return into liquor, and to separate one part from another. So as nature doth expatiate,

cause the latter, though known to exist, are for the most part invisible. See Arist. De Anim. i. 2.

although it hath not full liberty; whereby the true and ultime operations of heat are not attained. But if bodies may be altered by heat, and yet no such reciprocation of rarefaction and of condensation and of separation admitted, then it is like that this Proteus of matter, being held by the sleeves, will turn and change into many metamorphoses.[1] Take therefore a square vessel of iron, in form of a cube, and let it have good thick and strong sides. Put into it a cube of wood, that may fill it as close as may be, and let it have a cover of iron, as strong (at least) as the sides; and let it be well luted, after the manner of the chemists. Then place the vessel within burning coals, kept quick kindled, for some few hours' space. Then take the vessel from the fire, and take off the cover, and see what is become of the wood. I conceive that since all inflammation and evaporation are utterly prohibited, and the body still turned upon itself, that one of these two effects will follow: either that the body of the wood will be turned into a kind of *amalagma*, (as the chemists call it,) or that the finer part will be turned into air, and the grosser stick as it were baked and incrustate upon the sides of the vessel; being become of a denser matter than the wood itself, crude. And for another trial, take also water, and put it in the like vessel, stopped as before; but use a gentler

[1] I do not know what Bacon would have thought of the story told of the Emperor Frederick II. An old commentator on Dante affirms that, in order to prove the non-existence of the soul, the emperor enclosed a criminal in a chest, and kept him there until death took place. The chest being opened, he asked those whom he wished to refute what had become of the soul; but received quite as good an answer as the question deserved, namely, that it had escaped by the same route as the cries which, for some time after being shut in, the unhappy man had been heard to utter.

heat, and remove the vessel sometimes from the fire; and again, after some small time, when it is cold, renew the heating of it; and repeat this alteration some few times; and if you can once bring to pass, that the water, which is one of the simplest bodies, be changed in colour, odour, or taste, after the manner of compound bodies, you may be sure that there is a great work wrought in nature, and a notable entrance made into strange changes of bodies and productions; and also a way made to do that by fire in small time, which the sun and age do in long time. But of the admirable effects of this distillation in close (for so we will call it), which is like the wombs and matrices of living creatures, where nothing expireth nor separateth, we will speak fully in the due place; not that we aim at the making of Paracelsus' pygmies,[1] or any such prodigious follies; but that we know the effects of heat will be such as will scarce fall under the conceit of man, if the force of it be altogether kept in.

Experiment solitary touching the impossibility of annihilation.

100. There is nothing more certain in nature than that it is impossible for any body to be utterly annihilated; but that as it was the work of the omnipotency of God to make somewhat of nothing, so it requireth the like omnipotency to turn somewhat into nothing. And therefore it is well said by an obscure writer of the sect of the chemists, that there is no such way to effect the strange transmutations of bodies, as to endeavour and urge by all means the reducing of them to nothing. And herein is contained also a

[1] See Paracelsus, De Nymph. Sylph. Pygmæ. et Salam.

great secret of preservation of bodies from change; for if you can prohibit, that they neither turn into air, because no air cometh to them; nor go into the bodies adjacent, because they are utterly heterogeneal; nor make a round and circulation within themselves; they will never change, though they be in their nature never so perishable or mutable. We see how flies, and spiders, and the like, get a sepulchre in amber, more durable than the monument and embalming of the body of any king. And I conceive the like will be of bodies put into quicksilver. But then they must be but thin, as a leaf, or a piece of paper or parchment; for if they have a greater crassitude, they will alter in their own body, though they spend not. But of this we shall speak more when we handle the title of conservation of bodies.

NATURAL HISTORY.

CENTURY II.

Experiments in consort touching Music.

MUSIC, in the practice, hath been well pursued, and in good variety; but in the theory, and especially in the yielding of the causes of the practique, very weakly; being reduced into certain mystical subtilties, of no use and not much truth. We shall, therefore, after our manner, join the contemplative and active part together.

101. All sounds are either musical sounds, which we call tones; whereunto there may be an harmony; which sounds are ever equal; as singing, the sounds of stringed and wind-instruments, the ringing of bells, &c.; or immusical sounds; which are ever unequal; such as are the voice in speaking, all whisperings, all voices of beasts and birds, (except they be singing-birds,) all percussions of stones, wood, parchment, skins (as in drums), and infinite others.

102. The sounds that produce tones, are ever from such bodies as are in their parts and pores equal; as well as the sôunds themselves are equal; and such are the percussions of metal, as in bells; of glass, as in

the filliping of a drinking glass; of air, as in men's voices whilst they sing, in pipes, whistles, organs, stringed instruments, &c.; and of water, as in the nightingale-pipes of regals[1] or organs, and other hydraulics; which the ancients had, and Nero did so much esteem, but are now lost.[2] And if any man think that the string of the bow and the string of the viol are neither of them equal bodies, and yet produce tones, he is in an error. For the sound is not created between the bow or *plectrum* and the string; but between the string and the air; no more than it is between the finger or quill and the string, in other instruments. So there are (in effect) but three percussions that create tones; percussions of metals (comprehending glass and the like), percussions of air, and percussions of water.

103. The diapason or eighth in music is the sweetest concord; insomuch as it is in effect an unison; as we see in lutes that are strung in the base strings with two strings, one an eighth above another; which make but as one sound. And every eighth note in ascent (as from eight to fifteen, from fifteen to twenty-two, and so *in infinitum*,) are but scales of diapason. The cause is dark, and hath not been rendered by any; and therefore would be better contemplated. It seemeth that air (which is the subject of sounds) in sounds that are not tones (which are all unequal, as hath been said,) admitteth much variety; as we see in the voices of living creatures, and likewise in the voices of several

[1] See the note at § 172.

[2] Suetonius in Nero, c. 41. Hydraulic music is mentioned as one of the lost arts by Pancirollo. See his *Raccolta Breve*, &c., i. 7. See also Vitruvius, [lib. v. c. 5.].

men, (for we are capable to discern several men by their voices,) and in the conjugation of letters, whence articulate sounds proceed; which of all others are most various. But in the sounds which we call tones, (that are ever equal,) the air is not able to cast itself into any such variety; but is forced to recur into one and the same posture or figure, only differing in greatness and smallness. So we see figures may be made of lines, crooked and straight, in infinite variety, where there is inequality; but circles, or squares, or triangles equilateral (which are all figures of equal lines) can differ but in greater or lesser.

104. It is to be noted, (the rather lest any man should think that there is anything in this number of eight, to create the diapason,) that this computation of eight is a thing rather received than any true computation. For a true computation ought ever to be by distribution into equal portions. Now there be intervenient in the rise of eight (in tones) two beemols, or half-notes:[1] so as if you divide the tones equally, the eighth is but seven whole and equal notes; and if you subdivide that into half-notes, (as it is in the stops of a lute,) it maketh the number of thirteen.

105. Yet this is true, that in the ordinary rises and falls of the voice of man (not measuring the tone by whole notes and half-notes, which is the equal measure) there fall out to be two beemols (as hath been said) between the unison and the diapason: and this varying is natural. For if a man would endeavour to raise or fall his voice still by half-notes, like the stops of a lute, or by whole notes alone without halves, as

[1] Namely, between the third and fourth and between the seventh and eighth.

far as an eighth; he will not be able to frame his voice unto it. Which sheweth, that after every three whole notes, nature requireth, for all harmonical use, one half-note to be interposed.

106. It is to be considered, that whatsoever virtue is in numbers for conducing to concent of notes, is rather to be ascribed to the ante-number than to the entire number; as namely, that the sound returneth after six or after twelve; so that the seventh or the thirteenth is not the matter, but the sixth or the twelfth; and the seventh and the thirteenth are but the limits and boundaries of the return.

107. The concords in music which are perfect or semiperfect between the unison and the diapason, are the fifth, which is the most perfect; the third next; and the sixth, which is more harsh: and, as the ancients esteemed, and so do myself and some other yet, the fourth, which they call diatessaron.[1] As for the tenth, twelfth, thirteenth, and so *in infinitum*, they be but recurrences of the former, viz. of the third, the fifth, and the sixth, being an eighth respectively from them.

108. For discords, the second and the seventh are of all others the most odious in harmony to the sense;

[1] Hawkins remarks, "Hardly any question has been more agitated by the modern musicians than this, whether the diatessaron be a concord or a discord?" He goes on to quote a passage in favour of its being a concord from "a very learned and ingenious book," entitled *Principles of Music, &c.*, by Charles Butler, of Magdalen College, Oxford, 1636. Butler, after arguing the question, proceeds thus: "And therefore that honourable sage [Lord Verulam], whose general knowledge and judgment in all kind of literature is generally applauded by the learned, rejecting their novel fancy that reject this ancient concord, professes himself to be of another mind," — and then quotes the passage in the text. See Hawkins, *Hist. of Music*, iii. 134.

whereof the one is next above the unison, the other next under the diapason, which may shew that harmony requireth a competent distance of notes.

109. In harmony, if there be not a discord to the base, it doth not disturb the harmony though there be a discord to the higher parts; so the discord be not of the two that are odious; and therefore the ordinary consent of four parts consisteth of an eighth, a fifth, and a third to the base; but that fifth is a fourth to the treble, and the third is a sixth. And the cause is, for that the base striking more air, doth overcome and drown the treble, (unless the discord be very odious); and so hideth a small imperfection. For we see, that in one of the lower strings of a lute, there soundeth not the sound of the treble, nor any mixed sound, but only the sound of the base.

110. We have no music of quarter-notes;[1] and it may be they are not capable of harmony; for we see the half-notes themselves do but interpose sometimes. Nevertheless we have some slides or relishes of the voice or strings, as it were continued without notes from one tone to another, rising or falling, which are delightful.

111. The causes of that which is pleasing or ingrate to the hearing, may receive light by that which is pleasing or ingrate to the sight. There be two things pleasing to the sight, (leaving pictures and shapes aside, which are but secondary objects, and please or displease but in memory); these two are *colours* and *order*. The pleasing of colour symboliseth with the pleasing of any single tone to the ear; but the pleasing

[1] The diesis or quarter-note does not enter into our scales, but it did into the enharmonic scale of the Greeks.

of order doth symbolise with harmony. And therefore we see in garden-knots, and the frets of houses, and all equal and well answering figures, (as globes, pyramids, cones, cylinders, &c.,) how they please; whereas unequal figures are but deformities. And both these pleasures, that of the eye, and that of the ear, are but the effects of equality, good proportion, or correspondence: so that (out of question) equality and correspondence are the causes of harmony. But to find the proportion of that correspondence, is more abstruse; whereof notwithstanding we shall speak somewhat (when we handle tones) in the general inquiry of sounds.

112. Tones are not so apt altogether to procure sleep as some other sounds; as the wind, the purling of water, humming of bees, a sweet voice of one that readeth, &c. The cause whereof is, for that tones, because they are equal and slide not, do more strike and erect the sense than the other. And overmuch attention hindereth sleep.

113. There be in music certain figures or tropes; almost agreeing with the figures of rhetoric, and with the affections of the mind, and other senses. First, the division and quavering, which please so much in music, have an agreement with the glittering of light; as the moon-beams playing upon a wave. Again, the falling from a discord to a concord, which maketh great sweetness in music, hath an agreement with the affections, which are reintegrated to the better after some dislikes; it agreeth also with the taste, which is soon glutted with that which is sweet alone. The sliding from the close or cadence, hath an agreement with the figure in rhetoric which they call *præter expecta-*

tum; for there is a pleasure even[1] in being deceived. The reports and fuges have an agreement with the figures in rhetoric of repetition and traduction. The tripla's, and changing of times, have an agreement with the changes of motions; as when galliard time and measure time are in the medley of one dance.[2]

114. It hath been anciently held and observed, that the sense of hearing and the kinds of music have most operation upon manners; as to encourage men and make them warlike; to make them soft and effeminate; to make them grave; to make them light; to make them gentle and inclined to pity, &c. The cause is, for that the sense of hearing striketh the spirits more immediately than the other senses, and more incorporeally than the smelling. For the sight, taste, and feeling, have their organs not of so present and immediate access to the spirits, as the hearing hath. And as for the smelling, (which indeed worketh also immediately upon the spirits, and is forcible while the object remaineth,) it is with a communication of the breath or vapour of the object odorate; but harmony, entering easily, and mingling not at all, and coming with a manifest motion, doth by custom of often affecting the spirits and putting them into one kind of posture, alter not a little the nature of the spirits, even when the object is removed. And therefore we see that tunes and airs, even in their own nature, have in themselves some affinity with the affections: as there be merry tunes, doleful tunes, solemn tunes; tunes inclining men's minds to pity; warlike tunes, &c. So as it is no mar-

[1] So in the original; a mistake probably for *ever.* — *J. S.*

[2] Compare this passage with the [*De Augmentis*, iii. 1. and the corresponding passage in the] *Advancement of Learning.*

vel if they alter the spirits, considering that tunes have a predisposition to the motion of the spirits in themselves. But yet it hath been noted, that though this variety of tunes doth dispose the spirits to variety of passions conform unto them, yet generally music feedeth that disposition of the spirits which it findeth. We see also that several airs and tunes do please several nations and persons, according to the sympathy they have with their spirits.

Experiments in consort touching sounds; and first touching the nullity and entity of sounds.

Perspective hath been with some diligence inquired; and so hath the nature of sounds, in some sort, as far as concerneth music. But the nature of sounds in general hath been superficially observed. It is one of the subtilest pieces of nature. And besides, I practise as I do advise; which is, after long inquiry of things immerse in matter, to interpose some subject which is immateriate, or less materiate; such as this of sounds; to the end that the intellect may be rectified, and become not partial.

115. It is first to be considered, what great motions there are in nature which pass without sound or noise. The heavens turn about in a most rapid motion, without noise to us perceived; though in some dreams they have been said to make an excellent music. So the motions of the comets, and fiery meteors (as "stella cadens," &c.) yield no noise. And if it be thought that it is the greatness of distance from us, whereby the sound cannot be heard; we see that lightnings and

coruscations, which are near at hand, yield no sound neither. And yet in all these there is a percussion and division of the air. The winds in the upper region (which move the clouds above, which we call the *rack*, and are not perceived below,) pass without noise. The lower winds in a plain, except they be strong, make no noise; but amongst trees, the noise of such winds will be perceived. And the winds (generally) when they make a noise, do ever make it unequally, rising and falling, and sometimes (when they are vehement) trembling at the height of their blast. Rain or hail falling (though vehemently) yieldeth no noise in passing through the air, till it fall upon the ground, water, houses, or the like. Water in a river (though a swift stream) is not heard in the channel, but runneth in silence, if it be of any depth; but the very stream upon shallows, of gravel or pebble, will be heard. And waters, when they beat upon the shore, or are straitened (as in the falls of bridges), or are dashed against themselves by winds, give a roaring noise. Any piece of timber or hard body, being thrust forwards by another body contiguous without knocking, giveth no noise. And so bodies in weighing one upon another, though the upper body press the lower body down, make no noise. So the motion in the minute parts of any solid body (which is the principal cause of violent motion, though unobserved,) passeth without sound; for that sound that is heard sometimes, is produced only by the breaking of the air, and not by the impulsion of the parts. So it is manifest that where the anterior body giveth way as fast as the posterior cometh on, it maketh no noise, be the motion never so great or swift.

116. Air open, and at large, maketh no noise, except it be sharply percussed; as in the sound of a string, where air is percussed by a hard and stiff body, and with a sharp loose; for if the string be not strained, it maketh no noise. But where the air is pent and straitened, there breath or other blowing, (which carry but a gentle percussion) suffice to create sound; as in pipes and wind-instruments. But then you must note, that in recorders, which go with a gentle breath, the concave of the pipe, were it not for the fipple that straiteneth the air (much more than the simple concave), would yield no sound. For as for other wind-instruments, they require a forcible breath; as trumpets, cornets, hunters' horns, &c., which appeareth by the blown cheeks of him that windeth them. Organs also are blown with a strong wind by the bellows. And note again, that some kind of wind-instruments are blown at a small hole in the side, which straiteneth the breath at the first entrance; the rather, in respect of their traverse and stop above the hole, which performeth the fipple's part; as it is seen in flutes and fifes, which will not give sound by a blast at the end, as recorders &c. do. Likewise in all whistling, you contract the mouth; and to make it more sharp, men sometimes use their finger. But in open air, if you throw a stone or a dart, they give no sound; no more do bullets, except they happen to be a little hollowed in the casting; which hollowness penneth the air: nor yet arrows, except they be ruffled in their feathers, which likewise penneth the air. As for small whistles, or shepherds' oaten pipes, they give a sound because of their extreme slenderness, whereby the air is more pent than in a wider pipe. Again, the voices of men

and living creatures pass through the throat, which penneth the breath. As for the Jews-harp, it is a sharp percussion ; and besides hath the advantage of penning the air in the mouth.

117. Solid bodies, if they be very softly percussed, give no sound ; as when a man treadeth very softly upon boards. So chests or doors in fair weather, when they open easily, give no sound. And cart-wheels squeak not when they are liquored.

118. The flame of tapers or candles, though it be a swift motion and breaketh the air, yet passeth without sound. Air in ovens, though (no doubt) it doth (as it were) boil and dilate itself, and is repercussed, yet it is without noise.

119. Flame percussed by air giveth a noise ; as in blowing of the fire by bellows ; greater than if the bellows should blow upon the air itself. And so likewise flame percussing the air strongly (as when flame suddenly taketh and openeth) giveth a noise ; so great flames, while the one impelleth the other, give a bellowing sound.

120. There is a conceit runneth abroad, that there should be a white powder, which will discharge a piece without noise ; which is a dangerous experiment, if it should be true : for it may cause secret murders. But it seemeth to me unpossible ; for if the air pent be driven forth and strike the air open, it will certainly make a noise. As for the white powder, (if any such thing be, that may extinguish or dead the noise,) it is like to be a mixture of petre and sulphur, without coal. For petre alone will not take fire. And if any man think that the sound may be extinguished or deaded by discharging the pent air before it cometh to the

mouth of the piece and to the open air, that is not probable; for it will make more divided sounds: as if you should make a cross barrel hollow through the barrel of a piece, it may be it would give several sounds, both at the nose and the sides. But I conceive that if it were possible to bring to pass that there should be no air pent at the mouth of the piece, the bullet might fly with small or no noise. For first, it is certain there is no noise in the percussion of the flame upon the bullet. Next, the bullet in piercing through the air maketh no noise; as hath been said. And then, if there be no pent air that striketh upon open air, there is no cause of noise; and yet the flying of the bullet will not be stayed. For that motion (as hath been oft said) is in the parts of the bullet, and not in the air. So as trial must be made by taking some small concave of metal, no more than you mean to fill with powder, and laying the bullet in the mouth of it, half out in the open air.

121. I heard it affirmed by a man that was a great dealer in secrets, but he was but vain, that there was a conspiracy (which himself hindered) to have killed Queen Mary, sister to Queen Elizabeth, by a burning-glass, when she walked in St. James's Park, from the leads of the house. But thus much (no doubt) is true; that if burning-glasses could be brought to a great strength (as they talk generally of burning-glasses that are able to burn a navy [1]) the percussion of the air alone by such a burning-glass would make no noise; no more than is found in coruscations and lightnings without thunders.

[1] The story of Archimedes's burning the Roman fleet, rests on no good foundation. The authorities are collected by Peyrard in an appendix to his edition of Archimedes.

122. I suppose that impression of the air with sounds asketh a time to be conveyed to the sense, as well as the impression of species visible; or else they will not be heard. And therefore, as the bullet moveth so swift that it is invisible, so the same swiftness of motion maketh it inaudible: for we see that the apprehension of the eye is quicker than that of the ear.

123. All eruptions of air, though small and slight, give an entity of sound; which we call crackling, puffing, spitting, &c., as in bay-salt, and bay-leaves, cast into the fire: so in chestnuts, when they leap forth of the ashes; so in green wood laid upon the fire, especially roots; so in candles, that spit flame if they be wet; so in rasping, sneezing, &c.; so in a rose-leaf gathered together into the fashion of a purse, and broken upon the forehead or back of the hand, as children use.

Experiments in consort touching production, conservation, and delation of sounds; and the office of the air therein.

124. The cause given of sound, that it should be an elision of the air (whereby, if they mean anything, they mean a cutting or dividing, or else an attenuating of the air) is but a term of ignorance; and the notion[1] is but a catch of the wit upon a few instances; as the manner is in the philosophy received. And it is common with men, that if they have gotten a pretty expression by a word of art, that expression goeth current, though it be empty of matter. This conceit of elision appeareth most manifestly to be false, in that the sound of a bell, string, or the like, continueth

[1] *Motion* in the original. — *J. S.*

melting some time after the percussion; but ceaseth straightways, if the bell or string be touched and stayed; whereas, if it were the elision of the air that made the sound, it could not be that the touch of the bell or string should extinguish so suddenly that motion caused by the elision of the air. This appeareth yet more manifestly by chiming with a hammer upon the outside of a bell: for the sound will be according to the inward concave of the bell: whereas the elision or attenuation of the air cannot be but only between the hammer and the outside of the bell. So again, if it were an elision, a broad hammer, and a bodkin, struck upon metal, would give a diverse tone, as well as a diverse loudness: but they do not so: for though the sound of the one be louder, and of the other softer, yet the tone is the same. Besides, in echoes, (whereof some are as loud as the original voice,) there is no new elision, but a repercussion only. But that which convinceth it most of all is, that sounds are generated where there is no air at all. But these and the like conceits, when men have cleared their understanding by the light of experience, will scatter and break up like a mist.

125. It is certain that sound is not produced at the first, but with some local motion of the air, or flame, or some other medium; nor yet without some resistance, either in the air or the body percussed. For if there be a mere yielding or cession, it produceth no sound; as hath been said. And therein sounds differ from light or colours; which pass through the air, or other bodies, without any local motion of the air; either at the first or after. But you must attentively distinguish between the local motion of the air

(which is but *vehiculum causæ*, a carrier of the sounds) and the sounds themselves conveyed in the air. For as to the former, we see manifestly that no sound is produced (no not by air itself against other air, as in organs, &c.) but with a perceptible blast of the air; and with some resistance of the air strucken. For even all speech (which is one of the gentlest motions of air) is with expulsion of a little breath. And all pipes have a blast, as well as a sound. We see also manifestly that sounds are carried with wind; and therefore sounds will be heard further with the wind than against the wind; and likewise do rise and fall with the intension or remission of the wind. But for the impression of the sound, it is quite another thing, and is utterly without any local motion of the air, perceptible; and in that resembleth the species visible: for after a man hath lured, or a bell is rung, we cannot discern any perceptible motion at all in the air along as the sound goeth; but only at the first. Neither doth the wind (as far as it carrieth a voice) with the motion thereof confound any of the delicate and articulate figurations of the air, in variety of words. And if a man speak a good loudness against the flame of a candle, it will not make it tremble much; though most when those letters are pronounced which contract the mouth; as F, S, V, and some others. But gentle breathing, or blowing without speaking, will move the candle far more. And it is the more probable that sound is without any local motion of the air, because as it differeth from the sight in that it needeth a local motion of the air at first, so it paralleleth in so many other things with the sight and radiation of things invisible; which (without all question) induce no local motion in the air, as hath been said.

126. Nevertheless it is true, that upon the noise of thunder, and great ordnance, glass windows will shake; and fishes are thought to be frayed with the motion caused by noise upon the water.[1] But these effects are from the local motion of the air which is a concomitant of the sound (as hath been said), and not from the sound.

127. It hath been anciently reported,[2] and is still received, that extreme applauses and shouting of people assembled in great multitudes, have so rarified and broken the air, that birds flying over have fallen down, the air being not able to support them. And it is believed by some, that great ringing of bells in populous cities hath chased away thunder, and also dissipated pestilent air: all which may be also from the concussion of the air, and not from the sound.

128. A very great sound, near hand, hath strucken many deaf; and at the instant they have found, as it were, the breaking of a skin of parchment in their ear: and myself standing near one that lured [3] loud and shrill, had suddenly an offence, as if somewhat had broken or been dislocated in my ear; and immediately after a loud ringing (not an ordinary singing or hissing, but far louder and differing) so as I feared some deafness. But after some half quarter of an hour it vanished.

[1] Similarly it has been observed that discharge of artillery is injurious to lobsters.

[2] Plutarch in Flaminius, p. 375.

[3] To lure is properly to bring the falcon back by showing him the lure, an imitation of a bird, sometimes baited with a piece of flesh; secondarily, as in the text, to bring him back by whistling. *Lure*, in French *leurre* and *loirre*, is primarily *lorum*, the thong to which the falcon is attached. See Menage in voc.

This effect may be truly referred unto the sound: for (as is commonly received) an over-potent object doth destroy the sense; and spiritual species (both visible and audible) will work upon the sensories, though they move not any other body.

129. In delation of sounds, the inclosure of them preserveth them, and causeth them to be heard further. And we find in rolls of parchment or trunks,[1] the mouth being laid to the one end of the roll of parchment or trunk, and the ear to the other, the sound is heard much further than in the open air. The cause is, for that the sound spendeth and is dissipated in the open air; but in such concaves it is conserved and contracted. So also in a piece of ordnance, if you speak in the touch-hole, and another lay his ear to the mouth of the piece, the sound passeth, and is far better heard, than in the open air.

130. It is further to be considered, how it proveth and worketh when the sound is not inclosed all the length of his way, but passeth partly through open air; as where you speak some distance from a trunk; or where the ear is some distance from the trunk at the other end; or where both mouth and ear are distant from the trunk. And it is tried, that in a long trunk of some eight or ten foot, the sound is holpen, though both the mouth and the ear be a handful or more from the ends of the trunk; and somewhat more holpen, when the ear of the hearer is near, than when the mouth of the speaker. And it is certain that the voice is better heard in a chamber from abroad, than abroad from within the chamber.

[1] It is worth notice that telescopes were at first called "trunks;" as for instance by Harriott.

131. As the inclosure that is round about and entire, preserveth the sound; so doth a semi-concave, though in a less degree. And therefore, if you divide a trunk or a cane into two, and one speak at the one end, and you lay your ear at the other, it will carry the voice further than in the air at large. Nay further, if it be not a full semi-concave, but if you do the like upon the mast of a ship, or a long pole, or a piece of ordnance, (though one speak upon the surface of the ordnance, and not at any of the bores,) the voice will be heard further than in the air at large.

132. It would be tried, how, and with what proportion of disadvantage, the voice will be carried in an horn, which is a line arched; or in a trumpet, which is a line retorted; or in some pipe that were sinuous.

133. It is certain (howsoever it cross the received opinion) that sounds may be created without air, though air be the most favourable deferent of sounds. Take a vessel of water, and knap a pair of tongs some depth within the water, and you shall hear the sound of the tongs well, and not much diminished; and yet there is no air at all present.

134. Take one vessel of silver, and another of wood; and fill each of them full of water; and then knap the tongs together, as before, about an handful from the bottom; and you shall find the sound much more resounding from the vessel of silver, than from that of wood; and yet if there be no water in the vessel, so that you knap the tongs in the air, you shall find no difference between the silver and the wooden vessel. Whereby, beside the main point of creating sound without air, you may collect two things: the one, that

the sound communicateth with the bottom of the vessel; the other, that such a communication passeth far better through water than air.

135. Strike any hard bodies together in the midst of a flame; and you shall hear the sound with little difference from the sound in the air.

136. The pneumatical part, which is in all tangible bodies, and hath some affinity with the air, performeth in some degree the parts of the air; as when you knock upon an empty barrel, the sound is in part created by the air on the outside, and in part by the air in the inside; for the sound will be greater or lesser, as the barrel is more empty or more full; but yet the sound participateth also with the spirit in the wood, through which it passeth, from the outside to the inside. And so it cometh to pass in the chiming of bells on the outside; where also the sound passeth to the inside. And a number of other like instances, whereof we shall speak more when we handle the communication of sounds.

137. It were extreme grossness to think (as we have partly touched before) that the sound in strings is made or produced between the hand and the string, or the quill and the string, or the bow and the string, for those are but *vehicula motus*, passages to the creation of the sound; the sound being produced between the string and the air; and that not by any impulsion of the air from the first motion of the string, but by the return or result of the string, which was strained by the touch, to his former place; which motion of result is quick and sharp; whereas the first motion is soft and dull. So the bow tortureth the string continually, and thereby holdeth it in a continual trepidation.

Experiments in consort touching the magnitude and exility and damps of sound.

138. Take a trunk, and let one whistle at the one end, and hold your ear to the other, and you shall find the sound strike so sharp as you can scarce endure it. The cause is, for that sound diffuseth itself in round, and so spendeth itself; but if the sound, which would scatter in open air, be made to go all into a canal, it must needs give greater force to the sound. And so you may note that inclosures do not only preserve sound, but also increase and sharpen it.

139. A hunter's horn being greater at one end than at the other, doth increase the sound more than if the horn were all of an equal bore. The cause is, for that the air and sound being first contracted at the lesser end, and afterwards having more room to spread at the greater end, do dilate themselves; and in coming out strike more air; whereby the sound is the greater and baser. And even hunters' horns, which are sometimes made straight and not oblique, are ever greater at the lower end. It would be tried also in pipes, being made far larger at the lower end; or being made with a belly towards the lower end, and then issuing into a straight concave again.

140. There is in St. James's Fields a conduit of brick, unto which joineth a low vault; and at the end of that a round house of stone; and in the brick conduit there is a window; and in the round house a slit or rift of some little breadth; if you cry out in the rift, it will make a fearful roaring at the window.[1] The cause is the same with the former;

[1] Mr. Timbs, in his *Curiosities of London*, refers to this passage, and

for that all concaves that proceed from more narrow to more broad, do amplify the sound at the coming out.

141. Hawks' bells, that have holes in the sides, give a greater ring, than if the pellet did strike upon brass in the open air. The cause is the same with the first instance of the trunk; namely, for that the sound inclosed with the sides of the bell cometh forth at the holes unspent and more strong.

142. In drums, the closeness round about, that preserveth the sound from dispersing, maketh the noise come forth at the drum-hole far more loud and strong than if you should strike upon the like skin extended in the open air. The cause is the same with the two precedent.

143. Sounds are better heard, and further off, in an evening or in the night, than at the noon or in the day. The cause is, for that in the day, when the air is more thin, no doubt, the sound pierceth better; but when the air is more thick, as in the night, the sound spendeth and spreadeth abroad less: and so it is a degree of inclosure. As for the night, it is true also that the general silence helpeth.

144. There be two kinds of reflexions of sounds; the one at distance, which is the echo; wherein the original is heard distinctly, and the reflexion also distinctly; of which we shall speak hereafter: the other in concurrence; when the sound reflecting (the reflexion being near at hand) returneth immediately upon the original, and so iterateth it not, but amplifieth it. Therefore we see that music upon the water

states that the conduit in question stood near the spot now occupied by the statue of William III. in the garden of St. James's Square.

soundeth more; and so likewise music is better in chambers wainscotted than hanged.

145. The strings of a lute, or viol, or virginals, do give a far greater sound, by reason of the knot, and board, and concave underneath, than if there were nothing but only the flat of a board, without that hollow and knot, to let in the upper air into the lower. The cause is, the communication of the upper air with the lower, and penning of both from expence or dispersing.

146. An Irish harp hath open air on both sides of the strings: and it hath the concave or belly not along the strings, but at the end of the strings. It maketh a more resounding sound than a bandora, orpharion, or cittern,[1] which have likewise wire-strings. I judge the cause to be, for that open air on both sides helpeth, so that there be a concave; which is therefore best placed at the end.

147. In a virginal, when the lid is down, it maketh a more exile sound than when the lid is open. The cause is, for that all shutting in of air, where there is no competent vent, dampeth the sound: which maintaineth likewise the former instance; for the belly of the lute or viol doth pen the air somewhat.

148. There is a church at Gloucester, (and, as I have heard, the like is in some other places), where if you speak against a wall softly, another shall hear your voice better a good way off, than near at hand. Inquire more particularly of the frame of that place. I suppose there is some vault, or hollow, or isle,[2] be-

[1] The cittern and the lute are probably the same instrument. See Hawkins's *Hist. of Music*, iii. 162.; and for the bandora and orpharion, iii. 344.

[2] So in the original. I suppose *aisle* is meant. — *J. S.*

hind the wall, and some passage to it towards the further end of that wall against which you speak; so as the voice of him that speaketh slideth along the wall, and then entereth at some passage, and communicateth with the air of the hollow; for it is preserved somewhat by the plain wall; but that is too weak to give a sound audible, till it hath communicated with the back air.[1]

149. Strike upon a bow-string, and lay the horn of the bow near your ear, and it will increase the sound, and make a degree of a tone. The cause is, for that the sensory, by reason of the close holding, is percussed before the air disperseth. The like is, if you hold the horn betwixt your teeth: but that is a plain delation of the sound; from the teeth to the instrument of hearing; for there is a great intercourse between those two parts; as appeareth by this, that a harsh grating tune setteth the teeth on edge. The like falleth out, if the horn of the bow be put upon the temples; but that is but the slide of the sound from thence to the ear.

150. If you take a rod of iron or brass, and hold the one end to your ear, and strike upon the other, it maketh a far greater sound than the like stroke upon the rod not so made contiguous to the ear. By which, and by some other instances that have been partly touched, it should appear, that sounds do not only slide upon the surface of a smooth body, but do also communicate with the spirits that are in the pores of the body.

151. I remember in Trinity College in Cambridge,

[1] The church referred to is the cathedral, and the length of the gallery is said to be twenty-five yards. See Rudder, *History of Gloucestershire*, p. 178.

there was an upper chamber, which being thought weak in the roof of it, was supported by a pillar of iron of the bigness of one's arm, in the midst of the chamber; which if you had struck, it would make a little flat noise in the room where it was struck, but it would make a great bomb in the chamber beneath.[1]

152. The sound which is made by buckets in a well, when they touch upon the water, or when they strike upon the side of the well, or when two buckets dash the one against the other; these sounds are deeper and fuller than if the like percussion were made in the open air. The cause is, the penning and inclosure of the air in the concave of the well.

153. Barrels placed in a room under the floor of a chamber, make all noises in the same chamber more full and resounding.

So that there be five ways (in general) of majoration in sounds: inclosure simple; inclosure with dilatation; communication; reflexion concurrent; and approach to the sensory.

154. For exility of the voice or other sounds; it is certain that the voice doth pass through solid and hard bodies, if they be not too thick; and through water, which is likewise a very close body, and such an one as letteth not in air. But then the voice, or other sound, is reduced by such passage to a great weakness or exil-

[1] Mr. Edleston, fellow and steward of the college, who is probably as conversant with its history as any member of the present society, informs me that nothing is known of this chamber, and that he is therefore disposed to believe that it formed part of the buildings removed in the first years of the 17th century, in order to made room for what is now the Old Court.

ity. If therefore you stop the holes of a hawk's bell, it will make no ring, but a flat noise or rattle. And so doth the *aëtites* or eagle's-stone, which hath a little stone within it.[1]

155. And as for water, it is a certain trial: let a man go into a bath, and take a pail, and turn the bottom upward, and carry the mouth of it (even) down to the level of the water, and so press it down under the water some handful and an half, still keeping it even, that it may not tilt on either side, and so the air get out: then let him that is in the bath dive with his head so far under water, as he may put his head into the pail; and there will come as much air bubbling forth, as will make room for his head. Then let him speak; and any that shall stand without shall hear his voice plainly; but yet made extreme sharp and exile, like the voice of puppets: but yet the articulate sounds of the words will not be confounded. Note that it may be much more handsomely done, if the pail be put over the man's head above water, and then he cower down, and the pail be pressed down with him. Note that a man must kneel or sit, that he may be lower than the water. A man would think that the Sicilian poet had knowledge of this experiment; for he saith that Hercules' page, Hylas, went with a water-pot to fill it at a pleasant fountain that was near the shore, and that the nymphs of the fountain fell in love with the boy, and pulled him under the water, keeping him alive; and that Hercules missing his page, called him by his name aloud, that all the shore rang of it; and that Hylas from within the water answered his master, but (that which is to the present purpose) with so small and

[1] Pliny, x. 4.

exile a voice, as Hercules thought he had been three miles off, when the fountain indeed was fast by.[1]

156. In lutes and instruments of strings, if you stop a string high (whereby it hath less scope to tremble) the sound is more treble, but yet more dead.

157. Take two saucers, and strike the edge of the one against the bottom of the other, within a pail of water; and you shall find, that as you put the saucers lower and lower, the sound groweth more flat; even while part of the saucer is above the water; but that flatness of sound is joined with a harshness of sound; which no doubt is caused by the inequality of the sound which cometh from the part of the saucer under the water, and from the part above. But when the saucer is wholly under the water, the sound becometh more clear, but far more low; and as if the sound came from afar off.

158. A soft body dampeth the sound much more than a hard; as if a bell hath cloth or silk wrapped about it, it deadeth the sound more than if it were wood. And therefore in clericals[2] the keys are lined; and in colleges they use to line the tablemen.[3]

[1] Theocrit. Id. xiii. Poisson has shown *à priori* that in passing from water into air the intensity of sound is diminished in the ratio of 1: 200, and vice versâ in passing from air into water as 1:3600. The exility of tone mentioned in the text is connected with the velocity of propagation, which is four times as great in water as in air.

[2] Johnson suggests Claricords. But Clerical seems to be analogous to Regal and Virginal, which are known musical instruments. Luscinius, quoted by Hawkins, *Hist. of Music*, ii. 442., says that the clavichord or clarichord is used by the nuns in convents, and that in order not to disturb the sisters in the dormitory, the strings are muffled with small bits of fine woollen cloth.

[3] The tablemen are manifestly a part of some musical instrument. The only sense in which the word is commonly used, namely men for playing draughts, is irrelevant.

159. Trial was made in a recorder[1] after these several manners. The bottom of it was set against the palm of the hand; stopped with wax round about; set against a damask cushion; thrust into sand; into ashes; into water (half an inch under the water); close to the bottom of a silver basin; and still the tone remained. But the bottom of it was set against a woollen carpet; a lining of plush; a lock of wool (though loosely put in); against snow; and the sound of it was quite deaded, and but breath.

160. Iron hot produceth not so full a sound as when it is cold; for while it is hot, it appeareth to be more soft and less resounding. So likewise warm water, when it falleth, maketh not so full a sound as cold;[2] and I conceive it is softer, and nearer the nature of oil; for it is more slippery, as may be seen in that it scowreth better.

161. Let there be a recorder made with two fipples, at each end one: the trunk of it of the length of two recorders, and the holes answerable towards each end; and let two play the same lesson upon it, at an unison; and let it be noted whether the sound be confounded, or amplified, or dulled. So likewise, let a cross be made of two trunks, throughout hollow; and let two speak or sing, the one longways, the other traverse: and let two hear at the opposite ends; and note whether the sound be confounded, amplified, or dulled. Which two instances will also give light to the mixture of sounds; whereof we shall speak hereafter.

162. A bellows blown in at the hole of a drum, and the drum then strucken, maketh the sound a little flatter, but no other apparent alteration. The cause is

[1] The recorder was a kind of flute. [2] Arist. Prob. xi. 10.

manifest: partly for that it hindereth the issue of the sound, and partly for that it maketh the air, being blown together, less moveable.

Experiments in consort touching the loudness or softness of sounds, and their carriage at longer or shorter distance.

163. The loudness and softness of sounds is a thing distinct from the magnitude and exility of sounds; for a base string, though softly strucken, giveth the greater sound; but a treble string, if hard strucken, will be heard much further off. And the cause is, for that the base string striketh more air; and the treble less air, but with a sharper percussion.

164. It is therefore the strength of the percussion, that is a principal cause of the loudness or softness of sounds; as in knocking harder or softer; winding of a horn stronger or weaker; ringing of a hand-bell harder or softer, &c. And the strength of this percussion consisteth as much or more in the hardness of the body percussed, as in the force of the body percussing: for if you strike against a cloth, it will give a less sound; if against wood, a greater; if against metal, yet a greater; and in metals, if you strike against gold (which is the more pliant), it giveth the flatter sound; if against silver or brass, the more ringing sound. As for air, where it is strongly pent, it matcheth a hard body. And therefore we see in discharging of a piece, what a great noise it maketh. We see also, that the charge with bullet, or with paper wet and hard stopped, or with powder alone rammed in hard, maketh no great difference in the loudness of the report.

165. The sharpness or quickness of the percussion is

a great cause of the loudness, as well as the strength; as in a whip or wand, if you strike the air with it; the sharper and quicker you strike it, the louder sound it giveth. And in playing upon the lute or virginals, the quick stroke or touch is a great life to the sound. The cause is, for that the quick striking cutteth the air speedily; whereas the soft striking doth rather beat than cut.

Experiments in consort touching the communication of sounds.

The communication of sounds (as in bellies of lutes, empty vessels, &c.) hath been touched *obiter* in the majoration of sounds; but it is fit also to make a title of it apart.

166. The experiment for greatest demonstration of communication of sounds, is the chiming of bells; where if you strike with a hammer upon the upper part, and then upon the midst, and then upon the lower, you shall find the sound to be more treble and more base according unto the concave on the inside, though the percussion be only on the outside.

167. When the sound is created between the blast of the mouth and the air of the pipe, it hath nevertheless some communication with the matter of the sides of the pipe, and the spirits in them contained; for in a pipe or trumpet, of wood and brass, the sound will be diverse; so if the pipe be covered with cloth or silk, it will give a diverse sound from that it would do of itself; so if the pipe be a little wet on the inside, it will make a differing sound from the same pipe dry.

168. That sound made within water doth communi-

cate better with a hard body through water, than made in air it doth with air, *vide experimentum* 134.

Experiments in consort touching equality and inequality of sounds.

We have spoken before (in the inquisition touching music) of musical sounds whereunto there may be a concord or discord in two parts; which sounds we call tones; and likewise of immusical sounds; and have given the cause, that the tone proceedeth of equality, and the other of inequality. And we have also expressed there, what are the equal bodies that give tones, and what are the unequal that give none. But now we shall speak of such inequality of sounds, as proceedeth not from the nature of the bodies themselves, but is accidental; either from the roughness or obliquity of the passage, or from the doubling of the percutient, or from the trepidation of the motion.

169. A bell, if it have a rift in it, whereby the sound hath not a clear passage, giveth a hoarse and jarring sound: so the voice of man, when by cold taken the weasil groweth rugged, and (as we call it) furred, becometh hoarse. And in these two instances the sounds are ingrate, because they are merely unequal: but if they be unequal in equality, then the sound is grateful, but purling.

170. All instruments that have either returns, as trumpets; or flexions, as cornets; or are drawn up and put from, as sackbuts; have a purling sound: but the recorder or flute, that have none of these inequalities,

give a clear sound. Nevertheless, the recorder itself, or pipe, moistened a little in the inside, soundeth more solemnly, and with a little purling or hissing. Again, a wreathed string, such as are in the base strings of bandoras, giveth also a purling sound.[1]

171. But a lute-string, if it be merely unequal in his parts, giveth a harsh and untuneable sound; which strings we call *false*, being bigger in one place than in another; and therefore wire strings are never false. We see also, that when we try a false lute-string, we use to extend it hard between the fingers, and to fillip it; and if it giveth a double species, it is true; but if it giveth a treble, or more, it is false.[2]

172. Waters, in the noise they make as they run, represent to the ear a trembling noise; and in regals[3] (where they have a pipe they call the nightingale-pipe, which containeth water) the sound hath a continual trembling: and children have also little things they call cocks, which have water in them; and when they blow or whistle in them, they yield a trembling noise; which trembling of water hath an affinity with the letter *L*. All which inequalities of trepidation are rather pleasant than otherwise.

173. All base notes, or very treble notes, give an asper sound; for that the base striketh more air, than

[1] The varying sounds of the kettle suggested a curious fancy to the Finns. According to them the confusion of tongues was caused by a kettle which came down from heaven, and from the varying noises of which each family learnt a different language. V. Grimm on the Origin of Language.

[2] Bacon took this from Le Roy's *Instruction de partir toute Musique, &c.*, of which an English translation was published in 1574. See Hawkins's *History of Music*, iii. 166.

[3] See for some account of this instrument, Hawkins's *Hist. of Music*, ii. 448.

it can well strike equally; and the treble cutteth the air so sharp, as it returneth too swift to make the sound equal: and therefore a mean or tenor is the sweetest part.

174. We know nothing that can at pleasure make a musical or immusical sound by voluntary motion, but the voice of man and birds. The cause is (no doubt) in the weasil or windpipe (which we call *aspera arteria* [1]), which being well extended, gathereth equality; as a bladder that is wrinkled, if it be extended, becometh smooth. The extension is always more in tones than in speech: therefore the inward voice or whisper can never give a tone. And in singing, there is manifestly a greater working and labour of the throat, than in speaking; as appeareth in the thrusting out or drawing in of the chin, when we sing.

175. The humming of bees is an unequal buzzing, and is conceived by some of the ancients not to come forth at their mouth, but to be an inward sound; [2] but (it may be) it is neither; but from the motion of their wings: for it is not heard but when they stir.

176. All metals quenched in water give a sibilation

[1] This name for the windpipe, and its Greek equivalent *τραχεῖα,* owe their origin to the theory according to which all the arteries are air-vessels. It is worthy of notice that Aristotle uses the word *ἀρτηρία* to denote the windpipe exclusively, applying *φλέψ* to veins and arteries indiscriminately. He was not however unaware that there is a material difference in the structure of the two classes of blood-vessels.

[2] Arist. Hist. An. iv. 9., and Pliny, xi. 112. That the humming sound emitted by many insects is not due to the motion of their wings, appears according to Burmeister's experiments to be certain, as it continues after the wings are cut off, though with a change of note. His theory is that it is caused merely by breathing through the thoracic air-holes as the insect does when on the wing — the breathing going on silently while it is at rest through the abdominal air-holes. V. Taylor, Scientific Memoirs, i. 377.

or hissing sound (which hath an affinity with the letter *Z*); notwithstanding the sound be created between the water or vapour and the air. Seething also, if there be but small store of water in a vessel, giveth a hissing sound; but boiling in a full vessel giveth a bubbling sound, drawing somewhat near to the cocks used by children.

177. Trial would be made, whether the inequality or interchange of the medium will not produce an inequality of sound; as if three bells were made one within another, and air betwixt each, and then the outermost bell were chimed with a hammer; how the sound would differ from a simple bell. So likewise, take a plate of brass and a plank of wood, and join them close together, and knock upon one of them, and see if they do not give an unequal sound. So make two or three partitions of wood in a hogshead, with holes or knots in them; and mark the difference of their sound from the sound of an hogshead without such partitions.

Experiments in consort touching the more treble and the more base tones, or musical sounds.

178. It is evident, that the percussion of the greater quantity of air causeth the baser sound, and the less quantity the more treble sound. The percussion of the greater quantity of air is produced by the greatness of the body percussing; by the latitude of the concave by which the sound passeth; and by the longitude of the same concave. Therefore we see that a base string is greater than a treble; a base pipe hath a greater bore than a treble; and in pipes and the like, the lower the note-holes be, and the further off from the mouth

of the pipe, the more base sound they yield; and the nearer the mouth, the more treble. Nay more, if you strike an entire body, as an andiron of brass, at the top, it maketh a more treble sound; and at the bottom a baser.

179. It is also evident, that the sharper or quicker percussion of air causeth the more treble sound; and the slower or heavier, the more base sound. So we see in strings: the more they are wound up and strained, (and thereby give a more quick start-back,) the more treble is the sound; and the slacker they are, or less wound up, the baser is the sound. And therefore a bigger string more strained, and a lesser string less strained, may fall into the same tone.

180. Children, women, eunuchs, have more small and shrill voices than men.[1] The reason is, not for that men have greater heat, which may make the voice stronger, (for the strength of a voice or sound doth make a difference in the loudness or softness, but not in the tone); but from the dilatation of the organ; which (it is true) is likewise caused by heat. But the cause of changing the voice at the years of puberty, is more obscure. It seemeth to be, for that when much of the moisture of the body, which did before irrigate the parts, is drawn down to the spermatical vessels, it leaveth the body more hot than it was; whence cometh the dilatation of the pipes: for we see plainly all effects of heat do then come on; as pilosity, more roughness of the skin, hardness of the flesh, &c.

181. The industry of the musician hath produced two other means of straining or intension of strings, besides their winding up. The one is the stopping of

[1] Arist. Prob. xi. 16. 34. and 62.

the string with the finger; as in the necks of lutes, viols, &c. The other is the shortness of the string, as in harps, virginals, &c. Both these have one and the same reason; for they cause the string to give a quicker start.

182. In the straining of a string, the further it is strained the less superstraining goeth to a note; for it requireth good winding of a string before it will make any note at all: and in the stops of lutes, &c., the higher they go, the less distance is between the frets.

183. If you fill a drinking-glass with water (especially one sharp below, and wide above), and fillip upon the brim or outside; and after empty part of the water, and so more and more, and still try the tone by filliping; you shall find the tone fall and be more base, as the glass is more empty.

Experiments in consort touching the proportion of treble and base tones.

The just and measured proportion of the air percussed, towards the baseness or trebleness of tones, is one of the greatest secrets in the contemplation of sounds. For it discovereth the true coïncidence of tones into diapasons; which is the return of the same sound. And so of the concords and discords between the unison and diapason; which we have touched before in the experiments of music; but think fit to resume it here as a principal part of our inquiry touching the nature of sounds. It may be found out in the proportion of the winding of strings; in the proportion of the distance of frets; and in the proportion of the concave of pipes, &c., but most commodiously in the last of these.

184. Try therefore the winding of a string once about, as soon as it is brought to that extension as will give a tone: and then of twice about, and thrice about, &c.; and mark the scale or difference of the rise of the tone: whereby you shall discover, in one, two effects; both the proportion of the sound towards the dimension of the winding; and the proportion likewise of the sound towards the string, as it is more or less strained. But note that to measure this, the way will be to take the length in a right line of the string, upon any winding about of the peg.

185. As for the stops, you are to take the number of frets; and principally the length of the line, from the first stop of the string, unto such a stop as shall produce a diapason to the former stop upon the same string.

186. But it will best (as it is said) appear in the bores of wind-instruments: and therefore cause some half dozen pipes to be made, in length and all things else alike, with a single, double, and so on to a sextuple bore; and so mark what fall of tone every one giveth. But still in these three last instances, you must diligently observe what length of string, or distance of stop, or concave of air, maketh what rise of sound. As in the last of these, which (as we said) is that which giveth the aptest demonstration, you must set down what increase of concave goeth to the making of a note higher; and what of two notes; and what of three notes; and so up to the diapason: for then the great

secret of numbers and proportions will appear. It is not unlike that those that make recorders, &c., know this already: for that they make them in sets: and likewise bell-founders, in fitting the tune of their bells. So that inquiry may save trial. Surely it hath been observed by one of the ancients, that an empty barrel knocked upon with the finger, giveth a diapason to the sound of the like barrel full;[1] but how that should be I do not well understand; for that the knocking of a barrel, full or empty, doth scarce give any tone.

187. There is required some sensible difference in the proportion of creating a note, towards the sound itself, which is the passive: and that it be not too near, but at a distance. For in a recorder, the three uppermost holes yield one tone; which is a note lower than the tone of the first three. And the like (no doubt) is required in the winding or stopping of strings.

Experiments in consort touching exterior and interior sounds.

There is another difference of sounds, which we will call exterior and interior. It is not soft nor loud: nor it is not base nor treble: nor it is not musical nor immusical: though it be true, that there can be no tone in an interior sound; but on the other side, in an exterior sound there may be both musical and immusical. We shall therefore enu-

[1] Aristotle says that if of two equal vessels one is empty and the other half full, the note given by the latter will be an octave above that given by the former. See Prob. xix. 50. He gives the right explanation, that the case is analogous to that of two pipes, the length of one of which is twice that of the other. It is singular that Bacon appears to have been ignorant of the theory of the monochord, or that he here proposes as a subject of inquiry what was familiarly known to the Greeks.

merate them, rather than precisely distinguish them; though (to make some adumbration of what we mean) the interior is rather an impulsion or contusion of the air, than an elision or section of the same: so as the percussion of the one, towards the other, differeth as a blow differeth from a cut.

188. In speech of man, the whispering (which they call *susurrus* in Latin), whether it be louder or softer, is an interior sound; but the speaking out is an exterior sound;[1] and therefore you can never make a tone nor sing in whispering; but in speech you may. So breathing, or blowing by the mouth, bellows, or wind, (though loud,) is an interior sound; but the blowing through a pipe or concave, (though soft,) is an exterior. So likewise the greatest winds, if they have no coarctation, or blow not hollow, give an interior sound; the whistling or hollow wind yieldeth a singing or exterior sound; the former being pent by some other body; the latter being pent in by his own density: and therefore we see, that when the wind bloweth hollow, it is a sign of rain. The flame, as it moveth within itself or is blown by a bellows, giveth a murmur or interior sound.

189. There is no hard body, but struck against another hard body, will yield an exterior sound, greater or lesser: insomuch as if the percussion be over-soft, it may induce a nullity of sound; but never an interior sound; as when one treadeth so softly that he is not heard.

[1] Similarly Aristotle remarks that the noise emitted by an elephant through the mouth is analogous to sighing or groaning, but that, by means of the trunk, it can produce a sound resembling that of a trumpet.

190. Where the air is the percutient, pent or not pent, against a hard body, it never giveth an exterior sound; as if you blow strongly with a bellows against a wall.

191. Sounds (both exterior and interior) may be made as well by suction as by the emission of the breath: as in whistling or breathing.

Experiments in consort touching articulation of sounds.

192. It is evident, and it is one of the strangest secrets in sounds, that the whole sound is not in the whole air only; but the whole sound is also in every small part of the air. So that all the curious diversity of articulate sounds, of the voice of man or birds, will enter into a small cranny inconfused.

193. The unequal agitation of the winds and the like, though they be material to the carriage of the sounds further or less way, yet they do not confound the articulation of them at all, within that distance that they can be heard; though it may be, they make them to be heard less way than in a still; as hath been partly touched.

194. Over-great distance confoundeth the articulation of sounds; as we see that you may hear the sound of a preacher's voice, or the like, when you cannot distinguish what he saith. And one articulate sound will confound another; as when many speak at once.

195. In the experiment of speaking under water, when the voice is reduced to such an extreme exility, yet the articulate sounds (which are the words) are not confounded; as hath been said.

196. I conceive that an extreme small or an extreme

great sound cannot be articulate; but that the articulation requireth a mediocrity of sound: for that the extreme small sound confoundeth the articulation by contracting: and the great sound by dispersing: and although (as was formerly said) a sound articulate, already created, will be contracted into a small cranny; yet the first articulation requireth more dimension.

197. It hath been observed, that in a room or in a chapel vaulted below and vaulted likewise in the roof, a preacher cannot be heard so well, as in the like places not so vaulted. The cause is, for that the subsequent words come on before the precedent words vanish; and therefore the articulate sounds are more confused, though the gross of the sound be greater.

198. The motions of the tongue, lips, throat, palate, &c., which go to the making of the several alphabetical letters, are worthy inquiry, and pertinent to the present inquisition of sounds: but because they are subtile, and long to describe, we will refer them over, and place them amongst the experiments of speech. The Hebrews have been diligent in it, and have assigned which letters are labial, which dental, which guttural, &c. As for the Latins and Grecians, they have distinguished between semi-vowels and mutes, and in mutes between *mutæ tenues*, *mediæ*, and *aspiratæ*, not amiss, but yet not diligently enough. For the special strokes and motions that create those sounds, they have little inquired:[1] as, that the letters *B*, *P*, *F*,

[1] Notice however the interesting remark of Nigidius preserved by Aulus Gellius, xix. 14., that *N G* [or rather the sound of *N* when immediately followed by *G*], is not a true *N*, *sed adulterinum;* the test being that in pronouncing such words as *anguis*, *angaria*, *increpat*, and the like, the tip of the tongue does not touch the palate. I believe I have given the sense

M, are not expressed but with the contracting or shutting of the mouth; that the letters *N* and *B*, cannot be pronounced but that the letter *N* will turn into *M;* as *hecatonba* will be *hecatomba.* That *M* and *T* cannot be pronounced together but *P* will come between; as *emtus* is pronounced *emptus;* and a number of the like.[1] So that if you inquire to the full, you will find that to the making of the whole alphabet there will be fewer simple motions required than there are letters.

199. The lungs are the most spongy part of the body; and therefore ablest to contract and dilate itself;[2] and where it contracteth itself, it expelleth the air; which through the artire,[3] throat, and mouth, maketh the voice: but yet articulation is not made but with the help of the tongue, palate, and the rest of those they call instruments of voice.

200. There is found a similitude between the sound that is made by inanimate bodies, or by animate bodies that have no voice articulate, and divers letters of articulate voices: and commonly men have given such names to those sounds, as do allude unto the articulate letters. As trembling of water hath resemblance with the letter *L;* quenching of hot metals with the letter *Z;* snarling of dogs with the letter *R;* the noise of

of the remark correctly. It appears to show that our way of pronouncing such words is erroneous. We ought to divide the syllables after the second consonant. [One of the instances given is *ingenuus*, from which we may certainly infer that in Nigidius's time the *G* in that word was pronounced hard. — *J. S.*]

1 Compare Latham, *The English Language*, § 109.

2 The contraction and dilatation of the lungs is merely passive, and caused by the action of the diaphragm and abdominal muscles.

3 So in the original. I suppose the *aspera arteria*, or wind-pipe, is meant. See note 1. p. 256. — *J. S.*

scrich-owls with the letters *Sh;* voice of cats with the diphthong *Eu;* voice of cuckows with the diphthong *Ou;*[1] sounds of strings with the letters *Ng;* so that if a man (for curiosity or strangeness sake) would make a puppet or other dead body to pronounce a word, let him consider, on the one part, the motion of the instruments of voice; and on the other part, the like sounds made in inanimate bodies; and what conformity there is that causeth the similitude of sounds; and by that he may minister light to that effect.

[1] From this it would seem that in Bacon's time the letters *ou*, were used to describe the sound which we should now describe by *oo;* whence we must further infer that a large number of words were then pronounced as they are now in Scotland and the north of England. — *J. S.*

NATURAL HISTORY.

CENTURY III.

Experiments in consort touching the motions of sounds, in what lines they are; circular, oblique, straight; upwards, downwards; forwards, backwards.

201. All sounds whatsoever move round; that is to say, on all sides; upwards, downwards, forwards, and backwards. This appeareth in all instances.

202. Sounds do not require to be conveyed to the sense in a right line, as visibles do, but may be arched; though it be true, they move strongest in a right line; which nevertheless is not caused by the rightness of the line, but by the shortness of the distance. *Linea recta brevissima.* And therefore we see, if a wall be between, and you speak on the one side, you hear it on the other; which is not because the sound passeth through the wall, but archeth over the wall.

203. If the sound be stopped and repercussed, it cometh about on the other side in an oblique line. So, if in a coach one side of the boot be down and the other up, and a beggar beg on the close side, you would think that he were on the open side. So likewise, if a bell or clock be (for example) on the north side of a chamber, and the window of that chamber be

upon the south, he that is in the chamber will think the sound came from the south.

204. Sounds, though they spread round, (so that there is an orb or spherical area of the sound,) yet they move strongest and go furthest in the fore-lines, from the first local impulsion of the air. And therefore in preaching, you shall hear the preacher's voice better before the pulpit than behind it or on the sides, though it stand open. So a harquebuss or ordnance will be further heard forwards from the mouth of the piece, than backwards or on the sides.

205. It may be doubted, that sounds do move better downwards than upwards.[1] Pulpits are placed high above the people. And when the ancient generals spake to their armies, they had ever a mount of turf cast up, whereupon they stood. But this may be imputed to the stops and obstacles which the voice meeteth with, when one speaketh upon the level. But there seemeth to be more in it; for it may be that spiritual species, both of things visible and sounds, do move better downwards than upwards. It is a strange thing, that to men standing below on the ground, those that be on the top of Paul's seem much less than they are, and cannot be known: but to men above, those below seem nothing so much lessened, and may be known: yet it is true, that all things to them above seem also somewhat contracted, and better collected into figure: as knots in gardens shew best from an upper-window or terrace.

206. But to make an exact trial of it, let a man stand in a chamber not much above the ground, and speak out at the window, through a trunk, to one

[1] Aristotle asserts that they do. Prob. xi. 45.

standing on the ground, as softly as he can, the other laying his ear close to the trunk; then *via versa*, let the other speak below, keeping the same proportion of softness; and let him in the chamber lay his ear to the trunk: and this may be the aptest means to make a judgment whether sounds descend or ascend better.

Experiments in consort touching the lasting and perishing of sounds; and touching the time they require to their generation or delation.

207. After that sound is created (which is in a moment), we find it continueth some small time, melting by little and little. In this there is a wonderful error amongst men, who take this to be a continuance of the first sound; whereas (in truth) it is a renovation, and not a continuance; for the body percussed hath, by reason of the percussion, a trepidation wrought in the minute parts; and so reneweth the percussion of the air. This appeareth manifestly, because that the melting sound of a bell or of a string strucken, which is thought to be a continuance, ceaseth as soon as the bell or string are touched. As in a virginal, as soon as ever the jack falleth and toucheth the string, the sound ceaseth; and in a bell, after you have chimed upon it, if you touch the bell the sound ceaseth. And in this you must distinguish that there are two trepidations: the one manifest and local; as of the bell when it is pensile: the other secret, of the minute parts; such as is described in the ninth instance. But it is true, that the local helpeth the secret greatly. We see likewise that in pipes, and other wind instruments, the sound lasteth no longer than the breath bloweth. It is true, that in organs there is a confused murmur for a

while after you have played; but that is but while the bellows are in falling.

208. It is certain, that in the noise of great ordnance, where many are shot off together, the sound will be carried (at the least) twenty miles upon the land, and much further upon the water.[1] But then it will come to the ear, not in the instant of the shooting off, but it will come an hour or more later. This must needs be a continuance of the first sound; for there is no trepidation which should renew it. And the touching of the ordnance would not extinguish the sound the sooner: so that in great sounds the continuance is more than momentany.

209. To try exactly the time wherein sound is delated, let a man stand in a steeple, and have with him a taper; and let some veil be put before the taper; and let another man stand in the field a mile off. Then let him in the steeple strike the bell, and in the same instant withdraw the veil; and so let him in the field tell by his pulse what distance of time there is between the light seen, and the sound heard: for it is certain that the delation of light is in an instant. This may be tried in far greater distances, allowing greater lights and sounds.

210. It is generally known and observed that light, and the object of sight, move swifter than sound: for we see the flash of a piece is seen sooner than the noise is heard. And in hewing wood, if one be some distance off, he shall see the arm lifted up for a second stroke, before he hear the noise of the first. And the

[1] It is said that a cannonade has been heard 180 or 200 miles off, and it is particularly mentioned that during the sea fight with the Dutch in 1672 the firing was heard at Shrewsbury. But it may be doubted whether this be true.

greater the distance, the greater is the prevention: as we see in thunder which is far off, where the lightning precedeth the crack a good space.

211. Colours when they represent themselves to the eye, fade not, nor melt not by degrees, but appear still in the same strength; but sounds melt and vanish by little and little. The cause is, for that colours participate nothing with the motion of the air, but sounds do. And it is a plain argument, that sound participateth of some local motion of the air (as a cause *sine qua non*), in that it perisheth so suddenly; for in every section or impulsion of the air, the air doth suddenly restore and reunite itself; which the water also doth, but nothing so swiftly.

Experiments in consort touching the passage and interceptions of sounds.

In the trials of the passage or not passage of sounds, you must take heed you mistake not the passing by the sides of a body for the passing through a body; and therefore you must make the intercepting body very close; for sound will pass through a small chink.

212. Where sound passeth through a hard or close body, (as through water; through a wall; through metal, as in hawks' bells stopped, &c.), the hard or close body must be but thin and small; for else it deadeth and extinguisheth the sound utterly. And therefore in the experiment of speaking in air under water, the voice must not be very deep within the water: for then the sound pierceth not. So if you speak on the further side of a close wall, if the wall be very thick

you shall not be heard; and if there were an hogshead empty, whereof the sides were some two foot thick, and the bunghole stopped, I conceive the resounding sound, by the communication of the outward air with the air within, would be little or none: but only you shall hear the noise of the outward knock, as if the vessel were full.

213. It is certain, that in the passage of sounds through hard bodies the spirit or pneumatical part of the hard body itself doth co-operate; but much better when the sides of that hard body are struck, than when the percussion is only within, without touch of the sides. Take therefore a hawk's bell, the holes stopped up, and hang it by a thread within a bottle glass, and stop the mouth of the glass very close with wax; and then shake the glass, and see whether the bell give any sound at all, or how weak. But note, that you must instead of the thread take a wire; or else let the glass have a great belly; lest when you shake the bell, it dash upon the sides of the glass.

214. It is plain, that a very long and downright arch for the sound to pass, will extinguish the sound quite; so that that sound which would be heard over a wall, will not be heard over a church; nor that sound which will be heard if you stand some distance from the wall, will be heard if you stand close under the wall.

215. Soft and foraminous bodies, in the first creation of the sound, will dead it; for the striking against cloth or fur will make little sound; as hath been said: but in the passage of the sound, they will admit it better than harder bodies; as we see that

curtains and hangings will not stay the sound much; but glass windows, if they be very close, will check a sound more than the like thickness of cloth. We see also in the rumbling of the belly, how easily the sound passeth through the guts and skin.

216. It is worthy the inquiry, whether great sounds (as of ordnance or bells) become not more weak and exile when they pass through small crannies. For the subtilties of articulate sounds (it may be) may pass through small crannies not confused, but the magnitude of the sound (perhaps) not so well.

Experiments in consort touching the medium of sounds.

217. The mediums of sounds are, air; soft and porous bodies; also water. And hard bodies refuse not altogether to be mediums of sounds. But all of them are dull and unapt deferents, except the air.

218. In air, the thinner or drier air carrieth not the sound so well as the more dense; as appeareth in night sounds, and evening sounds, and sounds in moist weather and southern winds. The reason is already mentioned in the title of majoration of sounds; being for that thin air is better pierced; but thick air preserveth the sound better from waste. Let further trial be made by hollowing in mists and gentle showers; for (it may be) that will somewhat dead the sound.

219. How far forth flame may be a medium of sounds, (especially of such sounds as are created by air, and not betwixt hard bodies,) let it be tried in speaking where a bonfire is between; but then you must allow, for some disturbance, the noise that the flame itself maketh.

220. Whether any other liquors, being made mediums, cause a diversity of sound from water, it may be tried: as by the knapping of the tongs; or striking of the bottom of a vessel, filled either with milk or with oil; which though they be more light, yet are they more unequal bodies than air.

Of the natures of the mediums we have now spoken; as for the disposition of the said mediums, it doth consist in the penning, or not penning of the air; of which we have spoken before in the title of delation of sounds: it consisteth also in the figure of the concave through which it passeth; of which we will speak next.

Experiments in consort, what the figures of the pipes, or concaves, or the bodies deferent, conduce to the sounds.

How the figures of pipes, or concaves, through which sounds pass, or of other bodies deferent, conduce to the variety and alteration of the sounds; either in respect of the greater quantity or less quantity of air which the concaves receive, or in respect of the carrying of sounds longer or shorter way, or in respect of many other circumstances; they have been touched, as falling into other titles. But those figures which we are now to speak of, we intend to be as they concern the lines through which the sound passeth; as straight, crooked, angular, circular, &c.

221. The figure of a bell partaketh of the pyramis, but yet coming off and dilating more suddenly. The

figure of a hunter's horn and cornet is oblique; yet they have likewise straight horns; which, if they be of the same bore with the oblique, differ little in sound, save that the straight require somewhat a stronger blast. The figures of recorders, and flutes, and pipes, are straight; but the recorder hath a less bore and a greater; above and below. The trumpet hath the figure of the letter *S:* which maketh that purling sound, &c. Generally the straight line hath the cleanest and roundest sound, and the crooked the more hoarse and jarring.

222. Of a sinuous pipe, that may have some four flexions, trial would be made. Likewise of a pipe made like a cross, open in the midst. And so likewise of an angular pipe. And see what will be the effects of these several sounds. And so again of a circular pipe; as if you take a pipe perfect round, and make a hole whereinto you shall blow, and another hole not far from that; but with a traverse or stop between them; so that your breath may go the round of the circle, and come forth at the second hole. You may try likewise percussions of solid bodies of several figures; as globes, flats, cubes, crosses, triangles, &c.; and their combinations, as flat against flat, and convex against convex, and convex against flat, &c.; and mark well the diversities of the sounds. Try also the difference in sound of several crassitudes of hard bodies percussed; and take knowledge of the diversities of the sounds. I myself have tried, that a bell of gold yieldeth an excellent sound, not inferior to that of silver or brass, but rather better: yet we see that a piece of money of gold soundeth far more flat than a piece of money of silver.

223. The harp hath the concave, not along the strings, but across the strings; and no instrument hath the sound so melting and prolonged as the Irish harp. So as I suppose that if a virginal were made with a double concave; the one all the length, as the virginal hath; the other at the end of the strings, as the harp hath; it must needs make the sound perfecter, and not so shallow and jarring. You may try it without any sound-board along, but only harp-wise at one end of the strings; or lastly, with a double concave, at each end of the strings one.

Experiments in consort touching the mixture of sounds.

224. There is an apparent diversity between the species visible and audible in this, that the visible doth not mingle in the medium, but the audible doth. For if we look abroad, we see heaven, a number of stars, trees, hills, men, beasts, at once. And the species of the one doth not confound the other. But if so many sounds come from several parts, one of them would utterly confound the other. So we see that voices or consorts of music do make an harmony by mixture, which colours do not. It is true nevertheless that a great light drowneth a smaller, that it cannot be seen; as the sun that of a glowworm; as well as a great sound drowneth a lesser. And I suppose likewise, that if there were two lanthorns of glass, the one a crimson, and the other an azure, and a candle within either of them, those coloured lights would mingle, and cast upon a white paper a purple colour. And even in colours, they yield a faint and weak mixture: for white walls make rooms more lightsome than black, &c. But the cause

of the confusion in sounds and the inconfusion in species visible is, for that the sight worketh in right lines, and maketh several cones ; and so there can be no coincidence in the eye or visual point: but sounds, that move in oblique and arcuate lines, must needs encounter and disturb the one the other.

225. The sweetest and best harmony is, when every part or instrument is not heard by itself, but a conflation of them all; which requireth to stand some distance off. Even as it is in the mixture of perfumes; or the taking of the smells of several flowers in the air.

226. The disposition of the air in other qualities, except it be joined with sound, hath no great operation upon sounds: for whether the air be lightsome or dark, hot or cold, quiet or stirring (except it be with noise), sweet-smelling or stinking, or the like; it importeth not much. Some petty alteration or difference it may make.

227. But sounds do disturb and alter the one the other: sometimes the one drowning the other, and making it not heard; sometimes the one jarring and discording with the other, and making a confusion; sometimes the one mingling and compounding with the other, and making an harmony.

228. Two voices of like loudness will not be heard twice as far as one of them alone:[1] and two candles of like light, will not make things seen twice as far off as one. The cause is profound; but it seemeth that the impressions from the objects of the senses do mingle respectively, every one with his kind: but not in proportion, as is before demonstrated: and the reason may be, because the first impression, which is

[1] Arist. Prob. xi. 52.

from privative to active, (as from silence to noise, or from darkness to light,) is a greater degree than from less noise to more noise, or from less light to more light. And the reason of that again may be, for that the air, after it hath received a charge, doth not receive a surcharge, or greater charge, with like appetite as it doth the first charge. As for the increase of virtue, generally, what proportion it beareth to the increase of the matter, it is a large field, and to be handled by itself.

Experiments in consort touching melioration of sounds.

229. All reflexions concurrent do make sounds greater; but if the body that createth either the original sound or the reflexion be clean and smooth, it maketh them sweeter. Trial may be made of a lute or viol, with the belly of polished brass instead of wood. We see that even in the open air, the wire-string is sweeter than the string of guts. And we see that for reflexion water excelleth; as in music near the water, or in echoes.

230. It hath been tried, that a pipe a little moistened on the inside, but yet so as there be no drops left, maketh a more solemn sound than if the pipe were dry: but yet with a sweet degree of sibilation or purling; as we touched it before in the title of equality. The cause is, for that all things porous being superficially wet, and (as it were) between dry and wet, become a little more even and smooth; but the purling (which must needs proceed of inequality) I take to be bred between the smoothness of the inward surface of the pipe, which is wet, and the rest of the wood of the pipe, unto which the wet cometh not, but it remaineth dry.

231. In frosty weather music within doors soundeth better. Which may be by reason, not of the disposition of the air, but of the wood or string of the instrument, which is made more crisp, and so more porous and hollow: and we see that old lutes sound better than new for the same reason. And so do lute-strings that have been kept long.

232. Sound is likewise meliorated by the mingling of open air with pent air; therefore trial may be made of a lute or viol with a double belly; making another belly with a knot over the strings; yet so as there be room enough for the strings, and room enough to play below that belly. Trial may be also made of an Irish harp, with a concave on both sides; whereas it useth to have it but on one side. The doubt may be, lest it should make too much resounding, whereby one note would overtake another.

233. If you sing into the hole of a drum, it maketh the singing more sweet. And so I conceive it would, if it were a song in parts, sung into several drums; and for handsomeness and strangeness sake, it would not be amiss to have a curtain between the place where the drums are and the hearers.

234. When a sound is created in a wind-instrument between the breath and the air, yet if the sound be communicate with a more equal body of the pipe, it meliorateth the sound. For no doubt there would be a differing sound in a trumpet or pipe of wood, and again in a trumpet or pipe of brass. It were good to try recorders and hunters' horns of brass, what the sound would be.

235. Sounds are meliorated by the intension of the sense; where the common sense is collected most to

the particular sense of hearing, and the sight suspended: and therefore sounds are sweeter (as well as greater) in the night than in the day; and I suppose they are sweeter to blind men than to others: and it is manifest, that between sleeping and waking, (when all the senses are bound and suspended,) music is far sweeter than when one is fully waking.

Experiments in consort touching the imitation of sounds.

236. It is a thing strange in nature, when it is attentively considered, how children, and some birds, learn to imitate speech. They take no mark at all of the motion of the mouth of him that speaketh; for birds are as well taught in the dark as by light. The sounds of speech are very curious and exquisite: so one would think it were a lesson hard to learn. It is true that it is done with time, and by little and little, and with many essays and proffers: but all this dischargeth not the wonder. It would make a man think (though this which we shall say may seem exceeding strange) that there is some transmission of spirits; and that the spirit of the teacher put in motion, should work with the spirits of the learner a predisposition to offer to imitate; and so to perfect the imitation by degrees. But touching operations by transmissions of spirits, (which is one of the highest secrets in nature,) we shall speak in due place; chiefly when we come to inquire of imagination. But as for imitation, it is certain that there is in men and other creatures a predisposition to imitate. We see how ready apes and monkeys are to imitate all motions of man; and in the catching of dottrels, we see how the foolish bird playeth the ape in gestures: and no man (in effect) doth ac-

company with others, but he learneth (ere he is aware) some gesture or voice or fashion of the other.

237. In imitation of sounds, that man should be the teacher is no part of the matter; for birds will learn one of another; and there is no reward, by feeding or the like, given them for the imitation; and besides, you shall have parrots that will not only imitate voices, but laughing, knocking, squeaking of a door upon the hinges, or of a cart-wheel; and (in effect) any other noise they hear.

238. No beast can imitate the speech of man, but birds only; for the ape itself, that is so ready to imitate otherwise, attaineth not any degree of imitation of speech. It is true that I have known a dog, that if one howled in his ear, he would fall a howling a great while. What should be the aptness of birds, in comparison of beasts, to imitate the speech of man, may be further inquired. We see that beasts have those parts which they count the instruments of speech, (as lips, teeth, &c.,) liker unto man than birds. As for the neck, by which the throat passeth, we see many beasts have it, for the length, as much as birds. What better gorge or artire[1] birds have,[2] may be further in-

[1] That is, wind-pipe. See note 3, p. 265. — *J. S.*

[2] It does not appear that in any point of vocal organisation birds bear more resemblance to man than brutes. The characteristic distinction in this respect between birds and mammalia appears to be that in the former class the trachea is the real organ of voice; the air which passes into it from the lungs being set into vibration at the inferior larynx, whereas in the latter the sonorous vibrations commence at the glottis; the trachea, the rings of which are in this class seldom wholly osseous, serving merely to supply air. It is difficult completely to explain the differences in the voice of different birds. Cuvier was of opinion that, especially with regard to the power of imitating sounds, much depends not on the vocal organ, but on instinct It is worth remarking that birds which have a trumpet-shaped trachea, as for instance the cock, emit sounds which more or less resemble those of that instrument.

quired. The birds that are known to be speakers, are parrots, pies, jays, daws, and ravens; of which, parrots have an adunque bill, but the rest not.

239. But I conceive, that the aptness of birds is not so much in the conformity of the organs of speech, as in their attention. For speech must come by hearing and learning; and birds give more heed and mark sounds more than beasts; because naturally they are more delighted with them and practise them more; as appeareth in their singing. We see also that those that teach birds to sing, do keep them waking to increase their attention.[1] We see also that cock-birds amongst singing birds are ever the better singers; which may be because they are more lively and listen more.

240. Labour and intention to imitate voices, doth conduce much to imitation: and therefore we see that there be certain *pantomimi*, that will represent the voices of players of interludes so to life, as if you see them not you would think they were those players themselves; and so the voices of other men that they hear.

241. There have been some that could counterfeit the distance of voices (which is a secondary object of hearing) in such sort, as when they stand fast by you, you would think the speech came from afar off, in a fearful manner. How this is done may be further inquired. But I see no great use of it but for imposture, in counterfeiting ghosts or spirits.

[1] Frederick Cuvier has remarked, that when animals have been kept in a state of vigilance, as the means of taming them, they show no signs of anger against the person who, by making a noise, hinders them from sleeping, although the distress that the want of sleep produces is obvious; a curious proof of the narrow limits within which their power of referring a phenomenon to its cause is confined.

Experiments in consort touching the reflexion of sounds.

There be three kinds of reflexions of sounds; a reflexion concurrent; a reflexion iterant, which we call echo; and a super-reflexion, or an echo of an echo; whereof the first hath been handled in the title of magnitude of sounds: the latter two we will now speak of.

242. The reflexion of species visible, by mirrors, you may command; because passing in right lines, they may be guided to any point: but the reflexion of sounds is hard to master; because the sound filling great spaces in arched lines, cannot be so guided: and therefore we see there hath not been practised any means to make artificial echoes. And no echo already known returneth in a very narrow room.

243. The natural echoes are made upon walls, woods, rocks, hills, and banks; as for waters, being near, they make a concurrent echo; but being further off, (as upon a large river,) they make an iterant echo: for there is no difference between the concurrent echo and the iterant, but the quickness or slowness of the return. But there is no doubt but water doth help the delation of echo, as well as it helpeth the delation of original sounds.

244. It is certain, (as hath been formerly touched,) that if you speak through a trunk stopped at the further end, you shall find a blast return upon your mouth, but no sound at all. The cause is, for that the closeness, which preserveth the original, is not able to preserve the reflected sound: besides that echoes are seldom created but by loud sounds. And therefore

there is less hope of artificial echoes in air pent in a narrow concave. Nevertheless it hath been tried, that one leaning over a wall of twenty-five fathom deep, and speaking, though but softly, (yet not so soft as a whisper,) the water returned a good audible echo. It would be tried, whether speaking in caves, where there is no issue save where you speak, will not yield echoes, as wells do.

245. The echo cometh as the original sound doth, in a round orb of air: it were good to try the creating of the echo where the body repercussing maketh an angle: as against the return of a wall, &c. Also we see that in mirrors there is the like angle of incidence, from the object to the glass, and from the glass to the eye. And if you strike a ball side-long, not full upon the surface, the rebound will be as much the contrary way. Whether there be any such resilience in echoes, (that is, whether a man shall hear better if he stand aside the body repercussing, than if he stand where he speaketh, or anywhere in a right line between,) may be tried. Trial likewise would be made, by standing nearer the place of repercussing than he that speaketh; and again by standing further off than he that speaketh; and so knowledge would be taken, whether echoes, as well as original sounds, be not strongest near hand.

246. There be many places where you shall hear a number of echoes one after another: and it is when there is variety of hills or woods, some nearer, some further off: so that the return from the further, being last created, will be likewise last heard.

247. As the voice goeth round, as well towards the back as towards the front of him that speaketh; so

likewise doth the echo: for you have many back-echoes to the place where you stand.

248. To make an echo that will report three, or four, or five words distinctly, it is requisite that the body repercussing be a good distance off: for if it be near, and yet not so near as to make a concurrent echo, it choppeth with you upon the sudden. It is requisite likewise that the air be not much pent: for air at a great distance pent, worketh the same effect with air at large in a small distance. And therefore in the trial of speaking in the well, though the well was deep, the voice came back suddenly, and would bear the report but of two words.

249. For echoes upon echoes, there is a rare instance thereof in a place which I will now exactly describe. It is some three or four miles from Paris, near a town called Pont-Charenton; and some bird-bolt shot or more from the river of Seine.[1] The room is a chapel or small church. The walls all standing, both at the sides and at the ends. Two rows of pillars, after the manner of aisles[2] of churches, also standing; the roof all open, not so much as any embowment near any of the walls left. There was against every pillar a stack of billets above a man's height; which the watermen that bring wood down the Seine in stacks, and not in boats, laid there (as it seemeth) for their ease. Speaking at the one end, I did hear it return the voice thirteen several times; and I have heard of others, that it would return sixteen times: for I was there about three of the clock in the afternoon; and it

[1] The church in which this echo was heard was within the precincts of the Carmelite monastery at Charenton. See the *Encycl. Méthodique*, or that of Diderot and d'Alembert, in voc. Charenton.

[2] *Isles* in the original. — *J. S.*

is best (as all other echoes are) in the evening. It is manifest that it is not echoes from several places, but a tossing of the voice, as a ball, to and fro; like to reflexions in looking-glasses; where if you place one glass before and another behind, you shall see the glass behind with the image, within the glass before; and again, the glass before in that; and divers such super-reflexions, till the *species speciei* at last die. For it is every return weaker and more shady. In like manner the voice in that chapel createth *speciem speciei*, and maketh succeeding super-reflexions; for it melteth by degrees, and every reflexion is weaker than the former: so that if you speak three words, it will (perhaps) some three times report you the whole three words; and then the two latter words for some times; and then the last word alone for some times; still fading and growing weaker. And whereas in echoes of one return, it is much to hear four or five words; in this echo of so many returns, upon the matter, you hear above twenty words for three.

250. The like echo upon echo, but only with two reports, hath been observed to be, if you stand between a house and a hill, and lure towards the hill. For the house will give a back echo; one taking it from the other, and the latter the weaker.

251. There are certain letters that an echo will hardly express: as S for one, especially being principal in a word. I remember well, that when I went to the echo at Pont-Charenton, there was an old Parisian, who took it to be the work of spirits, and of good spirits. For (said he) call *Satan* and the echo will not deliver back the devil's name; but will say, *va t'en;* which is as much in French as *apage* or *avoid.*

And thereby I did hap to find that an echo would not return S, being but a hissing and an interior sound.

252. Echoes are some more sudden, and chop again as soon as the voice is delivered; as hath been partly said: others are more deliberate, that is, give more space between the voice and the echo; which is caused by the local nearness or distance: some will report a longer train of words, and some a shorter; some more loud, (full as loud as the original, and sometimes more loud,) and some weaker and fainter.

253. Where echoes come from several parts at the same distance, they must needs make (as it were) a quire of echoes, and so make the report greater, and even a continued echo; which you shall find in some hills that stand encompassed, theatre-like.

254. It doth not yet appear that there is refraction in sounds, as well as in species visible. For I do not think, that if a sound should pass through divers mediums, (as air, cloth, wood,) it would deliver the sound in a differing place from that unto which it is deferred; which is the proper effect of refraction. But majoration, which is also the work of refraction, appeareth plainly in sounds, (as hath been handled at full,) but it is not by diversity of mediums.

Experiments in consort touching the consent and dissent between visibles and audibles.[1]

We have *obiter*, for demonstration's sake, used

[1] See in illustration of this subject Dr. Whewell's *Philosophy of the Inductive Sciences*, iv. 2.

The analogy of sound and light has been recently illustrated by a curious experiment of M. Stendhaus. He has concentrated sound to a focus by means of an acoustic lens formed of carbonic acid gas enclosed in an envelope of collodion.

in divers instances the examples of the sight and things visible, to illustrate the nature of sounds. But we think good now to prosecute that comparison more fully.

Consent of visibles and audibles.

255. Both of them spread themselves in round, and fill a whole floor or orb, unto certain limits; and are carried a great way; and do languish and lessen by degrees, according to the distance of the objects from the sensories.

256. Both of them have the whole species in every small portion of the air, or medium; so as the species do pass through small crannies without confusion: as we see ordinarily in levels, as to the eye; and in crannies or chinks, as to the sound.

257. Both of them are of a sudden and easy generation and delation; and likewise perish swiftly and suddenly; as if you remove the light, or touch the bodies that give the sound.

258. Both of them do receive and carry exquisite and accurate differences; as of colours, figures, motions, distances, in visibles; and of articulate voices, tones, songs, and quaverings, in audibles.

259. Both of them, in their virtue and working, do not appear to emit any corporal substance into their mediums, or the orb of their virtue: neither again to raise or stir any evident local motion in their mediums as they pass; but only to carry certain spiritual species; the perfect knowledge of the cause whereof, being hitherto scarcely attained, we shall search and handle in due place.

260. Both of them seem not to generate or produce

any other effect in nature, but such as appertaineth to their proper objects and senses, and are otherwise barren.

261. But both of them, in their own proper action, do work three manifest effects. The first, in that the stronger species drowneth the lesser; as the light of the sun, the light of a glow-worm; the report of an ordnance, the voice: The second, in that an object of surcharge or excess destroyeth the sense; as the light of the sun the eye; a violent sound (near the ear) the hearing: The third, in that both of them will be reverberate; as in mirrors, and in echoes.

262. Neither of them doth destroy or hinder the species of the other, although they encounter in the same medium; as light or colour hinder not sound, nor *e contra*.

263. Both of them affect the sense in living creatures, and yield objects of pleasure and dislike: yet nevertheless the objects of them do also (if it be well observed) affect and work upon dead things; namely, such as have some conformity with the organs of the two senses; as visibles work upon a looking-glass, which is like the pupil of the eye; and audibles upon the places of echo, which resemble in some sort the cavern and structure of the ear.

264. Both of them do diversly work, as they have their medium diversly disposed. So a trembling medium (as smoke) maketh the object seem to tremble; and a rising or falling medium (as winds) maketh the sounds to rise or fall.

265. To both, the medium which is the most propitious and conducible, is air; for glass or water, &c., are not comparable.

266. In both of them, where the object is fine and accurate, it conduceth much to have the sense intentive and erect; insomuch as you contract your eye when you would see sharply; and erect your ear when you would hear attentively; which in beasts that have ears moveable is most manifest.

267. The beams of light, when they are multiplied and conglomerate, generate heat; which is a different action from the action of sight: and the multiplication and conglomeration of sounds doth generate an extreme rarefaction of the air; which is an action materiate, differing from the action of sound; if it be true (which is anciently reported) that birds with great shouts have fallen down.

Dissents of visibles and audibles.

268. The species of visibles seem to be emissions of beams from the objects seen; almost like odours; save that they are more incorporeal: but the species of audibles seem to participate more with local motion, like percussions or impressions made upon the air. So that whereas all bodies do seem to work in two manners; either by the communication of their natures, or by the impressions and signatures of their motions; the diffusion of species visible seemeth to participate more of the former operation, and the species audible of the latter.

269. The species of audibles seem to be carried more manifestly through the air than the species of visibles: for I conceive that a contrary strong wind will not much hinder the sight of visibles, as it will do the hearing of sounds.

270. There is one difference above all others be-

tween visibles and audibles, that is the most remarkable, as that whereupon many smaller differences do depend: namely, that visibles (except lights) are carried in right lines, and audibles in arcuate lines.[1] Hence it cometh to pass that visibles do not intermingle and confound one another, as hath been said before; but sounds do. Hence it cometh that the solidity of bodies doth not much hinder the sight, so that the bodies be clear, and the pores in a right line, as in glass, crystal, diamonds, water, &c.; but a thin scarf or handkerchief, though they be bodies nothing so solid, hinder the sight: whereas (contrariwise) these porous bodies do not much hinder the hearing, but solid bodies do almost stop it, or at least attenuate it. Hence also it cometh that to the reflexion of visibles small glasses suffice; but to the reverberation of audibles are required greater spaces, as hath likewise been said before.

271. Visibles are seen further off than sounds are heard; allowing nevertheless the rate of their bigness; for otherwise a great sound will be heard further off than a small body seen.

272. Visibles require (generally) some distance between the object and the eye, to be better seen; whereas in audibles, the nearer the approach of the sound is to the sense the better. But in this there may be a double error. The one because to seeing there is required light; and any thing that toucheth the pupil of the eye (all over) excludeth the light. For I

[1] Arist. Prob. xi. 49. and 58.; and xxv. 9. Aristotle explains the passage of light through transparent bodies as Bacon does. The latter's statement of the difference between sound and light is, as the phenomenon of diffraction shows, not strictly accurate. Both have in some degree the power of passing round the edges or corners of obstacles.

have heard of a person very credible, (who himself was cured of a cataract in one of his eyes,) that while the silver needle did work upon the sight of his eye to remove the film of the cataract, he never saw any thing more clear or perfect than that white needle: which (no doubt) was because the needle was lesser than the pupil of the eye, and so took not the light from it. The other error may be, for that the object of sight doth strike upon the pupil of the eye directly, without any interception; whereas the cave of the ear doth hold off the sound a little from the organ: and so nevertheless there is some distance required in both.

273. Visibles are swiftlier carried to the sense than audibles; as appeareth in thunder and lightning, flame and report of a piece, motion of the air in hewing of wood. All which have been set down heretofore, but are proper for this title.

274. I conceive also that the species of audibles do hang longer in the air than those of visibles: for although even those of visibles do hang some time, as we see in rings turned, that show like spheres; in lute-strings fillipped; a fire-brand carried along, which leaveth a train of light behind it; and in the twilight, and the like; yet I conceive that sounds stay longer, because they are carried up and down with the wind; and because of the distance of the time in ordnance discharged, and heard twenty miles off.

275. In visibles there are not found objects so odious and ingrate to the sense as in audibles. For foul sights do rather displease in that they excite the memory of foul things, than in the immediate objects. And therefore in pictures, those foul sights do not much offend;

but in audibles, the grating of a saw, when it is sharpened, doth offend so much, as it setteth the teeth on edge. And any of the harsh discords in music the ear doth straightway refuse.

276. In visibles, after great light, if you come suddenly into the dark, or contrariwise out of the dark into a glaring light, the eye is dazzled for a time, and the sight confused; but whether any such effect be after great sounds, or after a deep silence, may be better inquired. It is an old tradition, that those that dwell near the cataracts of Nilus are strucken deaf;[1] but we find no such effect in cannoniers, nor millers, nor those that dwell upon bridges.

277. It seemeth that the impression of colour is so weak, as it worketh not but by a cone of direct beams, or right lines; whereof the basis is in the object, and the vertical point in the eye; so as there is a corradiation and conjunction of beams; and those beams so sent forth, yet are not of any force to beget the like borrowed or second beams, except it be by reflexion, whereof we speak not. For the beams pass, and give little tincture to that air which is adjacent; which if they did, we should see colours out of a right line. But as this is in colours, so otherwise it is in the body of light. For when there is a skreen between the candle and the eye, yet the light passeth to the paper whereon one writeth; so that the light is seen where the body of the flame is not seen, and where any colour (if it were placed where the body of the flame is) would not be seen. I judge that sound is of this latter nature; for when two are placed on both sides of a wall, and the voice is heard, I judge it is not only the original

[1] Pliny, vi. 35. [Cic. Somn. Scip. c. 5.]

sound, which passeth in an arched line; but the sound which passeth above the wall in a right line, begetteth the like motion round about it as the first did, though more weak.

Experiments in consort touching the sympathy or antipathy of sounds one with another.

278. All concords and discords of music are (no doubt) sympathies and antipathies of sounds. And so likewise in that music which we call broken music, or consort music, some consorts of instruments are sweeter than others (a thing not sufficiently yet observed): as the Irish harp and base viol agree well; the recorder and stringed music agree well; organs and the voice agree well, &c.; but the virginals and the lute, or the Welsh harp and Irish harp, or the voice and pipes alone, agree not so well. But for the melioration of music there is yet much left (in this point of exquisite consorts) to try and inquire.

279. There is a common observation, that if a lute or viol be laid upon the back, with a small straw upon one of the strings, and another lute or viol be laid by it; and in the other lute or viol the unison to that string be strucken; it will make the string move; which will appear both to the eye, and by the straw's falling off. The like will be, if the diapason or eighth to that string be strucken, either in the same lute or viol, or in others lying by: but in none of these there is any report of sound, that can be discerned, but only motion.

280. It was devised, that a viol should have a lay of wire-strings below, as close to the belly as a lute; and then the strings of guts mounted upon a bridge, as

in ordinary viols; to the end that by this means the upper strings strucken should make the lower resound by sympathy, and so make the music the better; which if it be to purpose, then sympathy worketh as well by report of sound as by motion. But this device I conceive to be of no use; because the upper strings, which are stopped in great variety, cannot maintain a diapason or unison with the lower, which are never stopped. But if it should be of use at all, it must be in instruments which have no stops; as virginals and harps; wherein trial may be made of two rows of strings, distant the one from the other.

281. The experiment of sympathy may be transferred (perhaps) from instruments of strings to other instruments of sound. As to try, if there were in one steeple two bells of unison, whether the striking of the one would move the other, more than if it were another accord: and so in pipes (if they be of equal bore and sound) whether a little straw or feather would move in the one pipe, when the other is blown at an unison.

282. It seemeth, both in ear and eye, the instrument of sense hath a sympathy or similitude with that which giveth the reflexion, (as hath been touched before); for as the sight of the eye is like a crystal, or glass, or water; so is the ear a sinuous cave, with a hard bone to stop and reverberate the sound; which is like to the places that report echoes.

Experiments in consort touching the hindering or helping of the hearing.

283. When a man yawneth, he cannot hear so well.[1]

[1] Aristot. Prob. xi. 29. and 44. The reason appears to be that in the act

The cause is, for that the membrane of the ear is extended; and so rather casteth off the sound than draweth it to.

284. We hear better when we hold our breath than contrary; insomuch, as in all listening to attain a sound afar off, men hold their breath. The cause is, for that in all expiration the motion is outwards; and therefore rather driveth away the voice than draweth it: and besides, we see that in all labour to do things with any strength, we hold the breath;[1] and listening after any sound that is heard with difficulty, is a kind of labour.

285. Let it be tried, for the help of the hearing, (and I conceive it likely to succeed,) to make an instrument like a tunnel; the narrow part whereof may be of the bigness of the hole of the ear; and the broader end much larger, like a bell at the skirts; and the length half a foot or more. And let the narrow end of it be set close to the ear: and mark whether any sound, abroad in the open air, will not be heard distinctly from further distance than without that in-

of yawning, air is forced into the Eustachian tubes and, as Bacon rightly supposes, by increasing the tension of the tympanum diminishes its power of transmitting sound. Savart, who showed that an increase in the tension of a membrane had this effect, was of opinion that the use of the internal muscles of the ear is to increase by the mechanism of the bones the tension of the tympanum, and indirectly that of the membrane which covers the foramen rotundum, and that they are called into action when sounds would otherwise become painfully loud. It seems to me not improbable that the reflex action of these muscles excited by the vibration of the tympanum enters to a certain extent, in all cases, into the mechanism of hearing, and that the nerve is affected not only by the vibration of the surrounding pulp, but also by the varying pressure exercised by the stirrup bone. It is worthy of remark that Aristotle was aware of the existence of the Eustachian tube.

[1] The reason of this however is, that by holding the breath and thus keeping the chest dilated we increase the *purchase* of the muscles of the upper part of the body.

strument; being (as it were) an ear-spectacle. And I have heard there is in Spain an instrument in use to be set to the ear, that helpeth somewhat those that are thick of hearing.[1]

286. If the mouth be shut close, nevertheless there is yielded by the roof of the mouth a murmur, such as is used by dumb men. But if the nostrils be likewise stopped, no such murmur can be made, except it be in the bottom of the palate towards the throat. Whereby it appeareth manifestly, that a sound in the mouth, except such as aforesaid, if the mouth be stopped, passeth from the palate through the nostrils.

Experiments in consort touching the spiritual and fine nature of sounds.

287. The repercussion of sounds (which we call echo) is a great argument of the spiritual essence of sounds. For if it were corporeal, the repercussion should be created in the same manner, and by like instruments, with the original sound; but we see what a number of exquisite instruments must concur in speaking of words, whereof there is no such matter in the returning of them; but only a plain stop and repercussion.

288. The exquisite differences of articulate sounds, carried along in the air, shew that they cannot be signatures or impressions in the air, as hath been well refuted by the ancients.[2] For it is true, that seals

[1] Ear-trumpets are proposed by Porta: see his *Natural Magic*, xx. 5.

[2] Bacon's meaning is not clear, but he seems to allude to the doctrine of the atomists that sound is material, and to Aristotle's dissent from it. The latter, as we see in the *Prob.* xi. 6., and elsewhere, apprehended distinctly the difference between the propagation of sound and the motion of a projectile.

make excellent impressions; and so it may be thought of sounds in their first generation; but then the delation and continuance of them without any new sealing, shew apparently they cannot be impressions.

289. All sounds are suddenly made, and do suddenly perish: but neither that, nor the exquisite differences of them, is matter of so great admiration: for the quaverings and warblings of lutes and pipes are as swift; and the tongue (which is no very fine instrument) doth in speech make no fewer motions than there be letters in all the words which are uttered. But that sounds should not only be so speedily generated, but carried so far every way in such a momentany time, deserveth more admiration. As for example, if a man stand in the middle of a field and speak aloud, he shall be heard a furlong in round; and that shall be in articulate sounds; and those shall be entire in every little portion of the air; and this shall be done in the space of less than a minute.

290. The sudden generation and perishing of sounds must be one of these two ways. Either that the air suffereth some force by sound, and then restoreth itself; as water doth; which being divided, maketh many circles, till it restore itself to the natural consistence: or otherwise, that the air doth willingly imbibe the sound as grateful, but cannot maintain it; for that the air hath (as it should seem) a secret and hidden appetite of receiving the sound at the first; but then other gross and more materiate qualities of the air straightways suffocate it; like unto flame, which is generated with alacrity, but straight quenched by the enmity of the air or other ambient bodies.

There be these differences (in general) by which sounds are divided: 1. Musical, immusical. 2. Treble, base. 3. Flat, sharp. 4. Soft, loud. 5. Exterior, interior. 6. Clean, harsh or purling. 7. Articulate, inarticulate.

We have laboured (as may appear) in this inquisition of sounds diligently; both because sound is one of the most hidden portions of nature, (as we said in the beginning); and because it is a virtue which may be called incorporeal and immateriate; whereof there be in nature but few. Besides, we were willing (now in these our first centuries) to make a pattern or precedent of an exact inquisition; and we shall do the like hereafter in some other subjects which require it. For we desire that men should learn and perceive, how severe a thing the true inquisition of nature is; and should accustom themselves, by the light of particulars, to enlarge their minds to the amplitude of the world; and not to reduce the world to the narrowness of their minds.

Experiment solitary touching the orient colours in dissolution of metals.

291. Metals give orient and fine colours in dissolutions; as gold giveth an excellent yellow, quicksilver an excellent green, tin giveth an excellent azure: likewise in their putrefactions or rusts; as vermilion, verdigrise, bice, cirrus, &c., and likewise in their vitrifica-

tions. The cause is, for that by their strength of body they are able to endure the fire or strong waters, and to be put into an equal posture; and again to retain part of their principal spirit; which two things, (equal posture and quick spirits,) are required chiefly to make colours lightsome.

Experiment solitary touching prolongation of life.

292. It conduceth unto long life, and to the more placid motion of the spirits, which thereby do less prey and consume the juice of the body, either that men's actions be free and voluntary, that nothing be done *invita Minerva*, but *secundum genium;* or on the other side, that the actions of men be full of regulation and commands within themselves: for then the victory and performing of the command giveth a good disposition to the spirits; especially if there be a proceeding from degree to degree; for then the sense of victory is the greater. An example of the former of these is in a country life; and of the latter in monks and philosophers, and such as do continually enjoin themselves.[1]

Experiment solitary touching appetite of union in bodies.

293. It is certain that in all bodies there is an appetite of union, and evitation of solution of continuity; and of this appetite there be many degrees; but the most remarkable, and fit to be distinguished, are three. The first in liquors; the second in hard bodies; and the third in bodies cleaving or tenacious. In liquors this appetite is weak: we see in liquors the threading of them in stillicides, (as hath been said); the falling of them in round drops, (which is the form of union);

[1] The same doctrine is laid down in the *Hist. Vitæ et Mortis.*

and the staying of them for a little time in bubbles and froth. In the second degree or kind, this appetite is strong; as in iron, in stone, in wood, &c. In the third, this appetite is in a medium between the other two: for such bodies do partly follow the touch of another body, and partly stick and continue to themselves; and therefore they rope, and draw themselves in threads; as we see in pitch, glue, birdlime, &c. But note, that all solid bodies are cleaving, more or less; and that they love better the touch of somewhat that is tangible, than of air. For water, in small quantity, cleaveth to any thing that is solid; and so would metal too, if the weight drew it not off. And therefore gold foliate, or any metal foliate, cleaveth: but those bodies which are noted to be clammy and cleaving, are such as have a more indifferent appetite (at once) to follow another body, and to hold to themselves. And therefore they are commonly bodies ill mixed; and which take more pleasure in a foreign body, than in preserving their own consistence; and which have little predominance in drought or moisture.

Experiment solitary touching the like operations of heat and time.[1]

294. Time and heat are fellows in many effects. Heat drieth bodies that do easily expire; as parchment, leaves, roots, clay, &c. And so doth time or age arefy; as in the same bodies, &c. Heat dissolveth and melteth bodies that keep in their spirits; as in divers liquefactions: and so doth time in some bodies of a softer

[1] The analogy between the operations of heat and those of time are mentioned in the investigation of the form of heat in the *Novum Organum*. See the twentieth aphorism of the second book [Vol. I. p. 396.].

consistence; as is manifest in honey, which by age waxeth more liquid; and the like in sugar; and so in old oil, which is ever more clear, and more hot in medicinable use. Heat causeth the spirits to search some issue out of the body; as in the volatility of metals: and so doth time; as in the rust of metals. But generally heat doth that in small time which age doth in long.

Experiment solitary touching the differing operations of fire and time.

295. Some things which pass the fire are softest at first, and by time grow hard; as the crumb of bread. Some are harder when they come from the fire, and afterwards give again, and grow soft; as the crust of bread, bisket, sweet-meats, salt, &c. The cause is, for that in those things which wax hard with time, the work of the fire is a kind of melting; and in those that wax soft with time (contrariwise) the work of the fire is a kind of baking; and whatsoever the fire baketh, time doth in some degree dissolve.

Experiment solitary touching motions by imitation.[1]

296. Motions pass from one man to another, not so much by exciting imagination, as by imitation;[2] especially if there be an aptness or inclination before. Therefore gaping, or yawning, and stretching do pass from man to man; for that that causeth gaping and stretching is, when the spirits are a little heavy, by any vapour, or the like. For then they strive (as it

[1] This and the next paragraph seem to have been suggested by Arist. *Prob.* vii.

[2] *Invitation* in the original. — *J. S.*

were) to wring out and expel that which loadeth them. So men drowsy and desirous to sleep, or before the fit of an ague, do use to yawn and stretch; and do likewise yield a voice or sound, which is an interjection of expulsion: so that if another be apt and prepared to do the like, he followeth by the sight of another. So the laughing of another maketh to laugh.

Experiment solitary touching infectious diseases.

297. There be some known diseases that are infectious; and others that are not. Those that are infectious are: First, such as are chiefly in the spirits, and not so much in the humours, and therefore pass easily from body to body; such are pestilences, lippitudes, and such like. Secondly, such as taint the breath; which we see passeth manifestly from man to man; and not invisibly, as the affects of the spirits do; such are consumptions of the lungs, &c. Thirdly, such as come forth to the skin, and therefore taint the air or the body adjacent; especially if they consist in an unctuous substance, not apt to dissipate; such are scabs and leprosy. Fourthly, such as are merely in the humours, and not in the spirits, breath, or exhalations; and therefore they never infect but by touch only; and such a touch also as cometh within the *epidermis*; as the venom of the French pox, and the biting of a mad dog.

Experiment solitary touching the incorporation of powders and liquors.

298. Most powders grow more close and coherent by mixture of water, than by mixture of oil, though oil be the thicker body; as meal, &c. The reason is

the congruity of bodies; which if it be more, maketh a perfecter imbibition and incorporation; which in most powders is more between them and water, than between them and oil: but painters' colours ground, and ashes, do better incorporate with oil.

Experiment solitary touching exercise of the body.

299. Much motion and exercise is good for some bodies; and sitting and less motion for others. If the body be hot and void of superfluous moistures, too much motion hurteth; and it is an error in physicians to call too much upon exercise. Likewise men ought to beware that they use not exercise and a spare diet both: but if much exercise, then a plentiful diet; and if sparing diet, then little exercise. The benefits that come of exercise are: First, that it sendeth nourishment into the parts more forcibly. Secondly, that it helpeth to excern by sweat, and so maketh the parts assimilate the more perfectly. Thirdly, that it maketh the substance of the body more solid and compact, and so less apt to be consumed and depredated by the spirits. The evils that come of exercise are: First, that it maketh the spirits more hot and predatory. Secondly, that it doth absorb likewise, and attenuate too much the moisture of the body. Thirdly, that it maketh too great concussion (especially if it be violent) of the inward parts, which delight more in rest. But generally exercise, if it be much, is no friend to prolongation of life; which is one cause why women live longer than men, because they stir less.[1]

[1] For the same reason, according to Cardan, trees live longer than animals.

Experiment solitary touching meats that induce satiety.

300. Some food we may use long, and much, without glutting; as bread, flesh that is not fat or rank, &c. Some other (though pleasant) glutteth sooner; as sweet meats, fat meats, &c. The cause is, for that appetite consisteth in the emptiness of the mouth of the stomach; or possessing it with somewhat that is astringent, and therefore cold and dry. But things that are sweet and fat are more filling, and do swim and hang more about the mouth of the stomach, and go not down so speedily: and again turn sooner to choler, which is hot, and ever abateth the appetite. We see also that another cause of satiety is an over-custom, and of appetite is novelty; and therefore meats, if the same be continually taken, induce loathing. To give the reason of the distaste of satiety, and of the pleasure in novelty; and to distinguish not only in meats and drinks, but also in motions, loves, company, delights, studies, what they be that custom maketh more grateful, and what more tedious; were a large field. But for meats, the cause is attraction, which is quicker and more excited towards that which is new, than towards that whereof there remaineth a relish by former use. And (generally) it is a rule, that whatsoever is somewhat ingrate at first, is made grateful by custom; but whatsoever is too pleasing at first, groweth quickly to satiate.[1]

[1] The subject of this paragraph is discussed by Aristotle. *Prob.* xxi. 13. and 14. He points out the distinction between active and passive habits which has been more fully developed by later writers, and especially by Butler.

NATURAL HISTORY.

CENTURY IV.

Experiments in consort touching the clarification of liquors, and the accelerating thereof.

ACCELERATION of time, in works of nature, may well be esteemed *inter magnalia naturæ.* And even in divine miracles, accelerating of the time is next to the creating of the matter. We will now therefore proceed to the inquiry of it: and for acceleration of germination, we will refer it over unto the place where we shall handle the subject of plants generally; and will now begin with other accelerations.

301. Liquors are (many of them) at the first thick and troubled; as must, wort, juice of fruits, or herbs expressed, &c.; and by time they settle and clarify. But to make them clear before the time is a great work, for it is a spur to nature, and putteth her out of her pace: and besides, it is of good use for making drinks and sauces potable and serviceable speedily. But to know the means of accelerating clarification, we must first know the causes of clarification. The first

cause is, by the separation of the grosser parts of the liquor from the finer. The second, by the equal distribution of the spirits of the liquor with the tangible parts: for that ever representeth bodies clear and untroubled. The third, by the refining the spirit itself, which thereby giveth to the liquor more splendour and more lustre.

302. First, for separation; it is wrought by weight; as in the ordinary residence or settlement of liquors; by heat; by motion; by precipitation, or sublimation (that is, a calling of the several parts either up or down, which is a kind of attraction); by adhesion, as when a body more viscous is mingled and agitated with the liquor, which viscous body (afterwards severed) draweth with it the grosser parts of the liquor; and lastly, by percolation or passage.

303. Secondly, for the even distribution of the spirits; it is wrought by gentle heat; and by agitation or motion (for of time we speak not, because it is that we would anticipate and represent); and it is wrought also by mixture of some other body, which hath a virtue to open the liquor, and to make the spirits the better pass through.

304. Thirdly, for the refining of the spirit; it is wrought likewise by heat; by motion; and by mixing of some body which hath virtue to attenuate. So therefore (having shewn the causes) for the accelerating of clarification in general, and the inducing of it, take these instances and trials.

305. It is in common practice to draw wine or beer from the lees (which we call racking); whereby it will clarify much sooner; for the lees, though they keep the drink in heart, and make it lasting, yet

withal they cast up some spissitude: and this instance is to be referred to separation.

306. On the other side it were good to try what the adding to the liquor more lees than his own will work; for though the lees do make the liquor turbid, yet they refine the spirits. Take therefore a vessel of new beer, and take another vessel of new beer, and rack the one vessel from the lees, and pour the lees of the racked vessel into the unracked vessel, and see the effect: this instance is referred to the refining of the spirits.

307. Take new beer, and put in some quantity of stale beer into it, and see whether it will not accelerate the clarification, by opening the body of the beer, and cutting the grosser parts, whereby they may fall down into lees. And this instance again is referred to separation.

308. The longer malt or herbs, or the like, are infused in liquor, the more thick and troubled the liquor is; but the longer they be decocted in the liquor, the clearer it is. The reason is plain, because in infusion, the longer it is, the greater is the part of the gross body that goeth into the liquor: but in decoction, though more goeth forth, yet it either purgeth at the top, or settleth at the bottom. And therefore the most exact way to clarify is, first to infuse, and then to take off the liquor and decoct it; as they do in beer, which hath malt first infused in the liquor, and is afterwards boiled with the hop. This also is referred to separation.

309. Take hot embers, and put them about a bottle filled with new beer, almost to the very neck: let the bottle be well stopped, lest it fly out: and continue it, renewing the embers every day, by the space of ten days: and then compare it with another bottle of the

same beer set by. Take also lime both quenched and unquenched, and set the bottles in them *ut supra.* This instance is referred both to the even distribution, and also to the refining of the spirits by heat.

310. Take bottles, and swing them, or carry them in a wheel-barrow upon rough ground, twice in a day; but then you may not fill the bottles full, but leave some air; for if the liquor come close to the stopple, it cannot play nor flower: and when you have shaken them well either way, pour the drink into another bottle, stopped close after the usual manner; for if it stay with much air in it, the drink will pall; neither will it settle so perfectly in all the parts. Let it stand some twenty-four hours, then take it, and put it again into a bottle with air, *ut supra:* and thence into a bottle stopped, *ut supra:* and so repeat the same operation for seven days. Note that in the emptying of one bottle into another, you must do it swiftly, lest the drink pall. It were good also to try it in a bottle with a little air below the neck, without emptying. This instance is referred to the even distribution and refining of the spirits by motion.

311. As for percolation, inward and outward, (which belongeth to separation,) trial would be made of clarifying by adhesion, with milk put into new beer, and stirred with it: for it may be that the grosser part of the beer will cleave to the milk: the doubt is, whether the milk will sever well again: which is soon tried. And it is usual in clarifying hippocras to put in milk; which after severeth and carrieth with it the grosser parts of the hippocras, as hath been said elsewhere. Also for the better clarification by percolation, when they tun new beer, they use to let it pass through a strainer;

and it is like the finer the strainer is, the clearer it will be.

Experiments in consort touching maturation, and the accelerating thereof. And first, touching the maturation and quickening of drinks. And next, touching the maturation of fruits.

The accelerating of maturation we will now inquire of, and of maturation itself. It is of three natures. The maturation of fruits, the maturation of drinks, and the maturation of impostumes and ulcers. This last we refer to another place, where we shall handle experiments medicinal. There be also other maturations, as of metals, &c., whereof we will speak as occasion serveth. But we will begin with that of drinks, because it hath such affinity with the clarification of liquors.

312. For the maturation of drinks, it is wrought by the congregation of the spirits together, whereby they digest more perfectly the grosser parts: and it is effected partly by the same means that clarification is (whereof we spake before); but then note, that an extreme clarification doth spread the spirits so smooth, as they become dull, and the drink dead, which ought to have a little flowering. And therefore all your clear amber drink is flat.

313. We see the degrees of maturation of drinks, in must; in wine, as it is drunk; and in vinegar. Whereof must hath not the spirits well congregated; wine hath them well united, so as they make the parts somewhat more oily; vinegar hath them con-

gregated, but more jejune, and in smaller quantity, the greatest and finest spirit and part being exhaled: for we see vinegar is made by setting the vessel of wine against the hot sun; and therefore vinegar will not burn; for that much of the finer part is exhaled.

314. The refreshing and quickening of drink palled or dead, is by enforcing the motion of the spirit: so we see that open weather relaxeth the spirit, and maketh it more lively in motion. We see also bottling of beer or ale, while it is new and full of spirit, (so that it spirteth when the stopple is taken forth,) maketh the drink more quick and windy. A pan of coals in the cellar doth likewise good, and maketh the drink work again. New drink put to drink that is dead provoketh it to work again: nay, which is more, (as some affirm) a brewing of new beer, set by old beer, maketh it work again. It were good also to enforce the spirits by some mixtures that may excite and quicken them; as by the putting into the bottles, nitre, chalk, lime, &c. We see cream is matured, and made to rise more speedily, by putting in cold water; which, as it seemeth, getteth down the whey.

315. It is tried, that the burying of bottles of drink well stopped, either in dry earth a good depth, or in the bottom of a well within water, and best of all, the hanging of them in a deep well somewhat above the water, for some fortnight's space, is an excellent means of making drink fresh and quick; for the cold doth not cause any exhaling of the spirits at all; as heat doth, through it rarifieth the rest that remain; but cold maketh the spirits vigorous, and irritateth them, whereby they incorporate the parts of the liquor perfectly.

316. As for the maturation of fruits, it is wrought by the calling forth of the spirits of the body outward, and so spreading them more smoothly: and likewise by digesting in some degree the grosser parts; and this is effected by heat; motion; attraction; and by a rudiment of putrefaction; for the inception of putrefaction hath in it a maturation.

317. There were taken apples, and laid in straw; in hay; in flour; in chalk; in lime; covered over with onions; covered over with crabs; closed up in wax; shut in a box, &c. There was also an apple hanged up in smoke. Of all which the experiments sorted in this manner.

318. After a month's space, the apple inclosed in wax was as green and fresh as at the first putting in, and the kernels continued white. The cause is, for that all exclusion of open air (which is ever predatory) maintaineth the body in his first freshness and moisture; but the inconvenience is, that it tasteth a little of the wax; which, I suppose, in a pomegranate or some such thick-coated fruit, it would not do.

319. The apple hanged in the smoke turned like an old mellow apple, wrinkled, dry, soft, sweet, yellow within. The cause is, for that such a degree of heat which doth neither melt nor scorch (for we see that in a great heat, a roast apple softeneth and melteth; and pigs' feet, made of quarters of wardens, scorch and have a skin of coal,) doth mellow, and not adure: the smoke also maketh the apple (as it were) sprinkled with soot, which helpeth to mature. We see that in drying of pears and prunes in the oven, and removing of them often as they begin to sweat, there is a like

operation; but that is with a far more intense degree of heat.

320. The apples covered in the lime and ashes were well matured; as appeared both in their yellowness and sweetness. The cause is, for that that degree of heat which is in lime and ashes (being a smothering heat) is of all the rest most proper; for it doth neither liquefy nor arefy; and that is true maturation. Note, that the taste of those apples was good; and therefore it is the experiment fittest for use.

321. The apples covered with crabs and onions were likewise well matured. The cause is, not any heat; but for that the crabs and the onions draw forth the spirits of the apple, and spread them equally throughout the body; which taketh away hardness. So we see one apple ripeneth against another. And therefore in making of cyder they turn the apples first upon a heap. So one cluster of grapes that toucheth another whilst it groweth, ripeneth faster; *botrus contra botrum citius maturescit.*[1]

322. The apples in hay and the straw ripened apparently, though not so much as the other; but the apple in the straw more. The cause is, for that the hay and straw have a very low degree of heat, but yet close and smothering, and which drieth not.

323. The apple in the close box was ripened also: the cause is, for that all air kept close hath a degree of warmth; as we see in wool, fur, plush, &c.

Note, that all of these were compared with another apple of the same kind that lay of itself; and in comparison of that were more sweet and more yellow, and so appeared to be more ripe.

[1] This is taken from Erasmus's *Adages*, iii. 2. 49.

324. Take an apple or pear, or other like fruit, and roll it upon a table hard: we see in common experience, that the rolling doth soften and sweeten the fruit presently; which is nothing but the smooth distribution of the spirits into the parts; for the unequal distribution of the spirits maketh the harshness:[1] but this hard rolling is between concoction and a simple maturation; therefore, if you should roll them but gently, perhaps twice a day, and continue it some seven days, it is like they would mature more finely, and like unto the natural maturation.

325. Take an apple, and cut out a piece of the top, and cover it, to see whether that solution of continuity will not hasten a maturation: we see that where a wasp or a fly or a worm hath bitten in a grape or any fruit, it will sweeten hastily.

326. Take an apple, &c., and prick it with a pin full of holes, not deep, and smear it a little with sack, or cinnamon water, or spirit of wine, every day for ten days, to see if the virtual heat of the wine or strong waters will not mature it.

In these trials also, as was used in the first, set another of the same fruits by, to compare them; and try them by their yellowness and by their sweetness.

Experiment solitary touching the making of gold.

The world hath been much abused by the opinion of making of gold: the work itself I judge to be possible; but the means (hitherto propounded) to

[1] *Harrishness* in the original. — *J. S.*

effect it are, in the practice, full of error and imposture; and in the theory, full of unsound imaginations. For to say that nature hath an intention to make all metals gold; and that if she were delivered from impediments, she would perform her own work; and that if the crudities, impurities, and leprosies of metals were cured, they would become gold; and that a little quantity of the medicine, in the work of projection, will turn a sea of the baser metal into gold by multiplying: all these are but dreams; and so are many other grounds of alchemy. And to help the matter, the alchemists call in likewise many vanities out of astrology, natural magic, superstitious interpretations of Scriptures, auricular traditions, feigned testimonies of ancient authors, and the like. It is true, on the other side, they have brought to light not a few profitable experiments, and thereby made the world some amends. But we, when we shall come to handle the version and transmutation of bodies, and the experiments concerning metals and minerals, will lay open the true ways and passages of nature, which may lead to this great effect. And we commend the wit of the Chineses, who despair of making of gold, but are mad upon the making of silver:[1] for certain it is that it is more

[1] See Purchas's *Pilgrims*, iii. 332., and v. 467. But these passages do not show that the Chinese despaired of being able to make gold, and it is therefore probable that Bacon's information was derived from some other source.

difficult to make gold (which is the most ponderous and materiate amongst metals) of other metals less ponderous and less materiate, than (*via versa*) to make silver of lead or quicksilver; both which are more ponderous than silver; so that they need rather a further degree of fixation than any condensation. In the mean time, by occasion of handling the axioms touching maturation, we will direct a trial touching the maturing of metals, and thereby turning some of them into gold: for we conceive indeed that a perfect good concoction or digestion or maturation of some metals will produce gold. And here we call to mind that we knew a Dutchman, that had wrought himself into the belief of a great person by undertaking that he could make gold, whose discourse was, that gold might be made; but that the alchemists over-fired the work: for (he said) the making of gold did require a very temperate heat, as being in nature a subterrany work, where little heat cometh; but yet more to the making of gold than of any other metal; and therefore that he would do it with a great lamp that should carry a temperate and equal heat; and that it was the work of many months. The device of the lamp was folly; but the over-firing now used, and the equal heat to be required, and the making it a work of some good time, are no ill discourses.

We resort therefore to our axioms of maturation, in effect touched before. The first is, that there be used a temperate heat; for they are ever temperate heats that digest and mature: wherein we mean temperate according to the nature of the subject; for that may be temperate to fruits and liquors, which will not work at all upon metals. The second is, that the spirit of the metal be quickened, and the tangible parts opened: for without those two operations, the spirit of the metal wrought upon will not be able to digest the parts. The third is, that the spirits do spread themselves even, and move not subsultorily; for that will make the parts close and pliant. And this requireth a heat that doth not rise and fall, but continue as equal as may be. The fourth is, that no part of the spirit be emitted, but detained: for if there be emission of spirit, the body of the metal will be hard and churlish. And this will be performed, partly by the temper of the fire, and partly by the closeness of the vessel. The fifth is, that there be choice made of the likeliest and best prepared metal for the version: for that will facilitate the work. The sixth is, that you give time enough for the work; not to prolong hopes (as the alchemists do), but indeed to give nature a convenient space to work in. These principles are most certain and true; we will now derive a direction of trial out of them, which may perhaps by further meditation be improved.

327. Let there be a small furnace made, of a tem-

perate heat; let the heat be such as may keep the metal perpetually molten, and no more; for that above all importeth to the work. For the material, take silver, which is the metal that in nature symbolizeth most with gold;[1] put in also with the silver, a tenth part of quicksilver, and a twelfth part of nitre, by weight; both these to quicken and open the body of the metal; and so let the work be continued by the space of six months at the least. I wish also, that there be at some times an injection of some oiled substance; such as they use in the recovering of gold, which by vexing with separations hath been made churlish; and this is to lay the parts more close and smooth, which is the main work. For gold (as we see) is the closest (and therefore the heaviest) of metals; and is likewise the most flexible and tensible. Note, that to think to make gold of quicksilver, because it is the heaviest, is a thing not to be hoped; for quicksilver will not endure the manage of the fire. Next to silver, I think copper were fittest to be the material.

Experiment solitary touching the nature of gold.

328. Gold hath these natures; greatness of weight, closeness of parts, fixation, pliantness or softness, immunity from rust, colour or tincture of yellow. Therefore the sure way (though most about) to make gold, is to know the causes of the several natures before rehearsed, and the axioms concerning the same. For

[1] Beside the symbolisms between gold and silver with which Bacon was acquainted, two very remarkable relations have been since observed — their isomorphism, and the equality of their equivalent volumes. In both these respects they agree with Tellurium, and the three metals are frequently found combined or associated together.

if a man can make a metal that hath all these properties, let men dispute whether it be gold or no.

Experiments in consort touching the inducing and accelerating of putrefaction.

The inducing and accelerating of putrefaction is a subject of a very universal inquiry: for corruption is a reciprocal to generation: and they two are as nature's two terms or boundaries; and the guides to life and death. Putrefaction is the work of the spirits of bodies, which ever are unquiet to get forth and congregate with the air, and to enjoy the sunbeams. The getting forth, or spreading of the spirits (which is a degree of getting forth), have five differing operations. If the spirits be detained within the body, and move more violently, there followeth colliquation; as in metals, &c. If more mildly, there followeth digestion or maturation; as in drinks and fruits. If the spirits be not merely detained, but protrude a little, and that motion be confused and inordinate, there followeth putrefaction; which ever dissolveth the consistence of the body into much inequality; as in flesh, rotten fruits, shining wood, &c., and also in the rust of metals. But if that motion be in a certain order, there followeth vivification and figuration; as both in living creatures bred of putrefaction, and in living creatures perfect. But if the spirits issue out of the body, there followeth desiccation, induration, consumption, &c.; as in brick, evaporation of bodies liquid, &c.

329. The means to induce and accelerate putrefaction are, first, by adding some crude or watery moisture; as in wetting of any flesh, fruit, wood, with water, &c. For contrariwise unctuous and oily substance preserve.

330. The second is by invitation or excitation; as when a rotten apple lieth close to another apple that is sound; or when dung (which is a substance already putrefied) is added to other bodies. And this is also notably seen in church-yards, where they bury much; where the earth will consume the corpse in far shorter time than other earth will.

331. The third is by closeness and stopping, which detaineth the spirits in prison more than they would; and thereby irritateth them to seek issue; as in corn and clothes, which wax musty; and therefore open air, (which they call *aër perflabilis*,) doth preserve: and this doth appear more evidently in agues, which come (most of them) of obstructions, and penning the humours, which thereupon putrefy.

332. The fourth is by solution of continuity: as we see an apple will rot sooner if it be cut or pierced; and so will wood, &c. And so the flesh of creatures alive, where they have received any wound.

333. The fifth is either by the exhaling or by the driving back of the principal spirits, which preserve the consistence of the body; so that when their government is dissolved, every part returneth to his nature or homogeny. And this appeareth in urine and blood, when they cool, and thereby break: it appeareth also

in the gangrene, or mortification of flesh, either by opiates or by intense colds. I conceive also the same effect is in pestilences; for that the malignity of the infecting vapour daunteth[1] the principal spirits, and maketh them fly and leave their regiment; and then the humours, flesh, and secondary spirits, do dissolve and break, as in an anarchy.

334. The sixth is, when a foreign spirit, stronger and more eager than the spirit of the body, entereth the body; as in the stinging of serpents. And this is the cause (generally) that upon all poisons followeth swelling: and we see swelling followeth also when the spirits of the body itself congregate too much; as upon blows and bruises; or when they are pent in too much, as in swelling upon cold. And we see also, that the spirits coming of putrefaction of humours in agues, &c., which may be counted as foreign spirits though they be bred within the body, do extinguish and suffocate the natural spirits and heat.

335. The seventh is by such a weak degree of heat, as setteth the spirits in a little motion, but is not able either to digest the parts, or to issue the spirits; as is seen in flesh kept in a room that is not cool; whereas in a cool and wet larder it will keep longer. And we see that vivification (whereof putrefaction is the bastard brother) is effected by such soft heats; as the hatching of eggs, the heat of the womb, &c.

336. The eighth is by the releasing of the spirits, which before were close kept by the solidness of their coverture, and thereby their appetite of issuing checked; as in the artificial rusts induced by strong waters in iron, lead, &c. And therefore wetting

[1] *Daunceth* in the original. — *J. S.*

hasteneth rust or putrefaction of any thing, because it softeneth the crust for the spirits to come forth.

337. The ninth is by the interchange of heat and cold, or wet and dry; as we see in the mouldering of earth in frosts and sun: and in the more hasty rotting of wood that is sometimes wet, sometimes dry.

338. The tenth is by time, and the work and procedure of the spirits themselves, which cannot keep their station; especially if they be left to themselves, and there be not agitation or local motion. As we see in corn not stirred, and men's bodies not exercised.

339. All moulds are inceptions of putrefaction; as the moulds of pies and flesh; the moulds of oranges and lemons; which moulds afterwards turn into worms, or more odious putrefactions; and therefore (commonly) prove to be of ill odour. And if the body be liquid, and not apt to putrefy totally, it will cast up a mother in the top; as the mothers of distilled waters.

340. Moss is a kind of mould of the earth and trees. But it may be better sorted as a rudiment of germination, to which we refer it.

Experiments in consort touching prohibiting and preventing putrefaction.

It is an inquiry of excellent use to inquire of the means of preventing or staying putrefaction; for therein consisteth the means of conservation of bodies: for bodies have two kinds of dissolutions; the one by consumption and desiccation, the other by putrefaction. But as for the putrefactions of the bodies of men and living creatures (as in agues, worms, consumptions of the lungs, impostumes, and ulcers both inwards and outwards) they are a great part of physic and surgery; and therefore we will reserve the inquiry of them to the proper place, where we shall handle medicinal experiments of all sorts. Of the rest we will now enter into an inquiry: wherein much light may be taken from that which hath been said of the means to induce or accelerate putrefaction: for the removing that which caused putrefaction, doth prevent and avoid putrefaction.

341. The first means of prohibiting or checking putrefaction is cold: for so we see that meat and drink will last longer unputrefied, or unsoured, in winter than in summer: and we see that flowers and fruits, put in conservatories of snow, keep fresh. And this worketh by the detention of the spirits, and constipation of the tangible parts.

342. The second is astriction: for astriction prohibiteth dissolution; as we see (generally) in medicines, whereof such as are astringents do inhibit putrefaction: and by the same reason of astringency, some small quantity of oil of vitriol will keep fresh water long from putrefying. And this astriction is in a substance that hath a virtual cold; and it worketh (partly) by the same means that cold doth.

343. The third is the excluding of the air; and again, the exposing to the air: for these contraries (as it cometh often to pass) work the same effect, according to the nature of the subject matter. So we see that beer or wine, in bottles close stopped,

last long; that the garners under ground keep corn longer than those above ground; and that fruit closed in wax keepeth fresh; and likewise bodies put in honey and flour keep more fresh: and liquors, drinks, and juices, with a little oil cast on the top, keep fresh. Contrariwise, we see that cloth and apparel not aired do breed moths and mould; and the diversity is, that in bodies that need detention of spirits, the exclusion of the air doth good; as in drinks and corn: but in bodies that need emission of spirits to discharge some of the superfluous moisture, it doth hurt, for they require airing.

344. The fourth is motion and stirring; for putrefaction asketh rest: for the subtile motion which putrefaction requireth, is disturbed by any agitation: and all local motion keepeth bodies integral, and their parts together; as we see that turning over of corn in a garner, or letting it run like an hour-glass from an upper room into a lower, doth keep it sweet: and running waters putrefy not; and in men's bodies, exercise hindereth putrefaction; and contrariwise, rest and want of motion, or stoppings, (whereby the run of humours, or the motion of perspiration is stayed,) further putrefaction; as we partly touched a little before.

345. The fifth is the breathing forth of the adventitious moisture in bodies; for as wetting doth hasten putrefaction, so convenient drying (whereby the more radical moisture is only kept in) putteth back putrefaction; so we see that herbs and flowers, if they be dried in the shade, or dried in the hot sun for a small time, keep best. For the emission of the loose and adventitious moisture doth betray the radical moisture, and carrieth it out for company.

346. The sixth is the strengthening of the spirits of bodies; for as a great heat keepeth bodies from putrefaction, but a tepid heat inclineth them to putrefaction; so a strong spirit likewise preserveth, and a weak or faint spirit disposeth to corruption. So we find that salt water corrupteth not so soon as fresh: and salting of oysters, and powdering of meat, keepeth them from putrefaction. It would be tried also whether chalk put into water or drink doth not preserve it from putrefying or speedy souring. So we see that strong beer will last longer than small; and all things that are hot and aromatical do help to preserve liquors, or powders, &c.; which they do as well by strengthening the spirits, as by soaking[1] out the loose moisture.

347. The seventh is separation of the cruder parts, and thereby making the body more equal; for all unperfect mixture is apt to putrefy; and watery substances are more apt to putrefy than oily. So we see distilled waters will last longer than raw waters; and things that have passed the fire do last longer than those that have not passed the fire; as dried pears, &c.

348. The eighth is the drawing forth continually of that part where the putrefaction beginneth; which is (commonly) the loose and watery moisture; not only for the reason before given, that it provoketh the radical moisture to come forth with it; but because being detained in the body, the putrefaction taking hold of it, infecteth the rest: as we see in the embalming dead bodies; and the same reason is of preserving herbs, or fruits, or flowers, in bran or meal.

349. The ninth is the commixture of any thing that is more oily or sweet: for such bodies are least apt to

[1] So in the original. — *J. S.*

putrefy, the air working little upon them; and they not putrefying, preserve the rest. And therefore we see syrups and ointments will last longer than juices.

350. The tenth is the commixture of somewhat that is dry; for putrefaction beginneth first from the spirits, and then from the moisture: and that that is dry is unapt to putrefy: and therefore smoke preserveth flesh; as we see in bacon, and neats' tongues, and Martlemas beef,[1] &c.

351. The opinion of some of the ancients, that blown airs do preserve bodies longer than other airs, seemeth to me probable;[2] for that the blown airs, being overcharged and compressed, will hardly receive the exhaling of any thing, but rather repulse it. It was tried in a blown bladder, whereinto flesh was put, and likewise a flower, and it sorted not: for dry bladders will not blow; and new bladders rather further putrefaction: the way were therefore to blow strongly with a pair of bellows into a hogshead, putting into the hogshead (before) that which you would have preserved; and in the instant that you withdraw the bellows, stop the hole close.

Experiment solitary touching wood shining in the dark.

352. The experiment of wood that shineth in the dark, we have diligently driven and pursued: the rather, for that of all things that give light here below, it is the most durable, and hath least apparent motion. Fire and flame are in continual expence; sugar shineth only while it is in scraping; and salt-

[1] For an account of the phrase Martlemas-beef, see Macaulay, *History of England*, vol. i. p. 315.

[2] Arist. Prob. xxii. 4. and xxv. 17.

water while it is in dashing; glow-worms have their shining while they live, or a little after. Only scales of fishes (putrefied) seem to be of the same nature with shining wood: and it is true that all putrefaction hath with it an inward motion, as well as fire or light. The trial sorted thus: 1. The shining is in some pieces more bright, in some more dim; but the most bright of all doth not attain to the light of a glow-worm. 2. The woods that have been tried to shine, are chiefly sallow and willow: also the ash and hazle; it may be it holdeth in others. 3. Both roots and bodies do shine, but the roots better. 4. The colour of the shining part, by day-light, is in some pieces white, in some pieces inclining to red; which in the country they call the white and red garret. 5. The part that shineth is (for the most part) somewhat soft and moist to feel to; but some was found to be firm and hard; so as it might be figured into a cross, or into beads, &c. But you must not look to have an image, or the like, in any thing that is lightsome; for even a face in iron red-hot will not be seen, the light confounding the small differences of lightsome and darksome, which shew the figure. 6. There was the shining part pared off, till you came to that that did not shine; but within two days the part contiguous began also to shine, being laid abroad in the dew; so as it seemeth the putrefaction spreadeth. 7. There was other dead wood of like kind that was laid abroad, which shined not at the first; but after a night's lying abroad began to shine. 8. There was other wood that did first shine; and being laid dry in the house, within five or six days lost the shining; and laid abroad again, recovered the shining. 9. Shining woods being laid in a dry room, within a sevennight lost their shining; but being laid in a cellar, or dank room, kept the shining. 10. The boring of holes in that kind of wood, and then laying it abroad, seemeth to conduce to make it shine: the cause is, for that all solution of continuity doth help on putrefaction, as was touched before. 11. No wood hath been yet tried to shine, that was cut down alive, but such as was rotted both in stock and root while it grew. 12. Part of the wood that shined was steeped in oil, and retained the shining a fortnight. 13. The like succeeded in some steeped in water, and much better. 14. How long the shining will continue, if the wood be laid abroad every night, and taken in and sprinkled with water in the day, is not yet tried. 15. Trial was made of laying it abroad in frosty weather, which hurt it not. 16. There was a great piece of a root which did shine, and the shining part was cut off till no more shined; yet after two nights, though it were kept in a dry room, it got a shining.

Experiment solitary touching the acceleration of birth.

353. The bringing forth of living creatures may be accelerated in two respects: the one, if the embryo ripeneth and perfecteth sooner: the other, if there be some cause from the mother's body, of expulsion or putting it down: whereof the former is good, and argueth strength; the latter is ill, and cometh by accident or disease. And therefore the ancient observation is true, that the child born in the seventh month doth commonly well; but born in the eighth month doth (for the most part) die. But the cause assigned is fabulous; which is, that in the eighth month should

be the return of the reign of the planet Saturn, which (as they say) is a planet malign; whereas in the seventh is the reign of the moon, which is a planet propitious.[1] But the true cause is, for that where there is so great a prevention of the ordinary time, it is the lustiness of the child; but when it is less, it is some indisposition of the mother.

Experiment solitary touching the acceleration of growth and stature.

354. To accelerate growth or stature, it must proceed either from the plenty of the nourishment, or from the nature of the nourishment, or from the quickening and exciting of the natural heat. For the first, excess of nourishment is hurtful; for it maketh the child corpulent; and growing in breadth rather than in height. And you may take an experiment from plants, which if they spread much are seldom tall. As for the nature of the nourishment: First, it may not be too dry; and therefore children in dairy countries do wax more tall, than where they feed more upon bread and flesh. There is also a received tale, that boiling of daisy roots in milk (which it is certain are

[1] We read in Omar that the first month after conception "fit in dispositione Saturni disponitque eum per frigus." The second is similarly influenced by Jupiter, and so on. Thus the seventh is influenced by the Moon — "fit in dispositione Lunæ et perficitur in eo ejus imago. Qui si tunc in dispositione Lunæ fuerit natus evadet. Si vero fuerit natus in octavo revertitur in eo dispositio Saturni et morietur. Et si natus fuerit in nono mense revertitur dispositio ad Jovem et vivit, si Deus voluerit." — *Omar*, *De Nativitatibus*, iii., appended to the Basil edition of Julius Firmicus (1551).

Censorinus, *De Die natali*, c. 8., gives quite a different reason. The phrase "perficitur in eo ejus imago" means that in the seventh month the face of the child is perfected, and that it is an image or ectype of that which is seen in the moon.

great driers) will make dogs little. But so much is true, that an over-dry nourishment in childhood putteth back stature. Secondly, the nourishment must be of an opening nature ; for that attenuateth the juice, and furthereth the motion of the spirits upwards. Neither is it without cause, that Xenophon, in the nurture of the Persian children, doth so much commend their feeding upon cardamon ; which (he saith) made them grow better, and be of a more active habit.[2] Cardamon is in Latin *nasturtium*, and with us *water-cresses ;* which, it is certain, is an herb that, whilst it is young, is friendly to life. As for the quickening of natural heat, it must be done chiefly with exercise ; and therefore (no doubt) much going to school, where they sit so much, hindereth the growth of children ; whereas country people that go not to school, are commonly of better stature. And again men must beware how they give children any thing that is cold in operation ; for even long sucking doth hinder both wit and stature. This hath been tried, that a whelp that hath been fed with nitre in milk, hath become very little, but extreme lively : for the spirit of nitre is cold. And though it be an excellent medicine in strength of years for prolongation of life, yet it is in children and young creatures an enemy to growth ; and all for the same reason ; for heat is requisite to growth ; but after a man is come to his middle age, heat consumeth the spirits ; which the coldness of the spirit of nitre doth help to condense and correct.

[1] Xenophon, Cyropæd. i. 2.

Experiments in consort touching sulphur and mercury, two of Paracelsus' Principles.

There be two great families of things. You may term them by several names; sulphureous and mercurial, which are the chemist's words (for as for their *sal*, which is their third Principle, it is a compound of the other two); inflammable and not inflammable; mature and crude; oily and watery. For we see that in subterranies there are, as the fathers of their tribes, brimstone and mercury; in vegetables and living creatures there is water and oil; in the inferior order of pneumaticals there is air and flame; and in the superior there is the body of the star and the pure sky. And these pairs, though they be unlike in the primitive differences of matter, yet they seem to have many consents: for mercury and sulphur are principal materials of metals; water and oil are principal materials of vegetables and animals, and seem to differ but in maturation or concoction: flame (in vulgar opinion) is but air incensed; and they both have quickness of motion, and facility of cession, much alike: and the interstellar sky (though the opinion be vain, that the star is the denser part of his orb) hath notwithstanding so much affinity with the star, that there is a rotation of that, as well as of the star. Therefore it is one of the greatest *magnalia naturæ*, to turn water or watery juice into oil or oily juice: greater in nature, than to turn silver or quicksilver into gold.

355. The instances we have wherein crude and watery substance turneth into fat and oily, are of four kinds. First in the mixture of earth and water; which mingled by the help of the sun, gather a nitrous fatness, more than either of them have severally; as we see in that they put forth plants, which need both juices.

356. The second is in the assimilation of nourishment, made in the bodies of plants and living creatures; whereof plants turn the juice of mere water and earth into a great deal of oily matter: living creatures, though much of their fat and flesh are out of oily aliments (as meat and bread), yet they assimilate also in a measure their drink of water, &c. But these two ways of version of water into oil (namely, by mixture and by assimilation) are by many passages and percolations, and by continuance of soft heats, and by circuits of time.

357. The third is the inception of putrefaction; as in water corrupted; and the mothers of waters distilled; both which have a kind of fatness or oil.

358. The fourth is in the dulcoration of some metals, as *saccharum Saturni*, &c.

359. The intention of version of water into a more oily substance is by digestion; for oil is almost nothing else but water digested; and this digestion is principally by heat; which heat must be either outward or inward: again, it may be by provocation or excitation; which is caused by the mingling of bodies already oily or digested; for they will somewhat com-

municate their nature with the rest. Digestion also is strongly effected by direct assimilation of bodies crude into bodies digested; as in plants and living creatures, whose nourishment is far more crude than their bodies: but this digestion is by a great compass, as hath been said. As for the more full handling of these two principles, whereof this is but a taste, (the inquiry of which is one of the profoundest inquiries of nature), we leave it to the title of version of bodies; and likewise to the title of the first congregations of matter; which, like a general assembly of estates, doth give law to all bodies.

Experiment solitary touching chameleons.[1]

360. A chameleon is a creature about the bigness of an ordinary lizard: his head unproportionably big: his eyes great: he moveth his head without the writhing of his neck (which is inflexible) as a hog doth: his back crooked; his skin spotted with little tumours, less eminent nearer the belly; his tail slender and long: on each foot he hath five fingers, three on the outside, and two on the inside; his tongue of a marvellous length in respect of his body, and hollow at the end; which he will launch out to prey upon flies. Of colour green, and of a dusky yellow, brighter and whiter towards the belly; yet spotted with blue, white, and red. If he be laid upon green, the green predominateth; if upon yellow, the yellow; not so if he be laid upon blue, or red, or white; only the green spots

[1] This description is taken from Scaliger, *Exercit. adv. Cardan.* 196. 4. The "tradition in magic" at the end of the paragraph is given with a slight variation by Pliny, xxviii. 29. That the burning was to be on the house-top was probably suggested by the words "in tegulis" in the latter passage.

received a more orient lustre; laid upon black, he looketh all black, though not without a mixture of green. He feedeth not only upon air, (though that be his principal sustenance,) for sometimes he taketh flies, as was said; yet some that have kept chameleons a whole year together, could never perceive that ever they fed upon any thing else but air, and might observe their bellies to swell after they had exhausted the air; and closed their jaws; which they open commonly against the rays of the sun. They have a foolish tradition in magic, that if a chameleon be burnt upon the top of an house, it will raise a tempest; supposing (according to their vain dreams of sympathies,) because he nourisheth with air, his body should have great virtue to make impression upon the air.

Experiment solitary touching subterrany fires.[1]

361. It is reported by one of the ancients, that in part of Media there are eruptions of flames out of plains; and that those flames are clear, and cast not forth such smoke and ashes and pumice, as mountain flames do. The reason (no doubt) is, because the flame is not pent as it is in mountains and earthquakes which cast flame. There be also some blind fires under stone, which flame not out, but oil being poured upon them they flame out. The cause whereof is, for that it seemeth the fire is so choked, as not able to remove the stone, it is heat rather than flame; which nevertheless is sufficient to inflame the oil.

Experiment solitary touching nitre.

362. It is reported, that in some lakes[2] the water is

[1] Pliny, ii. 110. [2] Namely, lake Pæsa. Arist. Probl. xxiii. 40.

so nitrous, as, if foul clothes be put into it, it scoureth them of itself; and if they stay any whit long, they moulder away. And the scouring virtue of nitre is the more to be noted, because it is a body cold; and we see warm water scoureth better than cold. But the cause is, for that it hath a subtile spirit, which severeth and divideth any thing that is foul and viscous and sticketh upon a body.

Experiment solitary touching congealing of air.

363. Take a bladder, the greatest you can get; fill it full of wind, and tie it about the neck with a silk thread waxed; and upon that put likewise wax very close; so that when the neck of the bladder drieth, no air may possibly get in nor out. Then bury it three or four foot under the earth in a vault, or in a conservatory of snow, the snow being made hollow about the bladder; and after some fortnight's distance, see whether the bladder be shrunk; for if it be, then it is plain that the coldness of the earth or snow hath condensed the air, and brought it a degree nearer to water: which is an experiment of great consequence.

Experiment solitary touching congealing of water into crystal.

364. It is a report of some good credit, that in deep caves there are pensile crystals, and degrees of crystal that drop from above; and in some other (though more rarely) that rise from below: which though it be chiefly the work of cold, yet it may be that water that passeth through the earth gathereth a nature more clammy, and fitter to congeal and become solid, than water of itself. Therefore trial would be made, to lay

a heap of earth, in great frosts, upon a hollow vessel, putting a canvas between, that it falleth not in: and pour water upon it, in such quantity as will be sure to soak through; and see whether it will not make an harder ice in the bottom of the vessel, and less apt to dissolve, than ordinarily. I suppose also that if you make the earth narrower at the bottom than at the top, in fashion of a sugar-loaf reversed, it will help the experiment. For it will make the ice, where it issueth, less in bulk; and evermore smallness of quantity is a help to version.

Experiment solitary touching preserving of rose-leaves, both in colour and smell.

365. Take damask roses, and pull them; then dry them upon the top of an house, upon a lead or terrace, in the hot sun, in a clear day, between the hours (only) of twelve and two, or thereabouts. Then put them into a sweet dry earthen bottle, or a glass, with narrow mouths, stuffing them close together, but without bruising: stop the bottle or glass close, and these roses will retain not only their smell perfect, but their colour fresh, for a year at least. Note, that nothing doth so much destroy any plant or other body, either by putrefaction or arefaction, as the adventitious moisture which hangeth loose in the body, if it be not drawn out. For it betrayeth and tolleth forth the innate and radical moisture along with it, when itself goeth forth. And therefore in living creatures, moderate sweat doth preserve the juice of the body. Note, that these roses, when you take them from the drying, have little or no smell; so that the smell is a second smell, that issueth out of the flower afterwards.

Experiments in consort touching the continuance of flame.

366. The continuance of flame, according unto the diversity of the body inflamed, and other circumstances, is worthy the inquiry; chiefly, for that though flame be (almost) of a momentany lasting, yet it receiveth the more and the less: we will first therefore speak (at large) of bodies inflamed wholly and immediately, without any wick[1] to help the inflammation. A spoonful of spirit of wine, a little heated, was taken, and it burnt as long as came to one hundred and sixteen pulses. The same quantity of spirit of wine mixed with the sixth part of a spoonful of nitre, burnt but to the space of ninety-four pulses. Mixed with the like quantity of bay-salt, eighty-three pulses. Mixed with the like quantity of gunpowder, which dissolved into a black water, one hundred and ten pulses. A cube or pellet of yellow wax was taken, as much as half the spirit of wine, and set in the midst, and it burnt only to the space of eighty-seven pulses. Mixed with the sixth part of a spoonful of milk, it burnt to the space of one hundred pulses; and the milk was crudled. Mixed with the sixth part of a spoonful of water, it burnt to the space of eighty-six pulses; with an equal quantity of water, only to the space of four pulses. A small pebble was laid in the midst; and the spirit of wine burnt to the space of ninety-four pulses. A piece of wood of the bigness of an arrow, and about a finger's length, was set up in the midst, and the spirit of wine burnt to the space of ninety-four pulses. So that the spirit of wine simple endured the longest; and

[1] In the original this word is always spelt *wieke*. — *J. S.*

the spirit of wine with the bay-salt, and the equal quantity of water, were the shortest.

367. Consider well, whether the more speedy going forth of the flame be caused by the greater vigour of the flame in burning; or by the resistance of the body mixed, and the aversion thereof to take flame; which will appear by the quantity of the spirit of wine that remaineth after the going out of the flame. And it seemeth clearly to be the latter; for that the mixture of things least apt to burn is the speediest in going out. And note, by the way, that spirit of wine, burned till it go out of itself, will burn no more; and tasteth nothing so hot in the mouth as it did; no, nor yet sour (as if it were a degree towards vinegar), which burnt wine doth; but flat and dead.

368. Note, that in the experiment of wax aforesaid, the wax dissolved in the burning, and yet did not incorporate itself with the spirit of the wine to produce one flame: but wheresoever the wax floated, the flame forsook it, till at last it spread all over, and put the flame quite out.

369. The experiments of the mixtures of the spirit of wine inflamed, are things of discovery, and not of use: but now we will speak of the continuance of flames, such as are used for candles, lamps, or tapers; consisting of inflammable matters, and of a wick that provoketh inflammation. And this importeth not only discovery, but also use and profit; for it is a great saving in all such lights, if they can be made as fair and bright as others, and yet last longer. Wax pure made into a candle; and wax mixed severally into candle-stuff with the particulars that follow, (viz., water, aqua-vitæ, milk, bay-salt, oil, butter, nitre, brimstone, saw-

dust) ; every of these bearing a sixth part to the wax; and every of these candles mixed, being of the same weight and wick with the wax pure; proved thus in the burning and lasting. The swiftest in consuming was that with saw-dust; which first burned fair till some part of the candle was consumed, and the dust gathered about the snaste;[1] but then it made the snaste big and long, and to burn duskishly, and the candle wasted in half the time of the wax pure. The next in swiftness were the oil and butter, which consumed by a fifth part swifter than the pure wax. Then followed in swiftness the clear wax itself. Then the bay-salt, which lasted about an eighth part longer than the clear wax. Then followed the aqua vitæ, which lasted about a fifth part longer than the clear wax. Then followed the milk, and water, with little difference from the aqua vitæ, but the water slowest. And in these four last, the wick would spit forth little sparks. For the nitre, it would not hold lighted above some twelve pulses ; but all the while it would spit out portions of flame, which afterwards would go out into a vapour. For the brimstone, it would hold lighted much about the same time with the nitre; but then after a little while it would harden and cake about the snaste; so that the mixture of bay-salt with wax will win an eighth part of the time of lasting, and the water a fifth.

370. After the several materials were tried, trial was likewise made of several wicks; as of ordinary cotton, sewing thread, rush, silk, straw, and wood. The silk, straw, and wood would flame a little, till they came to

[1] *Snaste* is apparently the same word as snat, which is given in Bailey's Dictionary as a North-country word for burnt wick or snuff.

the wax, and then go out: of the other three, the thread consumed faster than the cotton, by a sixth part of time; the cotton next; then the rush consumed slower than the cotton, by at least a third part of time. For the bigness of the flame, the cotton and thread cast a flame much alike: and the rush much less and dimmer. *Quære*, whether wood and wicks both, as in torches, consume faster than the wicks simple.

371. We have spoken of the several materials, and the several wicks: but to the lasting of the flame it importeth also, not only what the material is, but in the same material whether it be hard, soft, old, new, &c. Good housewives, to make their candles burn the longer, use to lay them (one by one) in bran or flour, which make them harder, and so they consume the slower: insomuch as by this means they will outlast other candles of the same stuff almost half in half. For bran and flour have a virtue to harden; so that both age, and lying in the bran, doth help to the lasting. And we see that wax candles last longer than tallow candles, because wax is more firm and hard.

372. The lasting of flame also dependeth upon the easy drawing of the nourishment; as we see in the court of England there is a service which they call *Allnight;* which is (as it were) a great cake of wax, with the wick in the midst; whereby it cometh to pass, that the wick fetcheth the nourishment further off. We see also that lamps last longer, because the vessel is far broader than the breadth of a taper or candle.

373. Take a turreted lamp of tin, made in the form of a square:[1] the height of the turret being thrice as much as the length of the lower part whereupon the

[1] *Squire* in the original. — *J. S.*

lamp standeth: make only one hole in it, at the end of the return furthest from the turret. Reverse it, and fill it full of oil by that hole; and then set it upright again; and put a wick in at the hole, and lighten it: you shall find that it will burn slow, and a long time: which is caused (as was said last before) for that the flame fetcheth the nourishment afar off. You shall find also, that as the oil wasteth and descendeth, so the top of the turret by little and little filleth with air; which is caused by the rarefaction of the oil by the heat. It were worthy the observation, to make a hole in the top of the turret, and to try when the oil is almost consumed, whether the air made of the oil, if you put to it a flame of a candle, in the letting of it forth will inflame. It were good also to have the lamp made, not of tin, but of glass, that you may see how the vapour or air gathereth by degrees in the top.

374. A fourth point that importeth the lasting of the flame, is the closeness of the air wherein the flame burneth. We see that if wind bloweth upon a candle it wasteth apace. We see also it lasteth longer in a lanthorn than at large. And there are traditions of lamps and candles, that have burnt a very long time in caves and tombs.

375. A fifth point that importeth the lasting of the flame, is the nature of the air where the flame burneth; whether it be cold or hot, moist or dry. The air, if it be very cold, irritateth the flame, and maketh it burn more fiercely (as fire scorcheth in frosty weather) and so furthereth the consumption. The air once heated (I conceive) maketh the flame burn more mildly, and so helpeth the continuance. The air, if it be dry, is indifferent: the air, if it be moist, doth in a

degree quench the flame (as we see lights will go out in the damps of mines), and howsoever maketh it burn more dully, and so helpeth the continuance.

Experiments in consort touching burials or infusions of divers bodies in earth.

376. Burials in earth serve for preservation, and for condensation, and for induration of bodies. And if you intend condensation or induration, you may bury the bodies so as earth may touch them; as if you will make artificial porcelain, &c. And the like you may do for conservation, if the bodies be hard and solid; as clay, wood, &c. But if you intend preservation of bodies more soft and tender, then you must do one of these two: either you must put them in cases, whereby they may not touch the earth; or else you must vault the earth, whereby it may hang over them and not touch them: for if the earth touch them, it will do more hurt by the moisture, causing them to putrefy, than good by the virtual cold, to conserve them; except the earth be very dry and sandy.

377. An orange, lemon, and apple, wrapt in a linen cloth, being buried for a fortnight's space four foot deep within the earth, though it were in a moist place and a rainy time, yet came forth no ways mouldy or rotten, but were become a little harder than they were; otherwise fresh in their colour; but their juice somewhat flatted. But with the burial of a fortnight more they became putrefied.

378. A bottle of beer, buried in like manner as before, became more lively, better tasted, and clearer than it was. And a bottle of wine in like manner. A bottle of vinegar so buried came forth more lively

and more odoriferous, smelling almost like a violet. And after the whole month's burial, all the three came forth as fresh and lively, if not better than before.

379. It were a profitable experiment to preserve oranges, lemons, and pomegranates, till summer; for then their price will be mightily increased. This may be done, if you put them in a pot or vessel well covered, that the moisture of the earth come not at them; or else by putting them in a conservatory of snow. And generally, whosoever will make experiments of cold, let him be provided of three things; a conservatory of snow; a good large vault, twenty foot at least under the ground; and a deep well.

380. There hath been a tradition, that pearl, and coral, and turquois-stone, that have lost their colours, may be recovered by burying in the earth; which is a thing of great profit, if it would sort: but upon trial of six weeks' burial, there followed no effect. It were good to try it in a deep well; or in a conservatory of snow, where the cold may be more constringent; and so make the body more united, and thereby more resplendent.

Experiment solitary touching the affects in men's bodies from several winds.

381. Men's bodies are heavier, and less disposed to motion, when southern winds blow than when northern. The cause is, for that when the southern winds blow, the humours do (in some degree) melt and wax fluid, and so flow into the parts; as it is seen in wood and other bodies, which, when the southern winds blow, do swell. Besides, the motion and activity of

the body consisteth chiefly in the sinews, which, when the southern wind bloweth, are more relax.[1]

Experiments solitary touching winter and summer sicknesses.

382. It is commonly seen, that more are sick in the summer, and more die in the winter; except it be in pestilent diseases, which commonly reign in summer or autumn. The reason is, because diseases are bred (indeed) chiefly by heat; but then they are cured most by sweat and purge; which in the summer cometh on or is provoked more easily. As for pestilent diseases, the reason why most die of them in summer is because they are bred most in the summer: for otherwise those that are touched are in most danger in the winter.

Experiment solitary touching pestilential seasons.

383. The general opinion is, that years hot and moist are most pestilent; upon the superficial ground that heat and moisture cause putrefaction. In England it is found not true; for many times there have been great plagues in dry years. Whereof the cause may be, for that drought, in the bodies of islanders habituate to moist airs, doth exasperate the humours, and maketh them more apt to putrefy or inflame: besides, it tainteth the waters (commonly), and maketh them less wholesome. And again in Barbary, the plagues break up in the summer months, when the weather is hot and dry.

[1] The statement in this and the next two paragraphs is from Arist. Prob. i. 21. 24. and 25.

Experiment solitary touching an error received about epidemical diseases.

384. Many diseases (both epidemical and others) break forth at particular times. And the cause is falsely imputed to the constitution of the air at that time when they break forth or reign; whereas it proceedeth (indeed) from a precedent sequence and series of the seasons of the year: and therefore Hippocrates in his prognostics doth make good observations of the diseases that ensue upon the nature of the precedent four seasons of the year.[1]

Experiment solitary touching the alteration or preservation of liquors in wells or deep vaults.

385. Trial hath been made with earthen bottles well stopped, hanged in a well of twenty fathom deep at the least; and some of the bottles have been let down into the water, some others have hanged above, within about a fathom of the water; and the liquors so tried have been beer (not new, but ready for drinking), and wine, and milk. The proof hath been, that both the beer and the wine (as well within the water as above) have not been palled or deaded at all; but as good or somewhat better than bottles of the same drinks and staleness kept in a cellar. But those which did hang above water were apparently the best; and that beer did flower a little; whereas that under water did not, though it were fresh. The milk soured and began to putrefy. Nevertheless it is true, that there is a village near Blois,[2] where in deep caves they do thicken milk,

[1] See Hippocrates, De Aëre, Aquis, et Locis.

[2] The village of St. Gervais, near Blois, still retains its reputation for

in such sort that it becometh very pleasant: which was some cause of this trial of hanging milk in the well: but our proof was naught; neither do I know whether that milk in those caves be first boiled. It were good therefore to try it with milk sodden, and with cream; for that milk of itself is such a compound body, of cream, curds, and whey, as it is easily turned and dissolved. It were good also to try the beer when it is in wort, that it may be seen whether the hanging in the well will accelerate the ripening and clarifying of it.

Experiment solitary touching stutting.[1]

386. Divers, we see, do stut. The cause may be (in most) the refrigeration of the tongue; whereby it is less apt to move. And therefore we see that naturals do generally stut: and we see that in those that stut, if they drink wine moderately, they stut less, because it heateth: and so we see, that they that stut do stut more in the first offer to speak than in continuance; because the tongue is by motion somewhat heated. In some also, it may be (though rarely) the dryness of the tongue; which likewise maketh it less apt to move as well as cold: for it is an affect that cometh to some wise and great men; as it did unto Moses, who was *linguæ præpeditæ;*[2] and many stutters (we find) are very choleric men; choler inducing a dryness in the tongue.

Experiments in consort touching smells.

387. Smells and other odours are sweeter in the air

cream, made probably in the way here described, and probably resembling what is called at Edinburgh Corstophine cream.

[1] See Arist. Prob. xi. 54.

[2] Exodus, iv. 10.

at some distance, than near the nose; as hath been partly touched heretofore. The cause is double: first, the finer mixture or incorporation of the smell: for we see that in sounds likewise, they are sweetest when we cannot hear every part by itself. The other reason is, for that all sweet smells have joined with them some earthy or crude odours; and at some distance the sweet, which is the more spiritual, is perceived, and the earthy reacheth not so far.[1]

388. Sweet smells are most forcible in dry substances when they are broken; and so likewise in oranges or lemons, the nipping off their rind giveth out their smell more: and generally when bodies are moved or stirred, though not broken, they smell more; as a sweet-bag waved. The cause is double: the one, for that there is a greater emission of the spirit when way is made; and this holdeth in the breaking, nipping, or crushing; it holdeth also (in some degree) in the moving: but in this last there is a concurrence of the second cause, which is the impulsion of the air, that bringeth the scent faster upon us.

389. The daintiest smells of flowers are out of those plants whose leaves smell not; as violets, roses, wall-flowers, gilli-flowers, pinks, woodbines, vine-flowers, apple-blooms, limetree-blooms, bean-blooms, &c. The cause is, for that where there is heat and strength enough in the plant to make the leaves odorate, there the smell of the flower is rather evanid and weaker than that of the leaves; as it is in rosemary flowers, lavender flowers, and sweet-briar roses. But where there is less heat, there the spirit of the plant is di-

[1] Arist. Prob. xii. 1. and 2.

gested and refined, and severed from the grosser juice, in the efflorescence, and not before.

390. Most odours smell best broken or crushed, as hath been said: but flowers pressed or beaten do leese the freshness and sweetness of their odour.[1] The cause is, for that when they are crushed, the grosser and more earthy spirit cometh out with the finer, and troubleth it; whereas in stronger odours there are no such degrees of the issue of the smell.

Experiments in consort touching the goodness and choice of water.

391. It is a thing of very good use to discover the goodness of waters. The taste, to those that drink water only, doth somewhat: but other experiments are more sure. First, try waters by weight; wherein you may find some difference, though not much; and the lighter you may account the better.

392. Secondly, try them by boiling upon an equal fire; and that which consumeth away fastest, you may account the best.

393. Thirdly, try them in several bottles or open vessels, matches in every thing else, and see which of them last longest without stench or corruption. And that which holdeth unputrefied longest, you may likewise account the best.

394. Fourthly, try them by making drinks stronger or smaller with the same quantity of malt; and you may conclude that that water which maketh the stronger drink is the more concocted and nourishing; though perhaps it be not so good for medicinal use. And such water (commonly) is the water of large

[1] Arist. Prob. xxxiii. 3.

and navigable rivers; and likewise in large and clean ponds of standing water; for upon both them the sun hath more power than upon fountains or small rivers. And I conceive that chalk-water is next them the best for going furthest in drink: for that also helpeth concoction; so it be out of a deep well; for then it cureth the rawness of the water; but chalky water, towards the top of the earth, is too fretting; as it appeareth in laundry of clothes, which wear out apace if you use such waters.

395. Fifthly, the housewives do find a difference in waters, for the bearing or not bearing of soap: and it is likely that the more fat water will bear soap best; for the hungry water doth kill the unctuous nature of the soap.

396. Sixthly, you may make a judgment of waters according to the place whence they spring or come: the rain-water is by the physicians esteemed the finest and the best; but yet it is said to putrefy soonest; which is likely, because of the fineness of the spirit: and in conservatories of rain-water (such as they have in Venice, &c.) they are found not so choice waters; the worse, perhaps, because they are covered aloft, and kept from the sun. Snow-water is held unwholesome; insomuch as the people that dwell at the foot of the snow-mountains, or otherwise upon the ascent, (especially the women,) by drinking of snow-water, have great bags hanging under their throats.[1]

[1] Although it is at least very doubtful if snow-water produces the enlargement of the thyroid gland here referred to, yet it is difficult not to believe that elevation above the sea is at least a predisposing cause of the disease. It is found to exist in parts of South America, in which there is no snow, although the height above the sea is much greater than that of the Swiss valleys. Boussingault has suggested a hypothesis, — namely,

Well-water, except it be upon chalk, or a very plentiful spring, maketh meat red; which is an ill sign. Springs on the tops of high hills are the best: for both they seem to have a lightness and appetite of mounting; and besides, they are most pure and unmingled; and again are more percolated through a great space of earth. For waters in valleys join in effect under ground with all waters of the same level; whereas springs on the tops of hills pass though a great deal of pure earth, with less mixture of other waters.

397. Seventhly, judgment may be made of waters by the soil whereupon the water runneth; as pebble is the cleanest and best tasted; and next to that, clay-water; and thirdly, water upon chalk; fourthly, that upon sand; and worst of all upon mud. Neither may you trust waters that taste sweet, for they are commonly found in rising grounds of great cities, which must needs take in a great deal of filth.

Experiment solitary touching the temperate heat under the equinoctial.[1]

398. In Peru, and divers parts of the West Indies, though under the line, the heats are not so intolerable as they be in Barbary, and the skirts of the torrid zone. The causes are, first, the great *brizes* which the motion of the air in great circles (such as are under the girdle of the world) produceth; which do refrigerate; and therefore in those parts noon is nothing

that the diminished quantity of air which in consequence of diminished atmospherical pressure is contained in water at high levels, may be the cause of the phenomenon.

[1] This paragraph is taken from Acosta's account of the climate of Peru, contained in the second book of his *History of the Indies*. In the *Historia Ventorum* Bacon has often quoted him.

so hot, when the brizes are great, as about nine or ten of the clock in the forenoon. Another cause is, for that the length of the night, and the dews thereof, do compense the heat of the day. A third cause is the stay of the sun; not in respect of day and night (for that we spake of before), but in respect of the season; for under the line the sun crosseth the line, and maketh two summers and two winters; but in the skirts of the torrid zone it doubleth and goeth back again, and so maketh one long summer.

Experiment solitary touching the coloration of black and tawny Moors.

399. The heat of the sun maketh men black in some countries,[1] as in Æthiopia and Ginny, &c. Fire doth it not, as we see in glass-men, that are continually about the fire. The reason may be, because fire doth lick up the spirits and blood of the body, so as they exhale; so that it ever maketh men look pale and sallow; but the sun, which is a gentler heat, doth but draw the blood to the outward parts, and rather concocteth it than soaketh[2] it; and therefore we see that all Æthiopes are fleshy and plump, and have great lips; all which betoken moisture retained, and not drawn out. We see also, that the Negroes are bred in countries that have plenty of water, by rivers or otherwise; for Meroë, which was the metropolis of Æthiopia, was upon a great lake; and Congo, where the Negroes are, is full of rivers. And the confines of the river Niger, where the Negroes also are, are well watered: and the region about Capo Verde is likewise

[1] Arist. Prob. xxxviii. 8.

[2] So in the original as in Exp. 346. and in other places. — *J. S.*

moist, insomuch as it is pestilent through moisture; but the countries of the Abyssenes, and Barbary, and Peru, where they are tawny, and olivaster, and pale, are generally more sandy and dry. As for the Æthiopes, as they are plump and fleshy, so (it may be) they are sanguine and ruddy coloured, if their black skin would suffer it to be seen.

Experiment solitary touching motion after the instant of death.

400. Some creatures do move a good while after their head is off, as birds; some a very little time, as men and all beasts; some move, though cut in several pieces, as snakes, eels, worms, flies, &c. First, therefore, it is certain, that the immediate cause of death[1] is the resolution or extinguishment of the spirits; and that the destruction or corruption of the organs is but the mediate cause. But some organs are so peremptorily necessary, that the extinguishment of the spirits doth speedily follow; but yet so as there is an interim of a small time. It is reported by one of the ancients, of credit, that a sacrificed beast hath lowed after the heart hath been severed; and it is a report also of credit, that the head of a pig hath been opened, and the brain put into the palm of a man's hand, trembling, without breaking any part of it, or severing it from the marrow of the back-bone, during which time the pig hath been, in all appearance, stark dead, and without motion; and after a small time the brain hath been replaced, and the skull of the pig closed, and the pig hath a little after gone about. And certain it is, that an eye upon revenge hath been thrust forth, so as

[1] Arist. Prob. x. 69.

it hanged a pretty distance by the visual nerve; and during that time the eye hath been without any power of sight; and yet after (being replaced) recovered sight. Now the spirits are chiefly in the head and cells of the brain, which in men and beasts are large; and therefore, when the head is off, they move little or nothing. But birds have small heads, and therefore the spirits are a little more dispersed in the sinews, whereby motion remaineth in them a little longer; insomuch as it is extant in story, that an emperor of Rome, to shew the certainty of his hand, did shoot a great forked arrow at an ostrich,[1] as she ran swiftly upon the stage, and struck off her head; and yet she continued the race a little way with her head off.[2] As for worms, and flies, and eels, the spirits are diffused almost all over; and therefore they move in their several pieces.

[1] *Estrich* in the original. — *J. S.*
[2] Herodianus, in Commodo.

NATURAL HISTORY.

CENTURY V.

Experiments in consort touching the acceleration of germination.

We will now inquire of plants or vegetables, and we shall do it with diligence. They are the principal part of the third day's work. They are the first *producat*, which is the word of animation; for the other words are but the words of essence. And they are of excellent and general use for food, medicine, and a number of medicinal arts.

401. There was sown in a bed, turnip-seed, radish-seed, wheat, cucumber-seed, and peas. The bed we call a hot-bed, and the manner of it is this: There was taken horse-dung, old and well rotted; this was laid upon a bank half a foot high, and supported round about with planks; and upon the top was cast sifted earth, some two fingers deep; and then the seed sprinkled upon it, having been steeped all night in water mixed with cow-dung. The turnip-seed and the wheat came up half an inch above ground within two days after, without any watering. The rest the third

day. The experiment was made in October; and (it may be) in the spring the accelerating would have been the speedier. This is a noble experiment; for without this help they would have been four times as long in coming up. But there doth not occur to me, at this present, any use thereof for profit; except it should be for sowing of peas, which have their price very much increased by the early coming. It may be tried also with cherries, strawberries, and other fruit, which are dearest when they come early.

402. There was wheat steeped in water mixed with cow-dung; other in water mixed with horse-dung; other in water mixed with pigeon-dung; other in urine of man; other in water mixed with chalk powdered; other in water mixed with soot; other in water mixed with ashes; other in water mixed with bay-salt; other in claret wine; other in malmsey; other in spirit of wine. The proportion of the mixture was a fourth part of the ingredients to the water; save that there was not of the salt above an eighth part. The urine, and wines, and spirit of wine, were simple without mixture of water. The time of steeping was twelve hours. The time of the year October. There was also other wheat sown unsteeped, but watered twice a day with warm water. There was also other wheat sown simple, to compare it with the rest. The event was, that those that were in the mixture of dung, and urine, and soot, chalk, ashes, and salt, came up within six days; and those that afterwards proved the highest, thickest, and most lusty, were, first the urine; and then the dungs; next the chalk; next the soot; next the ashes; next the salt; next the wheat simple of itself, unsteeped and unwatered; next the watered twice

a day with warm water, next the claret wine. So that these three last were slower than the ordinary wheat of itself; and this culture did rather retard than advance. As for those that were steeped in malmsey, and spirit of wine, they came not up at all. This is a rich experiment for profit; for the most of the steepings are cheap things; and the goodness of the crop[1] is a great matter of gain, if the goodness of the crop answer the earliness of the coming up; as it is like it will; both being from the vigour of the seed; which also partly appeared in the former experiments, as hath been said. This experiment would be tried in other grains, seeds, and kernels: for it may be some steeping will agree best with some seeds. It would be tried also with roots steeped as before, but for longer time. It would be tried also in several seasons of the year, especially the spring.

403. Strawberries watered now and then (as once in three days) with water wherein hath been steeped sheep's-dung or pigeon's-dung, will prevent and come early. And it is like the same effect would follow in other berries, herbs, flowers, grains, or trees. And therefore it is an experiment, though vulgar in strawberries, yet not brought into use generally: for it is usual to help the ground with muck; and likewise to recomfort it sometimes with muck put to the roots; but to water it with muck water, which is like to be more forcible, is not practised.

404. Dung, or chalk, or blood, applied in substance (seasonably) to the roots of trees, doth set them for-

[1] So in the original. The words *goodness of the crop* have apparently been substituted by accident for *acceleration of the growth*, or some equivalent expression; the transcriber's eye catching them from the line below. —*J S.*

wards. But to do it unto herbs, without mixture of water or earth, it may be these helps are too hot.

405. The former means of helping germination, are either by the goodness and strength of the nourishment; or by the comforting and exciting the spirits in the plant, to draw the nourishment better. And of this latter kind, concerning the comforting of the spirits of the plant, are also the experiments that follow; though they be not applications to the root or seed. The planting of trees warm upon a wall against the south or south-east sun, doth hasten their coming on and ripening; and the south-east is found to be better than the south-west, though the south-west be the hotter coast. But the cause is chiefly, for that the heat of the morning succeedeth the cold of the night: and partly, because (many times) the south-west sun is too parching. So likewise the planting of them upon the back of a chimney where a fire is kept, doth hasten their coming on and ripening; nay more, the drawing of the boughs into the inside of a room where a fire is continually kept, worketh the same effect; which hath been tried with grapes; insomuch as they will come a month earlier than the grapes abroad.

406. Besides the two means of accelerating germination formerly described; that is to say, the mending of the nourishment, and comforting of the spirit of the plant; there is a third; which is the making way for the easy coming to the nourishment and drawing it. And therefore gentle digging and loosening of the earth about the roots of trees; and the removing herbs and flowers into new earth, once in two years, (which is the same thing, for the new earth is ever looser,)

doth greatly further the prospering and earliness of plants.

407. But the most admirable acceleration by facilitating the nourishment is that of water. For a standard of a damask rose with the root on, was set in a chamber where no fire was, upright in an earthen pan full of fair water without any mixture, half a foot under the water, the standard being more than two foot high above the water: within the space of ten days the standard did put forth a fair green leaf, and some other little buds, which stood at a stay, without any shew of decay or withering, more than seven days. But afterwards that leaf faded, but the young buds did sprout on; which afterward opened into fair leaves, in the space of three months; and continued so a while after, till upon removal we left the trial. But note, that the leaves were somewhat paler and lighter-coloured than the leaves use to be abroad. Note that the first buds were in the end of October; and it is likely that if it had been in the spring time, it would have put forth with greater strength, and (it may be) to have grown on to bear flowers. By this means you may have (as it seemeth) roses set in the midst of a pool, being supported by some stay; which is matter of rareness and pleasure, though of small use. This is the more strange, for that the like rose-standard was put at the same time into water mixed with horse-dung, the horse-dung about the fourth part to the water, and in four months' space (while it was observed) put not forth any leaf, though divers buds at the first, as the other.

408. A Dutch flower, that had a bulbous root, was likewise put at the same time all under water, some

two or three fingers deep; and within seven days sprouted, and continued long after further growing. There were also put in, a beet-root, a borage root, and a radish-root, which had all their leaves cut almost close to the roots; and within six weeks had fair leaves, and so continued till the end of November.

409. Note that if roots, or peas, or flowers, may be accelerated in their coming and ripening, there is a double profit; the one in the high price that those things bear when they come early; the other in the swiftness of their returns: for in some grounds which are strong, you shall have a radish, &c., come in a month, that in other grounds will not come in two; and so make double returns.

410. Wheat also was put into the water, and came not forth at all; so as it seemeth there must be some strength and bulk in the body put into the water, as it is in roots; for grains, or seeds, the cold of the water will mortify. But casually some wheat lay under the pan, which was somewhat moistened by the suing of the pan; which in six weeks (as aforesaid) looked mouldy to the eye, but it was sprouted forth half a finger's length.

411. It seemeth by these instances of water, that for nourishment the water is almost all in all, and that the earth doth but keep the plant upright, and save it from over-heat and over-cold; and therefore is a comfortable experiment for good drinkers. It proveth also that our former opinion; that drink incorporate with flesh or roots (as in capon-beer, &c.) will nourish more easily than meat and drink taken severally.

412. The housing of plants (I conceive) will both accelerate germination, and bring forth flowers and

plants in the colder seasons: and as we house hot-country plants, as lemons, oranges, myrtles, to save them; so we may house our own country plants, to forward them, and make them come in the cold seasons; in such sort, that you may have violets, strawberries, peas, all winter; so that you sow or remove them at fit times. This experiment is to be referred unto the comforting of the spirit of the plant by warmth, as well as housing their boughs, &c. So then the means to accelerate germination are in particular eight, in general three.

Experiments in consort touching the putting back or retardation of germination.[1]

413. To make roses or other flowers come late, it is an experiment of pleasure. For the ancients esteemed much of *rosa sera.*[2] And indeed the November-rose is the sweetest, having been less exhaled by the sun. The means are these. First, the cutting off their tops immediately after they have done bearing; and then they will come again the same year about November: but they will not come just on the tops where they were cut, but out of those shoots which were (as it were) *water-boughs.* The cause is, for that the sap, which otherwise would have fed the top (though after bearing), will by the discharge of that divert unto the side-sprouts; and they will come to bear, but later.

414. The second is the pulling off the buds of the rose, when they are newly knotted; for then the side-branches will bear. The cause is the same with the

[1] Compare the precepts here given with those in Porta's *Natural Magic*, iii. 10.

[2] Horace, Odes, i. 38.

former; for cutting off the tops, and pulling off the buds, work the same effect, in retention of the sap for a time, and diversion of it to the sprouts that were not so forward.

415. The third is the cutting off some few of the top-boughs in the spring-time, but suffering the lower boughs to grow on. The cause is, for that the boughs do help to draw up the sap more strongly; and we see that in polling of trees, many do use to leave a bough or two on the top, to help to draw up the sap. And it is reported also, that if you graft upon the bough of a tree, and cut off some of the old boughs, the new scions[1] will perish.

416. The fourth is by laying the roots bare about Christmas, some days. The cause is plain, for that it doth arrest the sap from going upwards for a time; which arrest is afterwards released by the covering of the root again with earth; and then the sap getteth up, but later.

417. The fifth is the removing of the tree, some month before it buddeth. The cause is, for that some time will be required after the remove for the re-settling, before it can draw the juice; and that time being lost, the blossom must needs come forth later.

418. The sixth is the grafting of roses in May, which commonly gardeners do not till July; and then they bear not till the next year; but if you graft them in May, they will bear the same year, but late.

419. The seventh is the girding of the body of the

[1] *Cions* in the original, both here and in Exp. 421.; and so the word is spelt throughout the volume, in the singular (*a cions*) as well as in the plural. — *J. S.*

tree about with some pack-thread; for that also in a degree restraineth the sap, and maketh it come up more late and more slowly.

420. The eighth is the planting of them in a shade, or in a hedge; the cause is, partly the keeping out of the sun, which hasteneth the sap to rise; and partly the robbing of them of nourishment by the stuff in the hedge. These means may be practised upon other, both trees and flowers, *mutatis mutandis.*

421. Men have entertained a conceit that sheweth prettily; namely, that if you graft a late-coming fruit upon a stock of a fruit-tree that cometh early, the graft will bear fruit early; as a peach upon a cherry; and contrariwise, if an early coming fruit upon a stock of a fruit-tree that cometh late, the graft will bear fruit late; as a cherry upon a peach. But these are but imaginations, and untrue.[1] The cause is, for that the scion over-ruleth the stock quite, and the stock is but passive only, and giveth aliment, but no motion, to the graft.

Experiments in consort touching the melioration of fruits, trees, and plants.

We will speak now, how to make fruits, flowers, and roots larger, in more plenty, and sweeter, than they use to be; and how to make the trees themselves more tall, more spread, and more hasty and sudden, than they use to be. Wherein there is no doubt but the former experiments of acceleration will serve much to these purposes; and again, that these experiments which we shall now set down,

[1] See Porta, ubi supra.

do serve also for acceleration; because both effects proceed from the increase of vigour in the tree. But yet to avoid confusion, and because some of the means are more proper for the one effect and some for the other, we will handle them apart.

422. It is an assured experience, that an heap of flint or stone, laid about the bottom of a wild tree, (as an oak, elm, ash, &c.,) upon the first planting, doth make it prosper double as much as without it. The cause is, for that it retaineth the moisture which falleth at any time upon the tree, and suffereth it not to be exhaled by the sun. Again it keepeth the tree warm from cold blasts and frosts, as it were in an house. It may be also there is somewhat in the keeping of it steady at the first. *Quære*, If laying of straw some height about the body of a tree, will not make the tree forwards. For though the root giveth the sap, yet it is the body that draweth it. But you must note, that if you lay stones about the stalk of lettuce, or other plants that are more soft, it will over-moisten the roots, so as the worms will eat them.

423. A tree, at the first setting, should not be shaken, until it hath taken root fully: and therefore some have put two little forks about the bottom of their trees to keep them upright; but after a year's rooting, then shaking doth the tree good, by loosening of the earth, and (perhaps) by exercising, as it were, and stirring the sap of the tree.

424. Generally the cutting away of boughs and suckers at the root and body doth make trees grow high; and contrariwise, the polling and cutting of

the top maketh them grow spread and bushy: as we see in pollards, &c.

425. It is reported, that to make hasty-growing coppice woods, the way is, to take willow, sallow, poplar, alder, of some seven years' growth; and to set them, not upright but aslope, a reasonable depth under the ground; and then instead of one root they will put forth many, and so carry more shoots upon a stem.

426. When you would have many new roots of fruit-trees, take a low tree, and bow it, and lay all his branches aflat upon the ground, and cast earth upon them; and every twig will take root.[1] And this is a very profitable experiment for costly trees, (for the boughs will make stocks without charge,) such as are apricots, peaches, almonds, cornelians, mulberries, figs, &c. The like is continually practised with vines, roses, musk-roses, &c.

427. From May to July you may take off the bark of any bough, being of the bigness of three or four inches, and cover the bare place, somewhat above and below, with loam well tempered with horse-dung, binding it fast down. Then cut off the bough about Allhallontide in the bare place, and set it in the ground; and it will grow to be a fair tree in one year. The cause may be, for that the baring from the bark keepeth the sap from descending towards winter, and so holdeth it in the bough; and it may be also that the loam and horse-dung applied to the bare place do moisten it and cherish it, and make it more apt to put forth the root. Note, that this may be a general means for keeping up the sap of trees in their boughs; which may serve to other effects.

[1] Compare Xen. Œcon. xix.

428. It hath been practised in trees that show fair and bear not, to bore a hole through the heart of the tree, and thereupon it will bear. Which may be, for that the tree before hath too much repletion, and was oppressed with its own sap; for repletion is an enemy to generation.[1]

429. It hath been practised in trees that do not bear, to cleave two or three of the chief roots, and to put into the cleft a small pebble, which may keep it open, and then it will bear. The cause may be, for that a root of a tree may be (as it were) hide-bound, no less than the body of the tree; but it will not keep open without somewhat put into it.

430. It is usually practised, to set trees that require much sun upon walls against the south; as apricots, peaches, plums, vines, figs, and the like. It hath a double commodity; the one, the heat of the wall by reflexion; the other, the taking away of the shade; for when a tree groweth round, the upper boughs over-shadow the lower: but when it is spread upon a wall, the sun cometh alike upon the upper and lower branches.

431. It hath also been practised (by some) to pull off some leaves from the trees so spread, that the sun may come upon the bough and fruit the better. There hath been practised also a curiosity, to set a tree upon the north side of a wall, and at a little height to draw him through the wall, and spread him upon the south side: conceiving that the root and lower part of the stock should enjoy the freshness of the shade; and the upper boughs and fruit, the comfort of the sun. But it sorted not; the cause is, for that the root requireth

[1] For this and the next paragraph, see Porta, *Villæ*, v. 3.

some comfort from the sun, though under earth, as well as the body: and the lower part of the body more than the upper, as we see in compassing a tree below with straw.

432. The lowness of the bough where the fruit cometh, maketh the fruit greater, and to ripen better; for you shall ever see, in apricots, peaches, or melocotones,[1] upon a wall, the greatest fruits towards the bottom. And in France, the grapes that make the wine, grow upon low vines bound to small stakes; and the raised vines in arbours make but verjuice. It is true, that in Italy and other countries where they have hotter sun, they raise them upon elms and trees; but I conceive, that if the French manner of planting low were brought in use there, their wines would be stronger and sweeter. But it is more chargeable in respect of the props. It were good to try whether a tree grafted somewhat near the ground, and the lower boughs only maintained, and the higher continually pruned[2] off, would not make a larger fruit.

433. To have fruit in greater plenty, the way is to graft not only upon young stocks, but upon divers boughs of an old tree; for they will bear great numbers of fruit: whereas if you graft but upon one stock, the tree can bear but few.

434. The digging yearly about the roots of trees, which is a great means both to the acceleration and melioration of fruits, is practised in nothing but in vines; which if it were transferred unto other trees and shrubs (as roses, &c.), I conceive would advance them likewise.

[1] That is, the quince, *μῆλον κυδώνιον*.

[2] *Proined* in the original. — *J. S.*

435. It hath been known, that a fruit-tree hath been blown up almost by the roots, and set up again, and the next year bare exceedingly. The cause of this was nothing but the loosening of the earth, which conforteth any tree, and is fit to be practised more than it is in fruit-trees: for trees cannot be so fitly removed into new grounds, as flowers and herbs may.

436. To revive an old tree, the digging of it about the roots, and applying new mould to the roots, is the way. We see also that draught-oxen put into fresh pasture gather new and tender flesh; and in all things, better nourishment than hath been used doth help to renew; especially if it be not only better, but changed, and differing from the former.

437. If an herb be cut off from the roots in the beginning of winter, and then the earth be trodden and beaten down hard with the foot and spade, the roots will become of very great magnitude in summer. The reason is, for that the moisture, being forbidden to come up in the plant, stayeth longer in the root, and so dilateth it. And gardeners use to tread down any loose ground, after they have sown onions, or turnips, &c.

438. If *panicum* be laid below and about the bottom of a root, it will cause the root to grow to an excessive bigness.[1] The cause is, for that being itself of a spongy substance, it draweth the moisture of the earth to it, and so feedeth the root. This is of greatest use for onions, turnips, parsnips, and carrots.

439. The shifting of ground is a means to better the tree and fruit; but with this caution, that all things

[1] Arist. Prob. xx. 8. But Aristotle is only speaking of the root of the selinum.

do prosper best when they are advanced to the better. Your nursery of stocks ought to be in a more barren ground than the ground is whereunto you remove them. So all graziers prefer their cattle from meaner pastures to better. We see also, that hardness in youth lengtheneth life, because it leaveth a cherishing to the better of the body in age: nay, in exercises, it is good to begin with the hardest, as dancing in thick shoes, &c.

440. It hath been observed, that hacking of trees in their bark, both downright and across, so as you make them rather in slices than in continued hacks, doth great good to trees, and especially delivereth them from being hide-bound, and killeth their moss.

441. Shade to some plants conduceth to make them large and prosperous more than sun; as in strawberries and bays, &c. Therefore amongst strawberries sow here and there some borage-seed, and you shall find the strawberries under those leaves far more large than their fellows. And bays you must plant to the north, or defend them from the sun by a hedge-row; and when you sow the berries, weed not the borders for the first half year; for the weed giveth them shade.

442. To increase the crops of plants, there would be considered not only the increasing the lust of the earth or of the plant, but the saving also of that which is spilt. So they have lately made a trial to set wheat; which nevertheless hath been left off, because of the trouble and pains: yet so much is true, that there is much saved by the setting, in comparison of that which is sown, both by keeping it from being picked up by birds, and by avoiding the shallow lying of it, whereby much that is sown taketh no root.

443. It is prescribed by some of the ancients, that you take small trees, upon which figs or other fruit grow, being yet unripe, and cover the trees in the middle of autumn with dung, until the spring; and then take them up in a warm day, and replant them in good ground; and by that means the former year's tree will be ripe, as by a new birth, when other trees of the same kind do but blossom.[1] But this seemeth to have no great probability.

444. It is reported, that if you take nitre, and mingle it with water to the thickness of honey, and therewith anoint the bud after the vine is cut, it will sprout forth within eight days. The cause is like to be, (if the experiment be true,) the opening of the bud and of the parts contiguous, by the spirit of the nitre; for nitre is (as it were) the life of vegetables.

445. Take seed or kernels of apples, pears, oranges; or a peach, or a plum-stone, &c., and put them into a squill, (which is like a great onion,) and they will come up much earlier than in the earth itself. This I conceive to be as a kind of grafting in the root; for as the stock of a graft yieldeth better prepared nourishment to the graft than the crude earth, so the squill doth the like to the seed. And I suppose the same would be done by putting kernels into a turnip or the like; save that the squill is more vigorous and hot. It may be tried also with putting onion-seed into an onion-head, which thereby (perhaps) will bring forth a larger and earlier onion.

446. The pricking of a fruit in several places, when it is almost at his bigness, and before it ripeneth, hath

[1] Pliny, xv. 19. This paragraph and those which follow it, to 448. inclusive, are taken from Porta, *Nat. Mag.* iii. 8.

been practised with success, to ripen the fruit more suddenly. We see the example of the biting of wasps or worms upon fruit, whereby it manifestly ripeneth the sooner.

447. It is reported, that *alga marina* (sea-weed), put under the roots of coleworts, and (perhaps) of other plants, will further their growth. The virtue (no doubt) hath relation to salt, which is a great help to fertility.

448. It hath been practised, to cut off the stalks of cucumbers, immediately after their bearing, close by the earth; and then to cast a pretty quantity of earth upon the plant that remaineth; and they will bear the next year fruit long before the ordinary time. The cause may be, for that the sap goeth down the sooner, and is not spent in the stalk or leaf, which remaineth after the fruit. Where note, that the dying in the winter of the roots of plants that are annual, seemeth to be partly caused by the over-expence of the sap into stalk and leaves; which being prevented, they will super-annuate,[1] if they stand warm.

449. The pulling off many of the blossoms from a fruit-tree doth make the fruit fairer. The cause is manifest; for that the sap hath the less to nourish. And it is a common experience, that if you do not pull off some blossoms the first time a tree bloometh, it will blossom itself to death.

450. It were good to try what would be the effect, if all the blossoms were pulled from a fruit-tree, or the acorns and chestnut-buds, &c. from a wild tree, for two years together. I suppose that the tree will either put forth the third year bigger and more plentiful fruit; or

[1] *Super-annate* in the original. — *J. S.*

else, the same years, larger leaves, because of the sap stored up.

451. It hath been generally received, that a plant watered with warm water will come up sooner and better than with cold water or with showers.[1] But our experiment of watering wheat with warm water (as hath been said) succeeded not; which may be, because the trial was too late in the year, viz. in the end of October. For the cold then coming upon the seed, after it was made more tender by the warm water, might check it.

452. There is no doubt, but that grafting (for the most part) doth meliorate the fruit. The cause is manifest; for that the nourishment is better prepared in the stock than in the crude earth; but yet note well, that there be some trees that are said to come up more happily from the kernel than from the graft; as the peach and melocotone. The cause I suppose to be, for that those plants require a nourishment of great moisture; and though the nourishment of the stock be finer and better prepared, yet it is not so moist and plentiful as the nourishment of the earth. And indeed we see those fruits are very cold fruits in their nature.

453. It hath been received, that a smaller pear grafted upon a stock that beareth a greater pear, will become great. But I think it is as true as that of the prime-fruit upon the late stock, and *e converso;* which we rejected before; for the scions will govern. Nevertheless it is probable enough, that if you can get a scion to grow upon a stock of another kind, that is much moister than his own stock, it may make the

[1] Porta, ubi supra.

fruit greater, because it will yield more plentiful nourishment; though it is like it will make the fruit baser. But generally the grafting is upon a drier stock; as the apple upon a crab, the pear upon a thorn, &c. Yet it is reported, that in the Low Countries they will graft an apple-scion upon the stock of a colewort, and it will bear a great flaggy apple, the kernel of which, if it be set, will be a colewort, and not an apple. It were good to try whether an apple-scion will prosper, if it be grafted upon a sallow, or upon a poplar, or upon an alder, or upon an elm, or upon an horse-plum, which are the moistest of trees. I have heard that it hath been tried upon an elm, and succeeded.

454. It is manifest by experience that flowers removed wax greater, because the nourishment is more easily come by in the loose earth. It may be, that oft regrafting of the same scion may likewise make fruit greater; as if you take a scion and graft it upon a stock the first year, and then cut it off and graft it upon another stock the second year, and so for a third or fourth year, and then let it rest, it will yield afterward, when it beareth, the greater fruit.

Of grafting there are many experiments worth the noting, but those we reserve to a proper place.

455. It maketh figs better, if a fig-tree, when it beginneth to put forth leaves, have his top cut off.[1] The cause is plain, for that the sap hath the less to feed, and the less way to mount: but it may be the fig will come somewhat later, as was formerly touched. The same may be tried likewise in other trees.

[1] Porta, Nat. Mag. iii. 19. The following paragraphs, to 462. inclusive, are from the same chapter.

456. It is reported, that mulberries will be fairer, and the trees more fruitful, if you bore the trunk of the tree through in several places, and thrust into the places bored wedges of some hot trees, as turpentine, mastic-tree, guaiacum, juniper, &c. The cause may be, for that adventive heat doth cheer up the native juice of the tree.

457. It is reported, that trees will grow greater, and bear better fruit, if you put salt, or lees of wine, or blood to the root. The cause may be the increasing the lust or spirit of the root; these things being more forcible than ordinary composts.

458. It is reported by one of the ancients[1] that artichokes will be less prickly and more tender, if the seeds have their tops dulled or grated off upon a stone.

459. Herbs will be tenderer and fairer, if you take them out of beds, when they are newly come up, and remove them into pots, with better earth. The remove from bed to bed was spoken of before; but that was in several years; this is upon the sudden. The cause is the same with other removes formerly mentioned.

460. Coleworts are reported by one of the ancients to prosper exceedingly, and to be better tasted, if they be sometimes watered with salt water; and much more with water mixed with nitre;[2] the spirit of which is less adurent than salt.

461. It is reported that cucumbers will prove more tender and dainty, if their seeds be steeped a little in milk; the cause may be, for that the seed being mollified with the milk, will be too weak to draw the

[1] Varro, Geopon. xii. 39.
[2] Columella is Porta's authority for this.

grosser juice of the earth, but only the finer. The same experiments may be made in artichokes and other seeds, when you would take away either their flashiness or bitterness. They speak also, that the like effect followeth of steeping in water mixed with honey; but that seemeth to me not so probable, because honey hath too quick a spirit.

462. It is reported that cucumbers will be less watery, and more melon-like, if in the pit where you set them, you fill it (half way up) with chaff or small sticks, and then pour earth upon them: for cucumbers, as it seemeth, do extremely affect moisture, and overdrink themselves; which this chaff or chips forbiddeth. Nay, it is further reported, that if, when a cucumber is grown, you set a pot of water about five or six inches distance from it, it will in twenty-four hours shoot so much out as to touch the pot; which, if it be true, it is an experiment of an higher nature than belongeth to this title: for it discovereth perception in plants to move towards that which should help and comfort them, though it be at a distance. The ancient tradition of the vine is far more strange: it is, that if you set a stake or prop some distance from it, it will grow that way; which is far stranger (as is said) than the other; for that water may work by a sympathy of attraction; but this of the stake seemeth to be a reasonable discourse.

463. It hath been touched before, that terebration of trees doth make them prosper better. But it is found also that it maketh the fruit sweeter and better. The cause is, for that notwithstanding the terebration, they may receive aliment sufficient, and yet no more than they can well turn and digest; and withal do sweat

out the coarsest and unprofitablest juice ;[1] even as it is in living creatures, which by moderate feeding, and exercise, and sweat, attain the soundest habit of body.

464. As terebration doth meliorate fruit, so upon the like reason doth letting of plants blood ; as pricking vines or other trees, after they be of some growth ; and thereby letting forth gum or tears ; though this be not to continue, as it is in terebration, but at some seasons. And it is reported that by this artifice bitter almonds have been turned into sweet.

465. The ancients for the dulcorating of fruit do commend swine's dung above all other dung : which may be because of the moisture of that beast, whereby the excrement hath less acrimony ; for we see swine's and pig's flesh is the moistest of fleshes.

466. It is observed by some, that all herbs wax sweeter, both in smell and taste, if after they be grown up some reasonable time they be cut, and so you take the latter sprout. The cause may be, for that the longer the juice stayeth in the root and stalk, the better it concocteth. For one of the chief causes why grains, seeds, and fruits, are more nourishing than leaves, is the length of time in which they grow to maturation. It were not amiss to keep back the sap of herbs, or the like, by some fit means, till the end of summer ; whereby (it may be) they will be more nourishing.

467. As grafting doth generally advance and meliorate fruits, above that which they would be if they

[1] "Noxium desudant humorem, ut in animalibus sæpenumero perspicere licet." — Porta, *Nat. Mag.* iii. 17.

The following paragraphs, to 467. inclusive, are from the same chapter, and the next three, to 470. inclusive, from the eleventh chapter of the same book.

were set of kernels or stones, in regard the nourishment is better concocted; so (no doubt) even in grafting, for the same cause, the choice of the stock doth much; always provided that it be somewhat inferior to the scion; for otherwise it dulleth it. They commend much the grafting of pears or apples upon a quince.

468. Besides the means of melioration of fruits before mentioned, it is set down as tried, that a mixture of bran and swines-dung, or chaff and swines-dung, (especially laid up together for a month to rot) is a very great nourisher and comforter to a fruit-tree.

469. It is delivered, that onions wax greater if they be taken out of the earth, and laid a drying twenty days, and then set again; and yet more, if the outermost pill be taken off all over.

470. It is delivered by some, that if one take the bough of a low fruit-tree newly budded, and draw it gently, without hurting it, into an earthen pot perforate at the bottom to let in the plant, and then cover the pot with earth, it will yield a very large fruit within the ground. Which experiment is nothing but potting of plants without removing, and leaving the fruit in the earth. The like (they say) will be effected by an empty pot without earth in it, put over a fruit, being propped up with a stake, as it hangeth upon the tree; and the better, if some few pertusions be made in the pot. Wherein, besides the defending of the fruit from extremity of sun or weather, some give a reason, that the fruit, loving and coveting the open air and sun, is invited by those pertusions to spread and approach as near the open air as it can; and so enlargeth in magnitude.

471. All trees in high and sandy grounds, are to be

set deep; and in watery grounds, more shallow. And in all trees, when they be removed, (especially fruit-trees) care ought to be taken that the sides of the trees be coasted (north and south, &c.) as they stood before.[1] The same is said also of stone out of the quarry, to make it more durable; though that seemeth to have less reason; because the stone lieth not so near the sun, as the tree groweth.

472. Timber trees in a coppice wood do grow better than in an open field; both because they offer not to spread so much, but shoot up still in height; and chiefly because they are defended from too much sun and wind, which do check the growth of all fruit; and so (no doubt) fruit-trees, or vines, set upon a wall against the sun, between elbows or buttresses of stone, ripen more than upon a plain wall.

473. It is said, that if potado-roots be set in a pot filled with earth, and then the pot with earth be set likewise within the ground some two or three inches, the roots will grow greater than ordinary. The cause may be, for that having earth enough within the pot to nourish them, and then being stopped by the bottom of the pot from putting strings downward, they must needs grow greater in breadth and thickness. And it may be, that all seeds or roots, potted and so set into the earth, will prosper the better.

474. The cutting off the leaves of radish, or other roots, in the beginning of winter, before they wither, and covering again the root something high with earth, will preserve the root all winter, and make it bigger in the spring following, as hath been partly touched before. So that there is a double use of this cutting off

[1] Porta, Villæ, iii. 14. and 16.

the leaves; for in plants where the root is the esculent, as radish and parsnips, it will make the root the greater; and so it will do to the heads of onions. And where the fruit is the esculent, by strengthening the root, it will make the fruit also the greater.

475. It is an experiment of great pleasure, to make the leaves of shady trees larger than ordinary. It hath been tried (for certain) that a scion of a weech-elm, grafted upon the stock of an ordinary elm, will put forth leaves almost as broad as the brim of one's hat. And it is very likely, that as in fruit-trees the graft maketh a greater fruit; so in trees that bear no fruit, it will make the greater leaves. It would be tried therefore in trees of that kind chiefly, as birch, asp, willow; and especially the shining willow, which they call swallow-tail, because of the pleasure of the leaf.

476. The barrenness of trees by accident, (besides the weakness of the soil, seed, or root, and the injury of the weather,) cometh either of their over-growing with moss, or their being hide-bound, or their planting too deep, or by issuing of the sap too much into the leaves. For all these there are remedies mentioned before.

Experiments in consort touching compound fruits and flowers.

We see that in living creatures, that have male and female, there is copulation of several kinds; and so compound creatures; as the mule, that is generated betwixt the horse and the ass; and some other compounds which we call monsters, though more rare; and it is held that that proverb, *Africa* *semper aliquid monstri parit*,[1] cometh, for that the fountains of waters there being rare, divers sorts of beasts come from several parts to drink; and so being refreshed, fall to couple, and many times with several kinds. The compounding or mixture of kinds in plants is not found out; which nevertheless, if it be possible, is more at command than that of living creatures, for that their lust requireth a voluntary motion; wherefore it were one of the most noble experiments touching plants to find it out: for so you may have great variety of new fruits and flowers yet unknown. Grafting doth it not. That mendeth the fruit, or doubleth the flowers, &c., but it hath not the power to make a new kind. For the scion ever over-ruleth the stock.

477. It hath been set down by one of the ancients, that if you take two twigs of several fruit-trees, and flat them on the sides, and then bind them close together and set them in the ground, they will come up in one stock; but yet they will put forth their several fruits without any commixture in the fruit. Wherein note (by the way) that unity of continuance is easier to procure than unity of species. It is reported also that vines of red and white grapes, being set in the ground, and the upper parts being flatted and bound close together, will put forth grapes of the several colours upon the same branch, and grape-stones of several colours within the same grape; but the more after a year or two; the unity (as it seemeth) growing

[1] Erasm. Adag. iii. 7. 10.

more perfect. And this will likewise help, if from the first uniting they be often watered; for all moisture helpeth to union. And it is prescribed also to bind the bud as soon as it cometh forth, as well as the stock; at the least for a time.[1]

478. They report that divers seeds, put into a clout and laid in earth well dunged, will put up plants contiguous; which afterwards being bound in, their shoots will incorporate. The like is said of kernels put into a bottle with a narrow mouth, filled with earth.

479. It is reported that young trees of several kinds, set contiguous without any binding, and very often watered, in a fruitful ground, with the very luxury of the trees will incorporate and grow together. Which seemeth to me the likeliest means that hath been propounded; for that the binding doth hinder the natural swelling of the tree; which, while it is in motion, doth better unite.

Experiments in consort touching the sympathy and antipathy of plants.

There are many ancient and received traditions and observations touching the sympathy and antipathy of plants; for that some will thrive best growing near others; which they impute to sympathy; and some worse; which they impute to antipathy. But these are idle and ignorant conceits, and forsake the true indication of the causes; as the most part of experiments that concern sympathies and antipathies do. For as to plants, neither is there

[1] Porta, Nat. Mag. iii. 4. The next two paragraphs are from the fifth chapter.

any such secret friendship or hatred as they imagine; and if we should be content to call it sympathy and antipathy, it is utterly mistaken; for their sympathy is an antipathy, and their antipathy is a sympathy: for it is thus; Wheresoever one plant draweth such a particular juice out of the earth, as it qualifieth the earth, so as that juice which remaineth is fit for the other plant; there the neighbourhood doth good; because the nourishments are contrary or several: but where two plants draw much the same juice, there the neighbourhood hurteth; for the one deceiveth the other.[1]

480. First therefore, all plants that do draw much nourishment from the earth, and so soak[2] the earth and exhaust it, hurt all things that grow by them; as great trees, (especially ashes) and such trees as spread their roots near the top of the ground. So the colewort is not an enemy, (though that were anciently received,) to the vine only;[3] but it is an enemy to any other plant; because it draweth strongly the fattest juice of the earth. And if it be true that the vine, when it creepeth near the colewort, will turn away; this may be because there it findeth worse nourish-

[1] This explanation is proposed by Fracastorius, *De Sympathiâ et Antipathiâ*, p. 46.; and it appears the most probable that has been hitherto suggested.

[2] *Soake* in the original. The word occurs so often in a similar context, that I suppose it may be considered as another form of the word *suck*. — *J. S.*

[3] Pliny, xxiv. 1. It is probable that the colewort, like the vine, requires a large supply of potash. A similar circumstance has led to a popular saying in South America that the cocoa-nut palm likes to listen to the human voice; the truth being, that it thrives near human habitations, where the soil contains a larger proportion of soda than elsewhere.

ment; for though the root be where it was, yet (I doubt) the plant will bend as it nourisheth.

481. Where plants are of several natures, and draw several juices out of the earth, there (as hath been said) the one set by the other helpeth: as it is set down by divers of the ancients, that rue doth prosper much, and becometh stronger, if it be set by a fig-tree;[1] which (we conceive) is caused not by reason of friendship, but by extraction of a contrary juice; the one drawing juice fit to result sweet, the other bitter. So they have set down likewise, that a rose set by garlic is sweeter:[2] which likewise may be, because the more fetid juice of the earth goeth into the garlic, and the more odorate into the rose.

482. This we see manifestly, that there be certain corn-flowers which come seldom or never in other places, unless they be set, but only amongst corn: as the blue-bottle, a kind of yellow marygold, wild poppy, and fumitory. Neither can this be by reason of the culture of the ground, by ploughing or furrowing; as some herbs and flowers will grow but in ditches new cast; for if the ground lie fallow and unsown, they will not come: so as it should seem to be the corn that qualifieth the earth, and prepareth it for their growth.

483. This observation, if it holdeth, (as it is very probable,) is of great use for the meliorating of taste in fruits and esculent herbs, and of the scent of flowers. For I do not doubt, but if the fig-tree do make the rue more strong and bitter (as the ancients have noted), good store of rue planted about the fig-tree will make the fig more sweet. Now the tastes that

[1] Pliny, xix. 45. [2] Porta, Nat. Mag. iii. 16.

do most offend in fruits and herbs and roots, are bitter, harsh, sour, and waterish or flashy. It were good therefore to make the trials following.

484. Take wormwood, or rue, and set it near lettuce, or coleflory, or artichoke; and see whether the lettuce, or the coleflory, &c., become not the sweeter.

485. Take a service-tree, or a cornelian-tree, or an elder-tree, which we know have fruits of harsh and binding juice, and set them near a vine or fig-tree, and see whether the grapes or figs will not be the sweeter.

486. Take cucumbers or pumpions, and set them (here and there) amongst musk-melons, and see whether the melons will not be more winy, and better tasted. Set cucumbers likewise amongst radish, and see whether the radish will not be made the more biting.

487. Take sorrel, and set it amongst rasps, and see whether the rasps will not be the sweeter.

488. Take common briar, and set it amongst violets or wall-flowers, and see whether it will not make the violets or wall-flowers sweeter, and less earthy in their smell. So set lettuce or cucumbers amongst rosemary or bays, and see whether the rosemary or bays will not be the more odorate or aromatical.

489. Contrariwise, you must take heed how you set herbs together, that draw much the like juice. And therefore I think rosemary will leese in sweetness, if it be set with lavender or bays, or the like. But yet if you will correct the strength of an herb, you shall do well to set other like herbs by him to take him down; as if you should set tansey by angelica, it may be the angelica would be the weaker, and fitter for mixture in perfume. And if you should set rue by common

wormwood, it may be the wormwood would turn to be liker Roman wormwood.

490. This axiom is of large extent; and therefore would be severed and refined by trial. Neither must you expect to have a gross difference by this kind of culture, but only further perfection.

491. Trial would be also made in herbs poisonous and purgative, whose ill quality perhaps may be discharged or attempered, by setting stronger poisons, or purgatives, by them.

492. It is reported, that the shrub called *Our Ladies Seal* (which is a kind of briony) and coleworts, set near together, one or both will die. The cause is, for that they be both great depredators of the earth, and one of them starveth the other. The like is said of reed and a brake; both which are succulent; and therefore the one deceiveth the other. And the like of hemlock and rue; both which draw strong juices.

493. Some of the ancients, and likewise divers of the modern writers that have laboured in natural magic, have noted a sympathy between the sun, moon, and some principal stars, and certain herbs and plants.[1] And so they have denominated some herbs *solar*, and some *lunar;* and such like toys put into great words. It is manifest that there are some flowers that have respect to the sun; in two kinds; the one by opening and shutting, and the other by bowing and inclining the head. For marygolds, tulippa's, pimpernel, and indeed most flowers, do open or spread their leaves abroad when the sun shineth serene and fair: and again (in some part) close them or gather them inward, either towards night, or when the sky is over-

[1] See Porta's Phytognomica, i. 18.

cast. Of this there needeth no such solemn reason to be assigned, as to say that they rejoice at the presence of the sun, and mourn at the absence thereof. For it is nothing else but a little loading of the leaves and swelling them at the bottom with the moisture of the air; whereas the dry air doth extend them. And they make it a piece of the wonder, that garden claver[1] will hide the stalk when the sun sheweth bright; which is nothing but a full expansion of the leaves. For the bowing and inclining the head, it is found in the great flower of the sun, in marygolds, wart-wort, mallow flowers, and others. The cause is somewhat more obscure than the former; but I take it to be no other, but that the part against which the sun beateth waxeth more faint and flaccid in the stalk, and thereby less able to support the flower.

494. What a little moisture will do in vegetables, even though they be dead and severed from the earth, appeareth well in the experiment of jugglers. They take the beard of an oat; which (if you mark it well) is wreathed at the bottom, and one smooth entire straw at the top. They take only the part that is wreathed, and cut off the other, leaving the beard half the breadth of a finger in length. Then they make a little cross of a quill, long-ways of that part of the quill which hath the pith; and cross-ways of that piece of the quill without pith; the whole cross being the breadth of a finger high. Then they prick the bottom where the pith is, and thereinto they put the oaten-beard, leaving half of it sticking forth of the quill: then they take a little white box of wood, to deceive men, as if some-

[1] So in the original: "now universally written *clover* (says Johnson in voc.) though not so properly." — *J. S.*

what in the box did work the feat; in which, with a pin, they make a little hole, enough to take the beard, but not to let the cross sink down, but to stick. Then, likewise by way of imposture, they make a question; as, Who is the fairest woman in the company? or, Who hath a glove or card? and cause another to name divers persons; and upon every naming they stick the cross in the box, having first put it towards their mouth, as if they charmed it; and the cross stirreth not; but when they come to the person that they would take, as they hold the cross to their mouth, they touch the beard with the tip of their tongue and wet it; and so stick the cross in the box; and then you shall see it turn finely and softly three or four turns; which is caused by the untwining of the beard by the moisture. You may see it more evidently, if you stick the cross between your fingers instead of the box; and therefore you may see that this motion, which is effected by so little wet, is stronger than the closing or bending of the head of a marygold.

495. It is reported by some that the herb called *rosa solis*[1] (whereof they make strong waters) will at the noon-day, when the sun shineth hot and bright, have a great dew upon it; and therefore that the right name is *ros solis;* which they impute to a delight and sympathy that it hath with the sun. Men favour wonders. It were good first to be sure that the dew that is found upon it be not the dew of the morning preserved, when the dew of other herbs is breathed away; for it hath a smooth and thick leaf, that doth not discharge the dew so soon as other herbs that are more spungy and porous. And it may be purslane, or some other herb,

[1] Drosera rotundifolia. The English name is Sundew.

doth the like, and is not marked. But if it be so that it hath more dew at noon than in the morning, then sure it seemeth to be an exudation of the herb itself; as plums sweat when they are set into the oven: for you will not (I hope) think that it is like Gideon's fleece of wool, that the dew should fall upon that and no where else.

496. It is certain, that the honey-dews are found more upon oak-leaves than upon ash, or beech, or the like: but whether any cause be from the leaf itself to concoct the dew, or whether it be only that the leaf is close and smooth, (and therefore drinketh not in the dew, but preserveth it,) may be doubted. It would be well inquired, whether manna, the drug, doth fall upon certain herbs or leaves only. Flowers that have deep sockets do gather in the bottom a kind of honey, as honeysuckles, (both the woodbine and the trefoil,) lilies, and the like. And in them certainly the flower beareth part with the dew.

497. The experience is, that the froth which they call woodseare (being like a kind of spittle) is found but upon certain herbs, and those hot ones; as lavender, lavender-cotton, sage, hyssop, &c. Of the cause of this inquire further; for it seemeth a secret. There falleth also mildew upon corn, and smutteth it; but it may be that the same falleth also upon other herbs, and is not observed.

498. It were good trial were made, whether the great consent between plants and water, which is a principal nourishment of them, will make an attraction at[1] distance, and not at touch only. Therefore take a vessel, and in the middle of it make a false bottom of

[1] *Or* in the original. — *J. S.*

coarse canvas: fill it with earth above the canvas, and let not the earth be watered; then sow some good seeds in that earth; but under the canvas, some half a foot in the bottom of the vessel, lay a great spunge thoroughly wet in water; and let it lie so some ten days; and see whether the seeds will sprout, and the earth become more moist, and the spunge more dry. The experiment formerly mentioned of the cucumber creeping to the pot of water, is far stranger than this.

Experiments in consort touching the making herbs and fruits medicinable.

499. The altering of the scent, colour, or taste of fruit, by infusing, mixing, or letting into the bark or root of the tree, herb, or flower, any coloured, aromatical, or medicinal substance, are but fancies. The cause is, for that those things have passed their period, and nourish not. And all alteration of vegetables in those qualities must be by somewhat that is apt to go into the nourishment of the plant. But this is true, that where kine feed upon wild garlic, their milk tasteth plainly of the garlic; and the flesh of muttons is better tasted where the sheep feed upon wild thyme, and other wholesome herbs. Galen also speaketh of the curing of the *scirrus* of the liver, by milk of a cow that feedeth but upon certain herbs;[1] and honey in Spain smelleth (apparently) of the rosemary, or orange, from whence the bee gathereth it: and there is an old tradition of a maiden that was fed with *napellus*

[1] Galen in several places speaks of the medicinal qualities which milk may derive from the herbs on which the cow has fed, but I have not found the passage to which Bacon appears to refer.

(which is counted the strongest poison of all vegetables) which with use did not hurt the maid, but poisoned some that had carnal company with her.[1] So it is observed by some, that there is a virtuous bezoar, and another without virtue, which appear to the show alike: but the virtuous is taken from the beast that feedeth upon the mountains, where there are theriacal herbs, and that without virtue, from those that feed in the vallies where no such herbs are. Thus far I am of opinion: that as steeped wines and beers are very medicinal; and likewise bread tempered with divers powders; so of meat also (as flesh, fish, milk, and eggs), that they may be made of great use for medicine and diet, if the beasts, fowl, or fish, be fed with a special kind of food fit for the disease. It were a dangerous thing also for secret empoisonments. But whether it may be applied unto plants and herbs, I doubt more; because the nourishment of them is a more common juice; which is hardly capable of any special quality, until the plant do assimilate it.

500. But lest our incredulity may prejudice any profitable operations in this kind, (especially since many of the ancients have set them down,) we think good briefly to propound the four means which they have devised of making plants medicinable.[2] The first is by slitting of the root, and infusing into it the medicine; as hellebore, opium, scammony, treacle, &c., and then binding it up again. This seemeth to me the least probable; because the root draweth immediately

[1] See for this story Mercurialis "De venenis et morbis venenosis;" who refers to Avicenna "De viribus cordis, i. 10." It occurs in the *Gesta Romanorum;* and Warton in his note refers for it to the 28th chapter of the *Secreta Secretorum*, a treatise ascribed in the middle ages to Aristotle.

[2] All these methods are mentioned by Porta, *Nat. Mag.* iii. 20.

from the earth; and so the nourishment is the more common and less qualified: and besides, it is a long time in going up ere it come to the fruit. The second way is, to perforate the body of the tree, and there to infuse the medicine; which is somewhat better: for if any virtue be received from the medicine, it hath the less way, and the less time, to go up. The third is, the steeping of the seed or kernel in some liquor wherein the medicine is infused: which I have little opinion of, because the seed (I doubt) will not draw the parts of the matter which have the propriety: but it will be far the more likely if you mingle the medicine with dung; for that the seed naturally drawing the moisture of the dung, may call in withal some of the propriety. The fourth is, the watering of the plant oft with an infusion of the medicine. This, in one respect, may have more force than the rest; because the medication is oft renewed; whereas the rest are applied but at one time; and therefore the virtue may the sooner vanish. But still I doubt that the root is somewhat too stubborn to receive those fine impressions; and besides (as I have said before) they have a great hill to go up. I judge therefore the likeliest way to be the perforation of the body of the tree in several places, one above the other; and the filling of the holes with dung mingled with the medicine; and the watering of those lumps of dung with squirts of an infusion of the medicine in dunged water, once in three or four days.

NATURAL HISTORY.

CENTURY VI.

Experiments in consort touching curiosities about fruits and plants.

Our experiments we take care to be (as we have often said) either *experimenta fructifera* or *lucifera;* either of use or of discovery: for we hate impostures, and despise curiosities. Yet because we must apply ourselves somewhat to others, we will set down some curiosities touching plants.

501. It is a curiosity to have several fruits upon one tree;[1] and the more, when some of them come early, and some come late; so that you may have upon the same tree ripe fruits all summer. This is easily done by grafting of several scions upon several boughs of a stock, in a good ground, plentifully fed. So you may have all kinds of cherries, and all kinds of plums, and peaches, and apricots, upon one tree; but I conceive the diversity of fruits must be such as will graft upon the same stock. And therefore I doubt whether you can have apples, or pears,

[1] Porta, Nat. Mag. iii. 19.

or oranges, upon the same stock upon which you graft plums.

502. It is a curiosity to have fruits of divers shapes and figures.[1] This is easily performed, by moulding them when the fruit is young, with moulds of earth or wood. So you may have cucumbers, &c., as long as a cane; or as round as a sphere; or formed like a cross. You may have also apples in the form of pears or lemons. You may have also fruit in more accurate figures, as we said of men, beasts, or birds, according as you make the moulds. Wherein you must understand, that you make the mould big enough to contain the whole fruit when it is grown to the greatest: for else you will choke the spreading of the fruit; which otherwise would spread itself, and fill the concave, and so be turned into the shape desired; as it is in mould-works of liquid things. Some doubt may be conceived, that the keeping of the sun from the fruit may hurt it: but there is ordinary experience of fruit that groweth covered. *Quære* also, whether some small holes may not be made in the wood to let in the sun. And note, that it were best to make the moulds partible, glued or cemented together, that you may open them when you take out the fruit.

503. It is a curiosity to have inscriptions or engravings in fruit or trees. This is easily performed, by writing with a needle, or bodkin, or knife, or the like, when the fruit or trees are young; for as they grow, so the letters will grow more large and graphical.

Tenerisque meos incidere amores
Arboribus; crescent illæ, crescetis amores.[2]

[1] See Porta, iii. 18.; from whom the substance of this and the next two paragraphs is taken.

[2] Ecl. x. 53.

504. You may have trees apparelled with flowers or herbs, by boring holes in the bodies of them, and putting into them earth holpen with muck, and setting seeds, or slips, of violets, strawberries, wild thyme, camomile, and such like, in the earth. Wherein they do but grow in the tree as they do in pots; though (perhaps) with some feeding from the trees. It would be tried also with shoots of vines, and roots of red roses; for it may be they being of a more ligneous nature, will incorporate with the tree itself.

505. It is an ordinary curiosity to form trees and shrubs (as rosemary, juniper, and the like,) into sundry shapes; which is done by moulding them within, and cutting them without. But they are but lame things, being too small to keep figure. Great castles made of trees upon frames of timber, with turrets and arches, were anciently matters of magnificence.

506. Amongst curiosities I shall place coloration, though it be somewhat better; for beauty in flowers is their pre-eminence. It is observed by some, that gilly-flowers, sweet-williams, violets, that are coloured, if they be neglected, and neither watered, nor new moulded, nor transplanted, will turn white.[1] And it is probable that the white with much culture may turn coloured. For this is certain, that the white colour cometh of scarcity of nourishment; except in flowers that are only white, and admit no other colours.

507. It is good therefore to see what natures do accompany what colours; for by that you shall have light how to induce colours, by producing those natures. Whites are more inodorate (for the most part) than flowers of the same kind coloured; as is found in

[1] Porta, Nat. Mag. iii. 15., on the authority of Theophrastus.

single white violets, white roses, white gilly-flowers, white stock-gilly-flowers, &c. We find also that blossoms of trees, that are white, are commonly inodorate; as cherries, pears, plums; whereas those of apples, crabs, almonds, and peaches, are blushy, and smell sweet. The cause is, for that the substance that maketh the flower is of the thinnest and finest of the plant; which also maketh flowers to be of so dainty colours. And if it be too sparing and thin, it attaineth no strength of odour; except it be in such plants as are very succulent; whereby they need rather to be scanted in their nourishment than replenished, to have them sweet. As we see in white satyrion, which is of a dainty smell; and in bean-flowers, &c. And again, if the plant be of nature to put forth white flowers only, and those not thin or dry, they are commonly of rank and fulsome smell; as may-flowers, and white lilies.

508. Contrariwise, in berries the white is commonly more delicate and sweet in taste than the coloured; as we see in white grapes, in white rasps, in white strawberries, in white currants, &c. The cause is, for that the coloured are more juiced, and coarser juiced; and therefore not so well and equally concocted; but the white are better proportioned to the digestion of the plant.

509. But in fruits the white commonly is meaner; as in pear-plums, damascenes, &c. And the choicest plums are black. The mulberry (which though they call it a berry, is a fruit,) is better the black than the white. The harvest white-plum is a base plum; and the verdoccio; and white date-plum, are no very good plums. The cause is, for that they are all over-watery: whereas an higher concoction is required for

sweetness, or pleasure of taste; and therefore all your dainty plums are a little dry, and come from the stone; as the muscle-plum, the damascene-plum, the peach, the apricot, &c. Yet some fruits, which grow not to be black, are of the nature of berries, sweetest such as are paler; as the cœur-cherry, which inclineth more to white, is sweeter than the red; but the egriot is more sour.

510. Take gilly-flower seed, of one kind of gilly-flower, (as of the clove-gilly-flower, which is the most common,) and sow it; and there will come up gilly-flowers, some of one colour, and some of another, casually, as the seed meeteth with nourishment in the earth; so that the gardeners find that they may have two or three roots amongst an hundred that are rare and of great price; as purple, carnation of several stripes: the cause is (no doubt) that in earth, though it be contiguous and in one bed, there are very several juices; and as the seed doth casually meet with them, so it cometh forth. And it is noted especially that those which do come up purple, do always come up single: the juice, as it seemeth, not being able to suffice a succulent colour and a double leaf. This experiment of several colours coming up from one seed, would be tried also in larks-foot, monks-hood, poppy, and holly-oak.

511. Few fruits are coloured red within: the queen-apple is; and another apple, called the rose-apple: mulberries likewise; and grapes, though most toward the skin. There is a peach also that hath a circle of red towards the stone: and the egriot cherry is somewhat red within; but no pear, nor warden, nor plum, nor apricot, although they have many times red

sides, are coloured red within. The cause may be inquired.

512. The general colour of plants is green, which is a colour that no flower is of. There is a greenish primrose, but it is pale, and scarce a green. The leaves of some trees turn a little murry or reddish, and they be commonly young leaves that do so; as it is in oaks, and vines, and hazle. Leaves rot into a yellow, and some hollies have part of their leaves yellow, that are, to all seeming, as fresh and shining as the green. I suppose also, that yellow is a less succulent colour than green, and a degree nearer white. For it hath been noted that those yellow leaves of holly stand ever towards the north or north-east. Some roots are yellow, as carrots; and some plants blood-red, stalk and leaf and all; as amaranthus. Some herb incline to purple and red; as a kind of sage doth, and a kind of mint, and rosa solis, &c. And some have white leaves, as another kind of sage, and another kind of mint; but azure and a fair purple are never found in leaves. This sheweth that flowers are made of a refined juice of the earth, and so are fruits; but leaves of a more coarse and common.

513. It is a curiosity also to make flowers double; which is effected by often removing them into new earth: as, on the contrary part, double flowers, by neglecting and not removing, prove single. And the way to do it speedily, is to sow or set seeds or slips of flowers; and as soon as they come up, to remove them into new ground that is good. Inquire also, whether inoculating of flowers, (as stock-gilly-flowers, roses, musk-roses, &c.,) doth not make them double. There is a cherry-tree that hath double blossoms; but that

tree beareth no fruit: and it may be, that the same means which, applied to the tree, doth extremely accelerate the sap to rise and break forth, would make the tree spend itself in flowers, and those to become double: which were a great pleasure to see, especially in apple-trees, peach-trees, and almond-trees, that have blossoms blush-coloured.

514. The making of fruits without core or stone, is likewise a curiosity; and somewhat better; because whatsoever maketh them so, is like to make them more tender and delicate. If a scion or shoot, fit to be set in the ground, have the pith finely taken forth (and not altogether, but some of it left, the better to save the life), it will bear a fruit with little or no core or stone. And the like is said to be of dividing a quick-tree down to the ground, and taking out the pith, and then binding it up again.[1]

515. It is reported also, that a citron grafted upon a quince will have small or no seeds; and it is very probable that any sour fruit grafted upon a stock that beareth a sweeter fruit, may both make the fruit sweeter, and more void of the harsh matter of kernels or seeds.

516. It is reported, that not only the taking out of the pith, but the stopping of the juice of the pith from rising in the midst, and turning it to rise on the outside, will make the fruit without core or stone; as if you should bore a tree clean through, and put a wedge in. It is true, there is some affinity between the pith and the kernel, because they are both of a harsh substance, and both placed in the midst.

[1] This and the succeeding paragraphs, to 517. inclusive, are from Porta, *Nat. Mag.* iii. 12.

517. It is reported, that trees watered perpetually with warm water, will make a fruit with little or no core or stone. And the rule is general, that whatsoever will make a wild tree a garden tree, will make a garden tree to have less core or stone.

Experiments in consort touching the degenerating of plants; and of the transmutation of them one into another.[1]

518. The rule is certain, that plants for want of culture degenerate to be baser in the same kind; and sometimes so far as to change into another kind. 1. The standing long, and not being removed, maketh them degenerate. 2. Drought, unless the earth of itself be moist, doth the like. 3. So doth removing into worse earth, or forbearing to compost the earth; as we see that water-mint turneth into field-mint, and the colewort into rape, by neglect, &c.

519. Whatsoever fruit useth to be set upon a root or a slip, if it be sown will degenerate. Grapes sown; figs, almonds, pomegranate kernels sown; make the fruits degenerate and become wild. And again, most of those fruits that use to be grafted, if they be set of kernels or stones, degenerate. It is true that peaches, (as hath been touched before,) do better upon stones set than upon grafting; and the rule of exception should seem to be this: that whatsoever plant requireth much moisture, prospereth better upon the stone or kernel, than upon the graft. For the stock, though it giveth a finer nourishment, yet it giveth a scanter, than the earth at large.

520. Seeds, if they be very old, and yet have

[1] See Porta, Nat. Mag. iii. 2.

strength enough to bring forth a plant, make the plant degenerate. And therefore skilful gardeners make trial of the seeds before they buy them, whether they be good or no, by putting them in water gently boiled; and if they be good, they will sprout within half an hour.

521. It is strange which is reported, that basil too much exposed to the sun doth turn into wild thyme;[1] although those two herbs seem to have small affinity; but basil is almost the only hot herb that hath fat and succulent leaves; which oiliness if it be drawn forth by the sun, it is like it will make a very great change.

522. There is an old tradition, that boughs of oak put into the earth will put forth wild vines:[2] which if it be true, no doubt it is not the oak that turneth into a vine, but the oak-bough putrefying qualifieth the earth to put forth a vine of itself.

523. It is not impossible, and I have heard it verified, that upon cutting down of an old timber tree, the stub hath put out sometimes a tree of another kind; as that beech hath put forth birch; which, if it be true, the cause may be, for that the old stub is too scant of juice to put forth the former tree; and therefore putteth forth a tree of smaller kind, that needeth less nourishment.

524. There is an opinion in the country, that if the same ground be oft sown with the grain that grew upon it, it will in the end grow to be of a baser kind.

525. It is certain, that in very sterile years corn sown will grow to another kind.

[1] The original authority for this is Palladius, *Apr.* iii.

[2] Porta gives this on the authority of Albertus Magnus.

Grandia sæpe quibus mandavimus hordea sulcis,
Infelix lolium et steriles dominantur avenæ.[1]

And generally it is a rule, that plants that are brought forth by culture, as corn, will sooner change into other species than those that come of themselves; for that culture giveth but an adventitious nature, which is more easily put off.

This work of the transmutation of plants one into another, is *inter magnalia naturæ:* for the transmutation of species is, in the vulgar philosophy, pronounced impossible; and certainly it is a thing of difficulty, and requireth deep search into nature; but seeing there appear some manifest instances of it, the opinion of impossibility is to be rejected, and the means thereof to be found out. We see that in living creatures that come of putrefaction, there is much transmutation of one into another; as caterpillars turn into flies, &c. And it should seem probable that whatsoever creature, having life, is generated without seed, that creature will change out of one species into another. For it is the seed, and the nature of it, which locketh and boundeth in the creature, that it doth not expatiate. So as we may well conclude, that seeing the earth of itself doth put forth plants without seed, therefore plants may well have a transmigration of species. Wherefore, wanting instances which do occur, we shall give directions of the

[1] Virg. Georg. i. 154.

most likely trials; and generally, we would not have those that read this our work of *Sylva Sylvarum* account it strange, or think that it is an over-haste, that we have set down particulars untried; for contrariwise, in our own estimation, we account such particulars more worthy than those that are already tried and known; for these latter must be taken as you find them; but the other do level point-blank at the inventing of causes and axioms.

526. First therefore, you must make account, that if you will have one plant change into another, you must have the nourishment over-rule the seed; and therefore you are to practise it by nourishments as contrary as may be to the nature of the herb; so nevertheless as the herb may grow; and likewise with seeds that are of the weakest sort, and have least vigour. You shall do well, therefore, to take marsh-herbs, and plant them on tops of hills and champaigns; and such plants as require much moisture, upon sandy and very dry grounds. As for example, marsh-mallows and sedge, upon hills; cucumber, and lettuce-seeds, and coleworts, upon a sandy plot; so contrariwise, plant bushes, heath, ling, and brakes, upon a wet or marsh ground. This I conceive also, that all esculent and garden herbs, set upon the tops of hills, will prove more medicinal, though less esculent than they were before. And it may be likewise, some wild herbs you may make sallet herbs. This is the first rule for transmutation of plants.

527. The second rule shall be, to bury some few

seeds of the herb you would change amongst other seeds; and then you shall see whether the juice of those other seeds do not so qualify the earth, as it will alter the seed whereupon you work. As for example, put parsley-seed amongst onion-seed, or lettuce-seed amongst parsley-seed, or basil-seed amongst thyme-seed; and see the change of taste or otherwise. But you shall do well to put the seed you would change into a little linen cloth, that it mingle not with the foreign seed.

528. The third rule shall be, the making of some medley or mixture of earth with some other plants bruised or shaved, either in leaf or root; as for example, make earth with a mixture of colewort leaves stamped, and set in it artichokes or parsnips: so take earth made with marjoram, or origanum, or wild thyme, bruised or stamped, and set in it fennel-seed, &c. In which operation the process of nature still will be (as I conceive), not that the herb you work upon should draw the juice of the foreign herb (for that opinion we have formerly rejected), but there will be a new confection of mould, which perhaps will alter the seed, and yet not to the kind of the former herb.

529. The fourth rule shall be, to mark what herbs some earths do put forth of themselves; and to take that earth and to pot it, or to vessel it; and in that to set the seed you would change: as for example, take from under walls or the like where nettles put forth in abundance, the earth which you shall there find, without any string or root of the nettles; and pot that earth, and set in it stock-gilly-flowers, or wall-flowers, &c.; or sow in the seeds of them; and see what the

event will be. Or take earth that you have prepared to put forth mushrooms of itself, (whereof you shall find some instances following,) and sow in it purslane-seed, or lettuce-seed; for in these experiments, it is likely enough that the earth being accustomed to send forth one kind of nourishment, will alter the new seed.

530. The fifth rule shall be, to make the herb grow contrary to his nature; as to make ground-herbs rise in height: as for example, carry camomile, or wild thyme, or the green strawberry, upon sticks, as you do hops upon poles; and see what the event will be.

531. The sixth rule shall be, to make plants grow out of the sun or open air; for that is a great mutation in nature, and may induce a change in the seed; as barrel up earth, and sow some seed in it, and put it in the bottom of a pond, or put it in some great hollow tree: try also the sowing of seeds in the bottoms of caves; and pots with seeds sown, hanged up in wells some distance from the water; and see what the event will be.

Experiments in consort touching the procerity and lowness and artificial dwarfing of trees.

532. It is certain that timber-trees in coppice-woods grow more upright, and more free from under-boughs, than those that stand in the fields: the cause whereof is, for that plants have a natural motion to get to the sun; and besides, they are not glutted with too much nourishment; for that the coppice shareth with them; and repletion ever hindereth stature: lastly, they are kept warm; and that ever in plants helpeth mounting.

533. Trees that are of themselves full of heat, (which heat appeareth by their inflammable gums,) as firs and pines, mount of themselves in height without side-boughs, till they come towards the top. The cause is partly heat, and partly tenuity of juice, both which send the sap upwards. As for juniper, it is but a shrub, and groweth not big enough in body to maintain a tall tree.

534. It is reported that a good strong canvas, spread over a tree grafted low, soon after it putteth forth, will dwarf it, and make it spread. The cause is plain; for that all things that grow, will grow as they find room.

535. Trees are generally set of roots or kernels; but if you set them of slips, (as of some trees you may, by name the mulberry,) some of the slips will take; and those that take (as is reported) will be dwarf trees. The cause is, for that a slip draweth nourishment more weakly than either a root or kernel.

536. All plants that put forth their sap hastily, have their bodies not proportionable to their length; and therefore they are winders and creepers; as ivy, briony, hops, woodbine; whereas dwarfing requireth a slow putting forth, and less vigour of mounting.

Experiments in consort touching the rudiments of plants; and of the excrescences of plants, or super-plants.

The Scripture saith that Salomon wrote a Natural History, from the cedar of Libanus, to the moss growing upon the wall; for so the best translations have it. And it is true that moss is but the rudiment of a plant; and (as it were) the mould of earth or bark.

537. Moss groweth chiefly upon ridges of houses tiled or thatched, and upon the crests of walls; and that moss is of a lightsome and pleasant green. The growing upon slopes is caused, for that moss, as on the one side it cometh of moisture and water, so on the other side the water must but slide, and not stand or pool. And the growing upon tiles, or walls, &c., is caused, for that those dried earths, having not moisture sufficient to put forth a plant, do practise germination by putting forth moss; though when by age, or otherwise, they grow to relent and resolve, they sometimes put forth plants; as wall-flowers. And almost all moss hath here and there little stalks, besides the low thrum.

538. Moss groweth upon alleys, especially such as lie cold and upon the north; as in divers terraces: and again, if they be much trodden; or if they were at the first gravelled; for wheresoever plants are kept down, the earth putteth forth moss.

539. Old ground, that hath been long unbroken up, gathereth moss; and therefore husbandmen use to cure their pasture grounds when they grow to moss, by tilling them for a year or two: which also dependeth upon the same cause; for that the more sparing and starving juice of the earth, insufficient for plants, doth breed moss.

540. Old trees are more mossy far than young; for that the sap is not so frank as to rise all to the boughs, but tireth by the way, and putteth out moss.

541. Fountains have moss growing upon the ground about them;

Muscosi fontes;[1]

The cause is, for that the fountains drain the water from the ground adjacent, and leave but sufficient moisture to breed moss: and besides, the coldness of the water conduceth to the same.

542. The moss of trees is a kind of hair; for it is the juice of the tree that is excerned, and doth not assimilate. And upon great trees the moss gathereth a figure, like a leaf.

543. The moister sort of trees yield little moss; as we see in asps, poplars, willows, beeches, &c.; which is partly caused for the reason that hath been given, of the frank putting up of the sap into the boughs; and partly for that the barks of those trees are more close and smooth than those of oaks and ashes; whereby the moss can the hardlier issue out.

544. In clay-grounds all fruit-trees grow full of moss, both upon body and boughs; which is caused partly by the coldness of the ground, whereby the plants nourish less; and partly by the toughness of the earth, whereby the sap is shut in, and cannot get up to spread so frankly as it should do.

545. We have said heretofore, that if trees be hidebound, they wax less fruitful, and gather moss; and that they are holpen by hacking, &c. And, therefore, by the reason of contraries, if trees be bound in with cords or some outward bands, they will put forth more moss: which, I think, happeneth to trees that stand bleak, and upon the cold winds. It would also be tried, whether, if you cover a tree somewhat thick upon the

[1] Virg. Ecl. vii. 45.

top after his polling, it will not gather more moss. I think also the watering of trees with cold fountain-water, will make them grow full of moss.

546. There is a moss the perfumers have, which cometh out of apple trees, that hath an excellent scent. *Quœre* particularly for the manner of the growth, and the nature of it. And for this experiment's sake, being a thing of price, I have set down the last experiments, how to multiply and call on mosses.

Next unto moss, I will speak of mushrooms; which are likewise an imperfect plant. The mushrooms have two strange properties; the one, that they yield so delicious a meat; the other, that they come up so hastily, as in a night; and yet they are unsown. And therefore such as are upstarts in state, they call in reproach mushrooms. It must needs be therefore, that they be made of much moisture; and that moisture fat, gross, and yet somewhat concocted. And indeed, we find that mushrooms cause the accident, which we call *incubus* or the mare, in the stomach. And therefore the surfeit of them may suffocate and empoison. And this sheweth that they are windy; and that windiness is gross and swelling, not sharp or griping. And upon the same reason mushrooms are a venereous meat.

547. It is reported, that the bark of white or red poplar, (which are of the moistest of trees), cut

small, and cast into furrows well dunged, will cause the ground to put forth mushrooms at all seasons of the year, fit to be eaten. Some add to the mixture leaven of bread, resolved in water.[1]

548. It is reported that if a hilly field, where the stubble is standing, be set on fire in the showery season, it will put forth great store of mushrooms.

549. It is reported that hartshorn, shaven or in small pieces, mixed with dung and watered, putteth up mushrooms. And we know that hartshorn is of a fat and clammy substance: and it may be ox-horn would do the like.

550. It hath been reported, though it be scarce credible, that ivy hath grown out of a stag's horn;[2] which they suppose did rather come from a confrication of the horn upon the ivy, than from the horn itself. There is not known any substance but earth, and the procedures of earth, (as tile, stone, &c.) that yieldeth any moss or herby substance. There may be trial made of some seeds, as that of fennel-seed, mustard-seed, and rape-seed, put into some little holes made in the horns of stags or oxen, to see if they will grow.

551. There is also another unperfect plant, that (in shew) is like a great mushroom; and it is sometimes as broad as one's hat; which they call a toad's-stool: but it is not esculent; and it groweth (commonly) by a dead stub of a tree; and likewise about the roots of rotten trees: and therefore seemeth to take his juice from wood putrefied. Which sheweth,

[1] Porta, Nat. Mag. iii. 1. From the same chapter are taken 548. and 550. and probably, though with some discrepancy, 549. also.

[2] Arist. Mirab. 5.

by the way, that wood putrefied yieldeth a frank moisture.

552. There is a cake that groweth upon the side of a dead tree, that hath gotten no name, but it is large, and of a chesnut colour, and hard and pithy; whereby it should seem, that even dead trees forget not their putting forth; no more than the carcasses of men's bodies, that put forth hair and nails for a time.

553. There is a cod, or bag, that groweth commonly in the fields; that at first is hard like a tennis-ball, and white; and after groweth of a mushroom colour, and full of light dust upon the breaking; and is thought to be dangerous for the eyes if the powder get into them; and to be good for kibes. Belike it hath a corrosive and fretting nature.

554. There is an herb called Jew's ear, that groweth upon the roots and lower parts of the bodies of trees; especially of elders, and sometimes ashes. It hath a strange property; for in warm water it swelleth, and openeth extremely. It is not green, but of a dusky brown colour. And it is used for squinancies and inflammations in the throat; whereby it seemeth to have a mollifying and lenifying virtue.

555. There is a kind of spungy excrescence, which groweth chiefly upon the roots of the laser-tree; and sometimes upon cedar and other trees. It is very white, and light, and friable; which we call agaric. It is famous in physic for the purging of tough phlegm. And it is also an excellent opener for the liver; but offensive to the stomach: and in taste, it is at the first sweet, and after bitter.

556. We find no super-plant that is a formed plant,

but misseltoe.[1] They have an idle tradition that there is a bird called a missel-bird, that feedeth upon a seed, which many times she cannot digest, and so expelleth it whole with her excrement: which falling upon the bough of a tree that hath some rift, putteth forth misseltoe. But this is a fable: for it is not probable that birds should feed upon that they cannot digest. But allow that, yet it cannot be for other reasons: for first, it is found but upon certain trees; and those trees bear no such fruit as may allure that bird to sit and feed upon them. It may be that bird feedeth upon the misseltoe-berries, and so is often found there; which may have given occasion to the tale. But that which maketh an end of the question is, that misseltoe hath been found to put forth under the boughs, and not only above the boughs; so it cannot be anything that falleth upon the bough. Misseltoe groweth chiefly upon crab-trees, apple-trees, sometimes upon hazles; and rarely upon oaks; the misseltoe whereof is counted very medicinal. It is ever green, winter and summer; and beareth a white glistering berry: and it is a plant utterly differing from the plant upon which it groweth. Two things therefore may be certainly set down: first, that superfœtation must be by abundance of sap in the bough that putteth it forth: secondly, that that sap must be such as the tree doth excern, and cannot

[1] We are now acquainted with many plants besides the misseltoe which are strictly parasitic, and yet what Bacon here calls perfect — that is, apparently, phanerogamous. I am not aware whether Decandolle's experiments with regard to the influence of the leaves of the misseltoe on the ascent of sap in the parent branch have been repeated, or extended to any other parasite.

The tradition that the misseltoe was condemned to become a parasite in consequence of having furnished the wood of the True Cross, is one of the most remarkable of the superstitions of which it is the subject.

assimilate; for else it would go into a bough; and besides, it seemeth to be more fat and unctuous than the ordinary sap of the tree; both by the berry, which is clammy; and by that it continueth green winter and summer, which the tree doth not.

557. This experiment of misseltoe may give light to other practices. Therefore trial would be made by ripping of the bough of a crab-tree in the bark, and watering of the wound every day with warm water dunged, to see if it would bring forth misseltoe, or any such like thing. But it were yet more likely to try it with some other watering or anointing, that were not so natural to the tree as water is; as oil, or barm of drink, &c.; so they be such things as kill not the bough.

558. It were good to try what plants would put forth, if they be forbidden to put forth their natural boughs. Poll therefore a tree, and cover it some thickness with clay on the top, and see what it will put forth. I suppose it will put forth roots; for so will a scion, being turned down into clay: therefore in this experiment also, the tree would be closed with somewhat that is not so natural to the plant as clay is. Try it with leather, or cloth, or painting, so it be not hurtful to the tree. And it is certain that a brake hath been known to grow out of a pollard.

559. A man may count the prickles of trees to be a kind of excrescence; for they will never be boughs, nor bear leaves. The plants that have prickles are, thorns, black and white, briar, rose, lemon-trees, crab-trees, gooseberry, berberry; these have it in the bough: the plants that have prickles in the leaf are, holly, juniper, whin-bush, thistle; nettles also have a

small venomous prickle; so hath borage, but harmless. The cause must be, hasty putting forth, want of moisture, and the closeness of the bark; for the haste of the spirit to put forth, and the want of nourishment to put forth a bough, and the closeness of the bark, cause prickles in boughs; and therefore they are ever like a pyramis, for that the moisture spendeth after a little putting forth. And for prickles in leaves, they come also of putting forth more juice into the leaf than can spread in the leaf smooth; and therefore the leaves otherwise are rough, as borage and nettles are. As for the leaves of holly, they are smooth, but never plain, but as it were with folds, for the same cause.

560. There be also plants, that though they have no prickles, yet they have a kind of downy or velvet rine upon their leaves; as rose-campion, stock-gilly-flowers, colt's-foot; which down or nap cometh of a subtile spirit, in a soft or fat substance. For it is certain that both stock-gilly-flowers and rose-campions, stamped, have been applied with success to the wrists of those that have had tertian or quartan agues; and the vapour of colt's-foot hath a sanative virtue towards the lungs; and the leaf also is healing in surgery.

561. Another kind of excrescence is an exudation of plants, joined with putrefaction; as we see in oak-apples, which are found chiefly upon the leaves of oaks; and the like upon willows: and country people have a kind of prediction, that if the oak-apple broken be full of worms, it is a sign of a pestilent year; which is a likely thing, because they grow of corruption.

562. There is also upon sweet or other briar, a fine

tuft or brush of moss, of divers colours; which if you cut you shall ever find full of little white worms.

Experiments in consort touching the producing of perfect plants without seeds.

563. It is certain that earth taken out of the foundations of vaults and houses, and bottoms of wells, and then put into pots, will put forth sundry kinds of herbs:[1] but some time is required for the germination: for if it be taken but from a fathom deep, it will put forth the first year; if much deeper, not till after a year or two.

564. The nature of the plants growing out of the earth so taken up, doth follow the nature of the mould itself; as if the mould be soft and fine, it putteth forth soft herbs; as grass, plantain, and the like; if the earth be harder and coarser, it putteth forth herbs more rough, as thistles, furze,[2] &c.

565. It is common experience, that where alleys are close gravelled, the earth putteth forth the first year knot-grass, and after spire-grass. The cause is, for that the hard gravel or pebble at the first laying will not suffer the grass to come forth upright, but turneth it to find his way where it can; but after that the earth is somewhat loosened at the top, the ordinary grass cometh up.

566. It is reported that earth being taken out of shady and watery woods some depth, and potted, will put forth herbs of a fat and juicy substance; as penny-wort, purslane, houseleek, penny-royal, &c.[3]

[1] Porta, Nat. Mag. iii. 1. The next paragraph seems to be taken from the same passage.

[2] *Firres* in the original. — *J. S.*

[3] Porta, ubi supra.

567. The water also doth send forth plants that have no roots fixed in the bottom; but they are less perfect plants, being almost but leaves, and those small ones; such is that we call duck-weed; which hath a leaf no bigger than a thyme-leaf, but of a fresher green, and putteth forth a little string into the water far from the bottom. As for the water-lily, it hath a root in the ground; and so have a number of other herbs that grow in ponds.

568. It is reported by some of the ancients, and some modern testimony likewise, that there be some plants that grow upon the top of the sea; being supposed to grow of some concretion of slime from the water, where the sun beateth hot, and where the sea stirreth little.[1] As for the alga marina (sea-weed) and eryngium (sea-thistle), both have roots; but the sea-weed under the water, the sea-thistle but upon the shore.

569. The ancients have noted, that there are some herbs that grow out of snow, laid up close together and putrefied; and that they are all bitter; and they name one specially, *flomus*, which we call moth-mullein.[2] It is certain that worms are found in snow commonly, like earth-worms; and therefore it is not unlike, that it may likewise put forth plants.

570. The ancients have affirmed that there are some herbs that grow out of stone;[3] which may be, for that it is certain that toads have been found in the middle of a free-stone. We see also that flints, lying above ground, gather moss; and wall-flowers, and some other flowers, grow upon walls; but whether upon the main

[1] See the treatise *De Plantis*, ascribed to Aristotle, ii. 4.
[2] Ib. ii. 3. [3] Ib. ii. 5.

brick or stone, or whether out of the lime or chinks, is not well observed; for elders and ashes have been seen to grow out of steeples; but they manifestly grow out of clefts; insomuch as when they grow big, they will disjoin the stone. And besides, it is doubtful whether the mortar itself putteth it forth, or whether some seeds be not let fall by birds. There be likewise rock-herbs; but I suppose those are where there is some mould or earth. It hath likewise been found that great trees growing upon quarries have put down their root into the stone.

571. In some mines in Germany, as is reported, there grow in the bottom vegetables; and the work-folks use to say they have magical virtue, and will not suffer men to gather them.

572. The sea-sands seldom bear plants. Whereof the cause is yielded by some of the ancients, for that the sun exhaleth the moisture before it can incorporate with the earth and yield a nourishment for the plant.[1] And it is affirmed also that sand hath always his root in clay; and that there be no veins of sand any great depth within the earth.

573. It is certain that some plants put forth for a time of their own store, without any nourishment from earth, water, stone, &c. Of which vide the experiment 29.

Experiments in consort touching foreign plants.

574. It is reported that earth that was brought out of the Indies and other remote countries for ballast for ships, cast upon some grounds in Italy, did put forth foreign herbs, to us in Europe not known; and, that

[1] See the treatise *De Plantis*, ascribed to Aristotle, ii. 3.

which is more, that of their roots, barks, and seeds, contused together, and mingled with other earth, and well watered with warm water, there came forth herbs much like the other.[1]

575. Plants brought out of hot countries will endeavour to put forth at the same time that they usually do in their own climate; and therefore to preserve them, there is no more required than to keep them from the injury of putting back by cold. It is reported also that grain out of the hotter countries translated into the colder, will be more forward than the ordinary grain of the cold country. It is likely that this will prove better in grains than in trees; for that grains are but annual, and so the virtue of the seed is not worn out; whereas in a tree it is embased by the ground to which it is removed.

576. Many plants which grow in the hotter countries, being set in the colder, will nevertheless, even in those cold countries, being sown of seeds late in the spring, come up and abide most part of the summer; as we find it in orange and lemon seeds, &c., the seeds whereof sown in the end of April will bring forth excellent sallets, mingled with other herbs. And I doubt not but the seeds of clove-trees, and pepper-seeds, &c., if they could come hither green enough to be sown, would do the like.

Experiments in consort touching the seasons in which plants come forth.

577. There be some flowers, blossoms, grains, and fruits, which come more early, and others which come more late in the year. The flowers that come early,

[1] Porta, Nat. Mag. iii. 1.; but not accurately copied.

with us, are, primroses, violets, anemonies, water-daffodillies, crocus vernus, and some early tulippa's. And they are all cold plants; which therefore (as it should seem) have a quicker perception of the heat of the sun increasing than the hot herbs have; as a cold hand will sooner find a little warmth than a hot. And those that come next after are wall-flowers, cowslips, hyacinths, rosemary flowers, &c.; and after them pinks, roses, flower-de-luces, &c.; and the latest are gilly-flowers, holly-oaks, larks-foot, &c. The earliest blossoms are the blossoms of peaches, almonds, cornelians, mezerions, &c.; and they are of such trees as have much moisture, either watery or oily. And therefore crocus vernus also, being an herb that hath an oily juice, putteth forth early; for those also find the sun sooner than the drier trees. The grains are, first rye and wheat, then oats and barley, then peas and beans. For though green peas and beans be eaten sooner, yet the dry ones that are used for horse-meat, are ripe last; and it seemeth that the fatter grain cometh first. The earliest fruits are strawberries, cherries, gooseberries, currants; and after them early apples, early pears, apricots, rasps; and after them, damascenes, and most kind of plums, peaches, &c.; and the latest are apples, wardens, grapes, nuts, quinces, almonds, sloes, briar-berries, heps, medlars, services, cornelians, &c.

578. It is to be noted, that (commonly) trees that ripen latest blossom soonest; as peaches, cornelians, sloes, almonds, &c.: and it seemeth to be a work of providence that they blossom so soon; for otherwise they could not have the sun long enough to ripen.

579. There be fruits (but rarely) that come twice a year; as some pears, strawberries, &c. And it seem-

eth they are such as abound with nourishment; whereby, after one period, before the sun waxeth too weak they can endure another. The violet also, amongst flowers, cometh twice a year; especially the double white; and that also is a plant full of moisture. Roses come twice, but it is not without cutting, as hath been formerly said.

580. In Muscovia, though the corn come not up till late spring, yet their harvest is as early as ours. The cause is, for that the strength of the ground is kept in with the snow; and we see with us, that if it be a long winter, it is commonly a more plentiful year: and after those kind of winters likewise, the flowers and corn, which are earlier and later, do come commonly at once, and at the same time; which troubleth the husbandman many times; for you shall have red roses and damask roses come together; and likewise the harvest of wheat and barley. But this happeneth ever, for that the earlier stayeth for the later, and not that the later cometh sooner.

581. There be divers fruit-trees in the hot countries, which have blossoms and young fruit and ripe fruit, almost all the year, succeeding one another. And it is said the orange hath the like with us for a great part of summer; and so also hath the fig. And no doubt the natural motion of plants is to have so; but that either they want juice to spend, or they meet with the cold of the winter; and therefore this circle of ripening cannot be but in succulent plants, and hot countries.

582. Some herbs are but annual, and die, root and all, once a year; as borage, lettuce, cucumbers, muskmelons, basil, tobacco, mustard-seed, and all kinds of

corn: some continue many years; as hyssop, germander, lavender, fennel, &c. The cause of the dying is double; the first is, the tenderness and weakness of the seed, which maketh the period in a small time; as it is in borage, lettuce, cucumbers, corn, &c.; and therefore none of these are hot. The other cause is, for that some herbs can worse endure cold; as basil, tobacco, mustard-seed. And these have all much heat.

Experiments in consort touching the lasting of herbs and trees.

583. The lasting of plants is most in those that are largest of body; as oaks, elm, chesnut, the loat-tree, &c.; and this holdeth in trees; but in herbs it is often contrary: for borage, coleworts, pompions, which are herbs of the largest size, are of small durance; whereas hyssop, winter-savoury, germander, thyme, sage, will last long. The cause is, for that trees last according to the strength and quantity of their sap and juice; being well munited by their bark against the injuries of the air; but herbs draw a weak juice, and have a soft stalk; and therefore those amongst them which last longest, are herbs of strong smell, and with a sticky stalk.

584. Trees that bear mast, and nuts, are commonly more lasting than those that bear fruits, especially the moister fruits; as oaks, beeches, chesnuts, walnuts, almonds, pine-trees, &c. last longer than apples, pears, plums, &c. The cause is the fatness and oiliness of the sap; which ever wasteth less than the more watery.

585. Trees that bring forth their leaves late in the year, and cast them likewise late, are more lasting than those that sprout their leaves early, or shed them be-

times. The cause is, for that the late coming forth sheweth a moisture more fixed; and the other more loose and more easily resolved. And the same cause is, that wild trees last longer than garden trees; and in the same kind, those whose fruit is acid, more than those whose fruit is sweet.

586. Nothing procureth the lasting of trees, bushes, and herbs, so much as often cutting; for every cutting causeth a renovation of the juice of the plant; that it neither goeth so far, nor riseth so faintly, as when the plant is not cut; insomuch as annual plants, if you cut them seasonably, and will spare the use of them, and suffer them to come up still young, will last more years than one; as hath been partly touched; such as is lettuce, purslane, cucumber, and the like. And for great trees, we see almost all overgrown trees in churchyards, or near ancient buildings, and the like, are pollards, or dottards, and not trees at their full height.

587. Some experiment would be made, how by art to make plants more lasting than their ordinary period: as to make a stalk of wheat, &c., last a whole year. You must ever presuppose, that you handle it so as the winter killeth it not; for we speak only of prolonging the natural period. I conceive that the rule will hold, that whatsoever maketh the herb come later than at his time, will make it last longer time: it were good to try it in a stalk of wheat, &c., set in the shade, and encompassed with a case of wood, not touching the straw, to keep out open air.

As for the preservation of fruits, as well upon the tree or stalk as gathered, we shall handle it under the title of conservation of bodies.

Experiments in consort touching the several figures of plants.

588. The particular figures of plants we leave to their descriptions; but some few things in general we will observe. Trees and herbs, in the growing forth of their boughs and branches, are not figured, and keep no order. The cause is, for that the sap being restrained in the rind and bark, breaketh not forth at all, (as in the bodies of trees, and stalks of herbs,) till they begin to branch; and then when they make an eruption, they break forth casually, where they find best way, in the bark or rind. It is true, that some trees are more scattered in their boughs; as sallow-trees, warden-trees, quince-trees, medlar-trees, lemon-trees, &c. Some are more in the form of a pyramis, and come almost to todd; as the pear-tree, (which the critics will have to borrow his name of πῦρ, *fire*,) orange-trees, fir-trees, service-trees, lime-trees, &c.; and some are more spread and broad; as beeches, hornbeam, &c. The rest are more indifferent. The cause of scattering the boughs, is the hasty breaking forth of the sap; and therefore those trees rise not in a body of any height, but branch near the ground. The cause of the pyramis is the keeping in of the sap long before it branch; and the spending of it, when it beginneth to branch, by equal degrees. The spreading is caused by the carrying up of the sap plentifully without expence; and then putting it forth speedily and at once.

589. There be divers herbs, but no trees, that may be said to have some kind of order in the putting forth of their leaves; for they have joints or knuckles, as it

were stops in their germination; as have gilly-flowers, pinks, fennel, corn, reeds, and canes. The cause whereof is, for that the sap ascendeth unequally, and doth (as it were) tire and stop by the way. And it seemeth they have some closeness and hardness in their stalk, which hindereth the sap from going up, until it hath gathered into a knot, and so is more urged to put forth. And therefore they are most of them hollow when the stalk is dry; as fennel-stalk, stubble, and canes.

590. Flowers have all exquisite figures; and the flower-numbers are (chiefly) five and four; as in primroses, briar-roses, single musk-roses, single pinks, and gilly-flowers, &c., which have five leaves: lilies, flower-de-luces, borage, bugloss, &c., which have four leaves.[1] But some put forth leaves not numbered; but they are ever small ones; as marygolds, trefoil, &c. We see also, that the sockets and supporters of flowers are figured; as in the five brethren of the rose, sockets of gilly-flowers, &c. Leaves also are all figured; some round, some long; none square; and many jagged on the sides; which leaves of flowers seldom are. For I account the jagging of pinks and gilly-flowers, to be like the inequality of oak leaves, or vine leaves, or the like: but they seldom or never have any small purls.[2]

[1] There are several errors in this remark; the flower number of the lily, as of almost all endogenous plants, being three, and that of borage and bugloss, five.

[2] According to Mr. MacCosh's observations, the venation of the leaf corresponds to the mode of growth of the branches, the veins being given off at the same angle as the branches.

Experiments in consort touching some principal differences in plants.

591. Of plants, some few put forth their blossoms before their leaves; as almonds, peaches, cornelians, black-thorn, &c. But most put forth some leaves before their blossoms; as apples, pears, plums, cherry, white-thorn, &c. The cause is, for that those that put forth their blossoms first, have either an acute and sharp spirit, (and therefore commonly they all put forth early in the spring and ripen very late, as most of the particulars before mentioned,) or else an oily juice, which is apter to put out flowers than leaves.

592. Of plants, some are green all winter; others cast their leaves. There are green all winter, holly, ivy, box, fir, yew, cypress, juniper, bays, rosemary, &c. The cause of the holding green, is the close and compact substance of their leaves, and the pedicles of them. And the cause of that again is either the tough and viscous juice of the plant, or the strength and heat thereof. Of the first sort is holly, which is of so viscous a juice as they make birdlime of the bark of it. The stalk of ivy is tough and not fragile, as we see in other small twigs dry. Fir yieldeth pitch. Box is a fast and heavy wood, as we see it in bowls. Yew is a strong and tough wood, as we see it in bows. Of the second sort is juniper, which is a wood odorate, and maketh a hot fire. Bays is likewise a hot and aromatical wood; and so is rosemary for a shrub. As for the leaves, their density appeareth, in that either they are smooth and shining, as in bays, holly, ivy, box, &c., or in that they are hard and spiry, as in the rest. And trial would be made of grafting of rose-

mary, and bays, and box, upon a holly-stock; because they are plants that come all winter. It were good to try it also with grafts of other trees, either fruit trees, or wild trees; to see whether they will not yield their fruit, or bear their leaves later and longer in the winter; because the sap of the holly putteth forth most in the winter. It may be also a mezerion-tree, grafted upon a holly, will prove both an earlier and a greater tree.

593. There be some plants that bear no flower, and yet bear fruit; there be some that bear flowers, and no fruit; there be some that bear neither flowers nor fruit. Most of the great timber-trees (as oaks, beeches, &c.) bear no apparent flowers; some few likewise of the fruit trees (as mulberry, walnuts, &c.) and some shrubs (as juniper, holly, &c.) bear no flowers. Divers herbs also bear seeds (which is as the fruit) and yet bear no flowers; as purslane, &c. Those that bear flowers and no fruit are few; as the double cherry, the sallow, &c. But for the cherry, it is doubtful whether it be not by art or culture; for if it be by art, then trial would be made whether apples' and other fruits' blossoms may not be doubled. There are some few that bear neither fruit nor flower; as the elm, the poplars, box, brakes, &c.

594. There be some plants that shoot still upwards and can support themselves; as the greatest part of trees and plants; there be some other that creep along the ground, or wind about other trees or props, and cannot support themselves; as vines, ivy, briar, briony, woodbines, hops, clematis, camomile, &c. The cause is (as hath been partly touched) for that all plants naturally move upwards; but if the sap put up too

fast, it maketh a slender stalk, which will not support the weight; and therefore these latter sort are all swift and hasty comers.

Experiments in consort touching all manner of composts and helps of ground.

595. The first and most ordinary help is stercoration. The sheep's dung is one of the best; and next, the dung of kine; and thirdly, that of horses; which is held to be somewhat too hot unless it be mingled. That of pigeons for a garden, or a small quantity of ground, excelleth. The ordering of dung is, if the ground be arable, to spread it immediately before the ploughing and sowing; and so to plough it in: for if you spread it long before, the sun will draw out much of the fatness of the dung: if the ground be grazing ground, to spread it somewhat late, towards winter; that the sun may have the less power to dry it up. As for special composts for gardens, (as a hot bed, &c.) we have handled them before.

596. The second kind of compost is the spreading of divers kinds of earths; as marl, chalk, sea-sand, earth upon earth, pond-earth; and the mixtures of them. Marl is thought to be the best; as having most fatness, and not heating the ground too much. The next is sea-sand, which (no doubt) obtaineth a special virtue by the salt: for salt is the first rudiment of life. Chalk over-heateth the ground a little; and therefore is best upon cold clay grounds, or moist grounds: but I heard a great husband say that it was a common error to think that chalk helpeth arable grounds, but helpeth not grazing grounds; whereas indeed it helpeth grass as well as corn: but that which breedeth the error is,

because after the chalking of the ground they wear it out with many crops without rest, and then indeed afterwards it will bear little grass, because the ground is tired out. It were good to try the laying of chalk upon arable grounds a little while before ploughing; and to plough it in, as they do the dung; but then it must be friable first by rain or lying. As for earth, it compasseth itself; for I knew a great garden that had a field (in a manner) poured upon it, and it did bear fruit excellently the first year of the planting: for the surface of the earth is ever the fruitfullest. And earth so prepared hath a double surface. But it is true, as I conceive, that such earth as hath salt-petre bred in it, if you can procure it without too much charge, doth excel. The way to hasten the breeding of salt-petre, is to forbid the sun, and the growth of vegetables. And therefore if you make a large hovel, thatched, over some quantity of ground; nay, if you do but plank the ground over, it will breed salt-petre. As for pond-earth, or river-earth, it is a very good compost; especially if the pond have been long uncleansed, and so the water be not too hungry: and I judge it will be yet better if there be some mixture of chalk.

597. The third help of ground is, by some other substances that have virtue to make ground fertile, though they be not merely earth; wherein ashes excel; insomuch as the countries about Ætna and Vesuvius have a kind of amends made them for the mischief the eruptions many times do, by the exceeding fruitfulness of the soil, caused by the ashes scattered about.[1] Soot also, though thin spread in a field or

[1] Sandys's Travels, p. 203.

garden, is tried to be a very good compost. For salt, it is too costly; but it is tried, that mingled with seed-corn, and sown together, it doth good; and I am of opinion, that chalk in powder, mingled with seed-corn, would do good; perhaps as much as chalking the ground all over. As for the steeping of the seeds in several mixtures with water to give them vigour, or watering grounds with compost-water, we have spoken of them before.

598. The fourth help of ground is, the suffering of vegetables to die into the ground, and so to fatten it; as the stubble of corn, especially peas. Brakes cast upon the ground in the beginning of winter, will make it very fruitful. It were good also to try whether leaves of trees swept together, with some chalk and dung mixed, to give them more heart, would not make a good compost; for there is nothing lost so much as leaves of trees; and as they lie scattered, and without mixture, they rather make the ground sour than otherwise.

599. The fifth help of ground is, heat and warmth. It hath been anciently practised to burn heath, and ling, and sedge, with the vantage of the wind, upon the ground. We see that warmth of walls and inclosures mendeth ground: we see also, that lying open to the south mendeth ground: we see again, that the foldings of sheep help ground, as well by their warmth as by their compost: and it may be doubted, whether the covering of the ground with brakes in the beginning of the winter (whereof we spake in the last experiment) helpeth it not, by reason of the warmth. Nay, some very good husbands do suspect that the gathering up of flints in flinty ground, and laying

them on heaps, (which is much used,) is no good husbandry; for that they would keep the ground warm.

600. The sixth help of ground is by watering and irrigation; which is in two manners; the one by letting in and shutting out waters at seasonable times: for water at some seasons, and with reasonable stay, doth good; but at some other seasons, and with too long stay, doth hurt: and this serveth only for meadows which are along some river. The other way is, to bring water from some hanging grounds where there are springs into the lower grounds, carrying it in some long furrows; and from those furrows, drawing it traverse to spread the water. And this maketh an excellent improvement, both for corn and grass. It is the richer if those hanging grounds be fruitful, because it washeth off some of the fatness of the earth; but howsoever it profiteth much. Generally where there are great overflows, in fens or the like, the drowning of them in the winter maketh the summer following more fruitful; the cause may be, for that it keepeth the ground warm, and nourisheth it. But the fen-men hold that the sewers must be kept so, as the water may not stay too long in the spring, till the weeds and sedge be grown up; for then the ground will be like a wood, which keepeth out the sun, and so continueth the wet; whereby it will never graze (to purpose) that year. Thus much for irrigation. But for avoidances and drainings of water, where there is too much, and the helps of ground in that kind, we shall speak of them in another place.

NATURAL HISTORY.

CENTURY VII.

Experiments in consort touching the affinities and differences between plants and inanimate bodies.

601. The differences between animate and inanimate bodies, we shall handle fully under the title of life, and living spirits, and powers. We shall therefore make but a brief mention of them in this place. The main differences are two. All bodies have spirits and pneumatical parts within them: but the main differences between animate and inanimate are two: the first is, that the spirits of things animate are all continued with themselves, and are branched in veins and secret canals, as blood is: and in living creatures, the spirits have not only branches, but certain cells or seats, where the principal spirits do reside, and whereunto the rest do resort; but the spirits in things inanimate are shut in and cut off by the tangible parts, and are not pervious one to another; as air is in snow. The second main difference is, that the spirits of animate bodies are all in some degree (more or less) kindled and inflamed; and have a fine commixture of flame, and an aërial substance. But inanimate bodies have their spirits no whit inflamed or kindled.

And this difference consisteth not in the heat or coolness of spirits; for cloves and other spices, naphtha and petroleum, have exceeding hot spirits, (hotter a great deal than oil, wax, or tallow, &c.) but not inflamed. And when any of those weak and temperate bodies come to be inflamed, then they gather a much greater heat than others have uninflamed; besides their light and motion, &c.

602. The differences, which are secondary, and proceed from these two radical differences, are: First, plants are all figurate and determinate; which inanimate bodies are not; for look how far the spirit is able to spread and continue itself, so far goeth the shape of figure, and then is determined. Secondly, plants do nourish; inanimate bodies do not; they have an accretion, but no alimentation. Thirdly, plants have a period of life; which inanimate bodies have not. Fourthly, they have a succession and propagation of their kind; which is not in bodies inanimate.

603. The differences between plants, and metals or fossils, besides those four before-mentioned (for metals I hold inanimate), are these: First, metals are more durable than plants. Secondly, they are more solid and hard. Thirdly, they are wholly subterrany; whereas plants are part above earth and part under earth.

604. There be very few creatures that participate of the nature of plants and metals both; coral is one of the nearest of both kinds: another is vitriol, for that is aptest to sprout with moisture.

605. Another special affinity is between plants and mould or putrefaction; for all putrefaction (if it dis-

solve not in arefaction) will in the end issue into plants or living creatures bred of putrefaction. I account moss, and mushrooms, and agaric, and other of those kinds, to be but moulds of the ground, walls, and trees, and the like. As for flesh, and fish, and plants themselves, and a number of other things, after a mouldiness, or rottenness, or corrupting, they will fall to breed worms. These putrefactions, which have affinity with plants, have this difference from them; that they have no succession or propagation, though they nourish, and have a period of life, and have likewise some figure.

606. I left once by chance a citron cut, in a close room, for three summer months that I was absent; and at my return there were grown forth, out of the pith cut, tufts of hairs an inch long, with little black heads, as if they would have been some herb.

Experiments in consort touching the affinities and differences of plants and living creatures, and the confiners and participles of them.

607. The affinities and differences between plants and living creatures are these that follow. They have both of them spirits continued, and branched, and also inflamed. But first, in living creatures the spirits have a cell or seat, which plants have not; as was also formerly said. And secondly, the spirits of living creatures hold more of flame than the spirits of plants do. And these two are the radical differences. For the secondary differences, they are as follow. First, plants are all fixed to the earth; whereas all living creatures are severed, and of themselves. Secondly, living creatures have local motion; plants have

not. Thirdly, living creatures nourish from their upper parts, by the mouth chiefly; plants nourish from below, namely from the roots. Fourthly, plants have their seed and seminal parts uppermost; living creatures have them lowermost: and therefore it was said, not elegantly alone, but philosophically; *Homo est planta inversa;*[1] Man is like a plant turned upwards: for the root in plants is as the head in living creatures. Fifthly, living creatures have a more exact figure than plants. Sixthly, living creatures have more diversity of organs within their bodies, and (as it were) inward figures, than plants have. Seventhly, living creatures have sense, which plants have not. Eighthly, living creatures have voluntary motion, which plants have not.

608. For the difference of sexes in plants, they are oftentimes by name distinguished; as male-piony, female-piony; male-rosemary, female-rosemary; he-holly, she-holly, &c.; but generation by copulation certainly extendeth not to plants. The nearest approach of it is between the he-palm and the she-palm; which (as they report), if they grow near, incline the one to the other; insomuch as (that which is more strange) they doubt not to report, that to keep the trees upright from bending, they tie ropes or lines from the one to the other, that the contact might be enjoyed by the contact of a

[1] See Scaliger, *Exercit. adv. Cardan.* 141. 2. The dictum in the text is founded upon what is said by Aristotle, *De Juvent. et Senect.* c. 1. But the analogy though ingenious is unsatisfactory, animals being in truth more analogous to leaves than to whole plants. But here we encounter one of the most difficult of all questions; namely, what constitutes individuality? a question which runs through all ontological systems and reappears in morphology; one of the many instances which show how impossible it is to degrade physical science into empiricism.

middle body. But this may be feigned, or at least amplified. Nevertheless I am apt enough to think, that this same *binarium* of a stronger and a weaker, like unto masculine and feminine, doth hold in all living bodies. It is confounded sometimes; as in some creatures of putrefaction, wherein no marks of distinction appear: and it is doubled sometimes; as in hermaphrodites: but generally there is a degree of strength in most species.

609. The participles or confiners between plants and living creatures, are such chiefly as are fixed, and have no local motion of remove, though they have a motion in their parts; such as are oysters, cockles, and such like. There is a fabulous narration, that in the northern countries there should be an herb that groweth in the likeness of a lamb, and feedeth upon the grass, in such sort as it will bare the grass round about.[1] But I suppose that the figure maketh the fable; for so we see there be bee-flowers, &c. And as for the grass, it seemeth the plant, having a great stalk and top, doth prey upon the grass a good way about, by drawing the juice of the earth from it.

Experiments promiscuous touching plants.

610. The Indian fig boweth his roots down so low in one year, as of itself it taketh root again; and so multiplieth from root to root, making of one tree a kind of wood.[2] The cause is the plenty of the sap, and the softness of the stalk, which maketh the bough, being over-loaden, and not stiffly upheld, weigh down.

[1] Cardan, De Rerum Variet. xxii. p. 63. The name given to this herb in the country where it grows is *boramets*, sc. *quasi agnus*.

[2] See Pliny, xx. 11.

It hath leaves as broad as a little target, but the fruit no bigger than beans. The cause is, for that the continual shade increaseth the leaves, and abateth the fruit; which nevertheless is of a pleasant taste. And that (no doubt) is caused by the suppleness and gentleness of the juice of that plant, being that which maketh the boughs also so flexible.

611. It is reported by one of the ancients that there is a certain Indian tree, having few but very great leaves, three cubits long and two broad, and that the fruit, being of good taste, groweth out of the bark.[1] It may be, there be plants that pour out the sap so fast, as they have no leisure either to divide into many leaves, or to put forth stalks to the fruit. With us, trees (generally) have small leaves in comparison. The fig hath the greatest; and next it the vine, mulberry, and sycamore; and the least are those of the willow, birch, and thorn. But there be found herbs with far greater leaves than any tree; as the bur, gourd, cucumber, and colewort. The cause is (like to that of the Indian fig) the hasty and plentiful putting forth of the sap.

612. There be three things in use for sweetness; sugar, honey, manna. For sugar, to the ancients it was scarce known, and little used.[2] It is found in canes: *Quære*, whether to the first knuckle, or further up? And whether the very bark of the cane itself do yield sugar, or no? For honey, the bee maketh it, or gathereth it; but I have heard from one that was industrious in husbandry, that the labour of the bee is about the wax; and that he hath known in the beginning of

[1] Pliny, xii. 12. But it is not said that the tree has but few leaves.
[2] Id. xii. 17.

May honeycombs empty of honey; and within a fortnight, when the sweet dews fall, filled like a cellar.[1] It is reported by some of the ancients, that there is a tree called occhus, in the valleys of Hyrcania, that distilleth honey in the mornings.[2] It is not unlike that the sap and tears of some trees may be sweet. It may be also, that some sweet juices, fit for many uses, may be concocted out of fruits, to the thickness of honey, or perhaps of sugar; the likeliest are raisins of the sun, figs, and currants; the means may be inquired.

613. The ancients report of a tree by the Persian sea, upon the shore-sands, which is nourished with the salt water; and when the tide ebbeth, you shall see the roots as it were bare without bark, (being as it seemeth corroded by the salt), and grasping the sands like a crab; which nevertheless beareth a fruit.[3] It were good to try some hard trees, as a service-tree, or fir-tree, by setting them within the sands.

614. There be of plants which they use for garments, these that follow: hemp, flax, cotton, nettles (whereof they make nettle-cloth), sericum, which is a growing silk; they make also cables of the bark of lime trees.[4] It is the stalk that maketh the filaceous

[1] Bacon's informant took the same view of the matter as Aristotle, and probably was directly or indirectly influenced by his opinion. According to Aristotle the bees manufacture the wax from flowers, but simply collect the honey which falls from the sky. He gives the reason in the text for this opinion, namely, the rapidity with which honey is stored up at certain seasons; and adds another argument, that if the bees are deprived of their honey in the autumn they appear to be unable to supply the loss, although there is still an abundance of flowers. The statement made in a subsequent paragraph, that a bee sometimes lives seven years, may also have been taken from Aristotle, *Hist. Anim.* v. 22.

[2] Pliny, xii. 18.

[3] Id. xii. 20.

[4] The common garden matting which comes to us from Russia is also made of this bark; and the same material, the philyra of the ancients, is used in Esthonia for shoes.

matter commonly; and sometimes the down that groweth above.

615. They have in some countries a plant of a rosy colour, which shutteth in the night, openeth in the morning, and openeth wide at noon; which the inhabitants of those countries say is a plant that sleepeth.[1] There be sleepers enow, then; for almost all flowers do the like.

616. Some plants there are, but rare, that have a mossy or downy root; and likewise that have a number of threads, like beards; as mandrakes, whereof witches and impostors make an ugly image, giving it the form of a face at the top of the root, and leaving those strings to make a broad beard down to the foot.[2] Also there is a kind of nard in Crete (being a kind of phu), that hath a root hairy, like a rough-footed dove's foot. So as you may see, there are of roots, bulbous roots, fibrous roots, and hirsute roots. And, I take it, in the bulbous, the sap hasteneth most to the air and sun; in the fibrous, the sap delighteth more in the earth, and therefore putteth downward; and the hirsute is a middle between both; that besides the putting forth upwards and downwards, putteth forth in round.

617. There are some tears of trees, which are kembed from the beards of goats: for when the goats bite and crop them, especially in the mornings, the dew being on, the tear cometh forth, and hangeth upon their beards: of this sort is some kind of ladanum.[3]

[1] Pliny, xii. 23. The flower was found at Tylos on the Persian Gulph.

[2] Id. xii. 26.

[3] Id. xii. 37. The resin which exudes from the hemp plant is in India

618. The irrigation of the plane-tree by wine, is reported by the ancients to make it fruitful.[1] It would be tried likewise with roots; for upon seeds it worketh no great effects.

619. The way to carry foreign roots a long way, is to vessel them close in earthen vessels. But if the vessels be not very great, you must make some holes in the bottom, to give some refreshment to the roots; which otherwise (as it seemeth) will decay and suffocate.

620. The ancient cinnamon was, of all other plants, while it grew, the driest; and those things which are known to comfort other plants, did make that more steril; for in showers it prospered worst; it grew also amongst bushes of other kinds, where commonly plants do not thrive; neither did it love the sun.[2] There might be one cause of all those effects; namely, the sparing nourishment which that plant required. *Quære*, how far cassia, which is now the substitute of cinnamon, doth participate of these things?

621. It is reported by one of the ancients, that cassia, when it is gathered, is put into the skins of beasts newly flayed; and that the skins corrupting and breeding worms, the worms do devour the pith and marrow of it, and so make it hollow; but meddle not with the bark, because to them it is bitter.[3]

622. There were in ancient time vines of far greater bodies than we know any; for there have been cups made of them, and an image of Jupiter. But it is like they were wild vines, for the vines that they use for wine, are so often cut, and so much digged and

collected much in the same way. Not however by the agency of goats, but by sending men through the fields in which the plant is cultivated.

[1] Pliny, xii. 4. [2] Id. xii. 42. [3] Id. xii. 43.

dressed, that their sap spendeth into the grapes, and so the stalk cannot increase much in bulk. The wood of vines is very durable, without rotting. And that which is strange, though no tree hath the twigs, while they are green, so brittle, yet the wood dried is extreme tough; and was used by the captains of armies amongst the Romans for their cudgels.[1]

623. It is reported that in some places vines are suffered to grow like herbs, spreading upon the ground; and that the grapes of those vines are very great. It were good to make trial, whether plants that use to be borne up by props, will put forth greater leaves and greater fruits, if they be laid along the ground; as hops, ivy, woodbine, &c.

624. Quinces or apples, &c., if you will keep them long, drown them in honey; but because honey (perhaps) will give them a taste over-luscious, it were good to make trial in powder of sugar, or in syrup of wine only boiled to height. Both these would likewise be tried in oranges, lemons, and pomegranates; for the powder of sugar, and syrup of wine, will serve for times more than once.

625. The conservation of fruit would be also tried in vessels filled with fine sand, or with powder of chalk; or in meal and flour; or in dust of oak wood; or in mill.

626. Such fruits as you appoint for long keeping, you must gather before they be full ripe; and in a fair and dry day, towards noon; and when the wind bloweth not south; and when the moon is under the earth, and in decrease.

627. Take grapes, and hang them in an empty

[1] Pliny, xvi. `. and 3.

vessel well stopped; and set the vessel not in a cellar, but in some dry place; and it is said they will last long. But it is reported by some, they will keep better in a vessel half full of wine, so that the grapes touch not the wine.[1]

628. It is reported that the preserving of the stalk helpeth to preserve the grape; especially if the stalk be put into the pith of elder, the elder not touching the fruit.

629. It is reported by some of the ancients that fruit put in bottles, and the bottles let down into wells under water, will keep long.

630. Of herbs and plants, some are good to eat raw; as lettuce, endive, purslane, tarragon, cresses, cucumbers, musk-melons, radish, &c. Others only after they are boiled, or have passed the fire; as parsley, clary, sage, parsnips, turnips, asparagus, artichokes (though they also being young are eaten raw). But a number of herbs are not esculent at all; as wormwood, grass, green corn, centory, hyssop, lavender, balm, &c. The causes are, for that the herbs that are not esculent do want the two tastes in which nourishment resteth; which are fat and sweet; and have (contrariwise) bitter and over-strong tastes, or a juice so crude as cannot be ripened to the degree of nourishment. Herbs and plants that are esculent raw, have fatness or sweetness (as all esculent fruits); such are onions, lettuce, &c. But then it must be such a fatness, (for as for sweet things, they are, in effect, always esculent,) as is not over-gross, and loading of the stomach: for parsnips and leeks have fatness, but it is too gross and heavy without boiling. It must be

[1] The substance of this and the two next paragraphs is in Pliny, xv. 18.

also in a substance somewhat tender; for we see wheat, barley, artichokes, are no good nourishment till they have passed the fire; but the fire doth ripen, and maketh them soft and tender, and so they become esculent. As for radish and tarragon, and the like, they are for condiments, and not for nourishment. And even some of those herbs which are not esculent, are notwithstanding poculent; as hops, broom, &c. *Quære*, what herbs are good for drink besides the two aforenamed; for that it may perhaps ease the charge of brewing, if they make beer to require less malt, or make it last longer.

631. Parts fit for the nourishment of man in plants are, seeds, roots, and fruits; but chiefly seeds and roots. For leaves, they give no nourishment at all, or very little: no more do flowers, or blossoms, or stalks. The reason is, for that roots, and seeds, and fruits, (inasmuch as all plants consist of an oily and watery substance commixed,) have more of the oily substance; and leaves, flowers, &c., of the watery. And secondly, they are more concocted; for the root which continueth ever in the earth, is still concocted by the earth; and fruits and grains (we see) are half a year or more in concocting; whereas leaves are out and perfect in a month.

632. Plants (for the most part) are more strong both in taste and smell in the seed, than in the leaf and root. The cause is, for that in plants that are not of a fierce and eager spirit, the virtue is increased by concoction and maturation, which is ever most in the seed; but in plants that are of a fierce and eager spirit, they are stronger whilst the spirit is inclosed in the root, and the spirits do but weaken and dissipate when

they come to the air and sun; as we see in onions, garlick, dragon, &c. Nay, there be plants that have their roots very hot and aromatical, and their seeds rather insipid; as ginger. The cause is (as was touched before) for that the heat of those plants is very dissipable; which under the earth is contained and held in; but when it cometh to the air it exhaleth.

633. The juices of fruits are either watery or oily. I reckon among the watery, all the fruits out of which drink is expressed; as the grape, the apple, the pear, the cherry, the pomegranate, &c. And there are some others which, though they be not in use for drink, yet they appear to be of the same nature; as plums, services, mulberries, rasps, oranges, lemons, &c. And for those juices that are so fleshy as they cannot make drink by expression, yet perhaps they may make drink by mixture of water.

Poculaque admistis imitantur vitea sorbis.[1]

And it may be heps and briar-berries would do the like. Those that have oily juices, are olives, almonds, nuts of all sorts, pine-apples, &c.; and their juices are all inflammable. And you must observe also, that some of the watery juices, after they have gathered spirit, will burn and inflame; as wine. There is a third kind of fruit that is sweet, without either sharpness or oiliness: such as is the fig and the date.

634. It hath been noted, that most trees, and specially those that bear mast, are fruitful but once in two years. The cause (no doubt) is the expence of sap; for many orchard trees, well cultured, will bear divers years together.

[1] Virg. Georg. iii. 379.

635. There is no tree which, besides the natural fruit, doth bear so many bastard fruits as the oak doth: for besides the acorn, it beareth galls, oak-apples, and certain oak-nuts, which are inflammable; and certain oak-berries, sticking close to the body of the tree without stalk. It beareth also misseltoe, though rarely. The cause of all these may be, the closeness and solidness of the wood and pith of the oak; which maketh several juices find several eruptions. And therefore if you will devise to make any super-plants, you must ever give the sap plentiful rising and hard issue.

636. There are two excrescences which grow upon trees; both of them in the nature of mushrooms: the one the Romans call boletus;[1] which groweth upon the roots of oaks, and was one of the dainties of their table; the other is medicinal, that is called agaric (whereof we have spoken before), which groweth upon the tops of oaks; though it be affirmed by some that it groweth also at the roots. I do conceive that many excrescences of trees grow chiefly where the tree is dead or faded; for that the natural sap of the tree corrupteth into some preternatural substance.

637. The greater part of trees bear most and best on the lower boughs; as oaks, figs, walnuts, pears, &c.; but some bear best on the top-boughs; as crabs, &c. Those that bear best below, are such as shade doth more good to than hurt. For generally all fruits bear best lowest, because the sap tireth not, having but a short way: and therefore in fruits spread upon walls, the lowest are the greatest, as was formerly said: so it is the shade that hindereth the lower boughs; except it be in such trees as delight in shade, or at least bear

[1] Pliny, xvi. 11. and 13.

it well. And therefore they are either strong trees, as the oak; or else they have large leaves, as the walnut and fig; or else they grow in pyramis, as the pear. But if they require very much sun, they bear best on the top; as it is in crabs, apples, plums, &c.

638. There be trees that bear best when they begin to be old; as almonds, pears, vines, and all trees that give mast. The cause is, for that all trees that bear mast have an oily fruit; and young trees have a more watery juice, and less concocted; and of the same kind also is the almond.[1] The pear likewise, though it be not oily, yet it requireth much sap, and well concocted; for we see it is a heavy fruit and solid, much more than apples, plums, &c. As for the vine, it is noted that it beareth more grapes when it is young; but grapes that make better wine when it is old; for that the juice is the better concocted; and we see that wine is inflammable, so as it hath a kind of oiliness. But the most part of trees, amongst which are apples, plums, &c., bear best when they are young.

639. There be plants that have a milk in them when they are cut; as figs, old lettuce, sow-thistles, spurge, &c. The cause may be an inception of putrefaction: for those milks have all an acrimony: though one would think they should be lenitive. For if you write upon paper with the milk of the fig, the letters will not be seen, until you hold the paper before the fire, and

[1] Whatever the reason may be, it is certainly true that the produce of the olive increases with the age of the tree, at least for a long period of years. It is said to be on this account that olive grounds are in France far less remunerative than in Italy or Spain, because hard winters occasionally occur and prevent the trees from attaining their full age. From the experience of the last century and a half it seems that in France a frost occurs sufficiently severe to destroy the trees about once in forty years. The statement with regard to the vine is taken from Pliny.

then they wax brown; which sheweth that it is a sharp or fretting juice: lettuce is thought poisonous, when it is so old as to have milk: spurge is a kind of poison in itself: and as for sow-thistles, though coneys eat them, yet sheep and cattle will not touch them: and besides, the milk of them rubbed upon warts, in short time weareth them away; which sheweth the milk of them to be corrosive. We see also that wheat and other corn sown, if you take them forth of the ground before they sprout, are full of milk; and the beginning of germination is ever a kind of putrefaction of the seed. Euphorbium also hath a milk, though not very white, which is of a great acrimony: and saladine hath a yellow milk, which hath likewise much acrimony; for it cleanseth the eyes. It is good also for cataracts.

640. Mushrooms are reported to grow as well upon the bodies of trees, as upon their roots, or upon the earth; and especially upon the oak. The cause is, for that strong trees are, towards such excrescences, in the nature of earth; and therefore put forth moss, mushrooms, and the like.

641. There is hardly found a plant that yieldeth a red juice in the blade or ear; except it be the tree that beareth sanguis draconis; which groweth chiefly in the island Soquotra: the herb amaranthus indeed is red all over; and brasil is red in the wood: and so is red sanders. The tree of sanguis draconis groweth in the form of a sugar-loaf. It is like that the sap of that plant concocteth in the body of the tree. For we see that grapes and pomegranates are red in the juice, but are green in the tear: and this maketh the tree of sanguis draconis lesser towards the top; because the juice

hasteneth not up; and besides, it is very astringent; and therefore of slow motion.

642. It is reported that sweet moss, besides that upon the apple trees, groweth likewise sometimes upon poplars; and yet (generally) the poplar is a smooth tree of bark, and hath little moss. The moss of the larix-tree burneth also sweet, and sparkleth in the burning. *Quære* of the mosses of odorate trees; as cedar, cypress, lignum aloës, &c.

643. The death that is most without pain, hath been noted to be upon the taking of the potion of hemlock; which in humanity was the form of execution of capital offenders in Athens. The poison of the asp, that Cleopatra used, hath some affinity with it. The cause is, for that the torments of death are chiefly raised by the strife of the spirits; and these vapours quench the spirits by degrees; like to the death of an extreme old man. I conceive it is less painful than opium, because opium hath parts of heat mixed.

644. There be fruits that are sweet before they be ripe, as myrobalanes; so fennel-seeds are sweet before they ripen, and after grow spicy. And some never ripen to be sweet; as tamarinds, berberries, crabs, sloes, &c. The cause is, for that the former kind have much and subtile heat, which causeth early sweetness; the latter have a cold and acid juice, which no heat of the sun can sweeten. But as for the myrobalane, it hath parts of contrary natures; for it is sweet, and astringent.

645. There be few herbs that have a salt taste; and contrariwise all blood of living creatures hath a saltness. The cause may be, for that salt, though it be the rudiment of life, yet in plants the original taste

remaineth not; for you shall have them bitter, sour, sweet, biting, but seldom salt; but in living creatures, all those high tastes may happen to be (sometimes) in the humours, but are seldom in the flesh or substance; because it is of a more oily nature; which is not very susceptible of those tastes; and the saltness itself of blood is but a light and secret saltness: and even among plants, some do participate of saltness, as alga marina, sampire, scurvy-grass, &c. And they report, there is in some of the Indian seas a swimming plant, which they call salgazus,[1] spreading over the sea, in such sort as one would think it were a meadow. It is certain that out of the ashes of all plants they extract a salt which they use in medicines.

646. It is reported by one of the ancients, that there is an herb growing in the water, called lincostis,[2] which is full of prickles: this herb putteth forth another small herb out of the leaf; which is imputed to some moisture that is gathered between the prickles, which putrefied by the sun germinateth. But I remember also I have seen, for a great rarity, one rose grow out of another, like honeysuckles, that they call top and top-gallants.

647. Barley (as appeareth in the malting) being steeped in water three days, and afterwards the water drained from it, and the barley turned upon a dry floor, will sprout half an inch long at least: and if it be let alone, and not turned, much more; until the heart be out. Wheat will do the same. Try it also with peas and beans. This experiment is not like that of the

[1] Cardan, De Subtilit. viii. p. 257. Salgazus is, of course, the same as Sargasso, and Bacon was thinking of the Mar di Sargasso in the Atlantic.

[2] See Cardan, De Subtil. viii. p. 259., who refers to Aristotle, in whose works however no plant of that name is, I believe, mentioned.

orpine and semper-vive; for there it is of the old store, for no water is added; but here it is nourished from the water. The experiment would be further driven: for it appeareth already, by that which hath been said, that earth is not necessary to the first sprouting of plants; and we see that rose-buds set in water will blow: therefore try whether the sprouts of such grains may not be raised to a further degree; as to an herb, or flower, with water only, or some small commixture of earth: for if they will, it should seem by the experiments before, both of the malt and of the roses, that they will come far faster on in water than in earth; for the nourishment is easilier drawn out of water than out of earth. It may give some light also, that drink infused with flesh, as that with the capon, &c., will nourish faster and easilier than meat and drink together. Try the same experiment with roots as well as with grains: as for example, take a turnip, and steep it a while, and then dry it, and see whether it will sprout.

648. Malt in the drenching will swell; and that in such a manner, as after the putting forth in sprouts, and the drying upon the kiln,[1] there will be gained at least a bushel in eight, and yet the sprouts are rubbed off; and there will be a bushel of dust besides the malt; which I suppose to be, not only by the loose and open laying of the parts, but by some addition of substance, drawn from the water in which it was steeped.

649. Malt gathereth a sweetness to the taste, which appeareth yet more in the wort. The dulcoration of things is worthy to be tried to the full; for that dulcoration importeth a degree to nourishment: and the making of things inalimental to become alimental,

[1] *Keele* in the original. — *J. S.*

may be an experiment of great profit for making new victual.

650. Most seeds in the growing, leave their husk or rind about the root; but the onion will carry it up, that it will be like a cap upon the top of the young onion. The cause may be, for that the skin or husk is not easy to break; as we see by the pilling of onions, what a holding substance the skin is.

651. Plants, that have curled leaves, do all abound with moisture; which cometh so fast on, as they cannot spread themselves plain, but must needs gather together. The weakest kind of curling is roughness; as in clary and bur: the second is curling on the sides; as in lettuce, and young cabbage: and the third is folding into an head; as in cabbage full grown and cabbage-lettuce.

652. It is reported that fir and pine, especially if they be old and putrefied, though they shine not as some rotten woods do, yet in the sudden breaking they will sparkle like hard sugar.

653. The roots of trees do (some of them) put downwards deep into the ground; as the oak, pine, fir, &c. Some spread more towards the surface of the earth; as the ash, cypress-tree, olive, &c. The cause of this latter may be, for that such trees as love the sun, do not willingly descend far into the earth; and therefore they are (commonly) trees that shoot up much; for in their body, their desire of approach to the sun maketh them spread the less. And the same reason, under ground, to avoid recess from the sun, maketh them spread the more. And we see it cometh to pass in some trees which have been planted too deep in the ground, that for love of approach to the sun,

they forsake their first root, and put out another more towards the top of the earth. And we see also that the olive is full of oily juice; and ash maketh the best fire; and cypress is an hot tree. As for the oak, which is of the former sort, it loveth the earth; and therefore groweth slowly. And for the pine, and fir likewise, they have so much heat in themselves, as they need less the heat of the sun. There be herbs also that have the same difference; as the herb they call morsus diaboli;[1] which putteth the root down so low, as you cannot pull it up without breaking; which gave occasion to the name and fable; for that it was said, it was so wholesome a root, that the devil, when it was gathered, bit it for envy: and some of the ancients do report that there was a goodly fir, (which they desired to remove whole,) that had a root underground eight cubits deep; and so the root came up broken.[2]

654. It hath been observed that a branch of a tree, being unbarked some space at the bottom, and so set into the ground, hath grown; even of such trees as, if the branch were set with the bark on, they would not grow; yet contrariwise we see that a tree pared round in the body above ground, will die. The cause may be, for that the unbarked part draweth the nourishment best, but the bark continueth it only.

655. Grapes will continue fresh and moist all winter long, if you hang them cluster by cluster in the roof of a warm room; especially if when you gather the cluster, you take off with the cluster some of the stock.

656. The reed or cane is a watery plant, and groweth not but in the water: it hath these properties: that

[1] Apparently a kind of scabious. See Gerard's Herbal. p. 726.
[2] Pliny, xvi. 56.

it is hollow; that it is knuckled both stalk and root; that being dry, it is more hard and fragile than other wood; that it putteth forth no boughs, though many stalks come out of one root. It differeth much in greatness; the smallest being fit for thatching of houses, and stopping the chinks of ships, better than glue or pitch. The second bigness is used for angle-rods and staves; and in China for beating of offenders upon the thighs. The differing kinds of them are, the common reed, the cassia fistula, and the sugar-reed. Of all plants it boweth the easiest and riseth again. It seemeth that amongst plants which are nourished with mixture of earth and water, it draweth most nourishment from water; which maketh it the smoothest of all others in bark, and the hollowest in body.

657. The sap of trees when they are let blood, is of differing natures. Some more watery and clear; as that of vines, of beeches, of pears. Some thick, as apples. Some gummy, as cherries. Some frothy, as elms. Some milky, as figs. In mulberries the sap seemeth to be (almost) towards the bark only; for if you cut the tree a little into the bark with a stone, it will come forth; if you pierce it deeper with a tool, it will be dry. The trees which have the moistest juices in their fruit, have commonly the moistest sap in their body; for the vines and pears are very moist; apples somewhat more spongy: the milk of the fig hath the quality of the rennet, to gather cheese; and so have certain sour herbs wherewith they make cheese in Lent.[1]

[1] The Greeks appear to have employed the juice of the fig for making cheese, as familiarly as rennet. Bacon's information on the subject was probably taken from Aristotle, *Hist. Animal.* iii. 21. Ælian mentions the use of the juice of a kind of thistle for the same purpose.

658. The timber and wood are in some trees more clean, in some more knotty; and it is a good trial to try it by speaking at one end, and laying the ear at the other; for if it be knotty, the voice will not pass well. Some have the veins more varied and chamlotted,[1] as oak, whereof wainscot is made; maple, whereof trenchers are made: some more smooth, as fir and walnut: some do more easily breed worms and spiders; some more hardly, as it is said of Irish trees: besides there be a number of differences that concern their use; as oak, cedar, and chesnut, are the best builders; some are best for plough-timber, as ash; some for piers, that are sometimes wet and sometimes dry, as elm; some for planchers, as deal; some for tables, cupboards, and desks, as walnuts: some for ship-timber, as oaks that grow in moist grounds; for that maketh the timber tough, and not apt to rift with ordnance; wherein English and Irish timber are thought to excel: some for masts of ships, as fir and pine, because of their length, straightness, and lightness: some for pale, as oak: some for fuel, as ash; and so of the rest.

659. The coming of trees and plants in certain regions, and not in others, is sometimes casual: for many have been translated, and have prospered well; as damask-roses, that have not been known in England above an hundred years, and now are so common. But the liking of plants in certain soils more than in others, is merely natural; as the fir and pine love the mountains; the poplar, willow, sallow, and alder, love rivers and moist places; the ash loveth coppices, but

[1] So spelt here in the original. Compare Exp. 741. where it is spelt *chamoletted.* — *J. S.*

is best in standards alone; juniper loveth chalk; and so do most fruit trees; sampire groweth but upon rocks; reeds and osiers grow where they are washed with water; the vine loveth sides of hills, turning upon the south-east sun, &c.

660. The putting forth of certain herbs discovereth of what nature the ground where they put forth is; as wild thyme sheweth good feeding-ground for cattle; betony and strawberries shew grounds fit for wood; camomile sheweth mellow grounds fit for wheat. Mustard-seed, growing after the plough, sheweth a good strong ground also for wheat: burnet sheweth good meadow; and the like.

661. There are found in divers countries some other plants that grow out of trees and plants, besides misseltoe: as in Syria there is an herb called cassytas, that groweth out of tall trees, and windeth itself about the same tree where it groweth; and sometimes about thorns. There is a kind of polypode that groweth out of trees, though it windeth not. So likewise an herb called faunos, upon the wild olive. And an herb called hippophæston upon the fuller's thorn: which, they say, is good for the falling sickness.[1]

662.[2] It hath been observed by some of the ancients, that howsoever cold and easterly winds are thought to be great enemies to fruit, yet nevertheless south winds are also found to do hurt; especially in the blossoming time; and the more if showers follow. It seemeth they call forth the moisture too fast. The west winds are the best. It hath been observed also that green

[1] All these are mentioned by Pliny, xvi. 92. But *cassytas* ought to be *cadytas*, on his authority and that of Theophrastus, whom he follows.

[2] The substance of this and the two next paragraphs is from Pliny, xvi. 92.

and open winters do hurt trees; insomuch as if two or three such winters come together, almond-trees, and some other trees, will die. The cause is the same with the former, because the lust of the earth over-spendeth itself: howsoever some other of the ancients have commended warm winters.

663. Snows lying long cause a fruitful year; for first they keep in the strength of the earth: secondly, they water the earth better than rain; for in snow, the earth doth (as it were) suck the water as out of the teat: thirdly, the moisture of snow is the finest moisture; for it is the froth of the cloudy waters.

664. Showers, if they come a little before the ripening of fruits, do good to all succulent and moist fruits; as vines, olives, pomegranates; yet it is rather for plenty than for goodness; for the best wines are in the driest vintages: small showers are likewise good for corn, so as parching heats come not upon them. Generally night showers are better than day showers, for that the sun followeth not so fast upon them; and we see, even in watering by the hand, it is best in summer time to water in the evening.

665. The differences of earths, and the trial of them, are worthy to be diligently inquired. The earth, that with showers doth easiliest soften, is commended; and yet some earth of that kind will be very dry and hard before the showers. The earth that casteth up from the plough a great clod, is not so good as that which casteth up a smaller clod. The earth that putteth forth moss easily, and may be called mouldy, is not good. The earth that smelleth well upon the digging or ploughing, is commended; as containing the juice of vegetables almost already

prepared. It is thought by some, that the ends of low rainbows fall more upon one kind of earth than upon another; as it may well be; for that that earth is most roscid: and therefore it is commended for a sign of good earth. The poorness of the herbs (it is plain) sheweth the poorness of the earth; and especially if they be in colour more dark: but if the herbs shew withered or blasted at the top, it sheweth the earth to be very cold; and so doth the mossiness of trees. The earth whereof the grass is soon parched with the sun and toasted, is commonly forced earth; and barren in his own nature.[1] The tender, chessome, and mellow earth is the best; being mere mould, between the two extremes of clay and sand; especially if it be not loamy and binding. The earth that after rain will scarce be ploughed, is commonly fruitful; for it is cleaving, and full of juice.

666. It is strange, which is observed by some of the ancients, that dust helpeth the fruitfulness of trees, and of vines by name; insomuch as they cast dust upon them of purpose.[2] It should seem that that powdering, when a shower cometh, maketh a kind of soiling to the tree, being earth and water finely laid on. And they note that countries where the fields and ways are dusty bear the best vines.

667. It is commended by the ancients, for an excellent help to trees, to lay the stalks and leaves of lupines about the roots; or to plough them into the

[1] All this is taken from Pliny, xvii. 3. The passage is obscure, but it does not seem that Pliny affirms that rainbows rest upon one kind of earth rather than another. He says that a good soil may be known by its odour, and that this odour is the same as that which is produced at the place at which a rainbow touches the ground.

[2] Pliny, xvii. 5.

ground where you will sow corn. The burning also of the cuttings of vines, and casting them upon land, doth much good. And it was generally received of old, that dunging of grounds when the west wind bloweth, and in the decrease of the moon, doth greatly help; the earth (as it seemeth) being then more thirsty and open to receive the dung.

668. The grafting of vines upon vines (as I take it) is not now in use. The ancients had it, and that three ways: the first was incision, which is the ordinary manner of grafting: the second was terebration through the middle of the stock, and putting in the scion there: and the third was paring of two vines that grow together to the marrow, and binding them close.[1]

669. The diseases and ill accidents of corn are worthy to be inquired; and would be more worthy to be inquired, if it were in men's power to help them; whereas many of them are not to be remedied. The mildew is one of the greatest; which (out of question) cometh by closeness of air; and therefore in hills, or large champaign grounds, it seldom cometh; such as is with us *York's Woald.* This cannot be remedied, otherwise than that in countries of small inclosure the grounds be turned into larger fields: which I have known to do good in some farms. Another disease is the putting forth of wild oats, whereinto corn oftentimes (especially barley) doth degenerate. It happeneth chiefly from the weakness of the grain that is sown: for if it be either too old or mouldy, it will bring forth wild oats. Another disease is the satiety of the ground; for if you sow

[1] Pliny, xvii. 25.

one ground still with the same corn, (I mean not the same corn that grew upon the same ground, but the same kind of grain, as wheat, barley, &c.,) it will prosper but poorly: therefore, besides the resting of the ground, you must vary the seed. Another ill accident is from the winds, which hurt at two times; at the flowering, by shaking off the flowers; and at the full ripening, by shaking out the corn. Another ill accident is drouth at the spindling of the corn; which with us is rare, but in hotter countries common: insomuch as the word *calamitas*[1] was first derived from *calamus*, when the corn could not get out of the stalk. Another ill accident is over-wet at sowing time; which with us breedeth much dearth; insomuch as the corn never cometh up; and (many times) they are forced to resow summer-corn where they sowed winter-corn. Another ill accident is bitter frosts, continued, without snow; especially in the beginning of the winter, after the seed is new sown. Another disease is worms; which sometimes breed in the root, and happen upon hot suns and showers immediately after the sowing; and another worm breedeth in the ear itself, especially when hot suns break often out of clouds. Another disease is weeds; and they are such as either choke and overshadow the corn, and bear it down, or starve the corn and deceive it of nourishment. Another disease is over-rankness of the corn: which they use to remedy by mowing it after it is come up, or putting sheep into it. Another ill accident is laying of corn with great rains, near or in harvest. Another ill acci-

[1] Calamitas is said to mean primarily the destruction of the calamus or stalk, either by storms or by disease. But this derivation seems improbable, and at any rate it does not support Bacon's remark.

dent is, if the seed happen to have touched oil, or anything that is fat; for those substances have an antipathy with nourishment of water.

670. The remedies of the diseases of corn have been observed as followeth.[1] The steeping of the grain, before sowing, a little time in wine, is thought a preservative: the mingling of seed-corn with ashes is thought to be good: the sowing at the wane of the moon is thought to make the corn sound: it hath not been practised, but it is thought to be of use to make some miscellane in corn; as if you sow a few beans with wheat, your wheat will be the better.[2] It hath been observed that the sowing of corn with houseleek doth good. Though grain that toucheth oil or fat receiveth hurt, yet the steeping of it in the dregs of oil when it beginneth to putrefy (which they call *amurca*) is thought to assure it against worms. It is reported also, that if corn be mowed, it will make the grain longer, but emptier, and having more of the husk.

671. It hath been noted, that seed of a year old is the best; and of two or three years is worse; and that which is more old is quite barren; though (no doubt) some seeds and grains last better than others. The corn which in the vanning lieth lowest is the best: and the corn which broken or bitten retaineth a little yellowness, is better than that which is very white.[3]

672. It hath been observed, that of all roots of

[1] The greater part of this paragraph is from Pliny, xviii. 45.

[2] This opinion probably gave rise to the practice, not long since discontinued, of sowing wheat and rye together. The produce was in Scotland called *mung corn;* which, though obviously only a corruption of meng or mingled corn, has been supposed to denote that the practice was a remnant of monastic husbandry.

[3] See Pliny, xviii. 54.

herbs, the root of sorrel goeth the furthest into the earth; insomuch as it hath been known to go three cubits deep: and that it is the root that continueth fit (longest) to be set again, of any root that groweth.[1] It is a cold and acid herb, that (as it seemeth) loveth the earth, and is not much drawn by the sun.

673. It hath been observed, that some herbs like best being watered with salt water: as radish, beet, rue, pennyroyal;[2] this trial would be extended to some other herbs; especially such as are strong; as tarragon, mustard-seed, rocket, and the like.

674. It is strange that is generally received, how some poisonous beasts affect odorate and wholesome herbs; as that the snake loveth fennel; that the toad will be much under sage; that frogs will be in cinquefoil. It may be it is rather the shade, or other coverture, that they take liking in, than the virtue of the herb.

675. It were a matter of great profit (save that I doubt it is too conjectural to venture upon) if one could discern what corn, herbs, or fruits, are like to be in plenty or scarcity, by some signs and prognostics in the beginning of the year: for as for those that are like to be in plenty, they may be bargained for upon the ground; as the old relation was of Thales; who, to shew how easy it was for a philosopher to be rich, when he foresaw a great plenty of olives, made a monopoly of them.[3] And for scarcity, men may make profit in keeping better the old store. Long continuance of snow is believed to make a fruitful year of corn: an early winter, or a very late winter, a barren year of corn: an open and serene winter, an ill year of

[1] Pliny, xix. 31. [2] Id. xix. 59. [3] Diog. Laert. i. 26.

fruit. These we have partly touched before: but other prognostics of like nature are diligently to be inquired.

676. There seem to be in some plants singularities, wherein they differ from all other. The olive hath the oily part only on the outside; whereas all other fruits have it in the nut or kernel. The fir hath (in effect) no stone, nut, nor kernel; except you will count the little grains kernels. The pomegranate and pine-apple have, only amongst fruits, grains distinct in several cells. No herbs have curled leaves but cabbage and cabbage-lettuce. None have double leaves, one belonging to the stalk, another to the fruit or seed, but the artichoke. No flower hath that kind of spread that the woodbine hath. This may be a large field of contemplation; for it sheweth that in the frame of nature there is, in the producing of some species, a composition of matter which happeneth oft, and may be much diversified: in other, such as happeneth rarely, and admitteth little variety. For so it is likewise in beasts: dogs have a resemblance with wolves and foxes; horses with asses; kine with bufles;[1] hares with coneys, &c. And so in birds: kites and kestrels have a resemblance with hawks; common doves with ring-doves and turtles; blackbirds with thrushes and mavises; crows with ravens, daws, and choughs, &c. But elephants and swine amongst beasts; and the bird of paradise and the peacock amongst birds; and some few others, have scarce any other species that have affinity with them.

We leave the description of plants and their virtues to herbals, and other like books of natural

[1] So in the original. — *J. S.*

history; wherein men's diligence hath been great, even to curiosity: for our experiments are only such as do ever ascend a degree to the deriving of causes and extracting of axioms; which we are not ignorant but that some both of the ancient and modern writers have also laboured; but their causes and axioms are so full of imagination, and so infected with the old received theories, as they are mere inquinations of experience, and concoct it not.

Experiment solitary touching healing of wounds.

677. It hath been observed by some of the ancients, that skins (especially of rams) newly pulled off, and applied to the wounds of stripes, do keep them from swelling and exulcerating; and likewise heal them and close them up; and that the whites of eggs do the same.[1] The cause is a temperate conglutination; for both bodies are clammy and viscous, and do bridle the deflux of humours to the hurts, without penning them in too much.

Experiment solitary touching fat diffused in flesh.

678. You may turn (almost) all flesh into a fatty substance, if you take flesh, and cut it into pieces, and put the pieces into a glass covered with parchment, and so let the glass stand six or seven hours in boiling water. It may be an experiment of profit for making of fat or grease for many uses; but then it must be of such flesh as is not edible; as horses, dogs, bears, foxes, badgers, &c.[2]

[1] Arist. Prob. ix. 1.

[2] There is of course no true conversion of muscular fibre or of albumen

Experiment solitary touching ripening of drink before the time.

679. It is reported by one of the ancients, that new wine put into vessels well stopped, and the vessels let down into the sea, will accelerate very much the making of them ripe and potable.[1] The same would be tried in wort.

Experiment solitary touching pilosity and plumage.

680. Beasts are more hairy than men, and savage men more than civil; and the plumage of birds exceedeth the pilosity of beasts. The cause of the smoothness in men is not any abundance of heat and moisture, though that indeed causeth pilosity; but there is requisite to pilosity, not so much heat and moisture, as excrementitious heat and moisture; (for whatsoever assimilateth, goeth not into the hair;) and excrementitious moisture aboundeth most in beasts, and men that are more savage. Much the same reason is there of the plumage of birds, for birds assimilate less, and excern more than beasts: for their excrements are ever liquid, and their flesh (generally) more dry: besides, they have not instruments for urine; and so all the excrementitious moisture goeth

into fat. Bacon's error is similar to that of the chemists who, in the early part of the present century, were misled by the appearance of bodies exhumed from a cemetery at Paris into believing that under certain circumstances fat can be produced by the azotized elements of animal tissues. It was in this case also thought that the experiment would be "of profit;" but Gay-Lussac showed that the change observed was merely the result of a partial saponification of the already existing fat, due to the production of ammonia during decomposition. A company was formed in England for the manufacture of what was called *adipocire*, chiefly, I believe, from horse-flesh; but the project led to no result.

[1] Wine so prepared was called Thalassites. See Pliny, xiv. 11.

into the feathers: and therefore it is no marvel though birds be commonly better meat than beasts, because their flesh doth assimilate more finely, and secerneth more subtilly. Again, the head of man hath hair upon the first birth, which no other part of the body hath. The cause may be want of perspiration; for much of the matter of hair, in the other parts of the body, goeth forth by insensible perspiration; and besides, the skull being of a more solid substance, nourisheth and assimilateth less, and excerneth more; and so likewise doth the chin. We see also that hair cometh not upon the palms of the hands, nor soles of the feet; which are parts more perspirable. And children likewise are not hairy, for that their skins are more perspirable.

Experiment solitary touching the quickness of motion in birds.

681. Birds are of swifter motion than beasts; for the flight of many birds is swifter than the race of any beasts. The cause is, for that the spirits in birds are in greater proportion, in comparison of the bulk of their body, than in beasts: for as for the reason that some give, that they are partly carried, whereas beasts go, that is nothing; for by that reason swimming should be swifter than running: and that kind of carriage also is not without labour of the wing.

Experiment solitary touching the different clearness of the sea.

682. The sea is clearer when the north wind bloweth, than when the south wind.[1] The cause is, for that

[1] Aristotle, on the contrary, asserts that the sea is clearer with a south wind than with a north. See the Problems, xxvi. 39.

salt water hath a little oiliness in the surface thereof, as appeareth in very hot days: and again, for that the southern wind relaxeth the water somewhat; as no water boiling is so clear as cold water.

Experiment solitary touching the different heats of fire and boiling water.

683. Fire burneth wood, making it first luminous, then black and brittle, and lastly broken and incinerate: scalding water doth none of these.[1] The cause is, for that by fire the spirit of the body is first refined, and then emitted; whereof the refining or attenuation causeth the light; and the emission, first the fragility, and after the dissolution into ashes; neither doth any other body enter: but in water the spirit of the body is not refined so much; and besides part of the water entereth, which doth increase the spirit, and in a degree extinguish it: therefore we see that hot water will quench fire. And again we see that in bodies wherein the water doth not much enter, but only the heat passeth, hot water worketh the effects of fire; as in eggs boiled and roasted (into which the water entereth not at all) there is scarce difference to be discerned;[2] but in fruit and flesh, whereinto the water entereth in some part, there is much more difference.

[1] Arist. Prob. xxiii. 3.

[2] Sir T. Brown has remarked that an egg loses weight by roasting, and not by boiling. That evaporation goes on through the shell is shown by the fact that eggs become lighter during incubation. In fact, according to St. Hilaire, if communication with the atmosphere is completely cut off, the development of the chick is prevented.

Experiment solitary touching the qualification of heat by moisture.

684. The bottom of a vessel of boiling water (as hath been observed) is not very much heated; so as men may put their hand under the vessel and remove it.[1] The cause is, for that the moisture of water, as it quencheth coals where it entereth, so it doth allay heat where it toucheth: and therefore note well, that moisture, although it doth not pass through bodies without communication of some substance (as heat and cold do), yet it worketh manifest effects; not by entrance of the body, but by qualifying of the heat and cold; as we see in this instance: and we see likewise that the water of things distilled in water (which they call the bath) differeth not much from the water of things distilled by fire. We see also that pewter dishes with water in them will not melt easily; but without it they will; nay we see more, that butter or oil, which in themselves are inflammable, yet by the virtue of their moisture will do the like.

Experiment solitary touching yawning.

685. It hath been noted by the ancients, that it is dangerous to pick one's ear whilst he yawneth.[2] The cause is, for that in yawning the inner parchment of the ear is extended, by the drawing in of the spirit and breath;[3] for in yawning and sighing both, the spirit is first strongly drawn in, and then strongly expelled.

[1] Arist. Prob. xxiii. 5.

[2] Id. Ib. xxxii. 13.

[3] The drum is not directly distended, if at all, by the effort of yawning; but it is pressed on by the air forced into the Eustachian tubes. In man and the mammalia generally, the drum is slightly depressed inwards. It may therefore become convex during yawning, and thus more liable to come into contact with anything inserted into the ear.

Experiment solitary touching the hiccough.

686. It hath been observed by the ancients, that sneezing doth cease the hiccough.[1] The cause is, for that the motion of the hiccough is a lifting up of the stomach ; which sneezing doth somewhat depress, and divert the motion another way. For first we see that the hiccough cometh of fulness of meat (especially in children), which causeth an extension of the stomach : we see also it is caused by acid meats or drinks, which is by the pricking of the stomach ; and this motion is ceased either by diversion, or by detention of the spirits ; diversion, as in sneezing ; detention, as we see holding of the breath doth help somewhat to cease the hiccough ; and putting a man into an earnest study doth the like ; as is commonly used : and vinegar put to the nostrils, or gargarised, doth it also ; for that it is astringent, and inhibiteth the motion of the spirits.

Experiment solitary touching sneezing.

687. Looking against the sun doth induce sneezing.[2] The cause is not the heating of the nostrils ; for then the holding up of the nostrils against the sun, though one wink, would do it ; but the drawing down of the moisture of the brain ; for it will make the eyes run with water : and the drawing of moisture to the eyes, doth draw it to the nostrils by motion of consent ; and so followeth sneezing : as contrariwise, the tickling of the nostrils within, doth draw the moisture to the nostrils, and to the eyes by consent ; for they also will water. But yet it hath been observed, that if one be about to sneeze, the rubbing of the eyes till they run

[1] Arist. Prob. xxxiii. 1., and elsewhere. [2] Id. ib. xxiii. 4.

with water will prevent it.[1] Whereof the cause is, for that the humour which was descending to the nostrils, is diverted to the eyes.

Experiment solitary touching the tenderness of the teeth.[2]

688. The teeth are more by cold drink or the like affected, than the other parts. The cause is double; the one, for that the resistance of bone to cold is greater than of flesh; for that the flesh shrinketh, but the bone resisteth, whereby the cold becometh more eager: the other is, for that the teeth are parts without blood; whereas blood helpeth to qualify the cold: and therefore we see that the sinews are much affected with cold, for that they are parts without blood; so the bones in sharp colds wax brittle: and therefore it hath been seen that all contusions of bones in hard weather are more difficult to cure.

Experiment solitary touching the tongue.

689. It hath been noted that the tongue receiveth more easily tokens of diseases, than the other parts; as of heats within, which appear most in the blackness of the tongue. Again, pyed cattle are spotted in their tongues, &c. The cause is (no doubt) the tenderness of the part; which thereby receiveth more easily all alterations, than any other parts of the flesh.

Experiment solitary touching the taste.

690. When the mouth is out of taste, it maketh things taste sometimes salt, chiefly bitter, and some-

[1] Arist. Prob. xxxiii. 8.

[2] See for the statements in this and the two next paragraphs Arist. Prob. xxxiv. 2, 3, 4, and 5.

times loathsome; but never sweet. The cause is, the corrupting of the moisture about the tongue, which many times turneth bitter, and salt, and loathsome; but sweet never: for the rest are degrees of corruption.

Experiment solitary touching some prognostics of pestilential seasons.

691. It was observed in the great plague of the last year, that there were seen, in divers ditches and low grounds about London, many toads that had tails two or three inches long at the least; whereas toads (usually) have no tails at all.[1] Which argueth a great disposition to putrefaction in the soil and air. It is reported likewise, that roots (such as carrots and parsnips) are more sweet and luscious in infectious years than in other years.

Experiment solitary touching special simples for medicines.

692. Wise physicians should with all diligence inquire what simples nature yieldeth, that have extreme subtile parts, without any mordication or acrimony: for they undermine that which is hard, they open that which is stopped and shut, and they expel that which is offensive, gently, without too much perturbation. Of this kind are elder-flowers, which therefore are proper

[1] But the tadpoles which become toads have; and it is possible that under certain circumstances the tails may not disappear until the limbs are sufficiently developed to make it doubtful whether the animal ought not to be called a toad. Milne Edwards has shown that tadpoles kept in the dark increase in size, but do not undergo the usual transformation. So many idle stories, however, are told in a time of general panic, that it is scarcely worth while to attempt to explain the statement in the text.

for the stone: of this kind is the dwarf-pine, which is proper for the jaundice: of this kind is hartshorn, which is proper for agues and infections: of this kind is piony, which is proper for stoppings in the head: of this kind is fumitory, which is proper for the spleen: and a number of others. Generally, divers creatures bred of putrefaction, though they be somewhat loathsome to take, are of this kind; as earth-worms, timber-sows, snails, &c. And I conceive that the trochischs of vipers, (which are so much magnified,) and the flesh of snakes some ways condited and corrected, (which of late are grown into some credit,) are of the same nature. So the parts of beasts putrefied (as castoreum and musk, which have extreme subtile parts,) are to be placed amongst them. We see also that putrefactions of plants (as agaric and Jew's-ear) are of greatest virtue. The cause is, for that putrefaction is the subtilest of all motions in the parts of bodies; and since we cannot take down the lives of living creatures, (which some of the Paracelsians say, if they could be taken down, would make us immortal,) the next is for subtilty of operation, to take bodies putrefied; such as may be safely taken.

Experiments in consort touching Venus.

693. It hath been observed by the ancients, that much use of Venus doth dim the sight; and yet eunuchs, which are unable to generate, are nevertheless also dim-sighted.[1] The cause of dimness of sight in the former, is the expence of spirits; in the latter, the over-moisture of the brain; for the over-moisture of the brain doth thicken the spirits visual, and obstructeth their passages; as we see by the decay in

[1] Arist. Prob. iv. 3.

the sight in age; where also the diminution of the spirits concurreth as another cause: we see also that blindness cometh by rheums and cataracts. Now in eunuchs there are all the notes of moisture; as the swelling of their thighs, the looseness of their belly, the smoothness of their skin, &c.

694. The pleasure in the act of Venus is the greatest of the pleasures of the senses: the matching of it with itch is unproper; though that also be pleasing to the touch.[1] But the causes are profound. First, all the organs of the senses qualify the motions of the spirits; and make so many several species of motions, and pleasures or displeasures thereupon, as there be diversities of organs. The instruments of sight, hearing, taste, and smell, are of several frame, and so are the parts for generation. Therefore Scaliger doth well to make the pleasure of generation a sixth sense;[2] and if there were any other differing organs, and qualified perforations for the spirits to pass, there would be more than the five senses: neither do we well know whether some beasts and birds have not senses that we know not: and the very scent of dogs is almost a sense by itself. Secondly, the pleasures of the touch are greater and deeper than those of the other senses; as we see in warming upon cold, or refrigeration upon heat; for as the pains of the touch are greater than the offences of other senses, so likewise are the pleasures. It is true, that the affecting of the spirits immediately, and (as it were) without an organ, is of the greatest pleasure; which is but in two things; sweet smells, and wine and the like sweet vapours. For smells, we see their great and sudden

[1] Arist. Prob. iv. 16. [2] Scaliger, Adv. Cardan. 236. 3.

effect in fetching men again when they swoon: for drink, it is certain that the pleasure of drunkenness is next the pleasure of Venus; and great joys likewise make the spirits move and touch themselves: and the pleasure of Venus is somewhat of the same kind.

695. It hath been always observed that men are more inclined to Venus in the winter, and women in the summer.[1] The cause is, for that the spirits, in a body more hot and dry (as the spirits of men are), by the summer are more exhaled and dissipated; and in the winter more condensed, and kept entire: but in bodies that are cold and moist (as women's are), the summer doth cherish the spirits, and calleth them forth; the winter doth dull them. Furthermore, the abstinence or intermission of the use of Venus in moist and well habituate bodies, breedeth a number of diseases: and especially dangerous imposthumations. The reason is evident; for that it is a principal evacuation, especially of the spirits; for of the spirits there is scarce any evacuation, but in Venus and exercise. And therefore the omission of either of them breedeth all diseases of repletion.

Experiments in consort touching the insecta.

The nature of vivification is very worthy the inquiry: and as the nature of things is commonly better perceived in small than in great, and in unperfect than in perfect, and in parts than in whole; so the nature of vivification is best inquired in creatures bred of putrefaction. The contemplation whereof hath many excellent fruits. First, in dis-

[1] Arist. Prob. iv. 26., and Hist. An. v. 8.

closing the original of vivification. Secondly, in disclosing the original of figuration. Thirdly, in disclosing many things in the nature of perfect creatures, which in them lie more hidden. And fourthly, in traducing, by way of operation, some observations in the insecta, to work effects upon perfect creatures. Note, that the word *insecta* agreeth not with the matter, but we ever use it for brevity's sake, intending by it creatures bred of putrefaction.

696. The insecta are found to breed out of several matters: some breed of mud or dung; as the earthworms, eels, snakes, &c. For they are both putrefactions: for water in mud doth putrefy, as not able to preserve itself: and for dung, all excrements are the refuse and putrefactions of nourishment. Some breed in wood, both growing and cut down. *Quære* in what woods most, and at what seasons? We see that the worms with many feet, which round themselves into balls, are bred chiefly under logs of timber, but not in the timber; and they are said to be found also (many times) in gardens where no logs are. But it seemeth their generation requireth a coverture, both from sun and rain or dew; as the timber is; and therefore they are not venomous, but (contrariwise) are held by the physicians to clarify the blood. It is observed that cimices are found in the holes of bedsides. Some breed in the hair of living creatures, as lice and tikes; which are bred by the sweat close kept and somewhat arefied by the hair. The excrements of living creatures do not only breed insecta when they are ex-

cerned, but also while they are in the body; as in worms, whereto children are most subject, and are chiefly in the guts. And it hath been lately observed by physicians, that in many pestilent diseases there are worms found in the upper parts of the body, where excrements are not, but only humours putrefied. Fleas breed principally of straw or mats, where there hath been a little moisture; or the chamber and bed-straw kept close and not aired. It is received that they are killed by strewing wormwood in the rooms. And it is truly observed that bitter things are apt rather to kill, than engender putrefaction; and they be things that are fat or sweet that are aptest to putrefy. There is a worm that breedeth in meal, of the shape of a large white maggot, which is given as a great dainty to nightingales. The moth breedeth upon cloth and other lanifices; especially if they be laid up dankish and wet. It delighteth to be about the flame of a candle. There is a worm called a wevil, bred under ground, and that feedeth upon roots; as parsnips, carrots, &c. Some breed in waters, especially shaded, but they must be by standing waters; as the water-spider that hath six legs. The fly called the gad-fly, breedeth of somewhat that swimmeth upon the top of the water, and is most about ponds. There is a worm that breedeth of the dregs of wine decayed; which afterwards (as is observed by some of the ancients) turneth into a gnat. It hath been observed by the ancients, that there is a worm that breeds in old snow, and is of colour reddish, and dull of motion, and dieth soon after it cometh out of snow.[1] Which should shew, that snow hath in it a secret warmth;

[1] Arist. Hist. An. v. 19.

for else it could hardly vivify. And the reason of the dying of the worm, may be the sudden exhaling of that little spirit, as soon as it cometh out of the cold, which had shut it in. For as butterflies quicken with heat, which were benumbed with cold; so spirits may exhale with heat, which were preserved in cold. It is affirmed both by ancient and modern observation, that in furnaces of copper and brass where chalcites (which is vitriol) is often cast in to mend the working, there riseth suddenly a fly, which sometimes moveth as if it took hold on the walls of the furnace, sometimes is seen moving in the fire below; and dieth presently as soon as it is out of the furnace:[1] which is a noble instance, and worthy to be weighed; for it sheweth, that as well violent heat of fire as the gentle heat of living creatures will vivify, if it have matter proportionable. Now the great axiom of vivification is, that there must be heat to dilate the spirit of the body; an active spirit to be dilated; matter viscous or tenacious to hold in the spirit; and that matter to be put forth and figured. Now a spirit dilated by so ardent a fire as that of the furnace, as soon as ever it cooleth never so little, congealeth presently. And no doubt this action is furthered by the chalcites, which hath a spirit that will put forth and germinate, as we see in chemical trials. Briefly, most things putrefied bring forth insecta of several names; but we will not take upon us now to enumerate them all.

697. The insecta have been noted by the ancients to feed little: but this hath not been diligently observed; for grasshoppers eat up the green of whole

[1] Arist. ubi supra.

countries; and silk-worms devour leaves swiftly; and ants make great provision. It is true, that creatures that sleep and rest much, eat little; as dormice and bats, &c. They are all without blood:[1] which may be, for that the juice of their bodies is almost all one; not blood, and flesh, and skin, and bone, as in perfect creatures; the integral parts have extreme variety, but the similar parts little. It is true that they have (some of them) a diaphragm and an intestine; and they have all skins; which in most of the insecta are cast often. They are not generally of long life; yet bees have been known to live seven years: and snakes are thought, the rather for the casting of their spoil, to live till they be old: and eels, which many times breed of putrefaction, will live and grow very long: and those that interchange from worms to flies in the summer, and from flies to worms in the winter, have been kept in boxes four years at the least. Yet there are certain flies, that are called ephemera, that live but a day. The cause is the exility of the spirit; or perhaps the absence of the sun; for that if they were brought in, or kept close, they might

[1] It has long been known that, contrary to the opinion of Aristotle, insects are not bloodless; and it now appears to be established, contrary to the opinion of as great a naturalist, that they possess a system of closed vessels which corresponds to the circulating system of other classes of animals. Cuvier's opinion that respiration by trachea is inconsistent with circulation in closed vessels must therefore be abandoned, if the results obtained by one or two Italian physiologists, and in France by Blanchard, are to be depended on. But the subject is confessedly obscure and difficult. There was perhaps in Cuvier, so difficult is it even for the greatest men absolutely to divest themselves of personal predilection, a tendency to underrate the position of the Articulata in the scale of creation, as compared with that of the Mollusca, whose complex organization he was the first to demonstrate. It is curious to observe that St. Hilaire, in the controversy between him and Cuvier which took place in 1830, insists, with the manifest intention of annoying his opponent, that the Mollusca have properly speaking no brain.

live longer. Many of the insecta (as butterflies and other flies) revive easily when they seem dead, being brought to the sun or fire. The cause whereof is the diffusion of the vital spirit, and the easy dilating of it by a little heat. They stir a good while after their heads are off, or that they be cut in pieces; which is caused also, for that their vital spirits are more diffused throughout all their parts, and less confined to organs than in perfect creatures.

698. The insecta have voluntary motion, and therefore imagination; and whereas some of the ancients have said that their motion is indeterminate and their imagination indefinite, it is negligently observed; for ants go right forwards to their hills; and bees do (admirably) know the way from a flowery heath two or three miles off to their hives. It may be, gnats and flies have their imagination more mutable and giddy, as small birds likewise have. It is said by some of the ancients, that they have only the sense of feeling;[1] which is manifestly untrue; for if they go forth-right to a place, they must needs have sight;[2] besides they delight more in one flower or herb than in another, and therefore have taste: and bees are called with sound upon brass, and therefore they have hearing; which sheweth likewise, that though their spirit be

[1] Aristotle, on the contrary, agrees with Bacon in thinking that insects possess all the senses, and gives much the same reasons. A curious proof of the existence of the sense of smell is that insects are deceived by the similarity of odours.

[2] The notion that the bee could only see a few inches before it, and consequently that its return to the same pasture was a proof of great memory, was founded upon an erroneous view of the nature of insect vision. The bee, like other insects, sees chiefly by means of a number of tubes, each pointed in its own direction, and each connected with a distinct nervous filament. There is therefore no assignable reason why it should not see as far as the stars. See Müller's Physiology.

diffused, yet there is a seat of their senses in their head.

Other observations concerning the insecta, together with the enumeration of them, we refer to that place where we mean to handle the title of animals in general.

Experiment solitary touching leaping.

699. A man leapeth better with weights in his hands than without.[1] The cause is, for that the weight (if it be proportionable) strengtheneth the sinews by contracting them. For otherwise, where no contraction is needful, weight hindereth; as we see in horse-races men are curious to foresee that there be not the least weight upon the one horse more than upon the other. In leaping with weights, the arms are first cast backwards, and then forwards with so much the greater force; for the hands go backward before they take their raise. *Quære*, if the contrary motion of the spirits, immediately before the motion we intend, doth not cause the spirits as it were to break forth with more force: as breath also drawn and kept in cometh forth more forcibly: and in casting of any thing, the arms, to make a greater swing, are first cast backward.

Experiment solitary touching the pleasures and displeasures of the senses, especially of hearing.

700. Of musical tones and unequal sounds we have spoken before; but touching the pleasure and displeasure of the senses, not so fully. Harsh sounds, as of a

[1] Arist. Problem. v. 8.

saw when it is sharpened; grinding of one stone against another; squeaking or skriching noise; make a shivering or horror in the body, and set the teeth on edge. The cause is, for that the objects of the ear do affect the spirits (immediately) most with pleasure and offence. We see there is no colour that affecteth the eye much with displeasure: there be sights that are horrible, because they excite the memory of things that are odious or fearful; but the same things painted do little affect. As for smells, tastes, and touches, they be things that do affect by a participation or impulsion of the body of the object. So it is sound alone that doth immediately and incorporeally affect most. This is most manifest in music, and concords and discords in music; for all sounds, whether they be sharp or flat, if they be sweet, have a roundness and equality; and if they be harsh, are unequal; for a discord itself is but a harshness of divers sounds meeting. It is true that inequality not stayed upon, but passing, is rather an increase of sweetness; as in the purling of a wreathed string; and in the raucity of a trumpet; and in the nightingale-pipe of a regal; and in a discord straight falling upon a concord: but if you stay upon it, it is offensive. And therefore there be these three degrees of pleasing and displeasing in sounds; sweet sounds; discords; and harsh sounds, which we call by divers names, as skriching or grating, such as we now speak of. As for the setting of the teeth on edge, we see plainly what an intercourse there is between the teeth and the organ of the hearing, by the taking of the end of a bow between the teeth, and striking upon the string.

A TABLE OF THE EXPERIMENTS.

CENTURY I.

CENTURY II.

CENTURY III.

CENTURY IV.

CENTURY V.

CENTURY VI.

CENTURY VII.

[For the remainder of this Table see the end of "Natural History" in vol. v. of this edition.]

END OF VOL. IV.

CAMBRIDGE: PRINTED BY H. O. HOUGHTON.