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Title: The Botanic Garden, a Poem in Two Parts. Part 1: the Economy of Vegetation

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Release date: January 1, 2006 [EBook #9612]
Most recently updated: January 2, 2021

Language: English

Produced by Jonathan Ingram, Robert Shimmin and PG

Distributed Proofreaders

[Illustration: FLORA attired by the ELEMENTS]

THE

BOTANIC GARDEN;

A Poem, in Two Parts.

PART I.

CONTAINING

THE ECONOMY OF VEGETATION.

PART II.

THE LOVES OF THE PLANTS.

WITH

Philosophical Notes.

ADVERTISEMENT.

The general design of the following sheets is to inlist Imagination under the banner of Science; and to lead her votaries from the looser analogies, which dress out the imagery of poetry, to the stricter, ones which form the ratiocination of philosophy. While their particular design is to induce the ingenious to cultivate the knowledge of Botany, by introducing them to the vestibule of that delightful science, and recommending to their attention the immortal works of the celebrated Swedish Naturalist, LINNEUS.

In the first Poem, or Economy of Vegetation, the physiology of Plants is delivered; and the operation of the Elements, as far as they may be supposed to affect the growth of Vegetables. In the second Poem, or Loves of the Plants, the Sexual System of Linneus is explained, with the remarkable properties of many particular plants.

APOLOGY.

It may be proper here to apologize for many of the subsequent conjectures on some articles of natural philosophy, as not being supported by accurate investigation or conclusive experiments. Extravagant theories however in those parts of philosophy, where our knowledge is yet imperfect, are not without their use; as they encourage the execution of laborious experiments, or the investigation of ingenious deductions, to confirm or refute them. And since natural objects are allied to each other by many affinities, every kind of theoretic distribution of them adds to our knowledge by developing some of their analogies.

The Rosicrucian doctrine of Gnomes, Sylphs, Nymphs, and Salamanders, was thought to afford a proper machinery for a Botanic poem; as it is probable, that they were originally the names of hieroglyphic figures representing the elements.

Many of the important operations of Nature were shadowed or allegorized in the heathen mythology, as the first Cupid springing from the Egg of Night, the marriage of Cupid and Psyche, the Rape of Proserpine, the Congress of Jupiter and Juno, Death and Resuscitation of Adonis, &c. many of which are ingeniously explained in the works of Bacon, Vol. V. p. 47. 4th Edit. London, 1778. The Egyptians were possessed of many discoveries in philosophy and chemistry before the invention of letters; these were then expressed in hieroglyphic paintings of men and animals; which after the discovery of the alphabet were described and animated by the poets, and became first the deities of Egypt, and afterwards of Greece and Rome. Allusions to those fables were therefore thought proper ornaments to a philosophical poem, and are occasionally introduced either as represented by the poets, or preserved on the numerous gems and medallions of antiquity.

TO

THE AUTHOR

OF THE

POEM ON THE LOVES OF THE PLANTS.

BY THE REV. W.B. STEPHENS.

Oft tho' thy genius, D——! amply fraught
With native wealth, explore new worlds of mind;
Whence the bright ores of drossless wisdom brought,
Stampt by the Muse's hand, enrich mankind;

Tho' willing Nature to thy curious eye,
Involved in night, her mazy depths betray;

Till at their source thy piercing search descry
The streams, that bathe with Life our mortal clay;

Tho', boldly soaring in sublimer mood
Through trackless skies on metaphysic wings,
Thou darest to scan the approachless Cause of Good,
And weigh with steadfast hand the Sum of Things;

Yet wilt thou, charm'd amid his whispering bowers
Oft with lone step by glittering Derwent stray,
Mark his green foliage, count his musky flowers,
That blush or tremble to the rising ray;

While FANCY, seated in her rock-roof'd dell,
Listening the secrets of the vernal grove,
Breathes sweetest strains to thy symphonious shell,
And gives new echoes to the throne of Love.

Repton, Nov. 28, 1788.

Argument of the First Canto.

The Genius of the place invites the Goddess of Botany. 1. She descends, is received by Spring, and the Elements, 59. Addresses the Nymphs of Fire. Star-light Night seen in the Camera Obscura, 81. I. Love created the Universe. Chaos explodes. All the Stars revolve. God. 97. II. Shooting Stars. Lightning. Rainbow. Colours of the Morning and Evening Skies. Exterior Atmosphere of inflammable Air. Twilight. Fire-balls. Aurora Borealis. Planets. Comets. Fixed Stars. Sun's Orb, 115. III. 1. Fires at the Earth's Centre. Animal Incubation, 137. 2. Volcanic Mountains. Venus visits the Cyclops, 149. IV. Heat confined on the Earth by the Air. Phosphoric lights in the Evening. Bolognian Stone. Calcined Shells. Memnon's Harp, 173. Ignis fatuus. Luminous Flowers. Glow-worm. Fire-fly. Luminous Sea-insects. Electric Eel. Eagle armed with Lightning, 189. V. 1. Discovery of Fire. Medusa, 209. 2. The chemical Properties of Fire. Phosphorus. Lady in Love, 223. 3. Gunpowder, 237. VI. Steam-engine applied to Pumps, Bellows, Water-engines, Corn-mills, Coining, Barges, Waggons, Flying-chariots, 253. Labours of Hercules. Abyla and Calpe, 297. VII. 1. Electric Machine. Hesperian Dragon. Electric kiss. Halo round the heads of Saints. Electric Shock. Fairy- rings, 335. 2. Death of Professor Richman, 371. 3. Franklin draws Lightning from the Clouds. Cupid snatches the Thunder-bolt from Jupiter, 383. VIII. Phosphoric Acid and Vital Heat produced in the Blood. The great Egg of Night, 399. IX. Western Wind unfettered. Naiad released. Frost assailed. Whale attacked, 421. X. Buds and Flowers expanded by Warmth, Electricity, and Light. Drawings with colourless sympathetic Inks; which appear when warmed by the Fire, 457. XI. Sirius. Jupiter and Semele. Northern Constellations. Ice-islands navigated into the Tropic Seas. Rainy Monsoons, 497. XII. Points erected to procure Rain. Elijah on Mount-Carmel, 549. Departure of the Nymphs of Fire like sparks from artificial Fireworks, 587.

THE ECONOMY OF VEGETATION.

CANTO I.

STAY YOUR RUDE STEPS! whose throbbing breasts infold
The legion-fiends of Glory, or of Gold!
Stay! whose false lips seductive simpers part,
While Cunning nestles in the harlot-heart!—
For you no Dryads dress the roseate bower,
For you no Nymphs their sparkling vases pour;
Unmark'd by you, light Graces swim the green,
And hovering Cupids aim their shafts, unseen.

"But THOU! whose mind the well-attemper'd ray
Of Taste and Virtue lights with purer day;

Whose finer sense each soft vibration owns
With sweet responsive sympathy of tones;
So the fair flower expands it's lucid form
To meet the sun, and shuts it to the storm;—
For thee my borders nurse the fragrant wreath,
My fountains murmur, and my zephyrs breathe;
Slow slides the painted snail, the gilded fly
Smooths his fine down, to charm thy curious eye;
On twinkling fins my pearly nations play,
Or win with sinuous train their trackless way;
My plumy pairs in gay embroidery dress'd
Form with ingenious bill the pensile nest,
To Love's sweet notes attune the listening dell,
And Echo sounds her soft symphonious shell.

[*So the fair flower*. l. 13. It seems to have been the original design of the philosophy of Epicurus to render the mind exquisitely sensible to agreeable sensations, and equally insensible to disagreeable ones.]

"And, if with Thee some hapless Maid should stray,
Disasterous Love companion of her way,
Oh, lead her timid steps to yonder glade,
Whose arching cliffs depending alders shade;
There, as meek Evening wakes her temperate breeze,
And moon-beams glimmer through the trembling trees,
The rills, that gurgle round, shall soothe her ear,
The weeping rocks shall number tear for tear;
There as sad Philomel, alike forlorn,
Sings to the Night from her accustomed thorn;
While at sweet intervals each falling note
Sighs in the gale, and whispers round the grot;
The sister-woe shall calm her aching breast,
And softer slumbers steal her cares to rest.—

[*Disasterous Love*. l. 26. The scenery is taken from a botanic garden about a mile from Lichfield, where a cold bath was erected by Sir John Floyer. There is a grotto surrounded by projecting rocks, from the edges of which trickles a perpetual shower of water; and it is here represented as adapted to love-scenes, as being thence a proper residence for the modern goddess of Botany, and the easier to introduce the next poem on the Loves of the Plants according to the system of Linneus.]

"Winds of the North! restrain your icy gales,
Nor chill the bosom of these happy vales!
Hence in dark heaps, ye gathering Clouds, revolve!
Disperse, ye Lightnings! and, ye Mists, dissolve!
—Hither, emerging from yon orient skies,
BOTANIC GODDESS! bend thy radiant eyes;
O'er these soft scenes assume thy gentle reign,
Pomona, Ceres, Flora in thy train;
O'er the still dawn thy placid smile effuse,
And with thy silver sandals print the dews;
In noon's bright blaze thy vermil vest unfold,
And wave thy emerald banner star'd with gold."

Thus spoke the GENIUS, as He stept along,
And bade these lawns to Peace and Truth belong;
Down the steep slopes He led with modest skill
The willing pathway, and the truant rill,
Stretch'd o'er the marshy vale yon willowy mound,
Where shines the lake amid the tufted ground,
Raised the young woodland, smooth'd the wavy green,
And gave to Beauty all the quiet scene.—

She comes!—the GODDESS!—through the whispering air,

Bright as the morn, descends her blushing car;
Each circling wheel a wreath of flowers intwines,
And gem'd with flowers the silken harness shines;
The golden bits with flowery studs are deck'd,
And knots of flowers the crimson reins connect.—
And now on earth the silver axle rings,
And the shell sinks upon its slender springs;
Light from her airy seat the Goddess bounds,
And steps celestial press the pansied grounds.

Fair Spring advancing calls her feather'd quire,
And tunes to softer notes her laughing lyre;
Bids her gay hours on purple pinions move,
And arms her Zephyrs with the shafts of Love,
Pleased GNOMES, ascending from their earthy beds,
Play round her graceful footsteps, as she treads;
Gay SYLPHS attendant beat the fragrant air
On winnowing wings, and waft her golden hair;
Blue NYMPHS emerging leave their sparkling streams,
And FIERY FORMS alight from orient beams;
Musk'd in the rose's lap fresh dews they shed,
Or breathe celestial lustres round her head.

[*Pleased Gnomes*. l. 73. The Rosicrucian doctrine of Gnomes, Sylphs, Nymphs, and Salamanders affords proper machinery for a philosophic poem; as it is probable that they were originally the names of hieroglyphic figures of the Elements, or of Genii presiding over their operations. The Fairies of more modern days seem to have been derived from them, and to have inherited their powers. The Gnomes and Sylphs, as being more nearly allied to modern Fairies are represented as either male or female, which distinguishes the latter from the Aurae of the Latin Poets, which were only female; except the winds, as Zephyrus and Auster, may be supposed to have been their husbands.]

First the fine Forms her dulcet voice requires,
Which bathe or bask in elemental fires;
From each bright gem of Day's refulgent car,
From the pale sphere of every twinkling star,
From each nice pore of ocean, earth, and air,
With eye of flame the sparkling hosts repair,
Mix their gay hues, in changeful circles play,
Like motes, that tenant the meridian ray.—
So the clear Lens collects with magic power
The countless glories of the midnight hour;
Stars after stars with quivering lustre fall,
And twinkling glide along the whiten'd wall.—
Pleased, as they pass, she counts the glittering bands,
And stills their murmur with her waving hands;
Each listening tribe with fond expectance burns,
And now to these, and now to those, she turns.

I. "NYMPHS OF PRIMEVAL FIRE! YOUR vestal train
Hung with gold-tresses o'er the vast inane,
Pierced with your silver shafts the throne of Night,
And charm'd young Nature's opening eyes with light;
When LOVE DIVINE, with brooding wings unfurl'd,
Call'd from the rude abyss the living world.
"—LET THERE BE LIGHT!" proclaim'd the ALMIGHTY LORD,
Astonish'd Chaos heard the potent word;—
Through all his realms the kindling Ether runs,
And the mass starts into a million suns;
Earths round each sun with quick explosions burst,
And second planets issue from the first;
Bend, as they journey with projectile force,
In bright ellipses their reluctant course;
Orbs wheel in orbs, round centres centres roll,
And form, self-balanced, one revolving Whole.

—Onward they move amid their bright abode,
Space without bound, THE BOSOM OF THEIR GOD!

[*Nymphs of primeval fire*. l. 97. The fluid matter of heat is perhaps the most extensive element in nature; all other bodies are immersed in it, and are preserved in their present state of solidity or fluidity by the attraction of their particles to the matter of heat. Since all known bodies are contractible into less space by depriving them of some portion of their heat, and as there is no part of nature totally deprived of heat, there is reason to believe that the particles of bodies do not touch, but are held towards each other by their self- attraction, and recede from each other by their attraction to the mass of heat which surrounds them; and thus exist in an equilibrium between these two powers. If more of the matter of heat be applied to them, they recede further from each other, and become fluid; if still more be applied, they take an aerial form, and are termed Gasses by the modern chemists. Thus when water is heated to a certain degree, it would instantly assume the form of steam, but for the pressure of the atmosphere, which prevents this change from taking place so easily; the same is true of quicksilver, diamonds, and of perhaps all other bodies in Nature; they would first become fluid, and then aeriform by appropriated degrees of heat. On the contrary, this elastic matter of heat, termed Calorique in the new nomenclature of the French Academicians, is liable to become consolidated itself in its combinations with some bodies, as perhaps in nitre, and probably in combustible bodies as sulphur and charcoal. See note on l. 232, of this Canto. Modern philosophers have not yet been able to decide whether light and heat be different fluids, or modifications of the same fluid, as they have many properties in common. See note on l. 462 of this Canto.]

[*When Love Divine*. l. 101. From having observed the gradual evolution of the young animal or plant from its egg or seed; and afterwards its successive advances to its more perfect state, or maturity; philosophers of all ages seem to have imagined, that the great world itself had likewise its infancy and its gradual progress to maturity; this seems to have given origin to the very antient and sublime allegory of Eros, or Divine Love, producing the world from the egg of Night, as it floated in Chaos. See l. 419. of this Canto.

The external crust of the earth, as far as it has been exposed to our view in mines or mountains, countenances this opinion; since these have evidently for the most part had their origin from the shells of fishes, the decomposition of vegetables, and the recrements of other animal materials, and must therefore have been formed progressively from small beginnings. There are likewise some apparently useless or incomplete appendages to plants and animals, which seem to shew they have gradually undergone changes from their original state; such as the stamens without anthers, and styles without stigmas of several plants, as mentioned in the note on Curcuma, Vol. II. of this work. Such is the halteres, or rudiments of wings of some two-winged insects; and the paps of male animals; thus swine have four toes, but two of them are imperfectly formed, and not long enough for use. The allantoide in some animals seems to have become extinct; in others is above tenfold the size, which would seem necessary for its purpose. Buffon du Cochon. T. 6. p. 257. Perhaps all the supposed monstrous births of Nature are remains of their habits of production in their former less perfect state, or attempts towards greater perfection.]

[*Through all his realms*. l. 105. Mr. Herschel has given a very sublime and curious account of the construction of the heavens with his discovery of some thousand nebulae, or clouds of stars; many of which are much larger collections of stars, than all those put together, which are visible to our naked eyes, added to those which form the galaxy, or milky zone, which surrounds us. He observes that in the vicinity of these clusters of stars there are proportionally fewer stars than in other parts of the heavens; and hence he concludes, that they have attracted each other, on the supposition that infinite space was at first equally sprinkled with them; as if it had at the beginning been filled with a fluid mass, which had coagulated. Mr. Herschel has further shewn, that the whole sidereal system is gradually moving round some centre, which may be an opake mass of matter, Philos. Trans. V. LXXIV. If all these Suns are moving round some great central body; they must have had a projectile force, as well as a centripetal one; and may thence be supposed to have emerged or been projected from the material, where they were produced. We can have no idea of a natural power, which could project a Sun out of Chaos, except by comparing it to the explosions or earthquakes owing to the sudden evolution of aqueous or of other more elastic vapours; of the power of which under immeasurable degrees of heat, and compression, we are yet ignorant.

It may be objected, that if the stars had been projected from a Chaos by explosions, that they must have returned again into it from the known laws of gravitation; this however would not happen, if the whole of Chaos, like grains of gunpowder, was exploded at the same time, and dispersed through infinite space at once, or in quick succession, in every possible direction. The same objection may be stated against the possibility of the planets having been thrown from the sun by explosions; and the secondary planets from the primary ones; which will be spoken of more at large in the second Canto,

but if the planets are supposed to have been projected from their suns, and the secondary from the primary ones, at the beginning of their course; they might be so influenced or diverted by the attractions of the suns, or sun, in their vicinity, as to prevent their tendency to return into the body, from which they were projected.

If these innumerable and immense suns thus rising out of Chaos are supposed to have thrown out their attendant planets by new explosions, as they ascended; and those their respective satellites, filling in a moment the immensity of space with light and motion, a grander idea cannot be conceived by the mind of man.]

II. "ETHEREAL POWERS! YOU chase the shooting stars,
Or yoke the vollied lightenings to your cars,
Cling round the aërial bow with prisms bright,
And pleased untwist the sevenfold threads of light;
Eve's silken couch with gorgeous tints adorn,
And fire the arrowy throne of rising Morn.
—OR, plum'd with flame, in gay battalion's spring
To brighter regions borne on broader wing;
Where lighter gases, circumfused on high,
Form the vast concave of exterior sky;
With airy lens the scatter'd rays assault,
And bend the twilight round the dusky vault;
Ride, with broad eye and scintillating hair,
The rapid Fire-ball through the midnight air;
Dart from the North on pale electric streams,
Fringing Night's sable robe with transient beams.
—OR rein the Planets in their swift careers,
Gilding with borrow'd light their twinkling spheres;
Alarm with comet-blaze the sapphire plain,
The wan stars glimmering through its silver train;
Gem the bright Zodiac, stud the glowing pole,
Or give the Sun's phlogistic orb to roll.

[*Chase the shooting stars*. l. 115. The meteors called shooting stars, the lightening, the rainbow, and the clouds, are phenomena of the lower regions of the atmosphere. The twilight, the meteors call'd fire-balls, or flying dragons, and the northern lights, inhabit the higher regions of the atmosphere. See additional notes, No. I.]

[*Cling round the aerial bow*. l. 117. See additional notes, No. II]

[*Eve's silken couch*. l. 119. See additional notes, No. III.]

[*Where lighter gases*. l. 123. Mr. Cavendish has shewn that the gas called inflammable air, is at least ten times lighter than common air; Mr. Lavoisier contends, that it is one of the component parts of water, and is by him called hydrogene. It is supposed to afford their principal nourishment to vegetables and thence to animals, and is perpetually rising from their decomposition; this source of it in hot climates, and in summer months, is so great as to exceed estimation. Now if this light gas passes through the atmosphere, without combining with it, it must compose another atmosphere over the aerial one; which must expand, when the pressure above it is thus taken away, to inconceivable tenuity.

If this supernatural gasseous atmosphere floats upon the aerial one, like ether upon water, what must happen? 1. it will flow from the line, where it will be produced in the greatest quantities, and become much accumulated over the poles of the earth; 2. the common air, or lower stratum of the atmosphere, will be much thinner over the poles than at the line; because if a glass globe be filled with oil and water, and whirled upon its axis, the centrifugal power will carry the heavier fluid to the circumference, and the lighter will in consequence be found round the axis. 3. There may be a place at some certain latitude between the poles and the line on each side the equator, where the inflammable supernatant atmosphere may end, owing to the greater centrifugal force of the heavier aerial atmosphere. 4. Between the termination of the aerial and the beginning of the gasseous atmosphere, the airs will occasionally be intermixed, and thus become inflammable by the electric spark; these circumstances will assist in explaining the phenomena of fire-balls, northern lights, and of some variable winds, and long continued rains.

Since the above note was first written, Mr. Volta I am informed has applied the supposition of a supernatant atmosphere of inflammable air, to explain some phenomena in meteorology. And Mr.

Lavoisier has announced his design to write on this subject. Traité de Chimie, Tom. I. I am happy to find these opinions supported by such respectable authority.]

[*And bend the twilight*. l. 126. The crepuscular atmosphere, or the region where the light of the sun ceases to be refracted to us, is estimated by philosophers to be between 40 and 50 miles high, at which time the sun is about 18 degrees below the horizon; and the rarity of the air is supposed to be from 4,000 to 10,000 times greater than at the surface of the earth. Cotes's Hydrost. p. 123. The duration of twilight differs in different seasons and in different latitudes; in England the shortest twilight is about the beginning of October and of March; in more northern latitudes, where the sun never sinks more than 18 degrees, below the horizon, the twilight continues the whole night. The time of its duration may also be occasionally affected by the varying height of the atmosphere. A number of observations on the duration of twilight in different latitudes might afford considerable information concerning the aerial strata in the higher regions of the atmosphere, and might assist in determining whether an exterior atmosphere of inflammable gas, or Hydrogene, exists over the aerial one.]

[*Alarm with Comet-blaze*. l. 133. See additional notes, No. IV.]

[*The Sun's phlogistic orb*. l. 136. See additional notes, No. V.]

III. NYMPHS! YOUR fine forms with steps impassive mock
Earth's vaulted roofs of adamantine rock;
Round her still centre tread the burning soil,
And watch the billowy Lavas, as they boil;
Where, in basaltic caves imprison'd deep,
Reluctant fires in dread suspension sleep;
Or sphere on sphere in widening waves expand,
And glad with genial warmth the incumbent land.
So when the Mother-bird selects their food
With curious bill, and feeds her callow brood;
Warmth from her tender heart eternal springs,
And pleased she clasps them with extended wings.

[*Round the still centre*. l. 139. Many philosophers have believed that the central parts of the earth consist of a fluid mass of burning lava, which they have called a subterraneous sun; and have supposed, that it contributes to the production of metals, and to the growth of vegetables. See additional notes, No. VI.]

[*Or sphere on sphere*. l. 143. See additional notes, No. VII.]

"YOU from deep cauldrons and unmeasured caves
Blow flaming airs, or pour vitrescent waves;
O'er shining oceans ray volcanic light,
Or hurl innocuous embers to the night.—
While with loud shouts to Etna Heccla calls,
And Andes answers from his beacon'd walls;
Sea-wilder'd crews the mountain-stars admire,
And Beauty beams amid tremendous fire.

[*Hurl innocuous embers*. l. 152. The immediate cause of volcanic eruptions is believed to be owing to the water of the sea, or from lakes, or inundations, finding itself a passage into the subterraneous fires, which may lie at great depths. This must first produce by its coldness a condensation of the vapour there existing, or a vacuum, and thus occasion parts of the earth's crust or shell to be forced down by the pressure of the incumbent atmosphere. Afterwards the water being suddenly raised into steam produces all the explosive effects of earthquakes. And by new accessions of water during the intervals of the explosions the repetition of the shocks is caused. These circumstances were hourly illustrated by the fountains of boiling water in Iceland, in which the surface of the water in the boiling wells sunk down low before every new ebullition.

Besides these eruptions occasioned by the steam of water, there seems to be a perpetual effusion of other vapours, more noxious and (as far as it is yet known) perhaps greatly more expansile than water from the Volcanos in various parts of the world. As these Volcanos are supposed to be spiracula or breathing holes to the great subterraneous fires, it is probable that the escape of elastic vapours from them is the cause, that the earthquakes of modern days are of such small extent compared to those of antient times, of which vestiges remain in every part of the world, and on this account may be said not

only to be innocuous, but useful.]

"Thus when of old, as mystic bards presume,
Huge CYCLOPS dwelt in Etna's rocky womb,
On thundering anvils rung their loud alarms,
And leagued with VULCAN forged immortal arms;
Descending VENUS sought the dark abode,
And sooth'd the labours of the grisly God.—
While frowning Loves the threatening falchion wield,
And tittering Graces peep behind the shield,
With jointed mail their fairy limbs o'erwhelm,
Or nod with pausing step the plumed helm;
With radiant eye She view'd the boiling ore,
Heard undismay'd the breathing bellows roar,
Admired their sinewy arms, and shoulders bare,
And ponderous hammers lifted high in air,
With smiles celestial bless'd their dazzled sight,
And Beauty blazed amid infernal night.

IV. "EFFULGENT MAIDS! YOU round deciduous day,
Tressed with soft beams, your glittering bands array;
On Earth's cold bosom, as the Sun retires,
Confine with folds of air the lingering fires;
O'er Eve's pale forms diffuse phosphoric light,
And deck with lambent flames the shrine of Night.
So, warm'd and kindled by meridian skies,
And view'd in darkness with dilated eyes,
BOLOGNA'S chalks with faint ignition blaze,
BECCARI'S shells emit prismatic rays.
So to the sacred Sun in MEMNON's fane,
Spontaneous concords quired the matin strain;
—Touch'd by his orient beam, responsive rings
The living lyre, and vibrates all it's strings;
Accordant ailes the tender tones prolong,
And holy echoes swell the adoring song.

[*Confine with folds of air*. l. 176. The air, like all other bad conductors of electricity, is known to be a bad conductor of heat; and thence prevents the heat acquired from the sun's rays by the earth's surface from being so soon dissipated, in the same manner as a blanket, which may be considered as a sponge filled with air, prevents the escape of heat from the person wrapped in it. This seems to be one cause of the great degree of cold on the tops of mountains, where the rarity of the air is greater, and it therefore becomes a better conductor both of heat and electricity. See note on Barometz, Vol. II. of this work.

There is however another cause to which the great coldness of mountains and of the higher regions of the atmosphere is more immediately to be ascribed, explained by Dr. Darwin in the Philos. Trans. Vol. LXXVIII. who has there proved by experiments with the air-gun and air-pump, that when any portion of the atmosphere becomes mechanically expanded, it absorbs heat from the bodies in its vicinity. And as the air which creeps along the plains, expands itself by a part of the pressure being taken off when it ascends the sides of mountains; it at the same time attracts heat from the summits of those mountains, or other bodies which happen to be immersed in it, and thus produces cold. Hence he concludes that the hot air at the bottom of the Andes becomes temperate by its own rarefaction when it ascends to the city of Quito; and by its further rarefaction becomes cooled to the freezing point when it ascends to the snowy regions on the summits of those mountains. To this also he attributes the great degree of cold experienced by the aeronauts in their balloons; and which produces hail in summer at the height of only two or three miles in the atmosphere.]

[*Diffuse phosphoric light*. l. 177. I have often been induced to believe from observation, that the twilight of the evenings is lighter than that of the mornings at the same distance from noon. Some may ascribe this to the greater height of the atmosphere in the evenings having been rarefied by the sun during the day; but as its density must at the same time be diminished, its power of refraction would continue the same. I should rather suppose that it may be owing to the phosphorescent quality (as it is called) of almost all bodies; that is, when they have been exposed to the sun they continue to emit light for a considerable time afterwards. This is generally believed to arise either from such bodies giving out the light which they had previously absorbed; or to the continuance of a slow combustion which the

light they had been previously exposed to had excited. See the next note.]

[*Beccari's shells*. l. 182. Beccari made many curious experiments on the phosphoric light, as it is called, which becomes visible on bodies brought into a dark room, after having been previously exposed to the sunshine. It appears from these experiments, that almost all inflammable bodies possess this quality in a greater or less degree; white paper or linen thus examined after having been exposed to the sunshine, is luminous to an extraordinary degree; and if a person shut up in a dark room, puts one of his hands out into the sun's light for a short time and then retracts it, he will be able to see that hand distinctly and not the other. These experiments seem to countenance the idea of light being absorbed and again emitted from bodies when they are removed into darkness. But Beccari further pretended, that some calcareous compositions when exposed to red, yellow, or blue light, through coloured glasses, would on their being brought into a dark room emit coloured lights. This mistaken fact of Beccari's, Mr. Wilson decidedly refutes; and among many other curious experiments discovered, that if oyster-shells were thrown into a common fire and calcined for about half an hour, and then brought to a person who had previously been some minutes in a dark room, that many of them would exhibit beautiful irises of prismatic colours, from whence probably arose Beccari's mistake. Mr. Wilson from hence contends, that these kinds of phosphori do not emit the light they had previously received, but that they are set on fire by the sun's rays, and continue for some time a slow combustion after they are withdrawn from the light. Wilson's Experiments on Phosphori. Dodsley, 1775.

The Bolognian stone is a selenite, or gypsum, and has been long celebrated for its phosphorescent quality after having been burnt in a sulphurous fire; and exposed when cold to the sun's light. It may be thus well imitated: Calcine oyster-shells half an hour, pulverize them when cold, and add one third part of flowers of sulphur, press them close into a small crucible, and calcine them for an hour or longer, and keep the powder in a phial close stopped. A part of this powder is to be exposed for a minute or two to the sunbeams, and then brought into a dark room. The calcined Bolognian stone becomes a calcareous hepar of sulphur; but the calcined shells, as they contain the animal acid, may also contain some of the phosphorus of Kunkel.]

[*In Memnon's fane*. l. 183. See additional notes. No. VIII.]

"YOU with light Gas the lamps nocturnal feed,
Which dance and glimmer o'er the marshy mead;
Shine round Calendula at twilight hours,
And tip with silver all her saffron flowers;
Warm on her mossy couch the radiant Worm,
Guard from cold dews her love-illumin'd form,
From leaf to leaf conduct the virgin light,
Star of the earth, and diamond of the night.
You bid in air the tropic Beetle burn,
And fill with golden flame his winged urn;
Or gild the surge with insect-sparks, that swarm
Round the bright oar, the kindling prow alarm;
Or arm in waves, electric in his ire,
The dread Gymnotus with ethereal fire.—
Onward his course with waving tail he helms,
And mimic lightenings scare the watery realms,
So, when with bristling plumes the Bird of JOVE
Vindictive leaves the argent fields above,
Borne on broad wings the guilty world he awes,
And grasps the lightening in his shining claws.

[*The lamps nocturnal*. l. 189. The ignis fatuus or Jack a lantern, frequently alluded to by poets, is supposed to originate from the inflammable air, or Hydrogene, given up from morasses; which being of a heavier kind from its impurity than that obtained from iron and water, hovers near the surface of the earth, and uniting with common air gives out light by its slow ignition. Perhaps such lights have no existence, and the reflection of a star on watery ground may have deceived the travellers, who have been said to be bewildered by them? if the fact was established it would much contribute to explain the phenomena of northern lights. I have travelled much in the night, in all seasons of the year, and over all kinds of soil, but never saw one of these Will o'wisps.]

[*Shine round Calendula*. l. 191. See note on Tropaeolum in Vol. II.]

[*The radiant Worm*. l. 193. See additional notes, No. IX.]

[*The dread Gymnotus*. l. 202. The Gymnotus electricus is a native of the river of Surinam in South America; those which were brought over to England about eight years ago were about three or four feet long, and gave an electric shock (as I experienced) by putting one finger on the back near its head, and another of the opposite hand into the water near its tail. In their native country they are said to exceed twenty feet in length, and kill any man who approaches them in an hostile manner. It is not only to escape its enemies that this surprizing power of the fish is used, but also to take its prey; which it does by benumbing them and then devouring them before they have time to recover, or by perfectly killing them; for the quantity of the power seemed to be determined by the will or anger of the animal; as it sometimes struck a fish twice before it was sufficiently benumbed to be easily swallowed.

The organs productive of this wonderful accumulation of electric matter have been accurately dissected and described by Mr. J. Hunter. Philos. Trans. Vol. LXV. And are so divided by membranes as to compose a very extensive surface, and are supplied with many pairs of nerves larger than any other nerves of the body; but how so large a quantity is so quickly accumulated as to produce such amazing effects in a fluid ill adapted for the purpose is not yet satisfactorily explained. The Torpedo possesses a similar power in a less degree, as was shewn by Mr. Walch, and another fish lately described by Mr. Paterson. Philo. Trans. Vol. LXXVI.

In the construction of the Leyden-Phial, (as it is called) which is coated on both sides, it is known, that above one hundred times the quantity of positive electricity can be condensed on every square inch of the coating on one side, than could have been accumulated on the same surface if there had been no opposite coating communicating with the earth; because the negative electricity, or that part of it which caused its expansion, is now drawn off through the glass. It is also well known, that the thinner the glass is (which is thus coated on both sides so as to make a Leyden-phial, or plate) the more electricity can be condensed on one of its surfaces, till it becomes so thin as to break, and thence discharge itself.

Now it is possible, that the quantity of electricity condensible on one side of a coated phial may increase in some high ratio in respect to the thinness of the glass, since the power of attraction is known to decrease as the squares of the distances, to which this circumstance of electricity seems to bear some analogy. Hence if an animal membrane, as thin as the silk-worm spins its silk, could be so situated as to be charged like the Leyden bottle, without bursting, (as such thin glass would be liable to do,) it would be difficult to calculate the immense quantity of electric fluid, which might be accumulated on its surface. No land animals are yet discovered which possess this power, though the air would have been a much better medium for producing its effects; perhaps the size of the necessary apparatus would have been inconvenient to land animals.]

[*In his shining claws*. l. 208. Alluding to an antique gem in the collection of the Grand Duke of Florence. Spence.]

V. 1. "NYMPHS! Your soft smiles uncultur'd man subdued,
And charm'd the Savage from his native wood;
You, while amazed his hurrying Hords retire
From the fell havoc of devouring FIRE,
Taught, the first Art! with piny rods to raise
By quick attrition the domestic blaze,
Fan with soft breath, with kindling leaves provide,
And lift the dread Destroyer on his side.
So, with bright wreath of serpent-tresses crown'd,
Severe in beauty, young MEDUSA frown'd;
Erewhile subdued, round WISDOM'S Aegis roll'd
Hiss'd the dread snakes, and flam'd in burnish'd gold;
Flash'd on her brandish'd arm the immortal shield,
And Terror lighten'd o'er the dazzled field.

[*Of devouring fire*. l. 212. The first and most important discovery of mankind seems to have been that of fire. For many ages it is probable fire was esteemed a dangerous enemy, known only by its dreadful devastations; and that many lives must have been lost, and many dangerous burns and wounds must have afflicted those who first dared to subject it to the uses of life. It is said that the tall monkies of Borneo and Sumatra lie down with pleasure round any accidental fire in their woods; and are arrived to that degree of reason, that knowledge of causation, that they thrust into the remaining fire the half-burnt ends of the branches to prevent its going out. One of the nobles of the cultivated people of Otaheita, when Captain Cook treated them with tea, catched the boiling water in his hand from the cock of the tea-urn, and bellowed with pain, not conceiving that water could become hot, like red fire.

Tools of steel constitute another important discovery in consequence of fire; and contributed perhaps principally to give the European nations so great superiority over the American world. By these two agents, fire and tools of steel, mankind became able to cope with the vegetable kingdom, and conquer provinces of forests, which in uncultivated countries almost exclude the growth of other vegetables, and of those animals which are necessary to our existence. Add to this, that the quantity of our food is also increased by the use of fire, for some vegetables become salutary food by means of the heat used in cookery, which are naturally either noxious or difficult of digestion; as potatoes, kidney-beans, onions, cabbages. The cassava when made into bread, is perhaps rendered mild by the heat it undergoes, more than by expressing its superfluous juice. The roots of white bryony and of arum, I am informed lose much of their acrimony by boiling.]

[*Young Medusa frowned*. l. 218. The Egyptian Medusa is represented on antient gems with wings on her head, snaky hair, and a beautiful countenance, which appears intensely thinking; and was supposed to represent divine wisdom. The Grecian Medusa, on Minerva's shield, as appears on other gems, has a countenance distorted with rage or pain, and is supposed to represent divine vengeance. This Medusa was one of the Gorgons, at first very beautiful and terrible to her enemies; Minerva turned her hair into snakes, and Perseus having cut off her head fixed it on the shield of that goddess; the sight of which then petrified the beholders. Dannet Dict.]

2. NYMPHS! YOU disjoin, unite, condense, expand,
And give new wonders to the Chemist's hand;
On tepid clouds of rising steam aspire,
Or fix in sulphur all it's solid fire;
With boundless spring elastic airs unfold,
Or fill the fine vacuities of gold;
With sudden flash vitrescent sparks reveal,
By fierce collision from the flint and steel;
Or mark with shining letter KUNKEL's name
In the pale Phosphor's self-consuming flame.
So the chaste heart of some enchanted Maid
Shines with insidious light, by Love betray'd;
Round her pale bosom plays the young Desire,
And slow she wastes by self-consuming fire.

[*Or fix in sulphur*. l. 226. The phenomena of chemical explosions cannot be accounted for without the supposition, that some of the bodies employed contain concentrated or solid heat combined with them, to which the French Chemists have given the name of Calorique. When air is expanded in the air-pump, or water evaporated into steam, they drink up or absorb a great quantity of heat; from this analogy, when gunpowder is exploded it ought to absorb much heat, that is, in popular language, it ought to produce a great quantity of cold. When vital air is united with phlogistic matter in respiration, which seems to be a slow combustion, its volume is lessened; the carbonic acid, and perhaps phosphoric acid are produced; and heat is given out; which according to the experiments of Dr. Crawford would seem to be deposited from the vital air. But as the vital air in nitrous acid is condensed from a light elastic gas to that of a heavy fluid, it must possess less heat than before. And hence a great part of the heat, which is given out in firing gunpowder, I should suppose, must reside in the sulphur or charcoal.

Mr. Lavoisier has shewn, that vital air, or Oxygene, looses less of its heat when it becomes one of the component parts of nitrous acid, than in any other of its combinations; and is hence capable of giving out a great quantity of heat in the explosion of gunpowder; but as there seems to be great analogy between the matter of heat, or Calorique, and the electric matter; and as the worst conductors of electricity are believed to contain the greatest quantity of that fluid; there is reason to suspect that the worst conductors of heat may contain the most of that fluid; as sulphur, wax, silk, air, glass. See note on l. 174 of this Canto.]

[*Vitrescent sparks*. l. 229. When flints are struck against other flints they have the property of giving sparks of light; but it seems to be an internal light, perhaps of electric origin, very different from the ignited sparks which are struck from flint and steel. The sparks produced by the collision of steel with flint appear to be globular particles of iron, which have been fused, and imperfectly scorified or vitrified. They are kindled by the heat produced by the collision; but their vivid light, and their fusion and vitrification are the effects of a combustion continued in these particles during their passage through the air. This opinion is confirmed by an experiment of Mr. Hawksbee, who found that these sparks could not be produced in the exhausted receiver. See Keir's Chemical Dict. art. Iron, and art. Earth vitrifiable.]

[*The pale Phosphor*. l. 232. See additionable notes, No. X.]

3. "YOU taught mysterious BACON to explore
Metallic veins, and part the dross from ore;
With sylvan coal in whirling mills combine
The crystal'd nitre, and the sulphurous mine;
Through wiry nets the black diffusion strain,
And close an airy ocean in a grain.—
Pent in dark chambers of cylindric brass
Slumbers in grim repose the sooty mass;
Lit by the brilliant spark, from grain to grain
Runs the quick fire along the kindling train;
On the pain'd ear-drum bursts the sudden crash,
Starts the red flame, and Death pursues the flash.—
Fear's feeble hand directs the fiery darts,
And Strength and Courage yield to chemic arts;
Guilt with pale brow the mimic thunder owns,
And Tyrants tremble on their blood-stain'd thrones.

[*And close an airy ocean*. l. 242. Gunpowder is plainly described in the works of Roger Bacon before the year 1267. He describes it in a curious manner, mentioning the sulphur and nitre, but conceals the charcoal in an anagram. The words are, sed tamen salis petrae *lure mope can ubre*, et sulphuris; et sic facies tonitrum, et corruscationem, si scias, artificium. The words lure mope can ubre are an anagram of carbonum pulvere. Biograph. Britan. Vol. I. Bacon de Secretis Operibus, Cap. XI. He adds, that he thinks by an artifice of this kind Gideon defeated the Midianites with only three hundred men. Judges, Chap. VII. Chamb. Dict. art. Gunpowder. As Bacon does not claim this as his own invention, it is thought by many to have been of much more antient discovery.

The permanently elastic fluid generated in the firing of gunpowder is calculated by Mr. Robins to be about 244 if the bulk of the powder be 1. And that the heat generated at the time of the explosion occasions the rarefied air thus produced to occupy about 1000 times the space of the gunpowder. This pressure may therefore be called equal to 1000 atmospheres or six tons upon a square inch. As the suddenness of this explosion must contribute much to its power, it would seem that the chamber of powder, to produce its greatest effect, should be lighted in the centre of it; which I believe is not attended to in the manufacture of muskets or pistols.

From the cheapness with which a very powerful gunpowder is likely soon to be manufactured from aerated marine acid, or from a new method of forming nitrous acid by means of mangonese or other calciform ores, it may probably in time be applied to move machinery, and supersede the use of steam.

There is a bitter invective in Don Quixot against the inventors of gun- powder, as it levels the strong with the weak, the knight cased in steel with the naked shepherd, those who have been trained to the sword, with those who are totally unskilful in the use of it; and throws down all the splendid distinctions of mankind. These very reasons ought to have been urged to shew that the discovery of gunpowder has been of public utility by weakening the tyranny of the few over the many.]

VI. NYMPHS! You erewhile on simmering cauldrons play'd,
And call'd delighted SAVERY to your aid;
Bade round the youth explosive STEAM aspire
In gathering clouds, and wing'd the wave with fire;
Bade with cold streams the quick expansion stop,
And sunk the immense of vapour to a drop.—
Press'd by the ponderous air the Piston falls
Resistless, sliding through it's iron walls;
Quick moves the balanced beam, of giant-birth,
Wields his large limbs, and nodding shakes the earth.

[*Delighted Savery*. l. 254. The invention of the steam-engine for raising water by the pressure of the air in consequence of the condensation of steam, is properly ascribed to Capt. Savery; a plate and description of this machine is given in Harris's Lexicon Technicum, art. Engine. Though the Marquis of Worcester in his Century of Inventions printed in the year 1663 had described an engine for raising water by the explosive power of steam long before Savery's. Mr. Desegulier affirms, that Savery bought up all he could procure of the books of the Marquis of Worcester, and destroyed them, professing himself then to have discovered the power of steam by accident, which seems to have been an

unfounded slander. Savery applied it to the raising of water to supply houses and gardens, but could not accomplish the draining of mines by it. Which was afterwards done by Mr. Newcomen and Mr. John Cowley at Dartmouth, in the year 1712, who added the piston.

A few years ago Mr. Watt of Glasgow much improved this machine, and with Mr. Boulton of Birmingham has applied it to variety of purposes, such as raising water from mines, blowing bellows to fuse the ore, supplying towns with water, grinding corn and many other purposes. There is reason to believe it may in time be applied to the rowing of barges, and the moving of carriages along the road. As the specific levity of air is too great for the support of great burthens by balloons, there seems no probable method of flying conveniently but by the power of steam, or some other explosive material; which another half century may probable discover. See additional notes, No. XI.]

"The Giant-Power from earth's remotest caves
Lifts with strong arm her dark reluctant waves;
Each cavern'd rock, and hidden den explores,
Drags her dark coals, and digs her shining ores.—
Next, in close cells of ribbed oak confined,
Gale after gale, He crowds the struggling wind;
The imprison'd storms through brazen nostrils roar,
Fan the white flame, and fuse the sparkling ore.
Here high in air the rising stream He pours
To clay-built cisterns, or to lead-lined towers;
Fresh through a thousand pipes the wave distils,
And thirsty cities drink the exuberant rills.—
There the vast mill-stone with inebriate whirl
On trembling floors his forceful fingers twirl.
Whose flinty teeth the golden harvests grind,
Feast without blood! and nourish human-kind.

[*Feast without blood!* l. 278. The benevolence of the great Author of all things is greatly manifest in the sum of his works, as Dr. Balguy has well evinced in his pamphlet on Divine Benevolence asserted, printed for Davis, 1781. Yet if we may compare the parts of nature with each other, there are some circumstances of her economy which seem to contribute more to the general scale of happiness than others. Thus the nourishment of animal bodies is derived from three sources: 1. the milk given from the mother to the offspring; in this excellent contrivance the mother has pleasure in affording the sustenance to the child, and the child has pleasure in receiving it. 2. Another source of the food of animals includes seeds or eggs; in these the embryon is in a torpid or insensible state, and there is along with it laid up for its early nourishment a store of provision, as the fruit belonging to some seeds, and the oil and starch belonging to others; when these are consumed by animals the unfeeling seed or egg receives no pain, but the animal receives pleasure which consumes it. Under this article may be included the bodies of animals which die naturally. 3. But the last method of supporting animal bodies by the destruction of other living animals, as lions preying upon lambs, these upon living vegetables, and mankind upon them all, would appear to be a less perfect part of the economy of nature than those before mentioned, as contributing less to the sum of general happiness.]

"Now his hard hands on Mona's rifted crest,
Bosom'd in rock, her azure ores arrest;
With iron lips his rapid rollers seize
The lengthening bars, in thin expansion squeeze;
Descending screws with ponderous fly-wheels wound
The tawny plates, the new medallions round;
Hard dyes of steel the cupreous circles cramp,
And with quick fall his massy hammers stamp.
The Harp, the Lily and the Lion join,
And GEORGE and BRITAIN guard the sterling coin.

[*Mona's rifted crest*. l. 279. Alluding to the very valuable copper- mines in the isle of Anglesey, the property of the Earl of Uxbridge.]

[*With iron-lips*. l. 281. Mr. Boulton has lately constructed at Soho near Birmingham, a most magnificent apparatus for Coining, which has cost him some thousand pounds; the whole machinery is moved by an improved steam-engine, which rolls the copper for half-pence finer than copper has before been rolled for the purpose of making money; it works the coupoirs or screw-presses for cutting out the

circular pieces of copper; and coins both the faces and edges of the money at the same time, with such superior excellence and cheapness of workmanship, as well as with marks of such powerful machinery as must totally prevent clandestine imitation, and in consequence save many lives from the hand of the executioner; a circumstance worthy the attention of a great minister. If a civic crown was given in Rome for preserving the life of one citizen, Mr. Boulton should be covered with garlands of oak! By this machinery four boys of ten or twelve years old are capable of striking thirty thousand guineas in an hour, and the machine itself keeps an unerring account of the pieces struck.]

"Soon shall thy arm, UNCONQUER'D STEAM! afar
Drag the slow barge, or drive the rapid car;
Or on wide-waving wings expanded bear
The flying-chariot through the fields of air.
—Fair crews triumphant, leaning from above,
Shall wave their fluttering kerchiefs as they move;
Or warrior-bands alarm the gaping crowd,
And armies shrink beneath the shadowy cloud.

"So mighty HERCULES o'er many a clime
Waved his vast mace in Virtue's cause sublime,
Unmeasured strength with early art combined,
Awed, served, protected, and amazed mankind.—
First two dread Snakes at JUNO'S vengeful nod
Climb'd round the cradle of the sleeping God;
Waked by the shrilling hiss, and rustling sound,
And shrieks of fair attendants trembling round,
Their gasping throats with clenching hands he holds;
And Death untwists their convoluted folds.
Next in red torrents from her sevenfold heads
Fell HYDRA'S blood on Lerna's lake he sheds;
Grasps ACHELOUS with resistless force,
And drags the roaring River to his course;
Binds with loud bellowing and with hideous yell
The monster Bull, and threefold Dog of Hell.

[*So mighty Hercules*. l. 297. The story of Hercules seems of great antiquity, as appears from the simplicity of his dress and armour, a lion's skin and a club; and from the nature of many of his exploits, the destruction of wild beasts and robbers. This part of the history of Hercules seems to have related to times before the invention of the bow and arrow, or of spinning flax. Other stories of Hercules are perhaps of later date, and appear to be allegorical, as his conquering the river- god Achilous, and bringing Cerberus up to day light; the former might refer to his turning the course of a river, and draining a morass, and the latter to his exposing a part of the superstition of the times. The strangling the lion and tearing his jaws asunder, are described from a statue in the Museum Florentinum, and from an antique gem; and the grasping Anteus to death in his arms as he lifts him from the earth, is described from another antient cameo. The famous pillars of Hercules have been variously explained. Pliny asserts that the natives of Spain and of Africa believed that the mountains of Abyla and Calpè on each side of the straits of Gibraltar were the pillars of Hercules; and that they were reared by the hands of that god, and the sea admitted between them. Plin. Hist. Nat. p. 46. Edit. Manut. Venet. 1609.

If the passage between the two continents was opened by an earthquake in antient times, as this allegorical story would seem to countenance, there must have been an immense current of water at first run into the Mediterranean from the Atlantic; since there is at present a strong stream sets always from thence into the Mediterranean. Whatever may be the cause, which now constantly operates, so as to make the surface of the Mediterranean lower than that of the Atlantic, it must have kept it very much lower before a passage for the water through the streights was opened. It is probable before such an event took place, the coasts and islands of the Mediterranean extended much further into that sea, and were then for a great extent of country, destroyed by the floods occasioned by the new rise of water, and have since remained beneath the sea. Might not this give rise to the flood of Deucalion? See note Cassia, V. II. of this work.]

"Then, where Nemea's howling forests wave,
He drives the Lion to his dusky cave;
Seized by the throat the growling fiend disarms,
And tears his gaping jaws with sinewy arms;
Lifts proud ANTEUS from his mother-plains,

And with strong grasp the struggling Giant strains;
Back falls his fainting head, and clammy hair,
Writhe his weak limbs, and flits his life in air;—
By steps reverted o'er the blood-dropp'd fen
He tracks huge CACUS to his murderous den;
Where breathing flames through brazen lips he fled,
And shakes the rock-roof'd cavern o'er his head.

"Last with wide arms the solid earth He tears,
Piles rock on rock, on mountain mountain rears;
Heaves up huge ABYLA on Afric's sand,
Crowns with high CALPÈ Europe's saliant strand,
Crests with opposing towers the splendid scene,
And pours from urns immense the sea between.—
—Loud o'er her whirling flood Charybdis roars,
Affrighted Scylla bellows round his shores,
Vesuvio groans through all his echoing caves,
And Etna thunders o'er the insurgent waves.

VII. 1. NYMPHS! YOUR fine hands ethereal floods amass
From the warm cushion, and the whirling glass;
Beard the bright cylinder with golden wire,
And circumfuse the gravitating fire.
Cold from each point cerulean lustres gleam,
Or shoot in air the scintillating stream.
So, borne on brazen talons, watch'd of old
The sleepless dragon o'er his fruits of gold;
Bright beam'd his scales, his eye-balls blazed with ire,
And his wide nostrils breath'd inchanted fire.

[*Ethereal floods amass*. l. 335. The theory of the accumulation of the electric fluid by means of the glass-globe and cushion is difficult to comprehend. Dr. Franklin's idea of the pores of the glass being opened by the friction, and thence rendered capable of attracting more electric fluid, which it again parts with, as the pores contract again, seems analogous in some measure to the heat produced by the vibration, or condensation of bodies, as when a nail is hammered or filed till it becomes hot, as mentioned in additional Notes, No. VII. Some philosophers have endeavoured to account for this phenomenon by supposing the existence of two electric fluids which may be called the vitreous and resinous ones, instead of the plus and minus of the same ether. But its accumulation on the rubbed glass bears great analogy to its accumulation on the surface of the Leyden bottle, and can not perhaps be explained from any known mechanical or chemical principle. See note on Gymnotus. l. 202, of this Canto.]

[*Cold from each point*. l. 339. See additional note, No. XIII.]

"YOU bid gold-leaves, in crystal lantherns held,
Approach attracted, and recede repel'd;
While paper-nymphs instinct with motion rife,
And dancing fauns the admiring Sage surprize.
OR, if on wax some fearless Beauty stand,
And touch the sparkling rod with graceful hand;
Through her fine limbs the mimic lightnings dart,
And flames innocuous eddy round her heart;
O'er her fair brow the kindling lustres glare,
Blue rays diverging from her bristling hair;
While some fond Youth the kiss ethereal sips.
And soft fires issue from their meeting lips.
So round the virgin Saint in silver streams
The holy Halo shoots it's arrowy beams.

[*You bid gold leaves*. l. 345. Alluding to the very sensible electrometer improved by Mr. Bennett, it consists of two slips of gold- leaf suspended from a tin cap in a glass cylinder, which has a partial coating without, communicating with the wooden pedestal. If a stick of sealing wax be rubbed for a moment on a dry cloth, and then held in the air *at the distance of two or three feet* from the cap of this instrument, the gold leaves seperate, such is its astonishing sensibility to electric influence! (See

Bennet on electricity, Johnson, Lond.) The nerves of sense of animal bodies do not seem to be affected by less quantities of light or heat!]

[*The holy Halo*. l. 358. I believe it is not known with certainty at what time the painters first introduced the luminous circle round the head to import a Saint or holy person. It is now become a part of the symbolic language of painting, and it is much to be wished that this kind of hieroglyphic character was more frequent in that art; as it is much wanted to render historic pictures both more intelligible, and more sublime; and why should not painting as well as poetry express itself in metaphor, or in indistinct allegory? A truly great modern painter lately endeavoured to enlarge the sphere of pictorial language, by putting a demon behind the pillow of a wicked man on his death bed. Which unfortunately for the scientific part of painting, the cold criticism of the present day has depreciated; and thus barred perhaps the only road to the further improvement in this science.]

"YOU crowd in coated jars the denser fire,
Pierce the thin glass, and fuse the blazing wire;
Or dart the red flash through the circling band
Of youths and timorous damsels, hand in hand.
—Starts the quick Ether through the fibre-trains
Of dancing arteries, and of tingling veins,
Goads each fine nerve, with new sensation thrill'd,
Bends the reluctant limbs with power unwill'd;
Palsy's cold hands the fierce concussion own,
And Life clings trembling on her tottering throne.—
So from dark clouds the playful lightning springs,
Rives the firm oak, or prints the Fairy-rings.

[*With new sensation thrill'd*. l. 365. There is probably a system of nerves in animal bodies for the purpose of perceiving heat; since the degree of this fluid is so necessary to health that we become presently injured either by its access or defect; and because almost every part of our bodies is supplied with branches from different pairs of nerves, which would not seem necessary for their motion alone: It is therefore probable, that our sensation of electricity is only of its violence in passing through our system by its suddenly distending the muscles, like any other mechanical violence; and that it is general pain alone that we feel, and not any sensation analogous to the specific quality of the object. Nature may seem to have been niggardly to mankind in bestowing upon them so few senses; since a sense to have perceived electricity, and another to have perceived magnetism might have been of great service to them, many ages before these fluids were discovered by accidental experiment, but it is possible an increased number of senses might have incommoded us by adding to the size of our bodies.]

[*Palsy's cold hands*. l. 367. Paralytic limbs are in general only incapable of being stimulated into action by the power of the will; since the pulse continues to beat and the fluids to be absorbed in them; and it commonly happens, when paralytic people yawn and stretch themselves, (which is not a voluntary motion,) that the affected limb moves at the same time. The temporary motion of a paralytic limb is likewise caused by passing the electric shock through it; which would seem to indicate some analogy between the electric fluid, and the nervous fluid, which is seperated from the blood by the brain, and thence diffused along the nerves for the purposes of motion and sensation. It probably destroys life by its sudden expansion of the nerves or fibres of the brain; in the same manner as it fuses metals and splinters wood or stone, and removes the atmosphere, when it passes from one object to another in a dense state.]

[*Prints the Fairy rings*. l. 370. See additional note No. XIII.]

2. NYMPHS! on that day YE shed from lucid eyes.
Celestial tears, and breathed ethereal sighs!
When RICHMAN rear'd, by fearless haste betrayed,
The wiry rod in Nieva's fatal shade;—
Clouds o'er the Sage, with fringed skirts succeed,
Flash follows flash, the warning corks recede;
Near and more near He ey'd with fond amaze
The silver streams, and watch'd the saphire blaze;
Then burst the steel, the dart electric sped,
And the bold Sage lay number'd with the dead!—
NYMPHS! on that day YE shed from lucid eyes
Celestial tears, and breathed ethereal sighs!

[*When Richman reared*. l. 373. Dr. Richman Professor of natural philosophy at Petersburgh about the year 1763, elevated an insulated metallic rod to collect the aerial electricity, as Dr. Franklin had previously done at Philadelphia; and as he was observing the repulsion of the balls of his electrometer approached too near the conductor, and receiving the lightening in his head with a loud explosion, was struck dead amidst his family.]

3. "YOU led your FRANKLIN to your glazed retreats,
Your air-built castles, and your silken seats;
Bade his bold arm invade the lowering sky,
And seize the tiptoe lightnings, ere they fly;
O'er the young Sage your mystic mantle spread,
And wreath'd the crown electric round his head.—
Thus when on wanton wing intrepid LOVE
Snatch'd the raised lightning from the arm of JOVE;
Quick o'er his knee the triple bolt He bent,
The cluster'd darts and forky arrows rent,
Snapp'd with illumin'd hands each flaming shaft,
His tingling fingers shook, and stamp'd, and laugh'd;
Bright o'er the floor the scatter'd fragments blaz'd,
And Gods retreating trembled as they gaz'd;
The immortal Sire, indulgent to his child,
Bow'd his ambrosial locks, and Heaven relenting smiled.

[*You led your Franklin*. l. 383. Dr. Franklin was the first that discovered that lightening consisted of electric matter, he elevated a tall rod with a wire wrapped round it, and fixing the bottom of a rod into a glass bottle, and preserving it from falling by means of silk- strings, he found it electrified whenever a cloud parted over it, receiving sparks by his finger from it, and charging coated phials. This great discovery taught us to defend houses and ships and temples from lightning, and also to understand, *that people are always perfectly safe in a room during a thunder storm if they keep themselves at three or four feet distance from the walls*; for the matter of lightning in passing from the clouds to the earth, or from the earth to the clouds, runs through the walls of a house, the trunk of a tree, or other elevated object; except there be some moister body, as an animal in contact with them, or nearly so; and in that case the lightning leaves the wall or tree, and passes through the animal; but as it can pass through metals with still greater facility, it will leave animal bodies to pass through metallic ones.

If a person in the open air be surprized by a thunderstorm, he will know his danger by observing on a second watch the time which passes between the flash and the crack, and reckoning a mile for every four seconds and a half, and a little more. For sound travels at the rate of 1142 feet in a second of time, and the velocity of light through such small distances is not to be estimated. In these circumstances a person will be safer by lying down on the ground, than erect, and still safer if within a few feet of his horse; which being then a more elevated animal will receive the shock, in preference as the cloud passes over. See additional notes, No. XIII.]

[*Intrepid Love*. l. 389. This allegory is uncommonly beautiful, representing Divine Justice as disarmed by Divine Love, and relenting of his purpose. It is expressed on an agate in the Great Duke's collection at Florence. Spence.]

VIII. "When Air's pure essence joins the vital flood,
And with phosphoric Acid dyes the blood,
YOUR VIRGIN TRAINS the transient HEAT dispart,
And lead the soft combustion round the heart;
Life's holy lamp with fires successive feed,
From the crown'd forehead to the prostrate weed,
From Earth's proud realms to all that swim or sweep
The yielding ether or tumultuous deep.
You swell the bulb beneath the heaving lawn,
Brood the live seed, unfold the bursting spawn;
Nurse with soft lap, and warm with fragrant breath
The embryon panting in the arms of Death;
Youth's vivid eye with living light adorn,
And fire the rising blush of Beauty's golden morn.

[*Transient heat dispart*. l. 401. Dr. Crawford in his ingenious work on animal heat has endeavoured to

prove, that during the combination of the pure part of the atmosphere with the phlogistic part of the blood, that much of the matter of the heat is given out from the air; and that this is the great and perpetual source of the heat of animals; to which we may add that the phosphoric acid is probably produced by this combination; by which acid the colour of the blood is changed in the lungs from a deep crimson to a bright scarlet. There seems to be however another source of animal heat, though of a similar nature; and that is from the chemical combinations produced in all the glands; since by whatever cause any glandular secretion is increased, as by friction or topical imflammation, the heat of that part becomes increased at the same time; thus after the hands have been for a time immersed in snow, on coming into a warm room, they become red and hot, without any increased pulmonary action. BESIDES THIS there would seem to be another material received from the air by respiration; which is so necessary to life, that the embryon must learn to breathe almost within a minute after its birth, or it dies. The perpetual necessity of breathing shews, that the material thus acquired is perpetually consuming or escaping, and on that account requires perpetual renovation. Perhaps the spirit of animation itself is thus acquired from the atmosphere, which if it be supposed to be finer or more subtle than the electric matter, could not long be retained in our bodies, and must therefore require perpetual renovation.]

"Thus when the Egg of Night, on Chaos hurl'd,
Burst, and disclosed the cradle of the world;
First from the gaping shell refulgent sprung
IMMORTAL LOVE, his bow celestial strung;—
O'er the wide waste his gaudy wings unfold,
Beam his soft smiles, and wave his curls of gold;—
With silver darts He pierced the kindling frame,
And lit with torch divine the ever-living flame."

[*Thus when the egg of Night*. l. 413. There were two Cupids belonging to the antient mythology, one much elder than the other. The elder cupid, or Eros, or divine Love, was the first that came out of the great egg of night, which floated in Chaos, and was broken by the horns of the celestial bull, that is, was hatched by the warmth of the spring. He was winged and armed, and by his arrows and torch pierced and vivified all things, producing life and joy. Bacon, Vol. V. p. 197. Quarto edit. Lond. 1778. "At this time, (says Aristophanes,) sable-winged night produced an egg, from whence sprung up like a blossom Eros, the lovely, the desirable, with his glossy golden wings." Avibus. Bryant's Mythology, Vol. II. p. 350. second edition. This interesting moment of this sublime allegory Mrs. Cosway has chosen for her very beautiful painting. She has represented Eros or divine Love with large wings having the strength of the eagle's wings, and the splendor of the peacocks, with his hair floating in the form of flame, and with a halo of light vapour round his head; which illuminates the painting; while he is in the act of springing forwards, and with his hands separating the elements.]

IX. The GODDESS paused, admired with conscious pride
The effulgent legions marshal'd by her side,
Forms sphered in fire with trembling light array'd,
Ens without weight, and substance without shade;
And, while tumultuous joy her bosom warms,
Waves her white hand, and calls her hosts to arms,

"Unite, ILLUSTRIOUS NYMPHS! your radiant powers,
Call from their long repose the VERNAL HOURS.
Wake with soft touch, with rosy hands unbind
The struggling pinions of the WESTERN WIND;
Chafe his wan cheeks, his ruffled plumes repair,
And wring the rain-drops from his tangled hair.
Blaze round each frosted rill, or stagnant wave,
And charm the NAIAD from her silent cave;
Where, shrined in ice, like NIOBE she mourns,
And clasps with hoary arms her empty urns.
Call your bright myriads, trooping from afar,
With beamy helms, and glittering shafts of war;
In phalanx firm the FIEND OF FROST assail,
Break his white towers, and pierce his crystal mail;
To Zembla's moon-bright coasts the Tyrant bear,
And chain him howling to the Northern Bear.

[*Of the Western Wind*. l. 430. The principal frosts of this country are accompanied or produced by a N.E. wind, and the thaws by a S.W. wind; the reason of which is that the N.E. winds consist of regions of air brought from the north, which appear to acquire an easterly direction as they advance; and the S.W. winds consist of regions of air brought from the south, which appear to acquire a westerly direction as they advance. The surface of the earth nearer the pole moves slower than it does in our latitude; whence the regions of air brought from thence, move slower, when they arrive hither, than the earth's surface with which they now become in contact; that is they acquire an apparent easterly direction, as the earth moves from west to east faster than this new part of its atmosphere. The S.W. winds on the contrary consist of regions of air brought from the south, where the surface of the earth moves faster than in our latitude; and have therefore a westerly direction when they arrive hither by their moving faster than the surface of the earth, with which they are in contact; and in general the nearer to the west and the greater the velocity of these winds the warmer they should be in respect to the season of the year, since they have been brought more expeditiously from the south, than those winds which have less westerly direction, and have thence been less cooled in their passage.

Sometimes I have observed the thaw to commence immediately on the change of the wind, even within an hour, if I am not mistaken, or sooner. At other times the S.W. wind has continued a day, or even two, before the thaw has commenced; during which time some of the frosty air, which had gone southwards, is driven back over us; and in consequence has taken a westerly direction, as well as a southern one. At other times I have observed a frost with a N.E. wind every morning, and a thaw with a S.W. wind every noon for several days together. See additional note, XXXIII.]

[*The Fiend of Frost*. l. 439. The principal injury done to vegetation by frost is from the expansion of the water contained in the vessels of plants. Water converted into ice occupies a greater space than it did before, as appears by the bursting of bottles filled with water at the time of their freezing. Hence frost destroys those plants of our island first, which are most succulent; and the most succulent parts first of other plants; as their leaves and last year's shoots; the vessels of which are distended and burst by the expansion of their freezing fluids, while the drier or more resinous plants, as pines, yews, laurels, and other ever-greens, are less liable to injury from cold. The trees in vallies are on this account more injured by the vernal frosts than those on eminencies, because their early succulent shoots come out sooner. Hence fruit trees covered by a six-inch coping of a wall are less injured by the vernal frosts because their being shielded from showers and the descending night-dews has prevented them from being moist at the time of their being frozen: which circumstance has given occasion to a vulgar error amongst gardeners, who suppose frost to descend.

As the common heat of the earth in this climate is 48 degrees, those tender trees which will bear bending down, are easily secured from the frost by spreading them upon the ground, and covering them with straw or fern. This particularly suits fig-trees, as they easily bear bending to the ground, and are furnished with an acrid juice, which secures them from the depredations of insects; but are nevertheless liable to be eaten by mice. See additional notes, No. XII.]

"So when enormous GRAMPUS, issuing forth
From the pale regions of the icy North;
Waves his broad tail, and opes his ribbed mouth,
And seeks on winnowing fin the breezy South;
From towns deserted rush the breathless hosts,
Swarm round the hills, and darken all the coasts;
Boats follow boats along the shouting tides,
And spears and javelins pierce his blubbery sides;
Now the bold Sailor, raised on pointed toe,
Whirls the wing'd harpoon on the slimy foe;
Quick sinks the monster in his oozy bed,
The blood-stain'd surges circling o'er his head,
Steers to the frozen pole his wonted track,
And bears the iron tempest on his back.

X. "On wings of flame, ETHEREAL VIRGINS! sweep
O'er Earth's fair bosom, and complacent deep;
Where dwell my vegetative realms benumb'd,
In buds imprison'd, or in bulbs intomb'd,
Pervade, PELLUCID FORMS! their cold retreat,
Ray from bright urns your viewless floods of *heat*;
From earth's deep wastes *electric* torrents pour,
Or shed from heaven the scintillating shower;
Pierce the dull root, relax its fibre-trains,

Thaw the thick blood, which lingers in its veins;
Melt with warm breath the fragrant gums, that bind
The expanding foliage in its scaly rind;
And as in air the laughing leaflets play,
And turn their shining bosoms to the ray,
NYMPHS! with sweet smile each opening glower invite,
And on its damask eyelids pour the *light*.

[*In buds imprison'd*. l. 460. The buds and bulbs of plants constitute what is termed by Linneus the Hybernaculum, or winter cradle of the embryon vegetable. The buds arise from the bark on the branches of trees, and the bulbs from the caudex of bulbous-rooted plants, or the part from which the fibres of the root are produced, they are defended from too much moisture, and from frosts, and from the depredations of insects by various contrivances, as by scales, hairs, resinous varnishes, and by acrid rinds.

The buds of trees are of two kinds, either flower-buds or leaf buds; the former of these produce their seeds and die; the latter produce other leaf buds or flower buds and die. So that all the buds of trees may be considered as annual plants, having their embryon produced during the preceeding summer. The same seems to happen with respect to bulbs; thus a tulip produces annually one flower-bearing bulb, sometimes two, and several leaf-bearing bulbs; and then the old root perishes. Next year the flower-bearing bulb produces seeds and other bulbs and perishes; while the leaf-bearing bulb, producing other bulbs only, perishes likewise; these circumstances establish a strict analogy between bulbs and buds. See additional notes, No. XIV.]

[*Viewless floods of heat*. l. 462. The fluid matter of heat, or Calorique, in which all bodies are immersed, is as necessary to vegetable as to animal existence. It is not yet determinable whether heat and light be different materials, or modifications of the same materials, as they have some properties in common. They appear to be both of them equally necessary to vegetable health, since without light green vegetables become first yellow, that is, they lose the blue colour, which contributed to produce the green; and afterwards they also lose the yellow and become white; as is seen in cellery blanched or etiolated for the table by excluding the light from it.

The upper surface of leaves, which I suppose to be their organ of respiration, seems to require light as well as air; since plants which grow in windows on the inside of houses are equally sollicitous to turn the upper side of their leaves to the light. Vegetables at the same time exsude or perspire a great quantity from their leaves, as animals do from their lungs; this perspirable matter as it rises from their fine vessels, (perhaps much finer than the pores of animal skins,) is divided into inconcievable tenuity; and when acted upon by the Sun's light appears to be decomposed; the hydrogene becomes a part of the vegetable, composing oils or resins; and the Oxygene combined with light or calorique ascends, producing the pure part of the atmosphere or vital air. Hence during the light of the day vegetables give up more pure air than their respiration injures; but not so in the night, even though equally exposed to warmth. This single fact would seem to shew, that light is essentially different from heat; and it is perhaps by its combination with bodies, that their combined or latent heat is set at liberty, and becomes sensible. See additional note, XXXIV.]

[*Electric torrents pour*. l. 463. The influence of electricity in forwarding the germination of plants and their growth seems to be pretty well established; though Mr. Ingenhouz did not succeed in his experiments, and thence doubts the success of those of others. And though M. Rouland from his new experiments believes, that neither positive nor negative electricity increases vegetation; both which philosophers had previously been supporters of the contrary doctrine; for many other naturalists have since repeated their experiments relative to this object, and their new results have confirmed their former ones. Mr. D'Ormoy and the two Roziers have found the same success in numerous experiments which they have made in the last two years; and Mr. Carmoy has shewn in a convincing manner that electricity accelerates germination.

Mr. D'Ormoy not only found various seeds to vegetate sooner, and to grow taller which were put upon his insulated table and supplied with electricity, but also that silk-worms began to spin much sooner which were kept electrified than those of the same hatch which were kept in the same place and manner, except that they were not electrified. These experiments of M. D'Ormoy are detailed at length in the Journal de Physique of Rozier, Tom. XXXV. p. 270.

M. Bartholon, who had before written a tract on this subject, and proposed ingenious methods for applying electricity to agriculture and gardening, has also repeated a numerous set of experiments; and shews both that natural electricity, as well as the artificial, increases the growth of plants, and the germination of seeds; and opposes Mr. Ingenhouz by very numerous and conclusive facts. Ib. Tom. XXXV. p. 401.

Since by the late discoveries or opinions of the Chemists there is reason to believe that water is decomposed in the vessels of vegetables; and that the Hydrogene or inflammable air, of which it in part consists, contributes to the nourishment of the plant, and to the production of its oils, rosins, gums, sugar, &c. and lastly as electricity decomposes water into these two airs termed Oxygene and Hydrogene, there is a powerful analogy to induce us to believe that it accelerates or contributes to the growth of vegetation, and like heat may possibly enter into combination with many bodies, or form the basis of some yet unanalised acid.]

"So shall my pines, Canadian wilds that shade,
Where no bold step has pierc'd the tangled glade,
High-towering palms, that part the Southern flood
With shadowy isles and continents of wood,
Oaks, whose broad antlers crest Britannia's plain,
Or bear her thunders o'er the conquer'd main,
Shout, as you pass, inhale the genial skies,
And bask and brighten in your beamy eyes;
Bow their white heads, admire the changing clime,
Shake from their candied trunks the tinkling rime;
With bursting buds their wrinkled barks adorn,
And wed the timorous floret to her thorn;
Deep strike their roots, their lengthening tops revive,
And all my world of foliage wave, alive.

"Thus with Hermetic art the ADEPT combines
The royal acid with cobaltic mines;
Marks with quick pen, in lines unseen portrayed,
The blushing mead, green dell, and dusky glade;
Shades with pellucid clouds the tintless field,
And all the future Group exists conceal'd;
Till waked by fire the dawning tablet glows,
Green springs the herb, the purple floret blows,
Hills vales and woods in bright succession rise,
And all the living landscape charms his eyes.

[*Thus with Hermetic art*. l. 487. The sympathetic inks made by Zaffre dissolved in the marine and nitrous acids have this curious property, that being brought to the fire one of them becomes green, and the other red; but what is more wonderful, they again lose these colours, (unless the heat has been too great,) on their being again withdrawn from the fire. Fire-screens have been thus painted, which in the cold have shewn only the trunk and branches of a dead tree, and sandy hills, which on their approach to the fire have put forth green leaves and red flowers, and grass upon the mountains. The process of making these inks is very easy, take Zaffre, as sold by the druggists, and digest it in aqua regia, and the calx of Cobalt will be dissolved; which solution must be diluted with a little common water to prevent it from making too strong an impression on the paper; the colour when the paper is heated becomes of a fine green-blue. If Zaffre or Regulus of Cobalt be dissolved in the same manner in spirit of nitre, or aqua fortis, a reddish colour is produced on exposing the paper to heat. Chemical Dictionary by Mr. Keir, Art. Ink Sympathetic.]

XI. "With crest of gold should sultry SIRIUS glare,
And with his kindling tresses scorch the air;
With points of flame the shafts of Summer arm,
And burn the beauties he designs to warm;—
—So erst when JOVE his oath extorted mourn'd,
And clad in glory to the Fair return'd;
While Loves at forky bolts their torches light,
And resting lightnings gild the car of Night;
His blazing form the dazzled Maid admir'd,
Met with fond lips, and in his arms expir'd;—
NYMPHS! on light pinion lead your banner'd hosts
High o'er the cliffs of ORKNEY'S gulphy coasts;
Leave on your left the red volcanic light,
Which HECCLA lifts amid the dusky night;
Mark on the right the DOFRINE'S snow-capt brow,
Where whirling MAELSTROME roars and foams below;

Watch with unmoving eye, where CEPHEUS bends
His triple crown, his scepter'd hand extends;
Where studs CASSIOPE with stars unknown
Her golden chair, and gems her sapphire zone;
Where with vast convolution DRACO holds
The ecliptic axis in his scaly folds,
O'er half the skies his neck enormous rears,
And with immense meanders parts the BEARS;
Onward, the kindred BEARS with footstep rude
Dance round the Pole, pursuing and pursued.

[*With stars unknown*. l. 515. Alluding to the star which appeared in the chair of Cassiopea in the year 1572, which at first surpassed Jupiter in magnitude and brightness, diminished by degrees and disappeared in 18 months; it alarmed all the astronomers of the age, and was esteemed a comet by some.—Could this have been the Georgium sidus?]

"There in her azure coif and starry stole,
Grey TWILIGHT sits, and rules the slumbering Pole;
Bends the pale moon-beams round the sparkling coast,
And strews with livid hands eternal frost.
There, NYMPHS! alight, array your dazzling powers,
With sudden march alarm the torpid Hours;
On ice-built isles expand a thousand sails,
Hinge the strong helms, and catch the frozen gales;
The winged rocks to feverish climates guide,
Where fainting Zephyrs pant upon the tide;
Pass, where to CEUTA CALPE'S thunder roars,
And answering echoes shake the kindred shores;
Pass, where with palmy plumes CANARY smiles,
And in her silver girdle binds her isles;
Onward, where NIGER'S dusky Naiad laves
A thousand kingdoms with prolific waves,
Or leads o'er golden sands her threefold train
In steamy channels to the fervid main,
While swarthy nations croud the sultry coast,
Drink the fresh breeze, and hail the floating Frost,
NYMPHS! veil'd in mist, the melting treasures steer,
And cool with arctic snows the tropic year.
So from the burning Line by Monsoons driven
Clouds sail in squadrons o'er the darken'd heaven;
Wide wastes of sand the gelid gales pervade,
And ocean cools beneath the moving shade.

[*On ice-built isles*. l. 529. There are many reasons to believe from the accounts of travellers and navigators, that the islands of ice in the higher northern latitudes as well as the Glaciers on the Alps continue perpetually to increase in bulk. At certain times in the ice- mountains of Switzerland there happen cracks which have shewn the great thickness of the ice, as some of these cracks have measured three or four hundred ells deep. The great islands of ice in the northern seas near Hudson's bay have been observed to have been immersed above one hundred fathoms beneath the surface of the sea, and to have risen a fifth or sixth part above the surface, and to have measured between three and four miles in circumference. Phil. Trans. No. 465. Sect. 2.

Dr. Lister endeavoured to shew that the ice of sea-water contains some salt and perhaps less air than common ice, and that it is therefore much more difficult of solution; whence he accounts for the perpetual and great increase of these floating islands of ice. Philos. Trans. No. 169.

As by a famous experiment of Mr. Boyles it appears that ice evaporates very fast in severe frosty weather when the wind blows upon it; and as ice in a thawing state is known to contain six times more cold than water at the same degree of sensible coldness, it is easy to understand that winds blowing over islands and continents of ice perhaps much below nothing on Farenheit's scale, and coming from thence into our latitude must bring great degrees of cold along with them. If we add to this the quantity of cold produced by the evaporation of the water as well as by the solution of the ice, we cannot doubt but that the northern ice is the principle source of the coldness of our winters, and that it is brought hither by the regions of air blowing from the north, and which take an apparent easterly direction by

their coming to a part of the surface of the earth which moves faster than the latitude they come from. Hence the increase of the ice in the polar regions by increasing the cold of our climate adds at the same time to the bulk of the Glaciers of Italy and Switzerland.

If the nations who inhabit this hemisphere of the globe, instead of destroying their sea-men and exhausting their wealth in unnecessary wars, could be induced to unite their labours to navigate these immense masses of ice into the more southern oceans, two great advantages would result to mankind, the tropic countries would be much cooled by their solution, and our winters in this latitude would be rendered much milder for perhaps a century or two, till the masses of ice became again enormous.

Mr. Bradley describes the cold winds and wet weather which sometimes happen in May and June to the solution of ice-islands accidentally floating from the north. Treatise on Husbandry and Gardening, Vol. II. p. 437. And adds, that Mr. Barham about the year 1718, in his voyage from Jamaica to England in the beginning of June, met with ice-islands coming from the north, which were surrounded with so great a fog that the ship was in danger of striking upon them, and that one of them measured fifty miles in length.

We have lately experienced an instance of ice-islands brought from the Southern polar regions, on which the Guardian struck at the beginning of her passage from the Cape of Good Hope towards Botany Bay, on December 22, 1789. These islands were involved in mist, were about one hundred and fifty fathoms long, and about fifty fathoms above the surface of the water. A part from the top of one of them broke off and fell into the sea, causing an extraordinary commotion in the water and a thick smoke all round it.]

[*Threefold train*. l. 539. The river Niger after traversing an immense tract of populous country is supposed to divide itself into three other great rivers. The Rio Grande, the Gambia, and the Senegal. Gold-dust is obtained from the sands of these rivers.]

[*Wide wastes of sand*. l. 547. When the sun is in the Southern tropic 36 deg. distant from the zenith, the thermometer is seldom lower than 72 deg. at Gondar in Abyssinia, but it falls to 60 or 53 deg. when the sun is immediately vertical; so much does the approach of rain counteract the heat of the sun. Bruce's Travels, Vol. 3. p. 670.]

XII. Should SOLSTICE, stalking through the sickening bowers,
Suck the warm dew-drops, lap the falling showers;
Kneel with parch'd lip, and bending from it's brink
From dripping palm the scanty river drink;
NYMPHS! o'er the soil ten thousand points erect,
And high in air the electric flame collect.
Soon shall dark mists with self-attraction shroud
The blazing day, and sail in wilds of cloud;
Each silvery Flower the streams aerial quaff,
Bow her sweet head, and infant Harvest laugh.

[*Ten thousand points erect*. l. 553. The solution of water in air or in calorique, seems to acquire electric matter at the same time, as appears from an experiment of Mr. Bennet. He put some live coals into an insulated funnel of metal, and throwing on them a little water observed that the ascending steam was electrised plus, and the water which descended through the funnel was electrised minus. Hence it appears that though clouds by their change of form may sometimes become electrised minus yet they have in general an accumulation of electricity. This accumulation of electric matter also evidently contributes to support the atmospheric vapour when it is condensed into the form of clouds, because it is seen to descend rapidly after the flashes of lightning have diminished its quantity; whence there is reason to conclude that very numerous metallic rods with fine points erected high in the air might induce it at any time to part with some of its water.

If we may trust the theory of Mr. Lavoisier concerning the composition and decomposition of water, there would seem another source of thunder- showers; and that is, that the two gasses termed oxygene gas or vital air, and hydrogene gas or inflammable air, may exist in the summer atmosphere in a state of mixture but not of combination, and that the electric spark or flash of lightning may combine them and produce water instantaneously.]

"Thus when ELIJA mark'd from Carmel's brow
In bright expanse the briny flood below;
Roll'd his red eyes amid the scorching air,
Smote his firm breast, and breathed his ardent prayer;

High in the midst a massy altar stood,
And slaughter'd offerings press'd the piles of wood;
While ISRAEL'S chiefs the sacred hill surround,
And famish'd armies crowd the dusty ground;
While proud Idolatry was leagued with dearth,
And wither'd famine swept the desert earth.—
"OH, MIGHTY LORD! thy woe-worn servant hear,
"Who calls thy name in agony of prayer;
"Thy fanes dishonour'd, and thy prophets slain,
"Lo! I alone survive of all thy train!—
"Oh send from heaven thy sacred fire,—and pour
"O'er the parch'd land the salutary shower,—
"So shall thy Priest thy erring flock recal,—
"And speak in thunder, "THOU ART LORD OF ALL."—
He cried, and kneeling on the mountain-sands,
Stretch'd high in air his supplicating hands.
—Descending flames the dusky shrine illume;
Fire the wet wood, the sacred bull consume;
Wing'd from the sea the gathering mists arise,
And floating waters darken all the skies;
The King with shifted reins his chariot bends,
And wide o'er earth the airy flood descends;
With mingling cries dispersing hosts applaud,
And shouting nations own THE LIVING GOD."

The GODDESS ceased,—the exulting tribes obey,
Start from the soil, and win their airy way;
The vaulted skies with streams of transient rays
Shine, as they pass, and earth and ocean blaze.
So from fierce wars when lawless Monarch's cease,
Or Liberty returns with laurel'd Peace;
Bright fly the sparks, the colour'd lustres burn,
Flash follows f
Blue serpents sweep along the dusky air,
Imp'd by long trains of scintillating hair;
Red rockets rise, loud cracks are heard on high,
And showers of stars rush headlong from the sky,
Burst, as in silver lines they hiss along,
And the quick flash unfolds the gazing throng.

Argument of the Second Canto.

Address to the Gnomes. I. The Earth thrown from a volcano of the Sun; it's atmosphere and ocean; it's journey through the zodiac; vicissitude of day-light, and of seasons, 11. II. Primeval islands. Paradise, or the golden Age. Venus rising from the sea, 33. III. The first great earthquakes; continents raised from the sea; the Moon thrown from a volcano, has no atmosphere, and is frozen; the earth's diurnal motion retarded; it's axis more inclined; whirls with the moon round a new centre. 67. IV. Formation of lime-stone by aqueous solution; calcareous spar; white marble; antient statue of Hercules resting from his labours. Antinous. Apollo of Belvidere. Venus de Medici. Lady Elizabeth Foster, and Lady Melbourn by Mrs. Damer. 93. V. 1. Of morasses. Whence the production of Salt by elutriation. Salt-mines at Cracow, 115. 2. Production of nitre. Mars and Venus caught by Vulcan, 143. 3. Production of iron. Mr. Michel's improvement of artificial magnets. Uses of Steel in agriculture, navigation, war, 183. 4. Production of acids, whence Flint. Sea-sand. Selenite. Asbestus. Fluor. Onyx, Agate, Mocho, Opal, Sapphire, Ruby, Diamond. Jupiter and Europa, 215. VI. 1. New subterraneous fires from fermentation. Production of Clays; manufacture of Porcelain in China; in Italy; in England. Mr. Wedgwood's works at Etruria in Staffordshire. Cameo of a Slave in Chains; of Hope. Figures on the Portland or Barberini vase explained, 271. 2. Coal; Pyrite; Naphtha; Jet; Amber. Dr. Franklin's discovery of disarming the Tempest of it's lightning. Liberty of America; of Ireland; of France, 349. VII. Antient central subterraneous fires. Production of Tin, Copper, Zink, Lead, Mercury, Platina, Gold and Silver. Destruction of Mexico. Slavery of Africa, 395. VIII. Destruction of the armies of Cambyses, 431. IX. Gnomes like stars of an Orrery. Inroads of the Sea stopped. Rocks cultivated. Hannibal passes the Alps, 499. X. Matter circulates. Manures to Vegetables like Chyle to Animals. Plants rising from the

THE ECONOMY OF VEGETATION.

CANTO II.

AND NOW THE GODDESS with attention sweet
Turns to the GNOMES, that circle round her feet;
Orb within orb approach the marshal'd trains,
And pigmy legions darken all the plains;
Thrice shout with silver tones the applauding bands,
Bow, ere She speaks, and clap their fairy hands.
So the tall grass, when noon-tide zephyr blows,
Bends it's green blades in undulating rows;
Wide o'er the fields the billowy tumult spreads,
And rustling harvests bow their golden heads.

I. "GNOMES! YOUR bright forms, presiding at her birth,
Clung in fond squadrons round the new-born EARTH;
When high in ether, with explosion dire,
From the deep craters of his realms of fire,
The whirling Sun this ponderous planet hurl'd,
And gave the astonish'd void another world.
When from it's vaporous air, condensed by cold,
Descending torrents into oceans roll'd;
And fierce attraction with relentless force
Bent the reluctant wanderer to it's course.

[*From the deep craters*. l. 14. The existence of solar volcanos is countenanced by their analogy to terrestrial, and lunar volcanos; and by the spots on the sun's disk, which have been shewn by Dr. Wilson to be excavations through its luminous surface, and may be supposed to be the cavities from whence the planets and comets were ejected by explosions. See additional notes, No. XV. on solar volcanos.]

[*When from its vaporous air*. l. 17. If the nucleus of the earth was thrown out from the sun by an explosion along with as large a quantity of surrounding hot vapour as its attraction would occasion to accompany it, the ponderous semi-fluid nucleus would take a spherical form from the attraction of its own parts, which would become an oblate spheroid from its diurnal revolution. As the vapour cooled the water would be precipitated, and an ocean would surround the spherical nucleus with a superincumbent atmosphere. The nucleus of solar lava would likewise become harder as it became cooler. To understand how the strata of the earth were afterwards formed from the sediments of this circumfluent ocean the reader is referred to an ingenious Treatise on the Theory of the Earth by Mr. Whitehurst, who was many years a watch-maker and engineer at Derby, but whose ingenuity, integrity, and humanity, were rarely equalled in any station of life.]

"Where yet the Bull with diamond-eye adorns
The Spring's fair forehead, and with golden horns;
Where yet the Lion climbs the ethereal plain,
And shakes the Summer from his radiant mane;
Where Libra lifts her airy arm, and weighs,
Poised in her silver ballance, nights and days;
With paler lustres where Aquarius burns,
And showers the still snow from his hoary urns;
YOUR ardent troops pursued the flying sphere,
Circling the starry girdle of the year;
While sweet vicissitudes of day and clime
Mark'd the new annals of enascent Time.

II. "You trod with printless step Earth's tender globe,
While Ocean wrap'd it in his azure robe;
Beneath his waves her hardening strata spread,
Raised her PRIMEVAL ISLANDS from his bed,
Stretch'd her wide lawns, and sunk her winding dells,
And deck'd her shores with corals, pearls, and shells.

[*While ocean wrap'd*. l. 34. See additional notes, No. XVI. on the production of calcareous earth.]

[*Her hardening srata spread*. l. 35. The granite, or moor-stone, or porphory, constitute the oldest part of the globe, since the limestone, shells, coralloids, and other sea-productions rest upon them; and upon these sea-productions are found clay, iron, coal, salt, and siliceous sand or grit-stone. Thus there seem to be three divisions of the globe distinctly marked; the first I suppose to have been the original nucleus of the earth, or lava projected from the sun; 2. over this lie the recrements of animal and vegetable matter produced in the ocean; and, 3. over these the recrements of animal and vegetable matter produced upon the land. Besides these there are bodies which owe their origin to a combination of those already mentioned, as siliceous sand, fluor, alabaster; which seem to have derived their acids originally from the vegetable kingdom, and their earthy bases from sea-productions. See additional notes, No. XVI. on calcareous earth.]

[*Raised her primeval islands*. l. 36. The nucleus of the earth, still covered with water, received perpetual increase by the immense quantities of shells and coralloids either annually produced and relinquishied, or left after the death of the animals. These would gradually by their different degrees of cohesion be some of them more and others less removable by the influence of solar tides, and gentle tropical breezes, which then must have probably extended from one pole to the other; for it is supposed the moon was not yet produced, and that no storms or unequal winds had yet existence.

Hence then the primeval islands had their gradual origin, were raised but a few feet above the level of the sea, and were not exposed to the great or sudden variations of heat and cold, as is so well explained in Mr. Whitehurst's Theory of the Earth, chap. xvi. Whence the paradise of the sacred writers, and the golden age of the profane ones, seems to have had a real existence. As there can be no rainbow, when the heavens are covered with clouds, because the sun-beams are then precluded from falling upon the rain-drops opposite to the eye of the spectator, the rainbow is a mark of gentle or partial showers. Mr. Whitehurst has endeavoured to show that the primitive islands were only moistened by nocturnal dews and not by showers, as occurs at this day to the Delta of Egypt; and is thence of opinion, that the rainbow had no existence till after the production of mountains and continents. As the salt of the sea has been gradually accumulating, being washed down into it from the recrements of animal and vegetable bodies, the sea must originally have been as fresh as river water; and as it is not yet saturated with salt, must become annually more saline. See note on l. 119 of this Canto.]

"O'er those blest isles no ice-crown'd mountains tower'd,
No lightnings darted, and no tempests lower'd;
Soft fell the vesper-drops, condensed below,
Or bent in air the rain-refracted bow;
Sweet breathed the zephyrs, just perceiv'd and lost;
And brineless billows only kiss'd the coast;
Round the bright zodiac danced the vernal hours,
And Peace, the Cherub, dwelt in mortal bowers!

"So young DIONE, nursed beneath the waves,
And rock'd by Nereids in their coral caves,
Charm'd the blue sisterhood with playful wiles,
Lisp'd her sweet tones, and tried her tender smiles.
Then, on her beryl throne by Triton's borne,
Bright rose the Goddess like the Star of morn;
When with soft fires the milky dawn He leads,
And wakes to life and love the laughing meads;—
With rosy fingers, as uncurl'd they hung
Round her fair brow, her golden locks she wrung;
O'er the smooth surge on silver sandals flood,
And look'd enchantment on the dazzled flood.—
The bright drops, rolling from her lifted arms,
In slow meanders wander o'er her charms,
Seek round her snowy neck their lucid track,

Pearl her white shoulders, gem her ivory back,
Round her fine waist and swelling bosom swim,
And star with glittering brine each crystal limb.—
—The immortal form enamour'd Nature hail'd,
And Beauty blazed to heaven and earth, unvail'd.

[*So young Dione*. l. 47. There is an antient gem representing Venus rising out of the ocean supported by two Tritons. From the formality of the design it would appear to be of great antiquity before the introduction of fine taste into the world. It is probable that this beautiful allegory was originally an hieroglyphic picture (before the invention of letters) descriptive of the formation of the earth from the ocean, which seems to have been an opinion of many of the most antient philosophers.]

III. "You! who then, kindling after many an age,
Saw with new fires the first VOLCANO rage,
O'er smouldering heaps of livid sulphur swell
At Earth's firm centre, and distend her shell,
Saw at each opening cleft the furnace glow,
And seas rush headlong on the gulphs below.—
GNOMES! how you shriek'd! when through the troubled air
Roar'd the fierce din of elemental war;
When rose the continents, and sunk the main,
And Earth's huge sphere exploding burst in twain.—
GNOMES! how you gazed! when from her wounded side
Where now the South-Sea heaves its waste of tide,
Rose on swift wheels the MOON'S refulgent car,
Circling the solar orb; a sister-star,
Dimpled with vales, with shining hills emboss'd,
And roll'd round Earth her airless realms of frost.

[*The first volcano*. l. 68. As the earth before the existence of earthquakes was nearly level, and the greatest part of it covered with sea; when the first great fires began deep in the internal parts of it, those parts would become much expanded; this expansion would be gradually extended, as the heat increased, through the whole terraqueous globe of 7000 miles diameter; the crust would thence in many places open into fissures, which by admitting the sea to flow in upon the fire, would produce not only a quantity of steam beyond calculation by its expansion, but would also by its decomposition produce inflammable air and vital air in quantities beyond conception, sufficient to effect those violent explosions, the vestiges of which all over the world excite our admiration and our study; the difficulty of understanding how subterraneous fires could exist without the presence of air has disappeared since Dr. Priestley's discoveries of such great quantities of pure air which constitute all the acids, and consequently exist in all saline bodies, as sea-salt, nitre, lime-stone, and in all calciform ores, as manganese, calamy, ochre, and other mineral substances. See an ingenious treatise by Mr. Michel on earthquakes in the Philos. Trans.

In these first tremendous ignitions of the globe, as the continents were heaved up, the vallies, which now hold the sea, were formed by the earth subsiding into the cavities made by the rising mountains; as the steam, which raised them condensed; which would thence not have any caverns of great extent remain beneath them, as some philosophers have imagined. The earthquakes of modern days are of very small extent indeed compared to those of antient times, and are ingeniously compared by M. De Luc to the operations of a mole-hill, where from a small cavity are raised from time to time small quantities of lava or pumice stone. Monthly Review, June, 1790.]

[*The moon's refulgent car*. l. 79. See additional notes, No. XV. on solar volcanos.]

[*Her airless realms of frost*. l. 82. If the moon had no atmosphere at the time of its elevation from the earth; or if its atmosphere was afterwards stolen from it by the earth's attraction; the water on the moon would rise quickly into vapour; and the cold produced by a certain quantity of this evaporation would congeal the remainder of it. Hence it is not probable that the moon is at present inhabited, but as it seems to have suffered and to continue to suffer much by volcanos, a sufficient quantity of air may in process of time be generated to produce an atmosphere; which may prevent its heat from so easily escaping, and its water from so easily evaporating, and thence become fit for the production of vegetables and animals.

That the moon possesses little or no atmosphere is deduced from the undiminished lustre of the stars, at the instant when they emerge from behind her disk. That the ocean of the moon is frozen, is

confirmed from there being no appearance of lunar tides; which, if they existed, would cover the part of her disk nearest the earth. See note on Canto III. l. 61.]

"GNOMES! how you trembled! with the dreadful force
When Earth recoiling stagger'd from her course;
When, as her Line in slower circles spun,
And her shock'd axis nodded from the sun,
With dreadful march the accumulated main
Swept her vast wrecks of mountain, vale, and plain;
And, while new tides their shouting floods unite,
And hail their Queen, fair Regent of the night;
Chain'd to one centre whirl'd the kindred spheres,
And mark'd with lunar cycles solar years.

[*When earth recoiling*. l. 84. On supposition that the moon was thrown from the earth by the explosion of water or the generation of other vapours of greater power, the remaining part of the globe would recede from its orbit in one direction as the moon receded in another, and that in proportion to the respective momentum of each, and would afterwards revolve round their common centre of gravity.

If the moon rose from any part of the earth except exactly at the line or poles, the shock would tend to turn the axis of the earth out of its previous direction. And as a mass of matter rising from deep parts of the globe would have previously acquired less diurnal velocity than the earth's surface from whence it rose, it would receive during the time of its rising additional velocity from the earth's surface, and would consequently so much retard the motion of the earth round its axis.

When the earth thus receded the shock would overturn all its buildings and forests, and the water would rush with inconceivable violence over its surface towards the new satellite, from two causes, both by its not at first acquiring the velocity with which the earth receded, and by the attraction of the new moon, as it leaves the earth; on these accounts at first there would be but one tide till the moon receded to a greater distance, and the earth moving round a common centre of gravity between them, the water on the side furthest from the moon would acquire a centrifugal force in respect to this common centre between itself and the moon.]

IV. "GNOMES! you then bade dissolving SHELLS distil
From the loose summits of each shatter'd hill,
To each fine pore and dark interstice flow,
And fill with liquid chalk the mass below.
Whence sparry forms in dusky caverns gleam
With borrow'd light, and twice refract the beam;
While in white beds congealing rocks beneath
Court the nice chissel, and desire to breathe.—

[Footnote: *Dissolving shells distil*. l. 93. The lime-stone rocks have had their origin from shells formed beneath the sea, the softer strata gradually dissolving and filling up the interstices of the harder ones, afterwards when these accumulations of shells were elevated above the waters the upper strata became dissolved by the actions of the air and dews, and filled up the interstices beneath, producing solid rocks of different kinds from the coarse lime-stones to the finest marbles. When those lime-stones have been in such a situation that they could form perfect crystals they are called spars, some of which possess a double refraction, as observed by Sir Isaac Newton. When these crystals are jumbled together or mixed with some colouring impurities it is termed marble, if its texture be equable and firm; if its texture be coarse and porous yet hard, it is called lime-stone; if its texture be very loose and porous it is termed chalk. In some rocks the shells remain almost unchanged and only covered, or bedded with lime-stone, which seems to have been dissolved and sunk down amongst them. In others the softer shells and bones are dissolved, and only sharks teeth or harder echini have preserved their form inveloped in the chalk or lime-stone; in some marbles the solution has been compleat and no vestiges of shell appear, as in the white kind called statuary by the workmen. See addit. notes, No. XVI.]

"Hence wearied HERCULES in marble rears
His languid limbs, and rests a thousand years;
Still, as he leans, shall young ANTINOUS please
With careless grace, and unaffected ease;
Onward with loftier step APOLLO spring,

And launch the unerring arrow from the string;
In Beauty's bashful form, the veil unfurl'd,
Ideal VENUS win the gazing world.
Hence on ROUBILIAC'S tomb shall Fame sublime
Wave her triumphant wings, and conquer Time;
Long with soft touch shall DAMER'S chissel charm,
With grace delight us, and with beauty warm;
FOSTER'S fine form shall hearts unborn engage,
And MELBOURN's smile enchant another age.

[*Hence wearied Hercules*. l. 101. Alluding to the celebrated Hercules of Glyco resting after his labours; and to the easy attitude of Antinous; the lofty step of the Apollo of Belvidere; and the retreating modesty of the Venus de Medici. Many of the designs by Roubiliac in Westminster Abbey are uncommonly poetical; the allegory of Time and Fame contending for the trophy of General Wade, which is here alluded to, is beautifully told; the wings of Fame are still expanded, and her hair still floating in the air; which not only shews that she has that moment arrived, but also that her force is not yet expended; at the same time, that the old figure of Time with his disordered wings is rather leaning backwards and yielding to her impulse, and must apparently in another instant be driven from his attack upon the trophy.]

[*Foster's fine form*. l. 113. Alluding to the beautiful statues of Lady Elizabeth Foster and of Lady Melbourn executed by the ingenious Mrs. Damer.]

V. GNOMES! you then taught transuding dews to pass
Through time-fall'n woods, and root-inwove morass
Age after age; and with filtration fine
Dispart, from earths and sulphurs, the saline.

[*Root-inwove morass*. l. 116. The great mass of matter which rests upon the lime-stone strata of the earth, or upon the granite where the lime- stone stratum has been removed by earthquakes or covered by lava, has had its origin from the recrements of vegetables and of air-breathing animals, as the lime-stone had its origin from sea animals. The whole habitable world was originally covered with woods, till mankind formed themselves into societies, and subdued them by fire and by steel. Hence woods in uncultivated countries have grown and fallen through many ages, whence morasses of immense extent; and from these as the more soluble parts were washed away first, were produced sea-salt, nitre, iron, and variety of acids, which combining with calcareous matter were productive of many fossil bodies, as flint, sea-sand, selenite, with the precious stones, and perhaps the diamond. See additional notes, No. XVII.]

1. "HENCE with diffusive SALT old Ocean steeps
His emerald shallows, and his sapphire deeps.
Oft in wide lakes, around their warmer brim
In hollow pyramids the crystals swim;
Or, fused by earth-born fires, in cubic blocks
Shoot their white forms, and harden into rocks.

[*Hence with diffusive salt*. l. 119. Salts of various kinds are produced from the recrements of animal and vegetable bodies, such as phosphoric, ammoniacal, marine salt, and others; these are washed from the earth by rains, and carried down our rivers into the sea; they seem all here to decompose each other except the marine salt, which has therefore from the beginning of the habitable world been perpetually accumulating.

There is a town in the immense salt-mines of Cracow in Poland, with a market-place, a river, a church, and a famous statue, (here supposed to be of Lot's wife) by the moist or dry appearance of which the subterranean inhabitants are said to know when the weather is fair above ground. The galleries in these mines are so numerous and so intricate, that workmen have frequently lost their way, their lights having been burnt out, and have perished before they could be found. Essais, &c. par M. Macquart. And though the arches of these different stories of galleries are boldly executed, yet they are not dangerous; as they are held together or supported by large masses of timber of a foot square; and these vast timbers remain perfectly sound for many centuries, while all other pillars whether of brick, cement, or salt soon dissolve or moulder away. Ibid. Could the timbers over water-mill wheels or cellars, be thus preserved by occasionally soaking them with brine? These immense masses of rock-salt seem to have been produced by the evaporation of sea-water in the early periods of the world by

subterranean fires. Dr. Hutton's Theory of the Earth. See also Theorie des Sources Salees, par Mr. Struve. Histoire de Sciences de Lausanne. Tom. II. This idea of Dr. Hutton's is confirmed by a fact mentioned in M. Macquart's Essais sur Minerologie, who found a great quantity of fossil shells, principally bi-valves and madre-pores, in the salt-mines of Wialiczka near Cracow. During the evaporation of the lakes of salt-water, as in artificial salt-works, the salt begins to crystallize near the edges where the water is shallowest, forming hollow inverted pyramids; which, when they become of a certain size, subside by their gravity; if urged by a stronger fire the salt fuses or forms large cubes; whence the salt shaped in hollow pyramids, called flake-salt, is better tasted and preserves flesh better, than the basket or powder salt; because it is made by less heat and thence contains more of the marine acid. The sea- water about our island contains from about one twenty-eighth to one thirtieth part of sea-salt, and about one eightieth of magnesian salt. See Brownrigg on Salt. See note on Ocymum, Vol. II. of this work.]

"Thus, cavern'd round in CRACOW'S mighty mines,
With crystal walls a gorgeous city shines;
Scoop'd in the briny rock long streets extend
Their hoary course, and glittering domes ascend;
Down the bright steeps, emerging into day,
Impetuous fountains burst their headlong way,
O'er milk-white vales in ivory channels spread,
And wondering seek their subterraneous bed.
Form'd in pellucid salt with chissel nice,
The pale lamp glimmering through the sculptured ice,
With wild reverted eyes fair LOTTA stands,
And spreads to Heaven, in vain, her glassy hands;
Cold dews condense upon her pearly breast,
And the big tear rolls lucid down her vest.
Far gleaming o'er the town transparent fanes
Rear their white towers, and wave their golden vanes;
Long lines of lustres pour their trembling rays,
And the bright vault returns the mingled blaze.

2. "HENCE orient NITRE owes it's sparkling birth,
And with prismatic crystals gems the earth,
O'er tottering domes in filmy foliage crawls,
Or frosts with branching plumes the mouldering walls.
As woos Azotic Gas the virgin Air,
And veils in crimson clouds the yielding Fair,
Indignant Fire the treacherous courtship flies,
Waves his light wing, and mingles with the skies.

[*Hence orient Nitre*. l. 143. Nitre is found in Bengal naturally crystallized, and is swept by brooms from earths and stones, and thence called sweepings of nitre. It has lately been found in large quantities in a natural bason of calcareous earth at Molfetta in Italy, both in thin strata between the calcareous beds, and in efflorescences of various beautiful leafy and hairy forms. An account of this nitre-bed is given by Mr. Zimmerman and abridged in Rozier's Journal de Physique Fevrier. 1790. This acid appears to be produced in all situations where animal and vegetable matters are compleatly decomposed, and which are exposed to the action of the air as on the walls of stables, and slaughter-houses; the crystals are prisms furrowed by longitudinal groves.

Dr. Priestley discovered that nitrous air or gas which he obtained by dissolving metals in nitrous acid, would combine rapidly with vital air, and produce with it a true nitrous acid; forming red clouds during the combination; the two airs occupy only the space before occupied by one of them, and at the same time heat is given out from the new combination. This dimunition of the bulk of a mixture of nitrous gas and vital air, Dr. Priestley ingeniously used as a test of the purity of the latter; a discovery of the greatest importance in the analysis of airs.

Mr. Cavendish has since demonstrated that two parts of vital air or oxygene, and one part of phlogistic air or azote, being long exposed to electric shocks, unite, and produce nitrous acid. Philos. Trans. Vols. LXXV. and LXXVIII.

Azote is one of the most abundant elements in nature, and combined with calorique or heat, it forms azotic gas or phlogistic air, and composes two thirds of the atmosphere; and is one of the principal component parts of animal bodies, and when united to vital air or oxygene produces the nitrous acid. Mr. Lavoisier found that 211/2 parts by weight of azote, and 431/2 parts of oxygene produced 64 parts

of nitrous gas, and by the further addition of 36 parts of oxygene nitrous acid was produced. Traité de Chimie. When two airs become united so as to produce an unelastic liquid much calorique or heat is of necessity expelled from the new combination, though perhaps nitrous acid and oxygenated marine acid admit more heat into their combinations than other acids.]

"So Beauty's GODDESS, warm with new desire,
Left, on her silver wheels, the GOD of Fire;
Her faithless charms to fiercer MARS resign'd,
Met with fond lips, with wanton arms intwin'd.
—Indignant VULCAN eyed the parting Fair,
And watch'd with jealous step the guilty pair;
O'er his broad neck a wiry net he flung,
Quick as he strode, the tinkling meshes rung;
Fine as the spider's flimsy thread He wove
The immortal toil to lime illicit love;
Steel were the knots, and steel the twisted thong,
Ring link'd in ring, indissolubly strong;
On viewless hooks along the fretted roof
He hung, unseen, the inextricable woof.—
—Quick start the springs, the webs pellucid spread,
And lock the embracing Lovers on their bed;
Fierce with loud taunts vindictive VULCAN springs,
Tries all the bolts, and tightens all the strings,
Shakes with incessant shouts the bright abodes,
Claps his rude hands, and calls the festive Gods.—
—With spreading palms the alarmed Goddess tries
To veil her beauties from celestial eyes,
Writhes her fair limbs, the slender ringlets strains,
And bids her Loves untie the obdurate chains;
Soft swells her panting bosom, as she turns,
And her flush'd cheek with brighter blushes burns.
Majestic grief the Queen of Heaven avows,
And chaste Minerva hides her helmed brows;
Attendant Nymphs with bashful eyes askance
Steal of intangled MARS a transient glance;
Surrounding Gods the circling nectar quaff,
Gaze on the Fair, and envy as they laugh.

3. "HENCE dusky IRON sleeps in dark abodes,
And ferny foliage nestles in the nodes;
Till with wide lungs the panting bellows blow,
And waked by fire the glittering torrents flow;
—Quick whirls the wheel, the ponderous hammer falls,
Loud anvils ring amid the trembling walls,
Strokes follow strokes, the sparkling ingot shines,
Flows the red slag, the lengthening bar refines;
Cold waves, immersed, the glowing mass congeal,
And turn to adamant the hissing Steel.

[*Hence dusky Iron*. l. 183. The production of iron from the decomposition of vegetable bodies is perpetually presented to our view; the waters oozing from all morasses are chalybeate, and deposit their ochre on being exposed to the air, the iron acquiring a calciform state from its union with oxygene or vital air. Where thin morasses lie on beds of gravel the latter are generally stained by the filtration of some of the chalybeate water through them. This formation of iron from vegetable recrements is further evinced by the fern leaves and other parts of vegetables, so frequently found in the centre of the knobs or nodules of some iron-ores.

In some of these nodules there is a nucleus of whiter iron-earth surrounded by many concentric strata of darker and lighter iron-earth alternately. In one, which now lies before me, the nucleus is a prism of a triangular form with blunted angles, and about half an inch high, and an inch and half broad; on every side of this are concentric strata of similar iron-earth alternately browner and less brown; each stratum is about a tenth of an inch in thickness and there are ten of them in number. To what known cause can this exactly regular distribution of so many earthy strata of different colours surrounding the nucleus be ascribed? I don't know that any mineralogists have attempted an

explanation of this wonderful phenomenon. I suspect it is owing to the polarity of the central nucleus. If iron-filings be regularly laid on paper by means of a small sieve, and a magnet be placed underneath, the filings will dispose themselves in concentric curves with vacant intervals between them. Now if these iron-filings are conceived to be suspended in a fluid, whose specific gravity is similar to their own, and a magnetic bar was introduced as an axis into this fluid, it is easy to foresee that the iron filings would dispose themselves into concentric spheres, with intervals of the circumnatant fluid between them, exactly as is seen in these nodules of iron-earth. As all the lavas consist of one fourth of iron, (Kirvan's Mineral) and almost all other known bodies, whether of animal or vegetable origin, possess more or less of this property, may not the distribution of a great portion of the globe of the earth into strata of greater or less regularity be owing to the polarity of the whole?]

[*And turn to adamant*. l. 192. The circumstances which render iron more valuable to mankind than any other metal are, 1. its property of being rendered hard to so great a degree and thus constituting such excellent tools. It was the discovery of this property of iron, Mr. Locke thinks, that gave such pre-eminence to the European world over the American one. 2. Its power of being welded; that is, when two pieces are made very hot and applied together by hammering, they unite compleatly, unless any scale of iron intervenes; and to prevent this it is usual for smiths to dip the very hot bar in sand, a little of which fuses into fluid glass with the scale and is squeezed out from between the uniting parts by the force of hammering. 3. Its power of acquiring magnetism.

It is however to be wished that gold or silver were discovered in as great quantity as iron, since these metals being indestructible by exposure to air, water, fire or any common acids would supply wholesome vessels for cookery, so much to be desired, and so difficult to obtain, and would form the most light and durable coverings for houses, as well as indestructible fire-grates, ovens, and boiling vessels. See additional notes, No. XVIII. on Steel.]

"Last MICHELL'S hands with touch of potent charm
The polish'd rods with powers magnetic arm;
With points directed to the polar stars
In one long line extend the temper'd bars;
Then thrice and thrice with steady eye he guides,
And o'er the adhesive train the magnet slides;
The obedient Steel with living instinct moves,
And veers for ever to the pole it loves.

[*Last Michell's hands*. l. 193. The discovery of the magnet seems to have been in very early times; it is mentioned by Plato, Lucretius, Pliny, and Galen, and is said to have taken its name of magnes from Magnesia, a sea-port of antient Lybia.

As every piece of iron which was made magnetical by the touch of a magnet became itself a magnet, many attempts were made to improve these artificial magnets, but without much success till Servingdon Savary, Esq. made them of hardened steel bars, which were so powerful that one of them weighing three pounds averdupois would lift another of the same weight. Philos. Trans.

After this Dr. Knight made very successful experiments on this subject, which, though he kept his method secret, seems to have excited others to turn their attention to magnetism. At this time the Rev. Mr. Michell invented an equally efficacious and more expeditious way of making strong artificial magnets, which he published in the end of the year 1750, in which he explained his method of what he called "the double touch", and which, since Mr. Knight's method has been known, appears to be somewhat different from it.

This method of rendering bars of hardened steel magnetical consists in holding vertically two or more magnetic bars nearly parallel to each other with their opposite poles very near each other (but nevertheless separated to a small distance), these are to be slided over a line of bars laid horizontally a few times backward and forward. See Michell on Magnetism, also a detailed account in Chamber's Dictionary.

What Mr. Michell proposed by this method was to include a very small portion of the horizontal bars, intended to be made magnetical, between the joint forces of two or more bars already magnetical, and by sliding them from end to end every part of the line of bars became successively included, and thus bars possessed of a very small degree of magnetism to begin with, would in a few times sliding backwards and forwards make the other ones much more magnetical than themselves, which are then to be taken up and used to touch the former, which are in succession to be laid down horizontally in a line.

There is still a great field remains for future discoveries in magnetism both in respect to experiment and theory; the latter consists of vague conjectures the more probable of which are perhaps those of Elpinus, as they assimulate it to electricity.

One conjecture I shall add, viz. that the polarity of magnetism may be owing to the earth's rotatory motion. If heat, electricity, and magnetism are supposed to be fluids of different gravities, heat being the heaviest of them, electricity the next heavy, and magnetism the lightest, it is evident that by the quick revolution of the earth the heat will be accumulated most over the line, electricity next beneath this, and that the magnetism will be detruded to the poles and axis of the earth, like the atmospheres of common air and of inflammable gas, as explained in the note on Canto I. l. 123.

Electricity and heat will both of them displace magnetism, and this shows that they may gravitate on each other; and hence when too great a quantity of the electric fluid becomes accumulated at the poles by descending snows, or other unknown causes, it may have a tendency to rise towards the tropics by its centrifugal force, and produce the northern lights. See additional notes, No. I.]

"Hail, adamantine STEEL! magnetic Lord!
King of the prow, the plowshare, and the sword!
True to the pole, by thee the pilot guides
His steady helm amid the struggling tides,
Braves with broad sail the immeasurable sea,
Cleaves the dark air, and asks no star but Thee.—
By thee the plowshare rends the matted plain,
Inhumes in level rows the living grain;
Intrusive forests quit the cultured ground,
And Ceres laughs with golden fillets crown'd.—
O'er restless realms when scowling Discord flings
Her snakes, and loud the din of battle rings;
Expiring Strength, and vanquish'd Courage feel
Thy arm resistless, adamantine STEEL!

4. "HENCE in fine streams diffusive ACIDS flow,
Or wing'd with fire o'er Earth's fair bosom blow;
Transmute to glittering Flints her chalky lands,
Or sink on Ocean's bed in countless Sands.
Hence silvery Selenite her chrystal moulds,
And soft Asbestus smooths his silky folds;
His cubic forms phosphoric Fluor prints,
Or rays in spheres his amethystine tints.
Soft cobweb clouds transparent Onyx spreads,
And playful Agates weave their colour'd threads;
Gay pictured Mochoes glow with landscape-dyes,
And changeful Opals roll their lucid eyes;
Blue lambent light around the Sapphire plays,
Bright Rubies blush, and living Diamonds blaze.

[*Diffusive Acids flow*. l. 215. The production of marine acid from decomposing vegetable and animal matters with vital air, and of nitrous acid from azote and vital air, the former of which is united to its basis by means of the exhalations from vegetable and animal matters, constitute an analogy which induces us to believe that many other acids have either their bases or are united to vital air by means of some part of decomposing vegetable and animal matters.

The great quantities of flint sand whether formed in mountains or in the sea would appear to derive its acid from the new world, as it is found above the strata of lime-stone and granite which constitute the old world, and as the earthy basis of flint is probably calcareous, a great part of it seems to be produced by a conjunction of the new and old world; the recrements of air-breathing animals and vegetables probably afford the acid, and the shells of marine animals the earthy basis, while another part may have derived its calcareous part also from the decomposition of vegetable and animal bodies.

The same mode of reasoning seems applicable to the siliceous stones under various names, as amethyst, onyx, agate, mochoe, opal, &c. which do not seem to have undergone any process from volcanic fires, and as these stones only differ from flint by a greater or less admixture of argillaceous and calcareous earths. The different proportions of which in each kind of stone may be seen in Mr. Kirwan's valuable Elements of Mineralogy. See additional notes, No. XIX.]

[*Living diamonds blaze*. l. 228. Sir Isaac Newton having observed the great power of refracting light, which the diamond possesses above all other crystallized or vitreous matter, conjectured that it was an inflammable body in some manner congealed. Insomuch that all the light is reflected which falls on any of its interior surfaces at a greater angle of incidence than 241/2 degrees; whereas an artificial gem of glass does not reflect any light from its hinder surface, unless that surface is inclined in an angle of 41 degrees. Hence the diamond reflects half as much more light as a factitious gem in similar circumstances; to which must be added its great transparency, and the excellent polish it is capable of. The diamond had nevertheless been placed at the head of crystals or precious stones by the mineralogists, till Bergman ranged it of late in the combustible class of bodies, because by the focus of Villette's burning mirror it was evaporated by a heat not much greater than will melt silver, and gave out light. Mr. Hoepfner however thinks the dispersion of the diamond by this great heat should be called a phosphorescent evaporation of it, rather than a combustion; and from its other analogies of crystallization, hardness, transparency, and place of its nativity, wishes again to replace it amongst the precious stones. Observ. sur la Physique, par Rozier, Tom. XXXV. p. 448. See new edition of the Translation of Cronsted, by De Costa.]

"Thus, for attractive earth, inconstant JOVE
Mask'd in new shapes forsook his realms above.—
First her sweet eyes his Eagle-form beguiles,
And HEBE feeds him with ambrosial smiles;
Next the chang'd God a Cygnet's down assumes,
And playful LEDA smooths his glossy plumes;
Then glides a silver Serpent, treacherous guest!
And fair OLYMPIA folds him in her breast;
Now lows a milk-white Bull on Afric's strand,
And crops with dancing head the daisy'd land.—
With rosy wreathes EUROPA'S hand adorns
His fringed forehead, and his pearly horns;
Light on his back the sportive Damsel bounds,
And pleased he moves along the flowery grounds;
Bears with slow step his beauteous prize aloof,
Dips in the lucid flood his ivory hoof;
Then wets his velvet knees, and wading laves
His silky sides amid the dimpling waves.
While her fond train with beckoning hands deplore,
Strain their blue eyes, and shriek along the shore;
Beneath her robe she draws her snowy feet,
And, half-reclining on her ermine seat,
Round his raised neck her radiant arms she throws,
And rests her fair cheek on his curled brows;
Her yellow tresses wave on wanton gales,
And high in air her azure mantle sails.
—Onward He moves, applauding Cupids guide,
And skim on shooting wing the shining tide;
Emerging Triton's leave their coral caves,
Sound their loud conchs, and smooth the circling waves,
Surround the timorous Beauty, as she swims,
And gaze enamour'd on her silver limbs.
—Now Europe's shadowy shores with loud acclaim
Hail the fair fugitive, and shout her name;
Soft echoes warble, whispering forests nod,
And conscious Nature owns the present God.
—Changed from the Bull, the rapturous God assumes
Immortal youth, with glow celestial blooms,
With lenient words her virgin fears disarms,
And clasps the yielding Beauty in his arms;
Whence Kings and Heroes own illustrious birth,
Guards of mankind, and demigods on earth.

[*Inconstant Jove*. l. 229. The purer air or ether in the antient mythology was represented by Jupiter, and the inferior air by Juno; and the conjunction of these deities was said to produce the vernal showers, and procreate all things, as is further spoken of in Canto III. l. 204. It is now discovered that pure air, or oxygene, uniting with variety of bases forms the various kinds of acids; as the vitriolic acid

from pure air and sulphur; the nitrous acid from pure air and phlogistic air, or azote; and carbonic acid, (or fixed air,) from pure air and charcoal. Some of these affinities were perhaps portrayed by the Magi of Egypt, who were probably learned in chemistry, in their hieroglyphic pictures before the invention of letters, by the loves of Jupiter with terrestrial ladies. And thus physically as well as metaphysically might be said "Jovis omnia plena."]

VI. "GNOMES! as you pass'd beneath the labouring soil,
The guards and guides of Nature's chemic toil,
YOU saw, deep-sepulchred in dusky realms,
Which Earth's rock-ribbed ponderous vault o'erwhelms,
With self-born fires the mass fermenting glow,
And flame-wing'd sulphurs quit the earths below.

[*With self-born fires*. l. 275. After the accumulation of plains and mountains on the calcareous rocks or granite which had been previously raised by volcanic fires, a second set of volcanic fires were produced by the fermentation of this new mass, by which after the salts or acids and iron had been washed away in part by elutriation, dissipated the sulphurous parts which were insoluble in water; whence argillaceous and siliceous earths were left in some places; in others, bitumen became sublimed to the upper part of the stratum, producing coals of various degrees of purity.]

1. "HENCE ductile CLAYS in wide expansion spread,
Soft as the Cygnet's down, their snow-white bed;
With yielding flakes successive forms reveal,
And change obedient to the whirling wheel.
—First CHINA'S sons, with early art elate,
Form'd the gay tea-pot, and the pictured plate;
Saw with illumin'd brow and dazzled eyes
In the red stove vitrescent colours rise;
Speck'd her tall beakers with enamel'd stars,
Her monster-josses, and gigantic jars;
Smear'd her huge dragons with metallic hues,
With golden purples, and cobaltic blues;
Bade on wide hills her porcelain castles glare,
And glazed Pagodas tremble in the air.

[*Hence ductile clays* l. 277. See additional notes, No. XX.]

[*Saw with illumin'd brow*. l. 283. No colour is distinguishable in the red-hot kiln but the red itself, till the workman introduces a small piece of dry wood, which by producing a white flame renders all the other colours visible in a moment.]

[*With golden purples*. l. 288. See additional notes, No. XXI.]

"ETRURIA! next beneath thy magic hands
Glides the quick wheel, the plaistic clay expands,
Nerved with fine touch, thy fingers (as it turns)
Mark the nice bounds of vases, ewers, and urns;
Round each fair form in lines immortal trace
Uncopied Beauty, and ideal Grace.

[*Etruria! next*. l. 291. Etruria may perhaps vie with China itself in the antiquity of its arts. The times of its greatest splendour were prior to the foundations of Rome, and the reign of one of its best princes, Janus, was the oldest epoch the Romans knew. The earliest historians speak of the Etruscans as being then of high antiquity, most probably a colony from Phoenicia, to which a Pelasgian colony acceded, and was united soon after Deucalion's flood. The peculiar character of their earthern vases consists in the admirable beauty, simplicity, and diversity of forms, which continue the best models of taste to the artists of the present times; and in a species of non-vitreous encaustic painting, which was reckoned, even in the time of Pliny, among the lost arts of antiquity, but which has lately been recovered by the ingenuity and industry of Mr. Wedgwood. It is supposed that the principal manufactories were about Nola, at the foot of Vesuvius; for it is in that neighbourhood that the greatest quantities of antique vases have been found; and it is said that the general taste of the inhabitants is apparently influenced by them; insomuch that strangers coming to Naples, are commonly struck with the diversity and

elegance even of the most ordinary vases for common uses. See D'Hancarville's preliminary discourses to the magnificent collection of Etruscan vases, published by Sir William Hamilton.]

"GNOMES! as you now dissect with hammers fine
The granite-rock, the nodul'd flint calcine;
Grind with strong arm, the circling chertz betwixt,
Your pure Ka-o-lins and Pe-tun-tses mixt;
O'er each red saggars burning cave preside,
The keen-eyed Fire-Nymphs blazing by your side;
And pleased on WEDGWOOD ray your partial smile,
A new Etruria decks Britannia's isle.—
Charm'd by your touch, the flint liquescent pours
Through finer sieves, and falls in whiter showers;
Charm'd by your touch, the kneaded clay refines,
The biscuit hardens, the enamel shines;
Each nicer mould a softer feature drinks,
The bold Cameo speaks, the soft Intaglio thinks.

[Illustration: *H. Webber init J. Holloway sculpt Copied from Capt. Phillip's Voyage to Botany Bay, by permission of the Proprietor*]

[Transcriber's note: names of painter and engraver are only guesswork.]

[Illustration: AM I NOT A MAN AND A BROTHER]

"To call the pearly drops from Pity's eye,
Or stay Despair's disanimating sigh,
Whether, O Friend of art! the gem you mould
Rich with new taste, with antient virtue bold;
Form the poor fetter'd SLAVE on bended knee
From Britain's sons imploring to be free;
Or with fair HOPE the brightening scenes improve,
And cheer the dreary wastes at Sydney-cove;
Or bid Mortality rejoice and mourn
O'er the fine forms on PORTLAND'S mystic urn.—

[*Form the poor fetter'd Slave*. l. 315. Alluding to two cameos of Mr. Wedgwood's manufacture; one of a Slave in chains, of which he distributed many hundreds, to excite the humane to attend to and to assist in the abolition of the detestable traffic in human creatures; and the other a cameo of Hope attended by Peace, and Art, and Labour; which was made of clay from Botany Bay; to which place he sent many of them to shew the inhabitants what their materials would do, and to encourage their industry. A print of this latter medallion is prefixed to Mr. Stockdale's edition of Philip's Expedition to Botany Bay.]

[*Portland's mystic urn*. l. 320. See additional notes, No. XXII.]

"*Here* by fall'n columns and disjoin'd arcades,
On mouldering stones, beneath deciduous shades,
Sits HUMANKIND in hieroglyphic state,
Serious, and pondering on their changeful state;
While with inverted torch, and swimming eyes,
Sinks the fair shade of MORTAL LIFE, and dies.
There the pale GHOST through Death's wide portal bends
His timid feet, the dusky steep descends;
With smiles assuasive LOVE DIVINE invites,
Guides on broad wing, with torch uplifted lights;
IMMORTAL LIFE, her hand extending, courts
The lingering form, his tottering step supports;
Leads on to Pluto's realms the dreary way,
And gives him trembling to Elysian day.
Beneath in sacred robes the PRIESTESS dress'd,
The coif close-hooded, and the fluttering vest,
With pointing finger guides the initiate youth,

Unweaves the many-colour'd veil of Truth,
Drives the profane from Mystery's bolted door,
And Silence guards the Eleusinian lore.—

[Illustration: *The Portland Vase*]

[Illustration: *The first Compartment*, London Published Dec'r 1st 1791 by J. Johnson, St. Paul's Church Yard.]

[Transcriber's note: 2nd line with date very small and nearly illegible]

[Illustration: *The second Compartment*]

[Illustration: *The Handles & Bottom of the Vase.* London Published Dec'r 1st 1791 by J. Johnson, St. Paul's Church Yard.]

"Whether, O Friend of Art! your gems derive
Fine forms from Greece, and fabled Gods revive;
Or bid from modern life the Portrait breathe,
And bind round Honour's brow the laurel wreath;
Buoyant shall sail, with Fame's historic page,
Each fair medallion o'er the wrecks of age;
Nor Time shall mar; nor steel, nor fire, nor rust
Touch the hard polish of the immortal bust.

[*Fine forms from Greece*. l. 342. In real stones, or in paste or soft coloured glass, many pieces of exquisite workmanship were produced by the antients. Basso-relievos of various sizes were made in coarse brown earth of one colour; but of the improved kind of two or more colours, and of a true porcelain texture, none were made by the antients, nor attempted I believe by the moderns, before those of Mr. Wedgwood's manufactory.]

2. "HENCE sable COAL his massy couch extends,
And stars of gold the sparkling Pyrite blends;
Hence dull-eyed Naphtha pours his pitchy streams,
And Jet uncolour'd drinks the solar beams,
Bright Amber shines on his electric throne,
And adds ethereal lustres to his own.
—Led by the phosphor-light, with daring tread
Immortal FRANKLIN sought the fiery bed;
Where, nursed in night, incumbent Tempest shrouds
The seeds of Thunder in circumfluent clouds,
Besieged with iron points his airy cell,
And pierced the monster slumbering in the shell.

[*Hence sable Coal*. l. 349. See additional notes, No. XXIII. on coal.]

[*Bright Amber shines*. l. 353. Coal has probably all been sublimed more or less from the clay, with which it was at first formed in decomposing morasses; the petroleum seems to have been separated and condensed again in superior strata, and a still finer kind of oil, as naphtha, has probably had the same origin. Some of these liquid oils have again lost their more volatile parts, and become cannel-coal, asphaltum, jet, and amber, according to the purity of the original fossil oil. Dr. Priestley has shewn, that essential oils long exposed to the atmosphere absorb both the vital and phlogistic part of it; whence it is probable their becoming solid may in great measure depend, as well as by the exhalation of their more volatile parts. On distillation with volatile alcaly all these fossil oils are shewn to contain the acid of amber, which evinces the identity of their origin. If a piece of amber be rubbed it attracts straws and hairs, whence the discovery of electricity, and whence its name, from electron the Greek word for amber.]

[*Immortal Franklin*. l. 356. See note on Canto I. l. 383.]

"So, born on sounding pinions to the WEST,
When Tyrant-Power had built his eagle nest;
While from his eyry shriek'd the famish'd brood,

Clenched their sharp claws, and champ'd their beaks for blood,
Immortal FRANKLIN watch'd the callow crew,
And stabb'd the struggling Vampires, ere they flew.
—The patriot-flame with quick contagion ran,
Hill lighted hill, and man electrised man;
Her heroes slain awhile COLUMBIA mourn'd,
And crown'd with laurels LIBERTY return'd.

"The Warrior, LIBERTY, with bending sails
Helm'd his bold course to fair HIBERNIA'S vales;—
Firm as he steps, along the shouting lands,
Lo! Truth and Virtue range their radiant bands;
Sad Superstition wails her empire torn,
Art plies his oar, and Commerce pours her horn.

"Long had the Giant-form on GALLIA'S plains
Inglorious slept, unconscious of his chains;
Round his large limbs were wound a thousand strings
By the weak hands of Confessors and Kings;
O'er his closed eyes a triple veil was bound,
And steely rivets lock'd him to the ground;
While stern Bastile with iron cage inthralls
His folded limbs, and hems in marble walls.
—Touch'd by the patriot-flame, he rent amazed
The flimsy bonds, and round and round him gazed;
Starts up from earth, above the admiring throng
Lifts his Colossal form, and towers along;
High o'er his foes his hundred arms He rears,
Plowshares his swords, and pruning hooks his spears;
Calls to the Good and Brave with voice, that rolls
Like Heaven's own thunder round the echoing poles;
Gives to the winds his banner broad unfurl'd,
And gathers in its shade the living world!

[*While stern Bastile*. l. 383. "We descended with great difficulty into the dungeons, which were made too low for our standing upright; and were so dark, that we were obliged at noon-day to visit them by the light of a candle. We saw the hooks of those chains, by which the prisoners were fastened by their necks to the walls of their cells; many of which being below the level of the water were in a constant state of humidity; from which issued a noxious vapour, which more than once extinguished the candles. Since the destruction of the building many subterraneous cells have been discovered under a piece of ground, which seemed only a bank of solid earth before the horrid secrets of this prison-house were disclosed. Some skeletons were found in these recesses with irons still fastened to their decayed bones." Letters from France, by H.M. Williams, p. 24.]

VII. "GNOMES! YOU then taught volcanic airs to force
Through bubbling Lavas their resistless course,
O'er the broad walls of rifted Granite climb,
And pierce the rent roof of incumbent Lime,
Round sparry caves metallic lustres fling,
And bear phlogiston on their tepid wing.

[*And pierce the rent roof*. l. 398. The granite rocks and the limestone rocks have been cracked to very great depths at the time they were raised up by subterranean fires; in these cracks are found most of the metallic ores, except iron and perhaps manganese, the former of which is generally found in horizontal strata, and the latter generally near the surface of the earth.

Philosophers possessing so convenient a test for the discovery of iron by the magnet, have long since found it in all vegetable and animal matters; and of late Mr. Scheele has discovered the existence of manganese in vegetable ashes. Scheele, 56 mem. Stock. 1774. Kirwan. Min. 353. Which accounts for the production of it near the surface of earth, and thence for its calciform appearance, or union with vital air. Bergman has likewise shewn, that the limestones which become bluish or dark coloured when calcined, possess a mixture of manganese, and are thence preferable as a cement to other kinds of lime. 2. Bergman, 229. Which impregnation with manganese has probably been received from the decomposition of superincumbent vegetable matters.

These cracks or perpendicular caverns in the granite or limestone pass to unknown depths; and it is up these channels that I have endeavoured to shew that the steam rises which becomes afterwards condensed and produces the warm springs of this island, and other parts of the world. (See note on Fucus, Vol. II.) And up these cracks I suppose certain vapours arise, which either alone, or by meeting with something descending into them from above, have produced most of the metals; and several of the materials in which they are bedded. Thus the ponderous earth, Barytes, of Derbyshire, is found in these cracks, and is stratified frequently with lead-ore, and frequently surrounds it. This ponderous earth has been found by Dr. Hoepfner in a granite in Switzerland, and may have thus been sublimed from immense depths by great heat, and have obtained its carbonic or vitriolic acid from above. Annales de Chimie. There is also reason to conclude that something from above is necessary to the formation of many of the metals: at Hawkstone in Shropshire, the seat of Sir Richard Hill, there is an elevated rock of siliceous sand which is coloured green with copper in many places high in the air; and I have in my possession a specimen of lead formed in the cavity of an iron nodule, and another of lead amid spar from a crack of a coal-stratum; all which countenance the modern production of those metals from descending materials. To which should be added, that the highest mountains of granite, which have therefore probably never been covered with marine productions on account of their early elevation, nor with vegetable or animal matters on account of their great coldness, contain no metallic ores, whilst the lower ones contain copper and tin in their cracks or veins, both in Saxony, Silesia, and Cornwall. Kirwan's Mineral. p. 374.

The transmutation of one metal into another, though hitherto undiscovered by the alchymists, does not appear impossible; such transmutations have been supposed to exist in nature, thus lapis calaminaris may have been produced from the destruction of lead-ore, as it is generally found on the top of the veins of lead, where it has been calcined or united with air, and because masses of lead-ore are often found intirely inclosed in it. So silver is found mixed in almost all lead-ores, and sometimes in seperate filaments within the cavities of lead-ore, as I am informed by Mr. Michell, and is thence probably a partial transmutation of the lead to silver, the rapid progress of modern chemistry having shewn the analogy between metallic calces and acids, may lead to the power of transmuting their bases: a discovery much to be wished.]

"HENCE glows, refulgent Tin! thy chrystal grains,
And tawny Copper shoots her azure veins;
Zinc lines his fretted vault with sable ore,
And dull Galena tessellates the floor;
On vermil beds in Idria's mighty caves
The living Silver rolls its ponderous waves;
With gay refractions bright Platina shines,
And studs with squander'd stars his dusky mines;
Long threads of netted gold, and silvery darts,
Inlay the Lazuli, and pierce the Quartz;—
—Whence roof'd with silver beam'd PERU, of old,
And hapless MEXICO was paved with gold.

"Heavens! on my sight what sanguine colours blaze!
Spain's deathless shame! the crimes of modern days!
When Avarice, shrouded in Religion's robe,
Sail'd to the West, and slaughter'd half the globe;
While Superstition, stalking by his side,
Mock'd the loud groans, and lap'd the bloody tide;
For sacred truths announced her frenzied dreams,
And turn'd to night the sun's meridian beams.—
Hear, oh, BRITANNIA! potent Queen of isles,
On whom fair Art, and meek Religion smiles,
Now AFRIC'S coasts thy craftier sons invade
With murder, rapine, theft,—and call it Trade!
—The SLAVE, in chains, on supplicating knee,
Spreads his wide arms, and lifts his eyes to Thee;
With hunger pale, with wounds and toil oppress'd,
"ARE WE NOT BRETHREN?" sorrow choaks the rest;—
—AIR! bear to heaven upon thy azure flood
Their innocent cries!—EARTH! cover not their blood!

VIII. "When Heaven's dread justice smites in crimes o'ergrown
The blood-nursed Tyrant on his purple throne,
GNOMES! YOUR bold forms unnumber'd arms outstretch,

And urge the vengeance o'er the guilty wretch.—
Thus when CAMBYSES led his barbarous hosts
From Persia's rocks to Egypt's trembling coasts,
Defiled each hallowed fane, and sacred wood,
And, drunk with fury, swell'd the Nile with blood;
Waved his proud banner o'er the Theban states,
And pour'd destruction through her hundred gates;
In dread divisions march'd the marshal'd bands,
And swarming armies blacken'd all the lands,
By Memphis these to ETHIOP'S sultry plains,
And those to HAMMON'S sand-incircled fanes.—
Slow as they pass'd, the indignant temples frown'd,
Low curses muttering from the vaulted ground;
Long ailes of Cypress waved their deepen'd glooms,
And quivering spectres grinn'd amid the tombs;
Prophetic whispers breathed from S
And MEMNON'S lyre with hollow murmurs rung;
Burst from each pyramid expiring groans,
And darker shadows stretch'd their lengthen'd cones.—
Day after day their deathful rout They steer,
Lust in the van, and rapine in the rear.

[*Thus when Cambyses*. l. 435. Cambyses marched one army from Thebes, after having overturned the temples, ravaged the country, and deluged it with blood, to subdue Ethiopia; this army almost perished by famine, insomuch, that they repeatedly slew every tenth man to supply the remainder with food. He sent another army to plunder the temple of Jupiter Ammon, which perished overwhelm'd with sand.]

[*Expiring groans*. l. 451. Mr. Savery or Mr. Volney in their Travels through Egypt has given a curious description of one of the pyramids, with the operose method of closing them, and immuring the body, (as they supposed) for six thousand years. And has endeavoured from thence to shew, that, when a monarch died, several of his favourite courtiers were inclosed alive with the mummy in these great masses of stone-work; and had food and water conveyed to them, as long as they lived, proper apertures being left for this purpose, and for the admission of air, and for the exclusion of any thing offensive.]

"GNOMES! as they march'd, You hid the gathered fruits,
The bladed grass, sweet grains, and mealy roots;
Scared the tired quails, that journey'd o'er their heads,
Retain'd the locusts in their earthy beds;
Bade on your sands no night-born dews distil,
Stay'd with vindictive hands the scanty rill.—
Loud o'er the camp the Fiend of Famine shrieks,
Calls all her brood, and champs her hundred beaks;
O'er ten square leagues her pennons broad expand,
And twilight swims upon the shuddering sand;
Perch'd on her crest the Griffin Discord clings,
And Giant Murder rides between her wings;
Blood from each clotted hair, and horny quill,
And showers of tears in blended streams distil;
High-poised in air her spiry neck she bends,
Rolls her keen eye, her Dragon-claws extends,
Darts from above, and tears at each fell swoop
With iron fangs the decimated troop.

"Now o'er their head the whizzing whirlwinds breathe,
And the live desert pants, and heaves beneath;
Tinged by the crimson sun, vast columns rise
Of eddying sands, and war amid the skies,
In red arcades the billowy plain surround,
And stalking turrets dance upon the ground.
—Long ranks in vain their shining blades extend,
To Demon-Gods their knees unhallow'd bend,
Wheel in wide circle, form in hollow square,
And now they front, and now they fly the war,

Pierce the deaf tempest with lamenting cries,
Press their parch'd lips, and close their blood-shot eyes.
—GNOMES! o'er the waste YOU led your myriad powers,
Climb'd on the whirls, and aim'd the flinty showers!—
Onward resistless rolls the infuriate surge,
Clouds follow clouds, and mountains mountains urge;
Wave over wave the driving desert swims,
Bursts o'er their heads, inhumes their struggling limbs;
Man mounts on man, on camels camels rush,
Hosts march o'er hosts, and nations nations crush,—
Wheeling in air the winged islands fall,
And one great earthy Ocean covers all!—
Then ceased the storm,—NIGHT bow'd his Ethiop brow
To earth, and listen'd to the groans below,—
Grim HORROR shook,—awhile the living hill
Heaved with convulsive throes,—and all was still!

[*And stalking turrets*. l. 478. "At one o'clock we alighted among some acacia trees at Waadi el Halboub, having gone twenty-one miles. We were here at once surprised and terrified by a sight surely one of the most magnificent in the world. In that vast expanse of desert, from W. to N.W. of us, we saw a number of prodigious pillars of sand at different distances, at times moving with great celerity, at others stalking on with a majestic slowness; at intervals we thought they were coming in a very few minutes to overwhelm us; and small quantities of sand did actually more than once reach us. Again they would retreat so as to be almost out of sight, their tops reaching to the very clouds. There the tops often separated from the bodies; and these, once disjoined, dispersed in the air, and did not appear more. Sometimes they were broken in the middle, as if struck with large cannon-shot. About noon they began to advance with considerable swiftness upon us, the wind being very strong at north. Eleven of them ranged along side of us about the distance of three miles. The greatest diameter of the largest appeared to me at that distance as if it would measure ten feet. They retired from us with a wind at S.E. leaving an impression upon my mind to which I can give no name, though surely one ingredient in it was fear, with a considerable deal of wonder and astonishment. It was in vain to think of flying; the swiftest horse, or fastest sailing ship, could be of no use to carry us out of this danger; and the full persuasion of this rivetted me as if to the spot where I stood.

"The same appearance of moving pillars of sand presented themselves to us this day in form and disposition like those we had seen at Waadi Halboub, only they seemed to be more in number and less in size. They came several times in a direction close upon us, that is, I believe, within less than two miles. They began immediately after sun rise like a thick wood and almost darkened the sun. His rays shining through them for near an hour, gave them an appearance of pillars of fire. Our people now became desperate, the Greeks shrieked out and said it was the day of judgment; Ismael pronounced it to be hell; and the Turcorories, that the world was on fire." Bruce's Travels, Vol. IV. p. 553,-555.

From this account it would appear, that the eddies of wind were owing to the long range of broken rocks, which bounded one side of the sandy desert, and bent the currents of air, which struck against their sides; and were thus like the eddies in a stream of water, which falls against oblique obstacles. This explanation is probably the true one, as these whirl-winds were not attended with rain or lightening like the tornadoes of the West-Indies.]

IX. "GNOMES! whose fine forms, impassive as the air,
Shrink with soft sympathy for human care;
Who glide unseen, on printless slippers borne,
Beneath the waving grass, and nodding corn;
Or lay your tiny limbs, when noon-tide warms,
Where shadowy cowslips stretch their golden arms,—
So mark'd on orreries in lucid signs,
Star'd with bright points the mimic zodiac shines;
Borne on fine wires amid the pictured skies
With ivory orbs the planets set and rise;
Round the dwarf earth the pearly moon is roll'd,
And the sun twinkling whirls his rays of gold.—
Call your bright myriads, march your mailed hosts,
With spears and helmets glittering round the coasts;
Thick as the hairs, which rear the Lion's mane,
Or fringe the Boar, that bays the hunter-train;

Watch, where proud Surges break their treacherous mounds,
And sweep resistless o'er the cultured grounds;
Such as erewhile, impell'd o'er Belgia's plain,
Roll'd her rich ruins to the insatiate main;
With piles and piers the ruffian waves engage,
And bid indignant Ocean stay his rage.

[*So mark'd on orreries*. l. 505. The first orrery was constructed by a Mr. Rowley, a mathematician born at Lichfield; and so named from his patron the Earl of Orrery. Johnson's Dictionary.]

"Where, girt with clouds, the rifted mountain yawns,
And chills with length of shade the gelid lawns,
Climb the rude steeps, the granite-cliffs surround,
Pierce with steel points, with wooden wedges wound;
Break into clays the soft volcanic slaggs,
Or melt with acid airs the marble craggs;
Crown the green summits with adventurous flocks,
And charm with novel flowers the wondering rocks.
—So when proud Rome the Afric Warrior braved,
And high on Alps his crimson banner waved;
While rocks on rocks their beetling brows oppose
With piny forests, and unfathomed snows;
Onward he march'd, to Latium's velvet ground
With fires and acids burst the obdurate bound,
Wide o'er her weeping vales destruction hurl'd,
And shook the rising empire of the world.

[*The granite-cliffs.* l. 523. On long exposure to air the granites or porphories of this country exhibit a ferrugenous crust, the iron being calcined by the air first becomes visible, and is then washed away from the external surface, which becomes white or grey, and thus in time seems to decompose. The marbles seem to decompose by loosing their carbonic acid, as the outside, which has been long exposed to the air, does not seem to effervesce so hastily with acids as the parts more recently broken. The immense quantity of carbonic acid, which exists in the many provinces of lime-stone, if it was extricated and decomposed would afford charcoal enough for fuel for ages, or for the production of new vegetable or animal bodies. The volcanic slaggs on Mount Vesuvius are said by M. Ferber to be changed into clay by means of the sulphur- acid, and even pots made of clay and burnt or vitrified are said by him to be again reducible to ductile clay by the volcanic steams. Ferber's Travels through Italy, p. 166.]

[*Wooden wedges wound*. l. 524. It is usual in seperating large mill- stones from the siliceous sand-rocks in some parts of Derbyshire to bore horizontal holes under them in a circle, and fill these with pegs made of dry wood, which gradually swell by the moisture of the earth, and in a day or two lift up the mill-stone without breaking it.]

[*With fires and acids*. l. 534. Hannibal was said to erode his way over the Alps by fire and vinegar. The latter is supposed to allude to the vinegar and water which was the beverage of his army. In respect to the former it is not improbable, but where wood was to be had in great abundance, that fires made round limestone precipices would calcine them to a considerable depth, the night-dews or mountain-mists would penetrate these calcined parts and pulverize them by the force of the steam which the generated heat would produce, the winds would disperse this lime-powder, and thus by repeated fires a precipice of lime-stone might be destroyed and a passage opened. It should be added, that according to Ferber's observations, these Alps consist of lime-stone. Letters from Italy.]

X. "Go, gentle GNOMES! resume your vernal toil,
Seek my chill tribes, which sleep beneath the soil;
On grey-moss banks, green meads, or furrow'd lands
Spread the dark mould, white lime, and crumbling sands;
Each bursting bud with healthier juices feed,
Emerging scion, or awaken'd seed.
So, in descending streams, the silver Chyle
Streaks with white clouds the golden floods of bile;
Through each nice valve the mingling currents glide,
Join their fine rills, and swell the sanguine tide;
Each countless cell, and viewless fibre seek,

Nerve the strong arm, and tinge the blushing cheek.

"Oh, watch, where bosom'd in the teeming earth,
Green swells the germ, impatient for its birth;
Guard from rapacious worms its tender shoots,
And drive the mining beetle from its roots;
With ceaseless efforts rend the obdurate clay,
And give my vegetable babes to day!
—Thus when an Angel-form, in light array'd,
Like HOWARD pierced the prison's noisome shade;
Where chain'd to earth, with eyes to heaven upturn'd,
The kneeling Saint in holy anguish mourn'd;—
Ray'd from his lucid vest, and halo'd brow
O'er the dark roof celestial lustres glow,
"PETER, arise!" with cheering voice He calls,
And sounds seraphic echo round the walls;
Locks, bolts, and chains his potent touch obey,
And pleased he leads the dazzled Sage to day.

XI. "YOU! whose fine fingers fill the organic cells,
With virgin earth, of woods and bones and shells;
Mould with retractile glue their spongy beds,
And stretch and strengthen all their fibre-threads.—
Late when the mass obeys its changeful doom,
And sinks to earth, its cradle and its tomb,
GNOMES! with nice eye the slow solution watch,
With fostering hand the parting atoms catch,
Join in new forms, combine with life and sense,
And guide and guard the transmigrating Ens.

[*Mould with retractile glue*. l. 567. The constituent parts of animal fibres are believed to be earth and gluten. These do not seperate except by long putrefaction or by fire. The earth then effervesces with acids, and can only be converted into glass by the greatest force of fire. The gluten has continued united with the earth of the bones above 2000 years in Egyptian mummies; but by long exposure to air or moisture it diffolves and leaves only the earth. Hence bones long buried, when exposed to the air, absorb moisture and crumble into powder. Phil. Trans. No. 475. The retractibility or elasticity of the animal fibre depends on the gluten; and of these fibres are composed the membranes muscles and bones. Haller. Physiol. Tom. I, p. 2.

For the chemical decomposition of animal and vegetable bodies see the ingenious work of Lavoisier, Traité de Chimie, Tom. I. p. 132. who resolves all their component parts into oxygene, hydrogene, carbone, and azote, the three former of which belong principally to vegetable and the last to animal matter.]

[*The transmigrating Ens*. l. 574, The perpetual circulation of matter in the growth and dissolution of vegetable and animal bodies seems to have given Pythagoras his idea of the metempsycosis or transmigration of spirit; which was afterwards dressed out or ridiculed in variety of amusing fables. Other philosophers have supposed, that there are two different materials or essences, which fill the universe. One of these, which has the power of commencing or producing motion, is called spirit; the other, which has the power of receiving and of communicating motion, but not of beginning it, is called matter. The former of these is supposed to be diffused through all space, filling up the interstices of the suns and planets, and constituting the gravitations of the sidereal bodies, the attractions of chemistry, with the spirit of vegetation, and of animation. The latter occupies comparatively but small space, constituting the solid parts of the suns and planets, and their atmospheres. Hence these philosophers have supposed, that both matter and spirit are equally immortal and unperishable; and that on the dissolution of vegetable or animal organization, the matter returns to the general mass of matter; and the spirit to the general mass of spirit, to enter again into new combinations, according to the original idea of Pythagoras.

The small apparent quantity of matter that exists in the universe compared to that of spirit, and the short time in which the recrements of animal or vegetable bodies become again vivified in the forms of vegetable mucor or microscopic insects, seems to have given rise to another curious fable of antiquity. That Jupiter threw down a large handful of souls upon the earth, and left them to scramble for the few bodies which were to be had.]

"So when on Lebanon's sequester'd hight
The fair ADONIS left the realms of light,
Bow'd his bright locks, and, fated from his birth
To change eternal, mingled with the earth;—
With darker horror shook the conscious wood,
Groan'd the sad gales, and rivers blush'd with blood;
On cypress-boughs the Loves their quivers hung,
Their arrows scatter'd, and their bows unstrung;
And BEAUTY'S GODDESS, bending o'er his bier,
Breathed the soft sigh, and pour'd the tender tear.—
Admiring PROSERPINE through dusky glades
Led the fair phantom to Elysian shades,
Clad with new form, with finer sense combined,
And lit with purer flame the ethereal mind.
—Erewhile, emerging from infernal night,
The bright Assurgent rises into light,
Leaves the drear chambers of the insatiate tomb,
And shines and charms with renovated bloom.—
While wondering Loves the bursting grave surround,
And edge with meeting wings the yawning ground,
Stretch their fair necks, and leaning o'er the brink
View the pale regions of the dead, and shrink;
Long with broad eyes ecstatic BEAUTY stands,
Heaves her white bosom, spreads her waxen hands;
Then with loud shriek the panting Youth alarms,
"My Life! my Love!" and springs into his arms."

[*Adonis*. l. 576. The very antient story of the beautiful Adonis passing one half of the year with Venus, and the other with Proserpine alternately, has had variety of interpretations. Some have supposed that it allegorized the summer and winter solstice; but this seems too obvious a fact to have needed an hieroglyphic emblem. Others have believed it to represent the corn, which was supposed to sleep in the earth during the winter months, and to rise out of it in summer. This does not accord with the climate of Egypt, where the harvest soon follows the seed-time.

It seems more probably to have been a story explaining some hieroglyphic figures representing the decomposition and resuscitation of animal matter; a sublime and interesting subject, and which seems to have given origin to the doctrine of the transmigration, which had probably its birth also from the hieroglyphic treasures of Egypt. It is remarkable that the cypress groves in the ancient greek writers, as in Theocritus, were dedicated to Venus; and afterwards became funereal emblems. Which was probably occasioned by the Cypress being an accompaniment of Venus in the annual processions, in which she was supposed to lament over the funeral of Adonis; a ceremony which obtained over all the eastern world from great antiquity, and is supposed to be referred to by Ezekiel, who accuses the idolatrous woman of weeping for Thammus.]

The GODDESS ceased,—the delegated throng
O'er the wide plains delighted rush along;
In dusky squadrons, and in shining groups,
Hosts follow hosts, and troops succeed to troops;
Scarce bears the bending grass the moving freight,
And nodding florets bow beneath their weight.
So when light clouds on airy pinions sail,
Flit the soft shadows o'er the waving vale;
Shade follows shade, as laughing Zephyrs drive,
And all the chequer'd landscape seems alive.

[*Zephyrs drive*. l. 609. These lines were originally written thus,

Shade follows shade by laughing Zephyrs drove,
And all the chequer'd landscape seems to move.

but were altered on account of the supposed false grammar in using the word drove for driven, according to the opinion of Dr. Lowth: at the same time it may be observed, 1. that this is in many cases only an ellipsis of the letter *n* at the end of the word; as froze, for frozen; wove, for woven; spoke, for spoken; and that then the participle accidentally becomes similar to the past tense: 2. that the language

seems gradually tending to omit the letter *n* in other kind of words for the sake of euphony; as housen is become houses; eyne, eyes; thine, thy, &c. and in common conversation, the words forgot, spoke, froze, rode, are frequently used for forgotten, spoken, frozen, ridden. 3. It does not appear that any confusion would follow the indiscriminate use of the same word for the past tense and the participle passive, since the auxiliary verb *have*, or the preceding noun or pronoun always clearly distinguishes them: and lastly, rhime-poetry must lose the use of many elegant words without this license.]

Argument of the Third Canto.

Address to the Nymphs. I. Steam rises from the ocean, floats in clouds, descends in rain and dew, or is condensed on hills, produces springs, and rivers, and returns to the sea. So the blood circulates through the body and returns to the heart. 11. II. 1. Tides, 57. 2. Echinus, nautilus, pinna, cancer. Grotto of a mermaid. 65. 3. Oil stills the waves. Coral rocks. Ship-worm, or Teredo. Maelstrome, a whirlpool on the coast of Norway. 85. III. Rivers from beneath the snows on the Alps. The Tiber. 103. IV. Overflowing of the Nile from African Monsoons, 129. V. 1. Giesar, a boiling fountain in Iceland, destroyed by inundation, and consequent earthquake, 145. 2. Warm medicinal springs. Buxton. Duke and Dutchess of Devonshire. 157. VI. Combination of vital air and inflammable gas produces water. Which is another source of springs and rivers. Allegorical loves of Jupiter and Juno productive of vernal showers. 201. VII. Aquatic Taste. Distant murmur of the sea by night. Sea-horse. Nereid singing. 261. VIII. The Nymphs of the river Derwent lament the death of Mrs. French, 297. IX. Inland navigation. Monument for Mr. Brindley, 341. X. Pumps explained. Child sucking. Mothers exhorted to nurse their children. Cherub sleeping. 365. XI. Engines for extinguishing fire. Story of two lovers perishing in the flames. 397. XII. Charities of Miss Jones, 447. XIII. Marshes drained. Hercules conquers Achilous. The horn of Plenty. 483. XIV. Showers. Dews. Floating lands with water. Lacteal system in animals. Caravan drinking. 529. Departure of the Nymphs like water spiders; like northern nations skaiting on the ice. 569.

THE ECONOMY OF VEGETATION.

CANTO III.

AGAIN the GODDESS speaks!—glad Echo swells
The tuneful tones along her shadowy dells,
Her wrinkling founts with soft vibration shakes,
Curls her deep wells, and rimples all her lakes,
Thrills each wide stream, Britannia's isle that laves,
Her headlong cataracts, and circumfluent waves.
—Thick as the dews, which deck the morning flowers,
Or rain-drops twinkling in the sun-bright showers,
Fair Nymphs, emerging in pellucid bands,
Rise, as she turns, and whiten all the lands.

I. "YOUR buoyant troops on dimpling ocean tread,
Wafting the moist air from his oozy bed,
AQUATIC NYMPHS!—YOU lead with viewless march
The winged vapours up the aerial arch,
On each broad cloud a thousand sails expand,
And steer the shadowy treasure o'er the land,
Through vernal skies the gathering drops diffuse,
Plunge in soft rains, or sink in silver dews.—
YOUR lucid bands condense with fingers chill
The blue mist hovering round the gelid hill;
In clay-form'd beds the trickling streams collect,
Strain through white sands, through pebbly veins direct;
Or point in rifted rocks their dubious way,
And in each bubbling fountain rise to day.

[*The winged vapours*. l. 14. See additional note No. XXV. on evaporation.]

[*On each broad cloud*. l. 15. The clouds consist of condensed vapour, the particles of which are too small separately to overcome the tenacity of the air, and which therefore do not descend. They are in such small spheres as to repel each other, that is, they are applied to each other by such very small surfaces, that the attraction of the particles of each drop to its own centre is greater than its attraction to the surface of the drop in its vicinity; every one has observed with what difficulty small spherules of quicksilver can be made to unite, owing to the same cause; and it is common to see on riding through shallow water on a clear day, numbers of very small spheres of water as they are thrown from the horses feet run along the surface for many yards before they again unite with it. In many cases these spherules of water, which compose clouds, are kept from uniting by a surplus of electric fluid; and fall in violent showers as soon as that is withdrawn from them, as in thunder storms. See note on Canto I. l. 553.

If in this state a cloud becomes frozen, it is torn to pieces in its descent by the friction of the air, and falls in white flakes of snow. Or these flakes are rounded by being rubbed together by the winds, and by having their angles thawed off by the warmer air beneath as they descend; and part of the water produced by these angles thus dissolved is absorbed into the body of the hailstone, as may be seen by holding a lump of snow over a candle, and there becomes frozen into ice by the quantity of cold which the hailstone possesses beneath the freezing point, or which is produced by its quick evaporation in falling; and thus hailstones are often found of greater or less density according as they consist of a greater portion of snow or ice. If hailstones consisted of the large drops of showers frozen in their descent, they would consist of pure transparent ice.

As hail is only produced in summer, and is always attended with storms, some philosophers have believed that the sudden departure of electricity from a cloud may effect something yet unknown in this phenomenon; but it may happen in summer independent of electricity, because the aqueous vapour is then raised higher in the atmosphere, whence it has further to fall, and there is warmer air below for it to fall through.]

[*Or sink in silver dews*. l. 18. During the coldness of the night the moisture before dissolved in the air is gradually precipitated, and as it subsides adheres to the bodies it falls upon. Where the attraction of the body to the particles of water is greater than the attractions of those particles to each other, it becomes spread upon their surface, or slides down them in actual contact; as on the broad parts of the blades of moist grass: where the attraction of the surface to the water is less than the attraction of the particles of water to each other, the dew stands in drops; as on the points and edges of grass or gorse, where the surface presented to the drop being small it attracts it so little as but just to support it without much changing its globular form: where there is no attraction between the vegetable surface and the dew drops, as on cabbage leaves, the drop does not come into contact with the leaf, but hangs over it repelled, and retains it natural form, composed of the attraction and pressure of its own parts, and thence looks like quicksilver, reflecting light from both its surfaces. Nor is this owing to any oiliness of the leaf, but simply to the polish of its surface, as a light needle may be laid on water in the same manner without touching it; for as the attractive powers of polished surfaces are greater when in actual contact, so the repulsive power is greater before contact.]

[*The blue mist*. l. 20. Mists are clouds resting on the ground, they generally come on at the beginning of night, and either fill the moist vallies, or hang on the summits of hills, according to the degree of moisture previously dissolved, and the eduction of heat from them. The air over rivers during the warmth of the day suspends much moisture, and as the changeful surface of rivers occasions them to cool sooner than the land at the approach of evening, mists are most frequently seen to begin over rivers, and to spread themselves over moist grounds, and fill the vallies, while the mists on the tops of mountains are more properly clouds, condensed by the coldness of their situation.

On ascending up the side of a hill from a misty valley, I have observed a beautiful coloured halo round the moon when a certain thickness of mist was over me, which ceased to be visible as soon as I emerged out of it; and well remember admiring with other spectators the shadow of the three spires of the cathedral church at Lichfield, the moon rising behind it, apparently broken off, and lying distinctly over our heads as if horizontally on the surface of the mist, which arose about as high as the roof of the church. There are some curious remarks on shadows or reflexions seen on the surface of mists from high mountains in Ulloa's Voyages. The dry mist of summer 1783, was probably occasioned by volcanic eruption, as mentioned in note on Chunda, Vol. II. and therefore more like the atmosphere of smoke which hangs on still days over great cities.

There is a dry mist, or rather a diminished transparence of the air, which according to Mr. Saussure accompanies fair weather, while great transparence of air indicates rain. Thus when large rivers two miles broad, such as at Liverpool, appear narrow, it is said to prognosticate rain; and when wide, fair

weather. This want of transparence of the air in dry weather, may be owing to new combinations or decompositions of the vapours dissolved in it, but wants further investigation. Essais sur L'Hygromet, p. 357.]

[*Round the gelid hill*. l. 20. See additional notes, No. XXVI. on the origin of springs.]

"NYMPHS! YOU then guide, attendant from their source,
The associate rills along their sinuous course;
Float in bright squadrons by the willowy brink,
Or circling slow in limpid eddies sink;
Call from her crystal cave the Naiad-Nymph,
Who hides her fine form in the passing lymph,
And, as below she braids her hyaline hair,
Eyes her soft smiles reflected in the air;
Or sport in groups with River-Boys, that lave
Their silken limbs amid the dashing wave;
Pluck the pale primrose bending from its edge,
Or tittering dance amid the whispering sedge.—

"Onward YOU pass, the pine-capt hills divide,
Or feed the golden harvests on their side;
The wide-ribb'd arch with hurrying torrents fill,
Shove the slow barge, or whirl the foaming mill.
OR lead with beckoning hand the sparkling train
Of refluent water to its parent main,
And pleased revisit in their sea-moss vales
Blue Nereid-forms array'd in shining scales,
Shapes, whose broad oar the torpid wave impels,
And Tritons bellowing through their twisted shells.

"So from the heart the sanguine stream distils,
O'er Beauty's radiant shrine in vermil rills,
Feeds each fine nerve, each slender hair pervades,
The skins bright snow with living purple shades,
Each dimpling cheek with warmer blushes dyes,
Laughs on the lips, and lightens in the eyes.
—Erewhile absorb'd, the vagrant globules swim
From each fair feature, and proportion'd limb,
Join'd in one trunk with deeper tint return
To the warm concave of the vital urn.

II. 1."AQUATIC MAIDS! YOU sway the mighty realms
Of scale and shell, which Ocean overwhelms;
As Night's pale Queen her rising orb reveals,
And climbs the zenith with refulgent wheels,
Car'd on the foam your glimmering legion rides,
Your little tridents heave the dashing tides,
Urge on the sounding shores their crystal course,
Restrain their fury, or direct their force.

[*Car'd on the foam*. l. 61. The phenomena of the tides have been well investigated and satisfactorily explained by Sir Isaac Newton and Dr. Halley from the reciprocal gravitations of the earth, moon, and sun. As the earth and moon move round a centre of motion near the earth's surface, at the same time that they are proceeding in their annual orbit round the sun, it follows that the water on the side of the earth nearest this centre of motion between the earth and moon will be more attracted by the moon, and the waters on the opposite side of the earth will be less attracted by the moon, than the central parts of the earth. Add to this that the centrifugal force of the water on the side of the earth furthest from the centre of the motion, round which the earth and moon move, (which, as was said before, is near the surface of the earth) is greater than that on the opposite side of the earth. From both these causes it is easy to comprehend that the water will rise on two sides of the earth, viz. on that nearest to the moon, and its opposite side, and that it will be flattened in consequence at the quadratures, and thus produce two tides in every lunar day, which consists of about twenty- four hours and forty-eight minutes.

These tides will be also affected by the solar attraction when it coincides with the lunar one, or

opposes it, as at new and full moon, and will also be much influenced by the opposing shores in every part of the earth.

Now as the moon in moving round the centre of gravity between itself and the earth describes a much larger orbit than the earth describes round the same centre, it follows that the centrifugal motion on the side of the moon opposite to the earth must be much greater than the centrifugal motion of the side of the earth opposite to the moon round the same centre. And secondly, as the attraction of the earth exerted on the moon's surface next to the earth is much greater than the attraction of the moon exerted on the earth's surface, the tides on the lunar sea, (if such there be,) should be much greater than those of our ocean. Add to this that as the same face of the moon always is turned to the earth, the lunar tides must be permanent, and if the solid parts of the moon be spherical, must always cover the phasis next to us. But as there are evidently hills and vales and volcanos on this side of the moon, the consequence is that the moon has no ocean, or that it is frozen.]

2."NYMPHS! YOU adorn, in glossy volumes roll'd,
The gaudy conch with azure, green, and gold.
You round Echinus ray his arrowy mail,
Give the keel'd Nautilus his oar and sail;
Firm to his rock with silver cords suspend
The anchor'd Pinna, and his Cancer-friend;
With worm-like beard his toothless lips array,
And teach the unwieldy Sturgeon to betray.—
Ambush'd in weeds, or sepulcher'd in sands,
In dread repose He waits the scaly bands,
Waves in red spires the living lures, and draws
The unwary plunderers to his circling jaws,
Eyes with grim joy the twinkling shoals beset,
And clasps the quick inextricable net.
You chase the warrior Shark, and cumberous Whale,
And guard the Mermaid in her briny vale;
Feed the live petals of her insect-flowers,
Her shell-wrack gardens, and her sea-fan bowers;
With ores and gems adorn her coral cell,
And drop a pearl in every gaping shell.

[*The gaudy conch*. l. 66. The spiral form of many shells seem to have afforded a more frugal manner of covering the long tail of the fish with calcareous armour; since a single thin partition between the adjoining circles of the fish was sufficient to defend both surfaces, and thus much cretaceous matter is saved; and it is probable that from this spiral form they are better enabled to feel the vibrations of the element in which they exist. See note on Canto IV. l. 162. This cretaceous matter is formed by a mucous secretion from the skin of the fish, as is seen in crab-fish, and others which annually cast their shells, and is at first a soft mucous covering, (like that of a hen's egg, when it is laid a day or two too soon,) and which gradually hardens. This may also be seen in common shell snails, if a part of their shell be broken it becomes repaired in a similar manner with mucus, which by degrees hardens into shell.

It is probable the calculi or stones found in other animals may have a similar origin, as they are formed on mucous membranes, as those of the kidney and bladder, chalk-stones in the gout, and gall-stones; and are probably owing to the inflammation of the membrane where they are produced, and vary according to the degree of inflammation of the membrane which forms them, and the kind of mucous which it naturally produces. Thus the shelly matter of different shell-fish differs, from the courser kinds which form the shells of crabs, to the finer kinds which produces the mother-pearl.

The beautiful colours of some shells originate from the thinness of the laminae of which they consist, rather than to any colouring matter, as is seen in mother-pearl, which reflects different colours according to the obliquity of the light which falls on it. The beautiful prismatic colours seen on the Labrodore stone are owing to a similar cause, viz. the thinness of the laminae of which it consists, and has probably been formed from mother-pearl shells.

It is curious that some of the most common fossil shells are not now known in their recent state, as the cornua ammonis; and on the contrary, many shells which are very plentiful in their recent state, as limpets, sea-ears, volutes, cowries, are very rarely found fossil. Da Costa's Conchology, p. 163. Were all the ammoniae destroyed when the continents were raised? Or do some genera of animals perish by the increasing power of their enemies? Or do they still reside at inaccessible depths in the sea? Or do some animals change their forms gradually and become new genera?]

[*Echinus. Nautilus*. l. 67, 68. See additional notes, No. XXVII.]

[*Pinna. Cancer*. l. 70. See additional notes, No. XXVII.]

[*With worm-like beard*. l. 71. See additional notes, No. XXVIII.]

[*Feed the live petals*. l. 82. There is a sea-insect described by Mr. Huges whose claws or tentacles being disposed in regular circles and tinged with variety of bright lively colours represent the petals of some most elegantly fringed and radiated flowers as the carnation, marigold, and anemone. Philos. Trans. Abridg. Vol. IX. p. 110. The Abbe Dicquemarre has further elucidated the history of the actinia; and observed their manner of taking their prey by inclosing it in these beautiful rays like a net. Phil. Trans. Vol. LXIII. and LXV. and LXVII.]

[*And drop a pearl*. l. 84. Many are the opinions both of antient and modern concerning the production of pearls. Mr. Reaumur thinks they are formed like the hard concretions in many land animals as stones of the bladder, gallstones, and bezoar, and hence concludes them to be a disease of the fish, but there seems to be a stricter analogy between these and the calcareous productions found in crab-fish called crab's eyes, which are formed near the stomach of the animal, and constitute a reservoir of calcareous matter against the renovation of the shell, at which time they are re-dissolved and deposited for that purpose. As the internal part of the shell of the pearl oyster or muscle consists of mother-pearl which is a similar material to the pearl and as the animal has annually occasion to enlarge his shell there is reason to suspect the loose pearls are similar reservoirs of the pearly matter for that purpose.]

3. "YOUR myriad trains o'er stagnant ocean's tow,
Harness'd with gossamer, the loitering prow;
Or with fine films, suspended o'er the deep,
Of oil effusive lull the waves to sleep.
You stay the flying bark, conceal'd beneath,
Where living rocks of worm-built coral breathe;
Meet fell TEREDO, as he mines the keel
With beaked head, and break his lips of steel;
Turn the broad helm, the fluttering canvas urge
From MAELSTROME'S fierce innavigable surge.
—'Mid the lorn isles of Norway's stormy main,
As sweeps o'er many a league his eddying train,
Vast watery walls in rapid circles spin,
And deep-ingulph'd the Demon dwells within;
Springs o'er the fear-froze crew with Harpy-claws,
Down his deep den the whirling vessel draws;
Churns with his bloody mouth the dread repast,
The booming waters murmuring o'er the mast.

[*Or with fine films*. l. 87. See additional notes, No. XXIX.]

[*Where living rocks*. l. 90. The immense and dangerous rocks built by the swarms of coral infects which rise almost perpendicularly in the southern ocean like walls are described in Cook's voyages, a point of one of these rocks broke off and stuck in the hole which it had made in the bottom of one of his ships, which would otherwise have perished by the admission of water. The numerous lime-stone rocks which consist of a congeries of the cells of these animals and which constitute a great part of the solid earth shew their prodigious multiplication in all ages of the world. Specimens of these rocks are to be seen in the Lime-works at Linsel near Newport in Shropshire, in Coal-brook Dale, and in many parts of the Peak of Derbyshire. The insect has been well described by M. Peyssonnel, Ellis, and others. Phil. Trans. Vol. XLVII. L. LII. and LVII.]

[*Meet fell Teredo*. l. 91. See additional notes, No. XXX.]

[*Turn the broad helm*. l 93. See additional notes, No. XXXI.]

III. "Where with chill frown enormous ALPS alarms
A thousand realms, horizon'd in his arms;
While cloudless suns meridian glories shed
From skies of silver round his hoary head,
Tall rocks of ice refract the coloured rays,
And Frost sits throned amid the lambent blaze;
NYMPHS! YOUR thin forms pervade his glittering piles,

His roofs of chrystal, and his glasy ailes;
Where in cold caves imprisoned Naiads sleep,
Or chain'd on mossy couches wake and weep;
Where round dark crags indignant waters bend
Through rifted ice, in ivory veins descend,
Seek through unfathom'd snows their devious track,
Heave the vast spars, the ribbed granites crack,
Rush into day, in foamy torrents shine,
And swell the imperial Danube or the Rhine.—
Or feed the murmuring TIBER, as he laves
His realms inglorious with diminish'd waves,
Hears his lorn Forum sound with Eunuch-strains,
Sees dancing slaves insult his martial plains;
Parts with chill stream the dim religious bower,
Time-mouldered bastion, and dismantled tower;
By alter'd fanes and nameless villas glides,
And classic domes, that tremble on his sides;
Sighs o'er each broken urn, and yawning tomb,
And mourns the fall of LIBERTY and ROME.

[*Where round dark craggs*. l. 113. See additional notes, No. XXXII.]

[*Heave the vast spars*. l. 116. Water in descending down elevated situations if the outlet for it below is not sufficient for its emission acts with a force equal to the height of the column, as is seen in an experimental machine called the philosophical bellows, in which a few pints of water are made to raise many hundred pounds. To this cause is to be ascribed many large promontories of ice being occasionally thrown down from the glaciers; rocks have likewise been thrown from the sides of mountains by the same cause, and large portions of earth have been removed many hundred yards from their situations at the foot of mountains. On inspecting the locomotion of about thirty acres of earth with a small house near Bilder's Bridge in Shropshire, about twenty years ago, from the foot of a mountain towards the river, I well remember it bore all the marks of having been thus lifted up, pushed away, and as it were crumpled into ridges, by a column of water contained in the mountain.

From water being thus confined in high columns between the strata of mountainous countries it has often happened that when wells or perforations have been made into the earth, that springs have arisen much above the surface of the new well. When the new bridge was building at Dublin Mr. G. Semple found a spring in the bed of the river where he meant to lay the foundation of a pierre, which, by fixing iron pipes into it, he raised many feet. Treatise on Building in Water, by G. Semple. From having observed a valley north-west of St. Alkmond's well near Derby, at the head of which that spring of water once probably existed, and by its current formed the valley, (but which in after times found its way out in its present situation,) I suspect that St. Alkmond's well might by building round it be raised high enough to supply many streets in Derby with spring-water which are now only supplied with river-water. See an account of an artificial spring of water, Phil. Trans. Vol. LXXV. p. 1.

In making a well at Sheerness the water rose 300 feet above its source in the well. Phil. Trans. Vol. LXXIV. And at Hartford in Connecticut there is a well which was dug seventy feet deep before water was found, then in boring an augur-hole through a rock the water rose so fast as to make it difficult to keep it dry by pumps till they could blow the hole larger by gunpowder, which was no sooner accomplished than it filled and run over, and has been a brook for near a century. Travels through America. Lond. 1789. Lane.]

IV. "Sailing in air, when dark MONSOON inshrouds
His tropic mountains in a night of clouds;
Or drawn by whirlwinds from the Line returns,
And showers o'er Afric all his thousand urns;
High o'er his head the beams of SIRIUS glow,
And, Dog of Nile, ANUBIS barks below.
NYMPHS! YOU from cliff to cliff attendant guide
In headlong cataracts the impetuous tide;
Or lead o'er wastes of Abyssinian sands
The bright expanse to EGYPT'S shower-less lands.
—Her long canals the sacred waters fill,
And edge with silver every peopled hill;
Gigantic SPHINX in circling waves admire;

And MEMNON bending o'er his broken lyre;
O'er furrow'd glebes and green savannas sweep,
And towns and temples laugh amid the deep.

[*Dark monsoon inshrouds*. l. 129. When from any peculiar situations of land in respect to sea the tropic becomes more heated, when the sun is vertical over it, than the line, the periodical winds called monsoons are produced, and these are attended by rainy seasons; for as the air at the tropic is now more heated than at the line it ascends by decrease of its specific gravity, and floods of air rush in both from the South West and North East, and these being one warmer than the other the rain is precipitated by their mixture as observed by Dr. Hutton. See additional notes, No. XXV. All late travellers have ascribed the rise of the Nile to the monsoons which deluge Nubia and Abyssinia with rain. The whirling of the ascending air was even seen by Mr. Bruce in Abyssinia; he says, "every morning a small cloud began to whirl round, and presently after the whole heavens became covered with clouds," by this vortex of ascending air the N.E. winds and the S.W. winds, which flow in to supply the place of the ascending column, became mixed more rapidly and deposited their rain in greater abundance.

Mr. Volney observes that the time of the rising of the Nile commences about the 19th of June, and that Abyssinia and the adjacent parts of Africa are deluged with rain in May, June, and July, and produce a mass of water which is three months in draining off. The Abbe Le Pluche observes that as Sirius, or the dog-star, rose at the time of the commencement of the flood its rising was watched by the astronomers, and notice given of the approach of inundation by hanging the figure of Anubis, which was that of a man with a dog's head, upon all their temples. Histoire de Ciel.]

[Illustration: Fertilization of Egypt.]

[*Egypt's shower-less lands*. l. 138. There seem to be two situations which may be conceived to be exempted from rain falling upon them, one where the constant trade-winds meet beneath the line, for here two regions of warm air are mixed together, and thence do not seem to have any cause to precipitate their vapour; and the other is, where the winds are brought from colder climates and become warmer by their contact with the earth of a warmer one. Thus Lower Egypt is a flat country warmed by the sun more than the higher lands of one side of it, and than the Mediterranean on the other; and hence the winds which blow over it acquire greater warmth, which ever way they come, than they possessed before, and in consequence have a tendency to acquire and not to part with their vapour like the north-east winds of this country. There is said to be a narrow spot upon the coast of Peru where rain seldom occurs, at the same time according to Ulloa on the mountainous regions of the Andes beyond there is almost perpetual rain. For the wind blows uniformly upon this hot part of the coast of Peru, but no cause of devaporation occurs till it begins to ascend the mountainous Andes, and then its own expansion produces cold sufficient to condense its vapour.]

V. 1. "High in the frozen North where HECCLA glows,
And melts in torrents his coeval snows;
O'er isles and oceans sheds a sanguine light,
Or shoots red stars amid the ebon night;
When, at his base intomb'd, with bellowing sound
Fell GIESAR roar'd, and struggling shook the ground;
Pour'd from red nostrils, with her scalding breath,
A boiling deluge o'er the blasted heath;
And, wide in air, in misty volumes hurl'd
Contagious atoms o'er the alarmed world;
NYMPHS! YOUR bold myriads broke the infernal spell,
And crush'd the Sorceress in her flinty cell.

[*Fell Giesar roar'd*. l. 150. The boiling column of water at Giesar in Iceland was nineteen feet in diameter, and sometimes rose to the height of ninety-two feet. On cooling it deposited a siliceous matter or chalcedony forming a bason round its base. The heat of this water before it rose out of the earth could not be ascertained, as water looses all its heat above 212 (as soon as it is at liberty to expand) by the exhalation of a part, but the flinty bason which is deposited from it shews that water with great degrees of heat will dissolve siliceous matter. Van Troil's Letters on Iceland. Since the above account in the year 1780 this part of Iceland has been destroyed by an earthquake or covered with lava, which was probably effected by the force of aqueous steam, a greater quantity of water falling on the subterraneous fires than could escape by the antient outlets and generating an increased quantity of vapour. For the dispersion of contagious vapours from volcanos see an account of the Harmattan in the notes on Chunda, Vol. II.]

2. "Where with soft fires in unextinguish'd urns,
Cauldron'd in rock, innocuous Lava burns;
On the bright lake YOUR gelid hands distil
In pearly mowers the parsimonious rill;
And, as aloft the curling vapours rise
Through the cleft roof, ambitious for the skies,
In vaulted hills condense the tepid steams,
And pour to HEALTH the medicated streams.
—So in green vales amid her mountains bleak
BUXTONIA smiles, the Goddess-Nymyh of Peak;
Deep in warm waves, and pebbly baths she dwells,
And calls HYGEIA to her sainted wells.

[*Buxtonia smiles*. l. 166. Some arguments are mentioned in the note on Fucus Vol. II. to shew that the warm springs of this country do not arise from the decomposition of pyrites near the surface of the earth, but that they are produced by steam rising up the fissures of the mountains from great depths, owing to water falling on subterraneous fires, and that this steam is condensed between the strata of the incumbent mountains and collected into springs. For further proofs on this subject the reader is referred to a Letter from Dr. Darwin in Mr. Pilkington's View of Derbyshire, Vol I. p. 256.]

"Hither in sportive bands bright DEVON leads
Graces and Loves from Chatsworth's flowery meads.—
Charm'd round the NYMPH, they climb the rifted rocks;
And steep in mountain-mist their golden locks;
On venturous step her sparry caves explore,
And light with radiant eyes her realms of ore;
—Oft by her bubbling founts, and shadowy domes,
In gay undress the fairy legion roams,
Their dripping palms in playful malice fill,
Or taste with ruby lip the sparkling rill;
Croud round her baths, and, bending o'er the side,
Unclasp'd their sandals, and their zones untied,
Dip with gay fear the shuddering foot undress'd,
And quick retract it to the fringed vest;
Or cleave with brandish'd arms the lucid stream,
And sob, their blue eyes twinkling in the steam.
—High o'er the chequer'd vault with transient glow
Bright lustres dart, as dash the waves below;
And Echo's sweet responsive voice prolongs
The dulcet tumult of their silver tongues.—
O'er their flush'd cheeks uncurling tresses flow,
And dew-drops glitter on their necks of snow;
Round each fair Nymph her dropping mantle clings,
And Loves emerging shake their showery wings.

[*And sob, their blue eyes*. l. 184. The bath at Buxton being of 82 degrees of heat is called a warm bath, and is so compared with common spring-water which possesses but 48 degrees of heat, but is nevertheless a cold bath compared to the heat of the body which is 98. On going into this bath there is therefore always a chill perceived at the first immersion, but after having been in it a minute the chill ceases and a sensation of warmth succeeds though the body continues to be immersed in the water. The cause of this curious phenomenon is to be looked for in the laws of animal sensation and not from any properties of heat. When a person goes from clear day-light into an obscure room for a while it appears gloomy, which gloom however in a little time ceases, and the deficiency of light becomes no longer perceived. This is not solely owing to the enlargement of the iris of the eye, since that is performed in an instant, but to this law of sensation, that when a less stimulus is applied (within certain bounds) the sensibility increases. Thus at going into a bath as much colder than the body as that of Buxton, the diminution of heat on the skin is at first perceived, but in about a minute the sensibility to heat increases and the nerves of the skin are equally excited by the lessened stimulus. The sensation of warmth at emerging from a cold-bath, and the pain called the hot-ach, after the hands have been immersed in snow, depend on the same principle, viz. the increased sensibility of the skin after having been previously exposed to a stimulus less than usual.]

"Here oft her LORD surveys the rude domain,

Fair arts of Greece triumphant in his train;
LO! as he steps, the column'd pile ascends,
The blue roof closes, or the crescent bends;
New woods aspiring clothe their hills with green,
Smooth slope the lawns, the grey rock peeps between;
Relenting Nature gives her hand to Taste,
And Health and Beauty crown the laughing waste.

[*Here oft her Lord*. l. 193. Alluding to the magnificent and beautiful crescent, and superb stables lately erected at Buxton for the accomodation of the company by the Duke of Devonshire; and to the plantations with which he has decorated the surrounding mountains.]

VI. "NYMPHS! YOUR bright squadrons watch with chemic eyes
The cold-elastic vapours, as they rise;
With playful force arrest them as they pass,
And to *pure* AIR betroth the *flaming* GAS.
Round their translucent forms at once they fling
Their rapturous arms, with silver bosoms cling;
In fleecy clouds their fluttering wings extend,
Or from the skies in lucid showers descend;
Whence rills and rivers owe their secret birth,
And Ocean's hundred arms infold the earth.

[*And to pure air*. l. 204. Until very lately water was esteemed a simple element, nor are all the most celebrated chemists of Europe yet converts to the new opinion of its decomposition. Mr. Lavoisier and others of the French school have most ingeniously endeavoured to shew that water consists of pure air, called by them oxygene, and of inflammable air, called hydrogene, with as much of the matter of heat, or calorique, as is necessary to preserve them in the form of gas. Gas is distinguished from steam by its preserving its elasticity under the pressure of the atmosphere, and in the greatest degrees of cold yet known. The history of the progress of this great discovery is detailed in the Memoires of the Royal Academy for 1781, and the experimental proofs of it are delivered in Lavoisier's Elements of Chemistry. The results of which are that water consists of eighty-five parts by weight of oxygene, and fifteen parts by weight of hydrogene, with a sufficient quantity of Calorique. Not only numerous chemical phenomena, but many atmospherical and vegetable facts receive clear and beautiful elucidation from this important analysis. In the atmosphere inflammable air is probably perpetually uniting with vital air and producing moisture which descends in dews and showers, while the growth of vegetables by the assistance of light is perpetually again decomposing the water they imbibe from the earth, and while they retain the inflammable air for the formation of oils, wax, honey, resin, &c. they give up the vital air to replenish the atmosphere.]

"So, robed by Beauty's Queen, with softer charms
SATURNIA woo'd the Thunderer to her arms;
O'er her fair limbs a veil of light she spread,
And bound a starry diadem on her head;
Long braids of pearl her golden tresses grac'd,
And the charm'd CESTUS sparkled round her waist.
—Raised o'er the woof, by Beauty's hand inwrought,
Breathes the soft Sigh, and glows the enamour'd Thought;
Vows on light wings succeed, and quiver'd Wiles,
Assuasive Accents, and seductive Smiles.
—Slow rolls the Cyprian car in purple pride,
And, steer'd by LOVE, ascends admiring Ide;
Climbs the green slopes, the nodding woods pervades,
Burns round the rocks, or gleams amid the shades.
—Glad ZEPHYR leads the train, and waves above
The barbed darts, and blazing torch of Love;
Reverts his smiling face, and pausing flings
Soft showers of roses from aurelian wings.
Delighted Fawns, in wreathes of flowers array'd,
With tiptoe Wood-Boys beat the chequer'd glade;
Alarmed Naiads, rising into air,
Lift o'er their silver urns their leafy hair;
Each to her oak the bashful Dryads shrink,

And azure eyes are seen through every chink.
—LOVE culls a flaming shaft of broadest wing,
And rests the fork upon the quivering string;
Points his arch eye aloft, with fingers strong
Draws to his curled ear the silken thong;
Loud twangs the steel, the golden arrow flies,
Trails a long line of lustre through the skies;
"'Tis done!" he shouts, "the mighty Monarch feels!"
And with loud laughter shakes the silver wheels;
Bends o'er the car, and whirling, as it moves,
His loosen'd bowstring, drives the rising doves.
—Pierced on his throne the slarting Thunderer turns,
Melts with soft sighs, with kindling rapture burns;
Clasps her fair hand, and eyes in fond amaze
The bright Intruder with enamour'd gaze.
"And leaves my Goddess, like a blooming bride,
"The fanes of Argos for the rocks of Ide?
"Her gorgeous palaces, and amaranth bowers,
"For cliff-top'd mountains, and aerial towers?"
He said; and, leading from her ivory seat
The blushing Beauty to his lone retreat,
Curtain'd with night the couch imperial shrouds,
And rests the crimson cushions upon clouds.—
Earth feels the grateful influence from above,
Sighs the soft Air, and Ocean murmurs love;
Etherial Warmth expands his brooding wing,
And in still showers descends the genial Spring.

[*And steer'd by love*. l. 222. The younger love, or Cupid, the son of Venus, owes his existence and his attributes to much later times than the Eros, or divine love, mentioned in Canto I. since the former is no where mentioned by Homer, though so many apt opportunities of introducing him occur in the works of that immortal bard. Bacon.]

[*And in still showers.* l. 260. The allegorical interpretation of the very antient mythology which supposes Jupiter to represent the superior part of the atmosphere or ether, and Juno the inferior air, and that the conjunction of these two produces vernal showers, as alluded to in Virgil's Georgics, is so analogous to the present important discovery of the production of water from pure air, or oxygene, and inflammable air, or hydrogene, (which from its greater levity probably resides over the former,) that one should be tempted to believe that the very antient chemists of Egypt had discovered the composition of water, and thus represented it in their hieroglyphic figures before the invention of letters.

In the passage of Virgil Jupiter is called ether, and descends in prolific showers on the bosom of Juno, whence the spring succeeds and all nature rejoices.

Tum pater omnipotens foecundis imbribus Aether
Conjugis in gremium laetae descendit, et omnes
Magnus alit, magno commixtus corpore, faetus.

Virg. Georg. Lib. II. l. 325.]

VII. "NYMPHS OF AQUATIC TASTE! whose placid smile
Breathes sweet enchantment o'er BRITANNIA'S isle;
Whose sportive touch in showers resplendent flings
Her lucid cataracts, and her bubbling springs;
Through peopled vales the liquid silver guides,
And swells in bright expanse her freighted tides.
YOU with nice ear, in tiptoe trains, pervade
Dim walks of morn or evening's silent shade;
Join the lone Nightingale, her woods among,
And roll your rills symphonious to her song;
Through fount-full dells, and wave-worn valleys move,
And tune their echoing waterfalls to love;
Or catch, attentive to the distant roar,
The pausing murmurs of the dashing shore;

Or, as aloud she pours her liquid strain,
Pursue the NEREID on the twilight main.
—Her playful Sea-horse woos her soft commands,
Turns his quick ears, his webbed claws expands,
His watery way with waving volutes wins,
Or listening librates on unmoving fins.
The Nymph emerging mounts her scaly seat,
Hangs o'er his glossy sides her silver feet,
With snow-white hands her arching veil detains,
Gives to his slimy lips the slacken'd reins,
Lifts to the star of Eve her eye serene,
And chaunts the birth of Beauty's radiant Queen.—
O'er her fair brow her pearly comb unfurls
Her beryl locks, and parts the waving curls,
Each tangled braid with glistening teeth unbinds
And with the floating treasure musks the winds.—
Thrill'd by the dulcet accents, as she sings,
The rippling wave in widening circles rings;
Night's shadowy forms along the margin gleam
With pointed ears, or dance upon the stream;
The Moon transported stays her bright career,
And maddening Stars shoot headlong from the sphere.

[*Her playful seahorse.* l. 277. Described form an antique gem.]

VIII. "NYMPHS! whose fair eyes with vivid lustres glow
For human weal, and melt at human woe;
Late as YOU floated on your silver shells,
Sorrowing and slow by DERWENT'S willowy dells;
Where by tall groves his foamy flood he steers
Through ponderous arches o'er impetuous wears,
By DERBY'S shadowy towers reflective sweeps,
And gothic grandeur chills his dusky deeps;
You pearl'd with Pity's drops his velvet sides,
Sigh'd in his gales, and murmur'd in his tides,
Waved o'er his fringed brink a deeper gloom,
And bow'd his alders o'er MILCENA'S tomb.

[*O'er Milcena's tomb*. l. 308. In memory of Mrs. French, a lady who to many other elegant accomplishments added a proficiency in botany and natural history.]

"Oft with sweet voice She led her infant-train,
Printing with graceful step his spangled plain,
Explored his twinkling swarms, that swim or fly,
And mark'd his florets with botanic eye.—
"Sweet bud of Spring! how frail thy transient bloom,
"Fine film," she cried, "of Nature's fairest loom!
"Soon Beauty fades upon its damask throne!"—
—Unconscious of the worm, that mined her own!—
—Pale are those lips, where soft caresses hung,
Wan the warm cheek, and mute the tender tongue,
Cold rests that feeling heart on Derwent's shore,
And those love-lighted eye-balls roll no more!

—HERE her sad Consort, stealing through the gloom
Of
Hangs in mute anguish o'er the scutcheon'd hearse,
Or graves with trembling style the votive verse.

"Sexton! oh, lay beneath this sacred shrine,
When Time's cold hand shall close my aching eyes,
Oh, gently lay this wearied earth of mine,
Where wrap'd in night my loved MILCENA lies.

"So shall with purer joy my spirit move,
When the last trumpet thrills the caves of Death,
Catch the first whispers of my waking love,
And drink with holy kiss her kindling breath.

"The spotless Fair, with blush ethereal warm,
Shall hail with sweeter smile returning day,
Rise from her marble bed a brighter form,
And win on buoyant step her airy way.

"Shall bend approved, where beckoning hosts invite,
On clouds of silver her adoring knee,
Approach with Seraphim the throne of light,
—And BEAUTY plead with angel-tongue for Me!"

IX. "YOUR virgin trains on BRINDLEY'S cradle smiled,
And nursed with fairy-love the unletter'd child,
Spread round his pillow all your secret spells,
Pierced all your springs, and open'd all your wells.—
As now on grass, with glossy folds reveal'd,
Glides the bright serpent, now in flowers conceal'd;
Far shine the scales, that gild his sinuous back,
And lucid undulations mark his track;
So with strong arm immortal BRINDLEY leads
His long canals, and parts the velvet meads;
Winding in lucid lines, the watery mass
Mines the firm rock, or loads the deep morass,
With rising locks a thousand hills alarms,
Flings o'er a thousand streams its silver arms,
Feeds the long vale, the nodding woodland laves,
And Plenty, Arts, and Commerce freight the waves.
—NYMPHS! who erewhile round BRINDLEY'S early bier
On show-white bosoms shower'd the incessant tear,
Adorn his tomb!—oh, raise the marble bust,
Proclaim his honours, and protect his dust!
With urns inverted, round the sacred shrine
Their ozier wreaths let weeping Naiads twine;
While on the top MECHANIC GENIUS stands,
Counts the fleet waves, and balances the lands.

[*On Brindley's cradle smiled*. l. 341. The life of Mr. Brindley, whose great abilities in the construction of canal navigation were called forth by the patronage of the Duke of Bridgwater, may be read in Dr. Kippis's Biographia Britannica, the excellence of his genius is visible in every part of this island. He died at Turnhurst in Staffordshire in 1772, and ought to have a monument in the cathedral church at Lichfield.]

X. "NYMPHS! YOU first taught to pierce the secret caves
Of humid earth, and lift her ponderous waves;
Bade with quick stroke the sliding piston bear
The viewless columns of incumbent air;—
Press'd by the incumbent air the floods below,
Through opening valves in foaming torrents flow,
Foot after foot with lessen'd impulse move,
And rising seek the vacancy above.—
So when the Mother, bending o'er his charms,
Clasps her fair nurseling in delighted arms;
Throws the thin kerchief from her neck of snow,
And half unveils the pearly orbs below;
With sparkling eye the blameless Plunderer owns
Her soft embraces, and endearing tones,
Seeks the salubrious fount with opening lips,
Spreads his inquiring hands, and smiles, and sips.

[*Lift her ponderous waves*. l. 366. The invention of the pump is of very antient date, being ascribed to

one Ctesebes an Athenian, whence it was called by the Latins machina Ctesebiana; but it was long before it was known that the ascent of the piston lifted the superincumbent column of the atmosphere, and that then the pressure of the surrounding air on the surface of the well below forced the water up into the vacuum, and that on that account in the common lifting pump the water would rise only about thirty-five feet, as the weight of such a column of water was in general an equipoise to the surrounding atmosphere. The foamy appearance of water, when the pressure of the air over it is diminished, is owing to the expansion and escape of the air previously dissolved by it, or existing in its pores. When a child first sucks it only presses or champs the teat, as observed by the great Harvey, but afterwards it learns to make an incipient vacuum in its mouth, and acts by removing the pressure of the atmosphere from the nipple, like a pump.]

"CONNUBIAL FAIR! whom no fond transport warms
To lull your infant in maternal arms;
Who, bless'd in vain with tumid bosoms, hear
His tender wailings with unfeeling ear;
The soothing kiss and milky rill deny
To the sweet pouting lip, and glistening eye!—
Ah! what avails the cradle's damask roof,
The eider bolster, and embroider'd woof!—
Oft hears the gilded couch unpity'd plains,
And many a tear the tassel'd cushion stains!
No voice so sweet attunes his cares to rest,
So soft no pillow, as his Mother's breast!—
—Thus charm'd to sweet repose, when twilight hours
Shed their soft influence on celestial bowers,
The Cherub, Innocence, with smile divine
Shuts his white wings, and sleeps on Beauty's shrine.

[*Ah! what avails*. l. 387. From an elegant little poem of Mr. Jerningham's intitled Il Latte, exhorting ladies to nurse their own children.]

XI. "From dome to dome when flames infuriate climb,
Sweep the long street, invest the tower sublime;
Gild the tall vanes amid the astonish'd night,
And reddening heaven returns the sanguine light;
While with vast strides and bristling hair aloof
Pale Danger glides along the falling roof;
And Giant Terror howling in amaze
Moves his dark limbs across the lurid blaze.
NYMPHS! you first taught the gelid wave to rise
Hurl'd in resplendent arches to the skies;
In iron cells condensed the airy spring,
And imp'd the torrent with unfailing wing;
—On the fierce flames the shower impetuous falls,
And sudden darkness shrouds the shatter'd walls;
Steam, smoak, and dust in blended volumes roll,
And Night and Silence repossess the Pole.—

[*Hurl'd in resplendent arches*. l. 406. The addition of an air-cell to machines for raising water to extinguish fire was first introduced by Mr. Newsham of London, and is now applied to similar engines for washing wall-trees in gardens, and to all kinds of forcing pumps, and might be applied with advantage to lifting pumps where the water is brought from a great distance horizontally. Another kind of machine was invented by one Greyl, in which a vessel of water was every way dispersed by the explosion of gun-powder lodging in the centre of it, and lighted by an adapted match; from this idea Mr. Godfrey proposed a water-bomb of similar construction. Dr. Hales to prevent the spreading of fire proposed to cover the floors and stairs of the adjoining houses with earth; Mr. Hartley proposed to prevent houses from taking fire by covering the cieling with thin iron-plates, and Lord Mahon by a bed of coarse mortar or plaister between the cieling and floor above it. May not this age of chemical science discover some method of injecting or soaking timber with lime-water and afterwards with vitriolic acid, and thus fill its pores with alabaster? or of penetrating it with siliceous matter, by processes similar to those of Bergman and Achard? See Cronstadt's Mineral. 2d. edit. Vol. I. p. 222.]

"Where were ye, NYMPHS! in those disasterous hours,
Which wrap'd in flames AUGUSTA'S sinking towers?
Why did ye linger in your wells and groves,
When sad WOODMASON mourn'd her infant loves?
When thy fair Daughters with unheeded screams,
Ill-fated MOLESWORTH! call'd the loitering streams?—
The trembling Nymph on bloodless fingers hung
Eyes from the tottering wall the distant throng,
With ceaseless shrieks her sleeping friends alarms,
Drops with singed hair into her lover's arms.—
The illumin'd Mother seeks with footsteps fleet,
Where hangs the safe balcony o'er the street,
Wrap'd in her sheet her youngest hope suspends,
And panting lowers it to her tiptoe friends;
Again she hurries on affection's wings,
And now a third, and now a fourth, she brings;
Safe all her babes, she smooths her horrent brow,
And bursts through bickering flames, unscorch'd, below.
So, by her Son arraign'd, with feet unshod
O'er burning bars indignant Emma trod.

[Footnote: *Woodmason, Molesworth*. l. 416. The histories of these unfortunate families may be seen in the Annual Register, or in the Gentleman's Magazine.]

"E'en on the day when Youth with Beauty wed,
The flames surprized them in their nuptial bed;—
Seen at the opening sash with bosom bare,
With wringing hands, and dark dishevel'd hair,
The blushing Beauty with disorder'd charms
Round her fond lover winds her ivory arms;
Beat, as they clasp, their throbbing hearts with fear,
And many a kiss is mix'd with many a tear;—
Ah me! in vain the labouring engines pour
Round their pale limbs the ineffectual shower!—
—Then crash'd the floor, while shrinking crouds retire,
And Love and Virtue sunk amid the fire!—
With piercing screams afflicted strangers mourn,
And their white ashes mingle in their urn.

XII. "PELLUCID FORMS! whose crystal bosoms show
The shine of welfare, or the shade of woe;
Who with soft lips salute returning Spring,
And hail the Zephyr quivering on his wing;
Or watch, untired, the wintery clouds, and share
With streaming eyes my vegetable care;
Go, shove the dim mist from the mountain's brow,
Chase the white fog, which floods the vale below;
Melt the thick snows, that linger on the lands,
And catch the hailstones in your little hands;
Guard the coy blossom from the pelting shower,
And dash the rimy spangles from the bower;
From each chill leaf the silvery drops repel,
And close the timorous floret's golden bell.

[*Shove the dim mist*. l. 453. See note on l. 20 of this Canto.]

[*Catch the hail-stones*. l. 456. See note on l. 15 of this Canto.]

[*From each chill leaf*. l. 459. The upper side of the leaf is the organ of vegetable respiration, as explained in the additional notes, No. XXXVII, hence the leaf is liable to injury from much moisture on this surface, and is destroyed by being smeared with oil, in these respects resembling the lungs of animals or the spiracula of insects. To prevent these injuries some leaves repel the dew-drops from their upper surfaces as those of cabbages; other vegetables close the upper surfaces of their leaves together in the night or in wet weather, as the sensitive plant; others only hang their leaves downwards

so as to shoot the wet from them, as kidney-beans, and many trees. See note on l. 18 of this Canto.]

[*Golden bell*. l. 460. There are muscles placed about the footstalks of the leaves or leaflets of many plants, for the purpose of closing their upper surfaces together, or of bending them down so as to shoot off the showers or dew-drops, as mentioned in the preceeding note. The claws of the petals or of the divisions of the calyx of many flowers are furnished in a similar manner with muscles, which are exerted to open or close the corol and calyx of the flower as in tragopogon, anemone. This action of opening and closing the leaves or flowers does not appear to be produced simply by *irritation* on the muscles themselves, but by the connection of those muscles with a *sensitive* sensorium or brain existing in each individual bud or flower. 1st. Because many flowers close from the defect of stimulus, not by the excess of it, as by darkness, which is the absence of the stimulus of light; or by cold, which is the absence of the stimulus of heat. Now the defect of heat, or the absence of food, or of drink, affects our *sensations*, which had been previously accustomed to a greater quantity of them; but a muscle cannot be said to be stimulated into action by a defect of stimulus. 2. Because the muscles around the footstalks of the subdivisions of the leaves of the sensitive plant are exerted when any injury is offered to the other extremity of the leaf, and some of the stamens of the flowers of the class Syngenesia contract themselves when others are irritated. See note on Chondrilla, Vol. II. of this work.

From this circumstance the contraction of the muscles of vegetables seems to depend on a disagreeable *sensation* in some distant part, and not on the *irritation* of the muscles themselves. Thus when a particle of dust stimulates the ball of the eye, the eye-lids are instantly closed, and when too much light pains the retina, the muscles of the iris contract its aperture, and this not by any connection or consent of the nerves of those parts, but as an effort to prevent or to remove a disagreeable sensation, which evinces that vegetables are endued with sensation, or that each bud has a common sensorium, and is furnished with a brain or a central place where its nerves were connected.]

"So should young SYMPATHY, in female form,
Climb the tall rock, spectatress of the storm;
Life's sinking wrecks with secret sighs deplore,
And bleed for others' woes, Herself on shore;
To friendless Virtue, gasping on the strand,
Bare her warm heart, her virgin arms expand,
Charm with kind looks, with tender accents cheer,
And pour the sweet consolatory tear;
Grief's cureless wounds with lenient balms asswage,
Or prop with firmer staff the steps of Age;
The lifted arm of mute Despair arrest,
And snatch the dagger pointed to his breast;
Or lull to slumber Envy's haggard mien,
And rob her quiver'd shafts with hand unseen.
—Sound, NYMPHS OF HELICON! the trump of Fame,
And teach Hibernian echoes JONES'S name;
Bind round her polish'd brow the civic bay,
And drag the fair Philanthropist to day.—
So from secluded springs, and secret caves,
Her Liffy pours his bright meandering waves,
Cools the parch'd vale, the sultry mead divides,
And towns and temples star his shadowy sides.

[*Jones's name*. l. 476. A young lady who devotes a great part of an ample fortune to well chosen acts of secret charity.]

XIII. "CALL YOUR light legions, tread the swampy heath,
Pierce with sharp spades the tremulous peat beneath;
With colters bright the rushy sward bisect,
And in new veins the gushing rills direct;—
So flowers shall rise in purple light array'd,
And blossom'd orchards stretch their silver shade;
Admiring glebes their amber ears unfold,
And Labour sleep amid the waving gold.

"Thus when young HERCULES with firm disdain
Braved the soft smiles of Pleasure's harlot train;
To valiant toils his forceful limbs assign'd,

And gave to Virtue all his mighty mind,
Fierce ACHELOUS rush'd from mountain-caves,
O'er sad Etolia pour'd his wasteful waves,
O'er lowing vales and bleating pastures roll'd,
Swept her red vineyards, and her glebes of gold,
Mined all her towns, uptore her rooted woods,
And Famine danced upon the shining floods.
The youthful Hero seized his curled crest,
And dash'd with lifted club the watery Pest;
With waving arm the billowy tumult quell'd,
And to his course the bellowing Fiend repell'd.

[*Fierce Achelous*. l. 495. The river Achelous deluged Etolia, by one of its branches or arms, which in the antient languages are called horns, and produced famine throughout a great tract of country, this was represented in hieroglyphic emblems by the winding course of a serpent and the roaring of a bull with large horns. Hercules, or the emblem of strength, strangled the serpent, and tore off one horn from the bull; that is, he stopped and turned the course of one arm of the river, and restored plenty to the country. Whence the antient emblem of the horn of plenty. Dict. par M. Danet.]

"Then to a Snake the finny Demon turn'd
His lengthen'd form, with scales of silver burn'd;
Lash'd with restless sweep his dragon-train,
And shot meandering o'er the affrighted plain.
The Hero-God, with giant fingers clasp'd
Firm round his neck, the hissing monster grasp'd;
With starting eyes, wide throat, and gaping teeth,
Curl his redundant folds, and writhe in death.

"And now a Bull, amid the flying throng
The grisly Demon foam'd, and roar'd along;
With silver hoofs the flowery meadows spurn'd,
Roll'd his red eye, his threatening antlers turn'd.
Dragg'd down to earth, the Warrior's victor-hands
Press'd his deep dewlap on the imprinted sands;
Then with quick bound his bended knee he fix'd
High on his neck, the branching horns betwixt,
Strain'd his strong arms, his sinewy shoulders bent,
And from his curled brow the twisted terror rent.
—Pleased Fawns and Nymphs with dancing step applaud,
And hang their chaplets round the resting God;
Link their soft hands, and rear with pausing toil
The golden trophy on the furrow'd soil;
Fill with ripe fruits, with wreathed flowers adorn,
And give to PLENTY her prolific horn.

[*Dragg'd down to earth*. l. 517. Described from an antique gem.]

XIV. "On Spring's fair lap, CERULEAN SISTERS! pour
From airy urns the sun-illumined shower,
Feed with the dulcet drops my tender broods,
Mellifluous flowers, and aromatic buds;
Hang from each bending grass and horrent thorn
The tremulous pearl, that glitters to the morn;
Or where cold dews their secret channels lave,
And Earth's dark chambers hide the stagnant wave,
O, pierce, YE NYMPHS! her marble veins, and lead
Her gushing fountains to the thirsty mead;
Wide o'er the shining vales, and trickling hills
Spread the bright treasure in a thousand rills.
So shall my peopled realms of Leaf and Flower
Exult, inebriate with the genial shower;
Dip their long tresses from the mossy brink,
With tufted roots the glassy currents drink;

Shade your cool mansions from meridian beams,
And view their waving honours in your streams.

[*Spread the bright treasure*. l. 540. The practice of flooding lands long in use in China has been but lately introduced into this country. Besides the supplying water to the herbage in dryer seasons, it seems to defend it from frost in the early part of the year, and thus doubly advances the vegetation. The waters which rise from springs passing through marl or limestone are replete with calcareous earth, and when thrown over morasses they deposit this earth and incrust or consolidate the morass. This kind of earth is deposited in great quantity from the springs at Matlock bath, and supplies the soft porous limestone of which the houses and walls are there constructed; and has formed the whole bank for near a mile on that side of the Derwent on which they stand.

The water of many springs contains much azotic gas, or phlogistic air, besides carbonic gas, or fixed air, as that of Buxton and Bath; this being set at liberty may more readily contribute to the production of nitre by means of the putrescent matters which it is exposed to by being spread upon the surface of the land; in the same manner as frequently turning over heaps of manure facilitates the nitrous process by imprisoning atmospheric air in the interstices of the putrescent materials. Water arising by land-floods brings along with it much of the most soluble parts of the manure from the higher lands to the lower ones. River-water in its clear state and those springs which are called soft are less beneficial for the purpose of watering lands, as they contain less earthy or saline matter; and water from dissolving snow from its slow solution brings but little earth along with it, as may be seen by the comparative clearness of the water of snow-floods.]

"Thus where the veins their confluent branches bend,
And milky eddies with the purple blend;
The Chyle's white trunk, diverging from its source,
Seeks through the vital mass its shining course;
O'er each red cell, and tissued membrane spreads
In living net-work all its branching threads;
Maze within maze its tortuous path pursues,
Winds into glands, inextricable clues;
Steals through the stomach's velvet sides, and sips
The silver surges with a thousand lips;
Fills each fine pore, pervades each slender hair,
And drinks salubrious dew-drops from the air.

"Thus when to kneel in Mecca's awful gloom,
Or press with pious kiss Medina's tomb,
League after league, through many a lingering day,
Steer the swart Caravans their sultry way;
O'er sandy wastes on gasping camels toil,
Or print with pilgrim-steps the burning soil;
If from lone rocks a sparkling rill descend,
O'er the green brink the kneeling nations bend,
Bathe the parch'd lip, and cool the feverish tongue,
And the clear lake reflects the mingled throng."

The Goddess paused,—the listening bands awhile
Still seem to hear, and dwell upon her smile;
Then with soft murmur sweep in lucid trains
Down the green slopes, and o'er the pebbly plains,
To each bright stream on silver sandals glide,
Reflective fountain, and tumultuous tide.

So shoot the Spider-broods at breezy dawn
Their glittering net-work o'er the autumnal lawn;
From blade to blade connect with cordage fine
The unbending grass, and live along the line;
Or bathe unwet their oily forms, and dwell
With feet repulsive on the dimpling well.

So when the North congeals his watery mass,
Piles high his snows, and floors his seas with glass;
While many a Month, unknown to warmer rays,
Marks its slow chronicle by lunar days;

Stout youths and ruddy damsels, sportive train,
Leave the white soil, and rush upon the main;
From isle to isle the moon-bright squadrons stray,
And win in easy curves their graceful way;
On step alternate borne, with balance nice
Hang o'er the gliding steel, and hiss along the ice.

Argument of the Fourth Canto.

Address to the Sylphs. I. Trade-winds. Monsoons. N.E. and S.W. winds. Land and sea breezes. Irregular winds. 9. II. Production of vital air from oxygene and light. The marriage of Cupid and Psyche. 25. III. 1. Syroc. Simoom. Tornado. 63. 2. Fog. Contagion. Story of Thyrsis and Aegle. Love and Death. 79. IV. 1. Barometer. Air-pump. 127. 2. Air- balloon of Mongulfier. Death of Rozier. Icarus. 143. V. Discoveries of Dr. Priestley. Evolutions and combinations of pure air. Rape of Proserpine. 165. VI. Sea-balloons, or houses constructed to move under the sea. Death of Mr. Day. Of Mr. Spalding. Of Captain Pierce and his Daughters. 195. VII. Sylphs of music. Cecelia singing. Cupid with a lyre riding upon a lion. 233. VIII. Destruction of Senacherib's army by a pestilential wind. Shadow of Death. 263. IX. 1. Wish to possess the secret of changing the course of the winds. 305. 2. Monster devouring air subdued by Mr. Kirwan. 321. X. 1. Seeds suspended in their pods. Stars discovered by Mr. Herschel. Destruction and resuscitation of all things. 351. 2. Seeds within seeds, and bulbs within bulbs. Picture on the retina of the eye. Concentric strata of the earth. The great seed. 381. 3. The root, pith, lobes, plume, calyx, coral, sap, blood, leaves respire and absorb light. The crocodile in its egg. 409. XI. Opening of the flower. The petals, style, anthers, prolific dust. Transmutation of the silkworm. 441. XII. 1. Leaf-buds changed into flower-buds by wounding the bark, or strangulating a part of the branch. 461. 2. Ingrafting. Aaron's rod pullulates. 477. XIII. 1. Insects on trees. Humming-bird alarmed by the spider-like apearance of Cyprepedia. 491. 2. Diseases of vegetables. Scratch on unnealed glass. 511. XIV. 1. Tender flowers. Amaryllis, fritillary, erythrina, mimosa, cerea. 523. 2. Vines. Oranges. Diana's trees. Kew garden. The royal family. 541. XV. Offering to Hygeia. 587. Departure of the Goddess. 629.

THE ECONOMY OF VEGETATION.

CANTO IV.

As when at noon in Hybla's fragrant bowers
CACALIA opens all her honey'd flowers;
Contending swarms on bending branches cling,
And nations hover on aurelian wing;
So round the GODDESS, ere she speaks, on high
Impatient SYLPHS in gawdy circlets fly;
Quivering in air their painted plumes expand,
And coloured shadows dance upon the land.

[*Cacalia opens*. l. 2. The importance of the nectarium or honey-gland in the vegetable economy is seen from the very complicated apparatus, which nature has formed in some flowers for the preservation of their honey from insects, as in the aconites or monkshoods; in other plants instead of a great apparatus for its protection a greater secretion of it is produced that thence a part may be spared to the depredation of insects. The cacalia suaveolens produces so much honey that on some days it may be smelt at a great distance from the plant. I remember once counting on one of these plants besides bees of various kinds without number, above two hundred painted butterflies, which gave it the beautiful appearance of being covered with additional flowers.]

I. "SYLPHS! YOUR light troops the tropic Winds confine,
And guide their streaming arrows to the Line;
While in warm floods ecliptic breezes rise,
And sink with wings benumb'd in colder skies.
You bid Monsoons on Indian seas reside,

And veer, as moves the sun, their airy tide;
While southern gales o'er western oceans roll,
And Eurus steals his ice-winds from the Pole.
Your playful trains, on sultry islands born,
Turn on fantastic toe at eve and morn;
With soft susurrant voice alternate sweep
Earth's green pavilions and encircling deep.
OR in itinerant cohorts, borne sublime
On tides of ether, float from clime to clime;
O'er waving Autumn bend your airy ring,
Or waft the fragrant bosom of the Spring.

[*The tropic winds*. l. 9. See additional notes, No. XXXIII.]

II. "When Morn, escorted by the dancing Hours,
O'er the bright plains her dewy lustre showers;
Till from her sable chariot Eve serene
Drops the dark curtain o'er the brilliant scene;
You form with chemic hands the airy surge,
Mix with broad vans, with shadowy tridents urge.
SYLPHS! from each sun-bright leaf, that twinkling shakes
O'er Earth's green lap, or shoots amid her lakes,
Your playful bands with simpering lips invite,
And wed the enamour'd OXYGENE to LIGHT.—
Round their white necks with fingers interwove,
Cling the fond Pair with unabating love;
Hand link'd in hand on buoyant step they rise,
And soar and glisten in unclouded skies.
Whence in bright floods the VITAL AIR expands,
And with concentric spheres involves the lands;
Pervades the swarming seas, and heaving earths,
Where teeming Nature broods her myriad births;
Fills the fine lungs of all that *breathe* or *bud*,
Warms the new heart, and dyes the gushing blood;
With Life's first spark inspires the organic frame,
And, as it wastes, renews the subtile flame.

[*The enamour'd oxygene*. l. 34. The common air of the atmosphere appears by the analysis of Dr. Priestley and other philosophers to consist of about three parts of an elastic fluid unfit for respiration or combustion, called azote by the French school, and about one fourth of pure vital air fit for the support of animal life and of combustion, called oxygene. The principal source of the azote is probably from the decomposition of all vegetable and animal matters by putrefaction and combustion; the principal source of vital air or oxygene is perhaps from the decomposition of water in the organs of vegetables by means of the sun's light. The difficulty of injecting vegetable vessels seems to shew that their perspirative pores are much less than those of animals, and that the water which constitutes their perspiration is so divided at the time of its exclusion that by means of the sun's light it becomes decomposed, the inflammable air or hydrogene, which is one of its constituent parts, being retained to form the oil, resin, wax, honey, &c. of the vegetable economy; and the other part, which united with light or heat becomes vital air or oxygene gas, rises into the atmosphere and replenishes it with the food of life.

Dr. Priestley has evinced by very ingenious experiments that the blood gives out phlogiston, and receives vital air, or oxygene-gas by the lungs. And Dr. Crawford has shewn that the blood acquires heat from this vital air in respiration. There is however still a something more subtil than heat, which must be obtained in respiration from the vital air, a something which life can not exist a few minutes without, which seems necessary to the vegetable as well as to the animal world, and which as no organized vessels can confine it, requires perpetually to be renewed. See note on Canto I. l. 401.]

"So pure, so soft, with sweet attraction shone
Fair PSYCHE, kneeling at the ethereal throne;
Won with coy smiles the admiring court of Jove,
And warm'd the bosom of unconquer'd LOVE.—
Beneath a moving shade of fruits and flowers

Onward they march to HYMEN'S sacred bowers;
With lifted torch he lights the festive train,
Sublime, and leads them in his golden chain;
Joins the fond pair, indulgent to their vows,
And hides with mystic veil their blushing brows.
Round their fair forms their mingling arms they fling,
Meet with warm lip, and clasp with rustling wing.—
—Hence plastic Nature, as Oblivion whelms
Her fading forms, repeoples all her realms;
Soft Joys disport on purple plumes unfurl'd,
And Love and Beauty rule the willing world.

[*Fair Psyche*. l. 48. Described from an antient gem on a fine onyx in possession of the Duke of Marlborough, of which there is a beautiful print in Bryant's Mythol. Vol II. p. 392. And from another antient gem of Cupid and Psyche embracing, of which there is a print in Spence's Polymetis. p. 82.]

[*Repeoples all her realms*. l. 60.

Quae mare navigerum et terras frugiferentes
Concelebras; per te quoniam genus omne animantum
Concipitur, visitque exortum lumina folis. Lucret.]

III. 1. "SYLPHS! Your bold myriads on the withering heath
Stay the fell SYROC'S suffocative breath;
Arrest SIMOOM in his realms of sand,
The poisoned javelin balanced in his hand;—
Fierce on blue streams he rides the tainted air,
Points his keen eye, and waves his whistling hair;
While, as he turns, the undulating soil
Rolls in red waves, and billowy deserts boil.

[*Arrest Simoom*. l. 65. "At eleven o'clock while we were with great pleasure contemplating the rugged tops of Chiggre, where we expected to solace ourselves with plenty of good water, Idris cried out with a loud voice, "fall upon your faces, for here is the simoom!" I saw from the S.E. a haze come in colour like the purple part of a rainbow, but not so compressed or thick; it did not occupy twenty yards in breadth, and was about twelve feet high from the ground. It was a kind of a blush upon the air, and it moved very rapidly, for I scarce could turn to fall upon the ground with my head to the northward, when I felt the heat of its current plainly upon my face. We all lay flat upon the ground, as if dead, till Idris told us it was blown over. The meteor, or purple haze, which I saw was indeed passed; but the light air that still blew was of heat to threaten suffocation. For my part I found distinctly in my breast, that I had imbibed a part of it; nor was I free of an asthmatic sensation till I had been some months in Italy." Bruce's Travels. Vol. IV. p. 557.

It is difficult to account for the narrow track of this pestilential wind, which is said not to exceed twenty yards, and for its small elevation of twelve feet. A whirlwind will pass forwards, and throw down an avenue of trees by its quick revolution as it passes, but nothing like a whirling is described as happening in these narrow streams of air, and whirlwinds ascend to greater heights. There seems but one known manner in which this channel of air could be effected, and that is by electricity.

The volcanic origin of these winds is mentioned in the note on Chunda in Vol. II. of this work; it must here be added, that Professor Vairo at Naples found, that during the eruption of Vesuvius perpendicular iron bars were electric; and others have observed suffocating damps to attend these eruptions. Ferber's Travels in Italy, p. 133. And lastly, that a current of air attends the passage of electric matter, as is seen in presenting an electrized point to the flame of a candle. In Mr. Bruce's account of this simoom, it was in its course over a quite dry desert of sand, (and which was in consequence unable to conduct an electric stream into the earth beneath it,) to some moist rocks at but a few miles distance; and thence would appear to be a stream of electricity from a volcano attended with noxious air; and as the bodies of Mr. Bruce and his attendants were insulated on the sand, they would not be sensible of their increased electricity, as it passed over them; to which it may be added, that a sulphurous or suffocating sensation is said to accompany flames of lightning, and even strong sparks of artificial electricity. In the above account of the simoom, a great redness in the air is said to be a certain sign of its approach, which may be occasioned by the eruption of flame from a distant volcano in these extensive and impenetrable deserts of sand. See Note on l. 294 of this Canto.]

You seize TORNADO by his locks of mist,
Burst his dense clouds, his wheeling spires untwist;
Wide o'er the West when borne on headlong gales,
Dark as meridian night, the Monster sails,
Howls high in air, and shakes his curled brow,
Lashing with serpent-train the waves below,
Whirls his black arm, the forked lightning flings,
And showers a deluge from his demon-wings.

[*Tornado's*. l. 71. See additional notes, No. XXXIII.]

2. "SYLPHS! with light shafts YOU pierce the drowsy FOG,
That lingering slumbers on the sedge-wove bog,
With webbed feet o'er midnight meadows creeps,
Or flings his hairy limbs on stagnant deeps.
YOU meet CONTAGION issuing from afar,
And dash the baleful conqueror from his car;
When, Guest of DEATH! from charnel vaults he steals,
And bathes in human gore his armed wheels.

[*On stagnant deeps*. l. 82. All contagious miasmata originate either from animal bodies, as those of the small pox, or from putrid morasses; these latter produce agues in the colder climates, and malignant fevers in the warmer ones. The volcanic vapours which cause epidemic coughs, are to be ranked amongst poisons, rather than amongst the miasmata, which produce contagious diseases.]

"Thus when the PLAGUE, upborne on Belgian air,
Look'd through the mist and shook his clotted hair,
O'er shrinking nations steer'd malignant clouds,
And rain'd destruction on the gasping crouds.
The beauteous AEGLE felt the venom'd dart,
Slow roll'd her eye, and feebly throbb'd her heart;
Each fervid sigh seem'd shorter than the last,
And starting Friendship shunn'd her, as she pass'd.
—With weak unsteady step the fainting Maid
Seeks the cold garden's solitary shade,
Sinks on the pillowy moss her drooping head,
And prints with lifeless limbs her leafy bed.
—On wings of Love her plighted Swain pursues,
Shades her from winds, and shelters her from dews,
Extends on tapering poles the canvas roof,
Spreads o'er the straw-wove matt the flaxen woof,
Sweet buds and blossoms on her bolster strows,
And binds his kerchief round her aching brows;
Sooths with soft kiss, with tender accents charms,
And clasps the bright Infection in his arms.—
With pale and languid smiles the grateful Fair
Applauds his virtues, and rewards his care;
Mourns with wet cheek her fair companions fled
On timorous step, or number'd with the dead;
Calls to its bosom all its scatter'd rays,
And pours on THYRSIS the collected blaze;
Braves the chill night, caressing and caress'd,
And folds her Hero-lover to her breast.—
Less bold, LEANDER at the dusky hour
Eyed, as he swam, the far love-lighted tower;
Breasted with struggling arms the tossing wave,
And sunk benighted in the watery grave.
Less bold, TOBIAS claim'd the nuptial bed,
Where seven fond Lovers by a Fiend had bled;
And drove, instructed by his Angel-Guide,
The enamour'd Demon from the fatal bride.—
—SYLPHS! while your winnowing pinions fan'd the air,
And shed gay visions o'er the sleeping pair;

LOVE round their couch effused his rosy breath,
And with his keener arrows conquer'd DEATH.

[*The beauteous Aegle*. l. 91. When the plague raged in Holland in 1636, a young girl was seized with it, had three carbuncles, and was removed to a garden, where her lover, who was betrothed to her, attended her as a nurse, and slept with her as his wife. He remained uninfected, and she recovered, and was married to him. The story is related by Vinc. Fabricius in the Misc. Cur. Ann. II. Obs. 188.]

IV. 1. "You charm'd, indulgent SYLPHS! their learned toil,
And crown'd with fame your TORRICELL, and BOYLE;
Taught with sweet smiles, responsive to their prayer,
The spring and pressure of the viewless air.
—How up exhausted tubes bright currents flow
Of liquid silver from the lake below,
Weigh the long column of the incumbent skies,
And with the changeful moment fall and rise.
—How, as in brazen pumps the pistons move,
The membrane-valve sustains the weight above;
Stroke follows stroke, the gelid vapour falls,
And misty dew-drops dim the crystal walls;
Rare and more rare expands the fluid thin,
And Silence dwells with Vacancy within.—
So in the mighty Void with grim delight
Primeval Silence reign'd with ancient Night.

[*Torricell and Boyle*. l. 128. The pressure of the atmosphere was discovered by Torricelli, a disciple of Galileo, who had previously found that the air had weight. Dr. Hook and M. Du Hamel ascribe the invention of the air-pump to Mr. Boyle, who however confesses he had some hints concerning its construction from De Guerick. The vacancy at the summit of the barometer is termed the Torricellian vacuum, and the exhausted receiver of an air pump the Boylean vacuum, in honour of these two philosophers.

The mist and descending dew which appear at first exhausting the receiver of an air-pump, are explained in the Phil. Trans. Vol. LXXVIII. from the cold produced by the expansion of air. For a thermometer placed in the receiver sinks some degrees, and in a very little time, as soon as a sufficient quantity of heat can be acquired from the surrounding bodies, the dew becomes again taken up. See additional notes, No. VII. Mr. Saussure observed on placing his hygrometer in a receiver of an air-pump, that though on beginning to exhaust it the air became misty, and parted with its moisture, yet the hair of his hygrometer contracted, and the instrument pointed to greater dryness. This unexpected occurrence is explained by M. Monge (Annales de Chymie, Tom. V.) to depend on the want of the usual pressure of the atmosphere to force the aqueous particles into the pores of the hair; and M. Saussure supposes, that his vesicular vapour requires more time to be redissolved, than is necessary to dry the hair of his thermometer. Essais sur l'Hygrom. p. 226. but I suspect there is a less hypothetical way of understanding it; when a colder body is brought into warm and moist air, (as a bottle of spring-water for instance,) a steam is quickly collected on its surface; the contrary occurs when a warmer body is brought into cold and damp air, it continues free from dew so long as it continues warm; for it warms the atmosphere around it, and renders it capable of receiving instead of parting with moisture. The moment the air becomes rarefied in the receiver of the air-pump it becomes colder, as appears by the thermometer, and deposits its vapour; but the hair of Mr. Saussure's hygrometer is now warmer than the air in which it is immersed, and in consequence becomes dryer than before, by warming the air which immediately surrounds it, a part of its moisture evaporating along with its heat.]

2. "SYLPHS! your soft voices, whispering from the skies,
Bade from low earth the bold MONGULFIER rise;
Outstretch'd his buoyant ball with airy spring,
And bore the Sage on levity of wing;—
Where were ye, SYLPHS! when on the ethereal main
Young ROSIERE launch'd, and call'd your aid in vain?
Fair mounts the light balloon, by Zephyr driven,
Parts the thin clouds, and sails along the heaven;
Higher and yet higher the expanding bubble flies,
Lights with quick flash, and bursts amid the skies.—
Headlong He rushes through the affrighted air

With limbs distorted, and dishevel'd hair,
Whirls round and round, the flying croud alarms,
And DEATH receives him in his sable arms!—
So erst with melting wax and loosen'd strings
Sunk hapless ICARUS on unfaithful wings;
His scatter'd plumage danced upon the wave,
And sorrowing Mermaids deck'd his watery grave;
O'er his pale corse their pearly sea-flowers shed,
And strew'd with crimson moss his marble bed;
Struck in their coral towers the pausing bell,
And wide in ocean toll'd his echoing knell.

[*Young Rosiere launch'd*. l. 148. M. Pilatre du Rosiere with a M. Romain rose in a balloon from Boulogne in June 1785, and after having been about a mile high for about half an hour the balloon took fire, and the two adventurers were dashed to pieces on their fall to the ground. Mr. Rosiere was a philosopher of great talents and activity, joined with such urbanity and elegance of manners, as conciliated the affections of his acquaintance and rendered his misfortune universally lamented. Annual Register for 1784 and 1785, p. 329.]

[*And wide in ocean*. l. 164. Denser bodies propagate vibration or sound better than rarer ones; if two stones be struck together under the water, they may be heard a mile or two by any one whose head is immersed at that distance, according to an experiment of Dr. Franklin. If the ear be applied to one end of a long beam of timber, the stroke of a pin at the other end becomes sensible; if a poker be suspended in the middle of a garter, each end of which is pressed against the ear, the least percussions on the poker give great sounds. And I am informed by laying the ear on the ground the tread of a horse may be discerned at a great distance in the night. The organs of hearing belonging to fish are for this reason much less complicated than of quadrupeds, as the fluid they are immersed in so much better conveys its vibrations. And it is probable that some shell-fish which have twisted shells like the cochlea and semicircular canals of the ears of men and quadrupeds may have no appropriated organ for perceiving the vibrations of the element they live in, but may by their spiral form be in a manner all ear.]

V. "SYLPHS! YOU, retiring to sequester'd bowers,
Where oft your PRIESTLEY woos your airy powers,
On noiseless step or quivering pinion glide,
As sits the Sage with Science by his side;
To his charm'd eye in gay undress appear,
Or pour your secrets on his raptured ear.
How nitrous Gas from iron ingots driven
Drinks with red lips the purest breath of heaven;
How, while Conferva from its tender hair
Gives in bright bubbles empyrean air;
The crystal floods phlogistic ores calcine,
And the pure ETHER marries with the MINE.

[*Where oft your Priestley*. l. 166. The fame of Dr. Priestley is known in every part of the earth where science has penetrated. His various discoveries respecting the analysis of the atmosphere, and the production of variety of new airs or gasses, can only be clearly understood by reading his Experiments on Airs, (3 vols. octavo, Johnson, London.) the following are amongst his many discoveries. 1. The discovery of nitrous and dephlogisticated airs. 2. The exhibition of the acids and alkalies in the form of air. 3. Ascertaining the purity of respirable air by nitrous air. 4. The restoration of vitiated air by vegetation. 5. The influence of light to enable vegetables to yield pure air. 6. The conversion by means of light of animal and vegetable substances, that would otherwise become putrid and offensive, into nourishment of vegetables. 7. The use of respiration by the blood parting with phlogiston, and imbibing dephlogisticated air.

The experiments here alluded to are, 1. Concerning the production of nitrous gas from dissolving iron and many other metals in nitrous acid, which though first discovered by Dr. Hales (Static. Ess. Vol. I. p. 224) was fully investigated, and applied to the important purpose of distinguishing the purity of atmospheric air by Dr. Priestley. When about two measures of common air and one of nitrous gas are mixed together a red effervescence takes place, and the two airs occupy about one fourth less space than was previously occupied by the common air alone.

2. Concerning the green substance which grows at the bottom of reservoirs of water, which Dr. Priestley discovered to yield much pure air when the sun shone on it. His method of collecting this air is

by placing over the green substance, which he believes to be a vegetable of the genus conferva, an inverted bell-glass previously filled with water, which subsides as the air arises; it has since been found that all vegetables give up pure air from their leaves, when the sun shines upon them, but not in the night, which may be owing to the sleep of the plant.

3. The third refers to the great quantity of pure air contained in the calces of metals. The calces were long known to weigh much more than the metallic bodies before calcination, insomuch that 100 pounds of lead will produce 112 pounds of minium; the ore of manganese, which is always found near the surface of the earth, is replete with pure air, which is now used for the purpose of bleaching. Other metals when exposed to the atmosphere attract the pure air from it, and become calces by its combination, as zinc, lead, iron; and increase in weight in proportion to the air, which they imbibe.]

"So in Sicilia's ever-blooming shade
When playful PROSERPINE from CERES stray'd,
Led with unwary step her virgin trains
O'er Etna's steeps, and Enna's golden plains;
Pluck'd with fair hand the silver-blossom'd bower,
And purpled mead,—herself a fairer flower;
Sudden, unseen amid the twilight glade,
Rush'd gloomy DIS, and seized the trembling maid.—
Her starting damsels sprung from mossy seats,
Dropp'd from their gauzy laps the gather'd sweets,
Clung round the struggling Nymph, with piercing cries,
Pursued the chariot, and invoked the skies;—
Pleased as he grasps her in his iron arms,
Frights with soft sighs, with tender words alarms,
The wheels descending roll'd in smoky rings,
Infernal Cupids flapp'd their demon wings;
Earth with deep yawn received the Fair, amaz'd,
And far in Night celestial Beauty blaz'd.

[*When playful Proserpine*. l. 178. The fable of Proserpine's being seized by Pluto as she was gathering flowers, is explained by Lord Bacon to signify the combination or marriage of etherial spirit with earthly materials. Bacon's Works, Vol. V. p. 470. edit. 4to. Lond. 1778. This allusion is still more curiously exact, from the late discovery of pure air being given up from vegetables, and that then in its unmixed state it more readily combines with metallic or inflammable bodies. From these fables which were probably taken from antient hieroglyphics there is frequently reason to believe that the Egyptians possessed much chemical knowledge, which for want of alphabetical writing perished with their philosophers.]

VI. "Led by the Sage, Lo! Britain's sons shall guide
Huge SEA-BALLOONS beneath the tossing tide;
The diving castles, roof'd with spheric glass,
Ribb'd with strong oak, and barr'd with bolts of brass,
Buoy'd with pure air shall endless tracks pursue,
And PRIESTLEY'S hand the vital flood renew.—
Then shall BRITANNIA rule the wealthy realms,
Which Ocean's wide insatiate wave o'erwhelms;
Confine in netted bowers his scaly flocks,
Part his blue plains, and people all his rocks.
Deep, in warm waves beneath the Line that roll,
Beneath the shadowy ice-isles of the Pole,
Onward, through bright meandering vales, afar,
Obedient Sharks shall trail her sceptred car,
With harness'd necks the pearly flood disturb,
Stretch the silk rein, and champ the silver curb;
Pleased round her triumph wondering Tritons play,
And Seamaids hail her on the watery way.
—Oft shall she weep beneath the crystal waves
O'er shipwreck'd lovers weltering in their graves;
Mingling in death the Brave and Good behold
With slaves to glory, and with slaves to gold;
Shrin'd in the deep shall DAY and SPALDING mourn,

Each in his treacherous bell, sepulchral urn!—
Oft o'er thy lovely daughters, hapless PIERCE!
Her sighs shall breathe, her sorrows dew their hearse.—
With brow upturn'd to Heaven, "WE WILL NOT PART!"
He cried, and clasp'd them to his aching heart,—
—Dash'd in dread conflict on the rocky grounds,
Crash the mock'd masts, the staggering wreck rebounds;
Through gaping seams the rushing deluge swims,
Chills their pale bosoms, bathes their shuddering limbs,
Climbs their white shoulders, buoys their streaming hair,
And the last sea-shriek bellows in the air.—
Each with loud sobs her tender sire caress'd,
And gasping strain'd him closer to her breast!—
—Stretch'd on one bier they sleep beneath the brine,
And their white bones with ivory arms intwine!

[*Led by the Sage*. l. 195. Dr. Priestley's discovery of the production of pure air from such variety of substances will probably soon be applied to the improvement of the diving bell, as the substances which contain vital air in immense quantities are of little value as manganese and minium. See additional notes, No. XXXIII. In every hundred weight of minium there is combined about twelve pounds of pure air, now as sixty pounds of water are about a cubic foot, and as air is eight hundred times lighter than water, five hundred weight of minium will produce eight hundred cubic feet of air or about six thousand gallons. Now, as this is at least thrice as pure as atmospheric air, a gallon of it may be supposed to serve for three minutes respiration for one man. At present the air can not be set at liberty from minium by vitriolic acid without the application of some heat, this is however very likely soon to be discovered, and will then enable adventurers to journey beneath the ocean in large inverted ships or diving balloons.

Mr. Boyle relates, that Cornelius Drebelle contrived not only a vessel to be rowed under water, but also a liquor to be caried in that vessel, which would supply the want of fresh air. The vessel was made by order of James I. and carried twelve rowers besides passengers. It was tried in the river Thames, and one of the persons who was in that submarine voyage told the particulars of the experiments to a person who related them to Mr. Boyle. Annual Register for 1774, p. 248.]

[*Day and Spalding mourn*. l. 217. Mr. Day perished in a diving bell, or diving boat, of his own construction at Plymouth in June 1774, in which he was to have continued for a wager twelve hours one hundred feet deep in water, and probably perished from his not possessing all the hydrostatic knowledge that was necessary. See note on Ulva, Vol. II. of this work. See Annual Register for 1774. p. 245.

Mr. Spalding was professionally ingenious in the art of constructing and managing the diving bell, and had practised the business many years with success. He went down accompanied by one of his young men twice to view the wreck of the Imperial East-Indiaman at the Kish bank in Ireland. On descending the third time in June, 1783, they remained about an hour under water, and had two barrels of air sent down to them, but on the signals from below not being again repeated, after a certain time, they were drawn up by their assistants and both found dead in the bell. Annual Register for 1783, p. 206. These two unhappy events may for a time check the ardor of adventurers in traversing the bottom of the ocean, but it is probable in another half century it may be safer to travel under the ocean than over it, since Dr. Priestley's discovery of procuring pure air in such great abundance from the calces of metals.]

[*Hapless Pierce!* l, 219. The Haslewell East-Indiaman, outward bound, was wrecked off Seacomb in the isle of Purbec on the 6th of January, 1786; when Capt. Pierce, the commander, with two young ladies, his daughters, and the greatest part of the crew and passengers perished in the sea. Some of the officers and about seventy seamen escaped with great difficulty on the rocks, but Capt. Pierce finding it was impossible to save the lives of the young ladies refused to quit the ship, and perished with them.]

"VII. SYLPHS OF NICE EAR! with beating wings you guide
The fine vibrations of the aerial tide;
Join in sweet cadences the measured words,
Or stretch and modulate the trembling cords.
You strung to melody the Grecian lyre,
Breathed the rapt song, and fan'd the thought of fire,
Or brought in combinations, deep and clear,
Immortal harmony to HANDEL'S ear.—

YOU with soft breath attune the vernal gale,
When breezy evening broods the listening vale;
Or wake the loud tumultuous sounds, that dwell
In Echo's many-toned diurnal shell.
YOU melt in dulcet chords, when Zephyr rings
The Eolian Harp, and mingle all its strings;
Or trill in air the soft symphonious chime,
When rapt CECILIA lifts her eye sublime,
Swell, as she breathes, her bosoms rising snow,
O'er her white teeth in tuneful accents slow,
Through her fair lips on whispering pinions move,
And form the tender sighs, that kindle love!

"So playful LOVE on Ida's flowery sides
With ribbon-rein the indignant Lion guides;
Pleased on his brinded back the lyre he rings,
And shakes delirious rapture from the strings;
Slow as the pausing Monarch stalks along,
Sheaths his retractile claws, and drinks the song;
Soft Nymphs on timid step the triumph view,
And listening Fawns with beating hoofs pursue;
With pointed ears the alarmed forest starts,
And Love and Music soften savage hearts.

[*Indignant lion guides*. l. 254. Described from an antient gem, expressive of the combined power of love and music, in the Museum Florent.]

VIII. "SYLPHS! YOUR bold hosts, when Heaven with justice dread
Calls the red tempest round the guilty head,
Fierce at his nod assume vindictive forms,
And launch from airy cars the vollied storms.—
From Ashur's vales when proud SENACHERIB trod,
Pour'd his swoln heart, defied the living GOD,
Urged with incessant shouts his glittering powers;
And JUDAH shook through all her massy towers;
Round her sad altars press'd the prostrate crowd,
Hosts beat their breasts, and suppliant chieftains bow'd;
Loud shrieks of matrons thrill'd the troubled air,
And trembling virgins rent their scatter'd hair;
High in the midst the kneeling King adored,
Spread the blaspheming scroll before the Lord,
Raised his pale hands, and breathed his pausing sighs,
And fixed on Heaven his dim imploring eyes,—
"Oh! MIGHTY GOD! amidst thy Seraph-throng
"Who sit'st sublime, the Judge of Right and Wrong;
"Thine the wide earth, bright sun, and starry zone,
"That twinkling journey round thy golden throne;
"Thine is the crystal source of life and light,
"And thine the realms of Death's eternal night.
"Oh, bend thine ear, thy gracious eye incline,
"Lo! Ashur's King blasphemes thy holy shrine,
"Insults our offerings, and derides our vows,—
"Oh! strike the diadem from his impious brows,
"Tear from his murderous hand the bloody rod,
"And teach the trembling nations, "THOU ART GOD!"—
—SYLPHS! in what dread array with pennons broad
Onward ye floated o'er the ethereal road,
Call'd each dank steam the reeking marsh exhales,
Contagious vapours, and volcanic gales,
Gave the soft South with poisonous breath to blow,
And rolled the dreadful whirlwind on the foe!—
Hark! o'er the camp the venom'd tempest sings,
Man falls on Man, on buckler buckler rings;
Groan answers groan, to anguish anguish yields,

And DEATH'S loud accents shake the tented fields!
—High rears the Fiend his grinning jaws, and wide
Spans the pale nations with colossal stride,
Waves his broad falchion with uplifted hand,
And his vast shadow darkens all the land.

[*Volcanic gales*. l. 294. The pestilential winds of the east are described by various authors under various denominations; as harmattan, samiel, samium, syrocca, kamsin, seravansum. M. de Beauchamp describes a remarkable south wind in the deserts about Bagdad, called seravansum, or poison-wind; it burns the face, impedes respiration, strips the trees of their leaves, and is said to pass on in a streight line, and often kills people in six hours. P. Cotte sur la Meteorol. Analytical Review for February, 1790. M. Volney says, the hot wind or ramsin seems to blow at the season when the sands of the deserts are the hottest; the air is then filled with an extreamly subtle dust. Vol. I. p. 61. These winds blow in all directions from the deserts; in Egypt the most violent proceed from the S.S.W. at Mecca from the E. at Surat from the N. at Bassora from the N.W. at Bagdad from the W. and in Syria from the S.E.

On the south of Syria, he adds, where the Jordan flows is a country of volcanos; and it is observed that the earthquakes in Syria happen after their rainy season, which is also conformable to a similar observation made by Dr. Shaw in Barbary. Travels in Egypt, Vol. I. p. 303.

These winds seem all to be of volcanic origin, as before mentioned, with this difference, that the Simoom is attended with a stream of electric matter; they seem to be in consequence of earthquakes caused by the monsoon floods, which fall on volcanic fires in Syria, at the same time that they inundate the Nile.]

IX. 1. "Ethereal cohorts! Essences of Air!
Make the green children of the Spring your care!
Oh, SYLPHS! disclose in this inquiring age
One GOLDEN SECRET to some favour'd sage;
Grant the charm'd talisman, the chain, that binds,
Or guides the changeful pinions of the winds!
—No more shall hoary Boreas, issuing forth
With Eurus, lead the tempests of the North;
Rime the pale Dawn, or veil'd in flaky showers
Chill the sweet bosoms of the smiling Hours.
By whispering Auster waked shall Zephyr rise,
Meet with soft kiss, and mingle in the skies,
Fan the gay floret, bend the yellow ear,
And rock the uncurtain'd cradle of the year;
Autumn and Spring in lively union blend,
And from the skies the Golden Age descend.

[*One golden secret*. l. 308. The suddenness of the change of the wind from N.E. to S.W. seems to shew that it depends on some minute chemical cause; which if it was discovered might probably, like other chemical causes, be governed by human agency; such as blowing up rocks by gunpowder, or extracting the lightening from the clouds. If this could be accomplished, it would be the most happy discovery that ever has happened to these northern latitudes, since in this country the N.E. winds bring frost, and the S.W. ones are attended with warmth and moisture; if the inferior currents of air could be kept perpetually from the S.W. supplied by new productions of air at the line, or by superior currents flowing in a contrary direction, the vegetation of this country would be doubled; as in the moist vallies of Africa, which know no frost; the number of its inhabitants would be increased, and their lives prolonged; as great abundance of the aged and infirm of mankind, as well as many birds and animals, are destroyed by severe continued frosts in this climate.]

2. "Castled on ice, beneath the circling Bear,
A vast CAMELION spits and swallows air;
O'er twelve degrees his ribs gigantic bend,
And many a league his leathern jaws extend;
Half-fish, beneath, his scaly volutes spread,
And vegetable plumage crests his head;
Huge fields of air his wrinkled skin receives,
From panting gills, wide lungs, and waving leaves;
Then with dread throes subsides his bloated form,

His shriek the thunder, and his sigh the storm.
Oft high in heaven the hissing Demon wins
His towering course, upborne on winnowing fins;
Steers with expanded eye and gaping mouth,
His mass enormous to the affrighted South;
Spreads o'er the shuddering Line his shadowy limbs,
And Frost and Famine follow as he swims.—
SYLPHS! round his cloud-built couch your bands array,
And mould the Monster to your gentle sway;
Charm with soft tones, with tender touches check,
Bend to your golden yoke his willing neck,
With silver curb his yielding teeth restrain,
And give to KIRWAN'S hand the silken rein.
—Pleased shall the Sage, the dragon-wings between,
Bend o'er discordant climes his eye serene,
With Lapland breezes cool Arabian vales,
And call to Hindostan antarctic gales,
Adorn with wreathed ears Kampschatca's brows,
And scatter roses on Zealandic snows,
Earth's wondering Zones the genial seasons share,
And nations hail him "MONARCH OF THE AIR."

[*A vast Camelion*. l. 322. See additional notes, No. XXXIII. on the destruction and reproduction of the atmosphere.]

[*To Kirwan's hand*. l. 342. Mr. Kirwan has published a valuable treatise on the temperature of climates, as a step towards investigating the theory of the winds; and has since written some ingenious papers on this subject in the Transactions of the Royal Irish Society.]

X. 1. "SYLPHS! as you hover on ethereal wing,
Brood the green children of parturient Spring!—
Where in their bursting cells my Embryons rest,
I charge you guard the vegetable nest;
Count with nice eye the myriad SEEDS, that swell
Each vaulted womb of husk, or pod, or shell;
Feed with sweet juices, clothe with downy hair,
Or hang, inshrined, their little orbs in air.

[*The myriad seeds*. l. 355. Nature would seem to have been wonderfully prodigal in the seeds of vegetables, and the spawn of fish; almost any one plant, if all its seeds should grow to maturity, would in a few years alone people the terrestrial globe. Mr. Ray asserts that 101 seeds of tobacco weighed only one grain, and that from one tobacco plant the seeds thus calculated amounted to 360,000! The seeds of the ferns are by him supposed to exceed a million on a leaf. As the works of nature are governed by general laws this exuberant reproduction prevents the accidental extinction of the species, at the same time that they serve for food for the higher orders of animation.

Every seed possesses a reservoir of nutriment designed for the growth of the future plant, this consists of starch, mucilage, or oil, within the coat of the seed, or of sugar and subacid pulp in the fruits, which belongs to it.

For the preservation of the immature seed nature has used many ingenious methods; some are wrapped in down, as the seeds of the rose, bean, and cotton-plant; others are suspended in a large air-vessel, as those of the bladder-sena, staphylaea, and pea.]

"So, late descry'd by HERSCHEL'S piercing sight,
Hang the bright squadrons of the twinkling Night;
Ten thousand marshall'd stars, a silver zone,
Effuse their blended lustres round her throne;
Suns call to suns, in lucid clouds conspire,
And light exterior skies with golden fire;
Resistless rolls the illimitable sphere,
And one great circle forms the unmeasured year.
—Roll on, YE STARS! exult in youthful prime,

Mark with bright curves the printless steps of Time;
Near and more near your beamy cars approach,
And lessening orbs on lessening orbs encroach;—
Flowers of the sky! ye too to age must yield,
Frail as your silken sisters of the field!
Star after star from Heaven's high arch shall rush,
Suns sink on suns, and systems systems crush,
Headlong, extinct, to one dark centre fall,
And Death and Night and Chaos mingle all!
—Till o'er the wreck, emerging from the storm,
Immortal NATURE lifts her changeful form,
Mounts from her funeral pyre on wings of flame,
And soars and shines, another and the same.

[*And light exterior*. l. 364. I suspect this line is from Dwight's Conquest of Canaan, a poem written by a very young man, and which contains much fine versification.]

[*Near and more near*. l. 369. From the vacant spaces in some parts of the heavens, and the correspondent clusters of stars in their vicinity, Mr. Herschel concludes that the nebulae or constellations of fixed stars are approaching each other, and must finally coalesce in one mass. Phil. Trans. Vol. LXXV.]

[*Till o'er the wreck*. l. 377. The story of the phenix rising from its own ashes with a twinkling star upon its head, seems to have been an antient hieroglyphic emblem of the destruction and resuscitation of all things.

There is a figure of the great Platonic year with a phenix on his hand on the reverse of a medal of Adrian. Spence's Polym. p. 189.]

2. "Lo! on each SEED within its slender rind
Life's golden threads in endless circles wind;
Maze within maze the lucid webs are roll'd,
And, as they burst, the living flame unfold.
The pulpy acorn, ere it swells, contains
The Oak's vast branches in its milky veins;
Each ravel'd bud, fine film, and fibre-line
Traced with nice pencil on the small design.
The young Narcissus, in it's bulb compress'd,
Cradles a second nestling on its breast;
In whose fine arms a younger embryon lies,
Folds its thin leaves, and shuts its floret-eyes;
Grain within grain successive harvests dwell,
And boundless forests slumber in a shell.
—So yon grey precipice, and ivy'd towers,
Long winding meads, and intermingled bowers,
Green files of poplars, o'er the lake that bow,
And glimmering wheel, which rolls and foams below,
In one bright point with nice distinction lie
Plan'd on the moving tablet of the eye.
—So, fold on fold, Earth's wavy plains extend,
And, sphere in sphere, its hidden strata bend;—
Incumbent Spring her beamy plumes expands
O'er restless oceans, and impatient lands,
With genial lustres warms the mighty ball,
And the GREAT SEED evolves, disclosing ALL;
LIFE *buds* or *breathes* from Indus to the Poles,
And the vast surface kindles, as it rolls!

[*Maze within maze*. l. 383. The elegant appearance on dissection of the young tulip in the bulb was first observed by Mariotte and is mentioned in the note on tulipa in Vol.II, and was afterwards noticed by Du Hamel. Acad. Scien. Lewenhook assures us that in the bud of a currant tree he could not only discover the ligneous part but even the berries themselves, appearing like small grapes. Chamb. Dict. art. Bud. Mr. Baker says he dissected a seed of trembling grass in which a perfect plant appeared with its root, sending forth two branches, from each of which several leaves or blades of grass proceeded.

Microsc. Vol. I. p. 252. Mr. Bonnet saw four generations of successive plants in the bulb of a hyacinth. Bonnet Corps Organ. Vol. I. p. 103. Haller's Physiol. Vol. I. p. 91. In the terminal bud of a horse-chesnut the new flower may be seen by the naked eye covered with a mucilaginous down, and the same in the bulb of a narcissus, as I this morning observed in several of them sent me by Miss —— for that purpose. Sept. 16.

Mr. Ferber speaks of the pleasure he received in observing in the buds of Hepatica and pedicularis hirsuta yet lying hid in the earth, and in the gems of the shrub daphne mezereon, and at the base of osmunda lunaria a perfect plant of the future year, discernable in all its parts a year before it comes forth, and in the seeds of nymphea nelumbo the leaves of the plant were seen so distinctly that the author found out by them what plant the seeds belonged to. The same of the seeds of the tulip tree or liriodendum tulipiferum. Amaen. Aced. Vol. VI.]

[*And the great seed*. l. 406. Alluding to the [Greek: proton oon], or first great egg of the antient philosophy, it had a serpent wrapped round it emblematical of divine wisdom, an image of it was afterwards preserved and worshipped in the temple of Dioscuri, and supposed to represent the egg of Leda. See a print of it in Bryant's Mythology. It was said to have been broken by the horns of the celestial bull, that is, it was hatched by the warmth of the Spring. See note on Canto I. l. 413.]

[*And the vast surface*. l. 408. L'Organization, le sentiment, le movement spontané, la vie, n'existent qu'a la surface de la terre, et dans le lieux exposes á la lumiére. Traité de Chymie par M. Lavoisier, Tom. I. p. 202.]

3. "Come, YE SOFT SYLPHS! who sport on Latian land,
Come, sweet-lip'd Zephyr, and Favonius bland!
Teach the fine SEED, instinct with life, to shoot
On Earth's cold bosom its descending root;
With Pith elastic stretch its rising stem,
Part the twin Lobes, expand the throbbing Gem;
Clasp in your airy arms the aspiring Plume,
Fan with your balmy breath its kindling bloom,
Each widening scale and bursting film unfold,
Swell the green cup, and tint the flower with gold;
While in bright veins the silvery Sap ascends,
And refluent blood in milky eddies bends;
While, spread in air, the leaves respiring play,
Or drink the golden quintessence of day.
—So from his shell on Delta's shower-less isle
Bursts into life the Monster of the Nile;
First in translucent lymph with cobweb-threads
The Brain's fine floating tissue swells, and spreads;
Nerve after nerve the glistening spine descends,
The red Heart dances, the Aorta bends;
Through each new gland the purple current glides,
New veins meandering drink the refluent tides;
Edge over edge expands the hardening scale,
And sheaths his slimy skin in silver mail.
—Erewhile, emerging from the brooding sand,
With Tyger-paw He prints the brineless strand,
High on the flood with speckled bosom swims,
Helm'd with broad tail, and oar'd with giant limbs;
Rolls his fierce eye-balls, clasps his iron claws,
And champs with gnashing teeth his massy jaws;
Old Nilus sighs along his cane-crown'd shores,
And swarthy Memphis trembles and adores.

[*Teach the fine seed*. l. 411. The seeds in their natural state fall on the surface of the earth, and having absorbed some moisture the root shoots itself downwards into the earth and the plume rises in air. Thus each endeavouring to seek its proper pabulum directed by a vegetable irritability similar to that of the lacteal system and to the lungs in animals.

The pith seems to push up or elongate the bud by its elasticity, like the pith in the callow quills of birds. This medulla Linneus believes to consist of a bundle of fibres, which diverging breaks through the bark yet gelatinous producing the buds.

The lobes are reservoirs of prepared nutriment for the young seed, which is absorbed by its placental vessels, and converted into sugar, till it has penetrated with its roots far enough into the earth to extract sufficient moisture, and has acquired leaves to convert it into nourishment. In some plants these lobes rise from the earth and supply the place of leaves, as in kidney-beans, cucumbers, and hence seem to serve both as a placenta to the foetus, and lungs to the young plant. During the process of germination the starch of the seed is converted into sugar, as is seen in the process of malting barley for the purpose of brewing. And is on this account very similar to the digestion of food in the stomachs of animals, which converts all their aliment into a chyle, which consists of mucilage, oil, and sugar; the placentation of buds will be spoken of hereafter.]

[*The silvery sap*. l. 419. See additional notes, No. XXXVI.]

[*Or drink the golden*. l. 422. Linneus having observed the great influence of light on vegetation, imagined that the leaves of plants inhaled electric matter from the light with their upper surface. (System of Vegetables translated, p. 8.)

The effect of light on plants occasions the actions of the vegetable muscles of their leaf-stalks, which turn the upper side of the leaf to the light, and which open their calyxes and chorols, according to the experiments of Abbe Tessier, who exposed variety of plants in a cavern to different quantities of light. Hist. de L'Academie Royal. Ann. 1783. The sleep or vigilance of plants seems owing to the presence or absence of this stimulus. See note on Nimosa, Vol. II.]

XI. "Come, YE SOFT SYLPHS! who fan the Paphian groves,
And bear on sportive wings the callow Loves;
Call with sweet whisper, in each gale that blows,
The slumbering Snow-drop from her long repose;
Charm the pale Primrose from her clay-cold bed,
Unveil the bashful Violet's tremulous head;
While from her bud the playful Tulip breaks,
And young Carnations peep with blushing cheeks;
Bid the closed *Petals* from nocturnal cold
The virgin *Style* in silken curtains fold,
Shake into viewless air the morning dews,
And wave in light their iridescent hues;
While from on high the bursting *Anthers* trust
To the mild breezes their prolific dust;
Or bend in rapture o'er the central Fair,
Love out their hour, and leave their lives in air.
So in his silken sepulchre the Worm,
Warm'd with new life, unfolds his larva-form;
Erewhile aloft in wanton circles moves,
And woos on Hymen-wings his velvet loves.

[*Love out their hour*. l. 456. The vegetable passion of love is agreeably seen in the flower of the parnassia, in which the males alternately approach and recede from the female, and in the flower of nigella, or devil in the bush, in which the tall females bend down to their dwarf husbands. But I was this morning surprised to observe, amongst Sir Brooke Boothby's valuable collection of plants at Ashbourn, the manifest adultery of several females of the plant Collinsonia, who had bent themselves into contact with the males of other flowers of the same plant in their vicinity, neglectful of their own. Sept. 16. See additional notes, No. XXXVIII.]

[*Unfolds his larva-form*. l. 458. The flower bursts forth from its larva, the herb, naked and perfect like a butterfly from its chrysolis; winged with its corol; wing-sheathed by its calyx; consisting alone of the organs of reproduction. The males, or stamens, have their anthers replete with a prolific powder containing the vivifying fovilla: in the females, or pistils, exists the ovary, terminated by the tubular stigma. When the anthers burst and shed their bags of dust, the male fovilla is received by the prolific lymph of the stigma, and produces the seed or egg, which is nourished in the ovary. System of Vegetables translated from Linneus by the Lichfield Society, p. 10.]

XII. 1. "If prouder branches with exuberance rude
Point their green gems, their barren shoots protrude;
Wound them, ye SYLPHS! with little knives, or bind
A wiry ringlet round the swelling rind;
Bisect with chissel fine the root below,

Or bend to earth the inhospitable bough.
So shall each germ with new prolific power
Delay the leaf-bud, and expand the flower;
Closed in the *Style* the tender pith shall end,
The lengthening Wood in circling *Stamens* bend;
The smoother Rind its soft embroidery spread
In vaulted *Petals* o'er their fertile bed;
While the rough Bark, in circling mazes roll'd,
Forms the green *Cup* with many a wrinkled fold;
And each small bud-scale spreads its foliage hard,
Firm round the callow germ, a *Floral Guard*.

[*Wound them, ye Sylphs!* l. 463. Mr. Whitmill advised to bind some of the most vigorous shoots with strong wire, and even some of the large roots; and Mr. Warner cuts, what he calls a wild worm about the body of the tree, or scores the bark quite to the wood like a screw with a sharp knife. Bradley on Gardening, Vol. II. p. 155. Mr. Fitzgerald produced flowers and fruit on wall trees by cutting off a part of the bark. Phil. Trans. Ann. 1761. M. Buffon produced the same effect by a straight bandage put round a branch, Act. Paris, Ann. 1738, and concludes that an ingrafted branch bears better from its vessels being compressed by the callous.

A compleat cylinder of the bark about an inch in height was cut off from the branch of a pear tree against a wall in Mr. Howard's garden at Lichfield about five years ago, the circumcised part is now not above half the diameter of the branch above and below it, yet this branch has been full of fruit every year since, when the other branches of the tree bore only sparingly. I lately observed that the leaves of this wounded branch were smaller and paler, and the fruit less in size, and ripened sooner than on the other parts of the tree. Another branch has the bark taken off not quite all round with much the same effect.

The theory of this curious vegetable fact has been esteemed difficult, but receives great light from the foregoing account of the individuality of buds. A flower-bud dies, when it has perfected its seed, like an annual plant, and hence requires no place on the bark for new roots to pass downwards; but on the contrary leaf-buds, as they advance into shoots, form new buds in the axilla of every leaf, which new buds require new roots to pass down the bark, and thus thicken as well as elongate the branch, now if a wire or string be tied round the bark, many of these new roots cannot descend, and thence more of the buds will be converted into flower-buds.

It is customary to debark oak-trees in the spring, which are intended to be felled in the ensuing autumn; because the bark comes off easier at this season, and the sap-wood, or alburnum, is believed to become harder and more durable, if the tree remains till the end of summer. The trees thus stripped of their bark put forth shoots as usual with acorns on the 6th 7th and 8th joint, like vines; but in the branches I examined, the joints of the debarked trees were much shorter than those of other oak- trees; the acorns were more numerous; and no new buds were produced above the joints which bore acorns. From hence it appears that the branches of debarked oak-trees produce fewer leaf-buds, and more flower- buds, which last circumstance I suppose must depend on their being sooner or later debarked in the vernal months. And, secondly, that the new buds of debarked oak-trees continue to obtain moisture from the alburnum after the season of the ascent of sap in other vegetables ceases; which in this unnatural state of the debarked tree may act as capillary tubes, like the alburnum of the small debarked cylinder of a pear-tree abovementioned; or may continue to act as placental vessels, as happens to the animal embryon in cases of superfetation; when the fetus continues a month or two in the womb beyond its usual time, of which some instances have been recorded, the placenta continues to supply perhaps the double office both of nutrition and of respiration.]

[*And bend to earth*. l. 466. Mr. Hitt in his treatise on fruit trees observes that if a vigorous branch of a wall tree be bent to the horizon, or beneath it, it looses its vigour and becomes a bearing branch. The theory of this I suppose to depend on the difficulty with which the leaf-shoots can protrude the roots necessary for their new progeny of buds upwards along the bended branch to the earth contrary to their natural habits or powers, whence more flower-shoots are produced which do not require new roots to pass along the bark of the bended branch, but which let their offspring, the seeds, fall upon the earth and seek roots for themselves.]

[*With new prolific power*. l. 467. About Midsummer the new buds are formed, but it is believed by some of the Linnean school, that these buds may in their early state be either converted into flower-buds or leaf-buds according to the vigour of the vegetating branch. Thus if the upper part of a branch be cut away, the buds near the extremity of the remaining stem, having a greater proportional supply of nutriment, or possessing a greater facility of shooting their roots, or absorbent vessels, down the

bark, will become leaf-buds, which might otherwise have been flower-buds. And the contrary as explained in note on l. 463. of this Canto.]

[*Closed in the style*. l. 469. "I conceive the medulla of a plant to consist of a bundle of nervous fibres, and that the propelling vital power separates their uppermost extremities. These, diverging, penetrate the bark, which is now gelatinous, and become multiplied in the new gem, or leaf-bud. The ascending vessels of the bark being thus divided by the nervous fibres, which perforate it, and the ascent of its fluids being thus impeded, the bark is extended into a leaf. But the flower is produced, when the protrusion of the medulla is greater than the retention of the including cortical part; whence the substance of the bark is expanded in the calyx; that of the rind, (or interior bark,) in the corol; that of the wood in the stamens, that of the medulla in the pistil. Vegetation thus terminates in the production of new life, the ultimate medullary and cortical fibres being collected in the seeds." Linnei Systema Veget. p. 6. edit. 14.]

2. "Where cruder juices swell the leafy vein,
Stint the young germ, the tender blossom stain;
On each lop'd shoot a softer scion bind,
Pith press'd to pith, and rind applied to rind,
So shall the trunk with loftier crest ascend,
And wide in air its happier arms extend;
Nurse the new buds, admire the leaves unknown,
And blushing bend with fruitage not its own.

[*Nurse the new buds*. l. 483. Mr. Fairchild budded a passion-tree, whose leaves were spotted with yellow, into one which bears long fruit. The buds did not take, nevertheless in a fortnight yellow spots began to shew themselves about three feet above the inoculation, and in a short time afterwards yellow spots appeared on a shoot which came out of the ground from another part of the plant. Bradley, Vol. II. p. 129. These facts are the more curious since from experiments of ingrafting red currants on black (Ib. Vol. II.) the fruit does not acquire any change of flavour, and by many other experiments neither colour nor any other change is produced in the fruit ingrafted on other stocks.

There is an apple described in Bradley's work which is said to have one side of it a sweet fruit which boils soft, and the other side a sour fruit which boils hard, which Mr. Bradley so long ago as the year 1721 ingeniously ascribes to the farina of one of these apples impregnating the other, which would seem the more probable if we consider that each division of an apple is a separate womb, and may therefore have a separate impregnation like puppies of different kinds in one litter. The same is said to have occurred in oranges and lemons, and grapes of different colours.]

"Thus when in holy triumph Aaron trod,
And offer'd on the shrine his mystic rod;
First a new bark its silken tissue weaves,
New buds emerging widen into leaves;
Fair fruits protrude, enascent flowers expand,
And blush and tremble round the living wand.

XIII. 1. "SYLPHS! on each Oak-bud wound the wormy galls,
With pigmy spears, or crush the venom'd balls;
Fright the green Locust from his foamy bed,
Unweave the Caterpillar's gluey thread;
Chase the fierce Earwig, scare the bloated Toad,
Arrest the snail upon his slimy road;
Arm with sharp thorns the Sweet-brier's tender wood,
And dash the Cynips from her damask bud;
Steep in ambrosial dews the Woodbine's bells,
And drive the Night-moth from her honey'd cells.
So where the Humming-bird in Chili's bowers
On murmuring pinions robs the pendent flowers;
Seeks, where fine pores their dulcet balm distill,
And sucks the treasure with proboscis-bill;
Fair CYPREPEDIA with successful guile
Knits her smooth brow, extinguishes her smile;
A Spiders bloated paunch and jointed arms
Hide her fine form, and mask her blushing charms;
In ambush sly the mimic warrior lies,

510 And on quick wing the panting plunderer flies.

[*Fair Cyprepedia*. l. 505. The cyprepedium from South America is supposed to be of larger size and brighter colours than that from North America from which this print is taken; it has a large globular nectary about the size of a pidgeon's egg of a fleshy colour, and an incision or depression on its upper part, much resembling the body of the large American spider; this globular nectary is attached to divergent slender petals not unlike the legs of the same animal. This spider is called by Linneus Arenea avicularia, with a convex orbicular thorax, the center transversely excavated, he adds that it catches small birds as well as insects, and has the venemous bite of a serpent. System Nature, Tom. I. p. 1034. M. Lonvilliers de Poincy, (Histoire Nat. des Antilles, Cap. xiv. art. III.) calls it Phalange, and describes the body to be the size of a pidgeon's egg, with a hollow on its back like a navel, and mentions its catching the humming-bird in its strong nets.

The similitude of this flower to this great spider seems to be a vegetable contrivance to prevent the humming-bird from plundering its honey. About Matlock in Derbyshire the fly-ophris is produced, the nectary of which so much resembles the small wall-bee, perhaps the apis ichneumonea, that it may be easily mistaken for it at a small distance. It is probable that by this means it may often escape being plundered. See note on lonicera in the next poem.

A bird of our own country called a willow-wren (Motacilla) runs up the stem of the crown-imperial (Frittillaria coronalis) and sips the pendulous drops within its petals. This species of Motacilla is called by Ray Regulus non cristatus. White's Hist. of Selborne.]

[Illustration: *Cypripedium. London, Published Dec'r 1st 1791 by J. Johnson, St. Paul's Church Yard.*]

2. "Shield the young Harvest from devouring blight,
The Smut's dark poison, and the Mildew white;
Deep-rooted Mould, and Ergot's horn uncouth,
And break the Canker's desolating tooth.
515 First in one point the festering wound confin'd
Mines unperceived beneath the shrivel'd rin'd;
Then climbs the branches with increasing strength,
Spreads as they spread, and lengthens with their length;
—Thus the slight wound ingraved on glass unneal'd
520 Runs in white lines along the lucid field;
Crack follows crack, to laws elastic just,
And the frail fabric shivers into dust.

[*Shield the young harvest*. l. 511. Linneus enumerates but four diseases of plants; Erysyche, the white mucor or mould, with sessile tawny heads, with which the leaves are sprinkled, as is frequent on the hop, humulus, maple, acer, &c. Rubigo, the ferrugineous powder sprinkled under the leaves frequent in lady's mantle, alchemilla, &c.

Clavus, when the seeds grow out into larger horns black without, as in rye. This is called Ergot by the french writers.

Ustulago, when the fruit instead of seed produces a black powder, as in barley, oats, &c. To which perhaps the honey-dew ought to have been added, and the canker, in the former of which the nourishing fluid of the plant seems to be exsuded by a retrograde motion of the cutaneous lymphatics, as in the sweating sickness of the last century. The latter is a phagedenic ulcer of the bark, very destructive to young apple- trees, and which in cherry-trees is attended with a deposition of gum arabic, which often terminates in the death of the tree.]

[*Ergot's horn*. l. 513. There is a disease frequently affects the rye in France, and sometimes in England in moist seasons, which is called Ergot, or horn seed; the grain becomes considerably elongated and is either straight or crooked, containing black meal along with the white, and appears to be pierced by insects, which were probably the cause of the disease. Mr. Duhamel ascribes it to this cause, and compares it to galls on oak-leaves. By the use of this bad grain amongst the poor diseases have been produced attended with great debility and mortification of the extremities both in France and England. Dict. Raison. art. Siegle. Philosop. Transact.]

[*On glass unneal'd*. l. 519. The glass makers occasionally make what they call *proofs*, which are cooled hastily, whereas the other glass vessels are removed from warmer ovens to cooler ones, and suffered to cool by slow degrees, which is called annealing, or nealing them. If an unnealed glass be

scratched by even a grain of sand falling into it, it will seem to consider of it for some time, or even a day, and will then crack into a thousand pieces.

The same happens to a smooth surfaced lead-ore in Derbyshire, the workmen having cleared a large face of it scratch it with picks, and in a few hours many tons of it crack to pieces and fall, with a kind of explosion. Whitehurst's Theory of Earth.

Glass dropped into cold water, called Prince Rupert's drops, explode when a small part of their tails are broken off, more suddenly indeed, but probably from the same cause. Are the internal particles of these elastic bodies kept so far from each other by the external crust that they are nearly in a state of repulsion into which state they are thrown by their vibrations from any violence applied? Or, like elastic balls in certain proportions suspended in contact with each other, can motion once began be increased by their elasticity, till the whole explodes? And can this power be applied to any mechanical purposes?]

XIV. I. "SYLPHS! if with morn destructive Eurus springs,
O, clasp the Harebel with your velvet wings;
Screen with thick leaves the Jasmine as it blows,
And shake the white rime from the shuddering Rose;
Whilst Amaryllis turns with graceful ease
Her blushing beauties, and eludes the breeze.—
SYLPHS! if at noon the Fritillary droops,
With drops nectareous hang her nodding cups;
Thin clouds of Gossamer in air display,
And hide the vale's chaste Lily from the ray;
Whilst Erythrina o'er her tender flower
Bends all her leaves, and braves the sultry hour;—
Shield, when cold Hesper sheds his dewy light,
Mimosa's soft sensations from the night;
Fold her thin foilage, close her timid flowers,
And with ambrosial slumbers guard her bowers;
O'er each warm wall while Cerea flings her arms,
And wastes on night's dull eye a blaze of charms.

[Illustration: *Erythrina Corallodendron. London Published Dec'r 1st by J. Johnson St. Paul's Church Yard.*]

[*With ambrosial slumbers*. l. 538. Many vegetables during the night do not seem to respire, but to sleep like the dormant animals and insects in winter. This appears from the mimosa and many other plants closing the upper sides of their leaves together in their sleep, and thus precluding that side of them from both light and air. And from many flowers closing up the polished or interior side of their petals, which we have also endeavoured to shew to be a respiratory organ.

The irritability of plants is abundantly evinced by the absorption and pulmonary circulation of their juices; their sensibility is shewn by the approaches of the males to the females, and of the females to the males in numerous instances; and, as the essential circumstance of sleep consists in the temporary abolition of voluntary power alone, the sleep of plants evinces that they possess voluntary power; which also indisputably appears in many of them by closing their petals or their leaves during cold, or rain, or darkness, or from mechanic violence.]

2. Round her tall Elm with dewy fingers twine
The gadding tendrils of the adventurous Vine;
From arm to arm in gay festoons suspend
Her fragrant flowers, her graceful foliage bend;
Swell with sweet juice her vermil orbs, and feed
Shrined in transparent pulp her pearly seed;
Hang round the Orange all her silver bells,
And guard her fragrance with Hesperian spells;
Bud after bud her polish'd leaves unfold,
And load her branches with successive gold.
So the learn'd Alchemist exulting sees
Rise in his bright matrass DIANA'S trees;
Drop after drop, with just delay he pours
The red-fumed acid on Potosi's ores;
With sudden flash the fierce bullitions rise,

And wide in air the gas phlogistic flies;
Slow shoot, at length, in many a brilliant mass
Metallic roots across the netted glass;
Branch after branch extend their silver stems,
Bud into gold, and blossoms into gems.

[*Diana's trees*, l. 552. The chemists and astronomers from the earliest antiquity have used the same characters to represent the metals and the planets, which were most probably outlines or abstracts of the original hieroglyphic figures of Egypt. These afterwards acquired niches in their temples, and represented Gods as well as metals and planets; whence silver is called Diana, or the moon, in the books of alchemy.

The process for making Diana's silver tree is thus described by Lemeri. Dissolve one ounce of pure silver in acid of nitre very pure and moderately strong; mix this solution with about twenty ounces of distilled water; add to this two ounces of mercury, and let it remain at rest. In about four days there will form upon the mercury a tree of silver with branches imitating vegetation.

1. As the mercury has a greater affinity than silver with the nitrous acid, the silver becomes precipitated; and, being deprived of the nitrous oxygene by the mercury, sinks down in its metallic form and lustre. 2. The attraction between silver and mercury, which causes them readily to amalgamate together, occasions the precipitated silver to adhere to the surface of the mercury in preference to any other part of the vessel. 3. The attraction of the particles of the precipitated silver to each other causes the beginning branches to thicken and elongate into trees and shrubs rooted on the mercury. For other circumstances concerning this beautiful experiment see Mr. Keir's Chemical Dictionary, art. Arbor Dianae; a work perhaps of greater utility to mankind than the lost Alexandrian Library; the continuation of which is so eagerly expected by all, who are occupied in the arts, or attached to the sciences.]

So sits enthron'd in vegetable pride
Imperial KEW by Thames's glittering side;
Obedient sails from realms unfurrow'd bring
For her the unnam'd progeny of spring;
Attendant Nymphs her dulcet mandates hear,
And nurse in fostering arms the tender year,
Plant the young bulb, inhume the living seed,
Prop the weak stem, the erring tendril lead;
Or fan in glass-built fanes the stranger flowers
With milder gales, and steep with warmer showers.
Delighted Thames through tropic umbrage glides,
And flowers antarctic, bending o'er his tides;
Drinks the new tints, the sweets unknown inhales,
And calls the sons of science to his vales.
In one bright point admiring Nature eyes
The fruits and foliage of discordant skies,
Twines the gay floret with the fragrant bough,
And bends the wreath round GEORGE'S royal brow.
—Sometimes retiring, from the public weal
One tranquil hour the ROYAL PARTNERS steal;
Through glades exotic pass with step sublime,
Or mark the growths of Britain's happier clime;
With beauty blossom'd, and with virtue blaz'd,
Mark the fair Scions, that themselves have rais'd;
Sweet blooms the Rose, the towering Oak expands,
The Grace and Guard of Britain's golden lands.

XV. SYLPHS! who, round earth on purple pinions borne,
Attend the radiant chariot of the morn;
Lead the gay hours along the ethereal hight,
And on each dun meridian shower the light;
SYLPHS! who from realms of equatorial day
To climes, that shudder in the polar ray,
From zone to zone pursue on shifting wing,
The bright perennial journey of the spring;
Bring my rich Balms from Mecca's hallow'd glades,
Sweet flowers, that glitter in Arabia's shades;

Fruits, whose fair forms in bright succession glow
Gilding the Banks of Arno, or of Po;
Each leaf, whose fragrant steam with ruby lip
Gay China's nymphs from pictur'd vases sip;
Each spicy rind, which sultry India boasts,
Scenting the night-air round her breezy coasts;
Roots whose bold stems in bleak Siberia blow,
And gem with many a tint the eternal snow;
Barks, whose broad umbrage high in ether waves
O'er Ande's steeps, and hides his golden caves;
—And, where yon oak extends his dusky shoots
Wide o'er the rill, that bubbles from his roots;
Beneath whose arms, protected from the storm
A turf-built altar rears it's rustic form;
SYLPHS! with religious hands fresh garlands twine,
And deck with lavish pomp HYGEIA'S shrine.

"Call with loud voice the Sisterhood, that dwell
On floating cloud, wide wave, or bubbling well;
Stamp with charm'd foot, convoke the alarmed Gnomes
From golden beds, and adamantine domes;
Each from her sphere with beckoning arm invite,
Curl'd with red flame, the Vestal Forms of light.
Close all your spotted wings, in lucid ranks
Press with your bending knees the crowded banks,
Cross your meek arms, incline your wreathed brows,
And win the Goddess with unwearied vows.

"Oh, wave, HYGEIA! o'er BRITANNIA'S throne
Thy serpent-wand, and mark it for thy own;
Lead round her breezy coasts thy guardian trains,
Her nodding forests, and her waving plains;
Shed o'er her peopled realms thy beamy smile,
And with thy airy temple crown her isle!"

The GODDESS ceased,—and calling from afar
The wandering Zephyrs, joins them to her car;
Mounts with light bound, and graceful, as she bends,
Whirls the long lash, the flexile rein extends;
On whispering wheels the silver axle slides,
Climbs into air, and cleaves the crystal tides;
Burst from its pearly chains, her amber hair
Streams o'er her ivory shoulders, buoy'd in air;
Swells her white veil, with ruby clasp confined
Round her fair brow, and undulates behind;
The lessening coursers rise in spiral rings,
Pierce the slow-sailing clouds, and stretch their shadowy wings.

CONTENTS

OF

THE NOTES.

CANTO I.

Gradual progress of the formation of the earth, and of plants and animals. Monstrous births 101

Fixed stars approach towards each other, they were projected from chaos by explosion, and the planets projected from them 105

An atmosphere of inflammable air above the common atmosphere principally about the poles 123

Twilight fifty miles high. Wants further observations 126

Immediate cause of volcanos from steam and other vapours. They prevent greater earthquakes 152

Conductors of heat. Cold on the tops of mountains 176

Phosphorescent light in the evening from all bodies 177

Phosphoric light from calcined shells. Bolognian stone. Experiments of Beccari and Wilson 182

Ignis fatuus doubtful 189

Electric Eel. Its electric organs. Compared to the electric Leyden phial 202

Discovery of fire. Tools of steel. Forests subdued. Quantity of food increased by cookery 212

Medusa originally an hieroglyphic of divine wisdom 218

Cause of explosions from combined heat. Heat given out from air in respiration. Oxygene looses less heat when converted into nitrous acid than in any other of its combinations 226

Sparks from the collision of flints are electric. From the collision of flint and steel are from the combustion of the steel 229

Gunpowder described by Bacon. Its power. Should be lighted in the centre. A new kind of it. Levels the weak and strong 242

Steam-engine invented by Savery. Improved by Newcomen. Perfected by Watt and Boulton 254

Divine benevolence. The parts of nature not of equal excellence 278

Mr. Boulton's steam-engine for the purpose of coining would save many lives from the executioner 281

Labours of Hercules of great antiquity. Pillars of Hercules. Surface of the Mediteranean lower than the Atlantic. Abyla and Calpe. Flood of Deucalion 297

Accumulation of electricity not from friction 335

Mr. Bennet's sensible electrometer 345

Halo of saints is pictorial language 358

We have a sense adapted to perceive heat but not electricity 365

Paralytic limbs move by electric influence 367

Death of Professor Richman by electricity 373

Lightning drawn from the clouds. How to be safe in thunder storms 383

Animal heat from air in respiration. Perpetual necessity of respiration. Spirit of animation perpetually renewed 401

Cupid rises from the egg of night. Mrs. Cosway's painting of this subject 413

Western-winds. Their origin. Warmer than south-winds. Produce a thaw 430

Water expands in freezing. Destroys succulent plants, not resinous ones. Trees in valleys more liable to injury. Fig-trees bent to the ground in winter 439

Buds and bulbs are the winter cradle of the plant. Defended from frost and from insects. Tulip produces one flower-bulb and several leaf-bulbs, and perishes. 460

Matter of heat is different from light. Vegetables blanched by exclusion of light. Turn the upper

surface of their leaves to the light. Water decomposed as it escapes from their pores. Hence vegetables purify air in the day time only. 462

Electricity forwards the growth of plants. Silk-worms electrised spin sooner. Water decomposed in vegetables, and by electricity 463

Sympathetic inks which appear by heat, and disappear in the cold. Made from cobalt 487

Star in Cassiope's chair 515

Ice-islands 100 fathoms deep. Sea-ice more difficult of solution. Ice evaporates producing great cold. Ice-islands increase. Should be navigated into southern climates. Some ice-islands have floated southwards 60 miles long. Steam attending them in warm climates 529

Monsoon cools the sands of Abyssinia 547

Ascending vapours are electrised plus, as appears from an experiment of Mr. Bennet. Electricity supports vapour in clouds. Thunder showers from combination of inflammable and vital airs 553

CANTO II.

Solar volcanos analogous to terrestrial and lunar ones. Spots of the sun are excavations 14

Spherical form of the earth. Ocean from condensed vapour. Character of
Mr. Whitehurst 17

Granite the oldest part of the earth. Then limestone. And lastly, clay, iron, coal, sandstone. Three great concentric divisions of the globe 35

Formation of primeval islands before the production of the moon. Paradise. The Golden Age. Rainbow. Water of the sea originally fresh 36

Venus rising from the sea an hieroglyphic emblem of the production of the earth beneath the ocean 47

First great volcanos in the central parts of the earth. From steam, inflammable gas, and vital air. Present volcanos like mole-hills 68

Moon has little or no atmosphere. Its ocean is frozen. Is not yet inhabited, but may be in time 82

Earth's axis changed by the ascent of the moon. Its diurnal motion retarded. One great tide 84

Limestone produced from shells. Spars with double refractions. Marble.
Chalk 93

Antient statues of Hercules. Antinous. Apollo. Venus. Designs of
Roubiliac. Monument of General Wade. Statues of Mrs. Damer 101

Morasses rest on limestone. Of immense extent 116

Salts from animal and vegetable bodies decompose each other, except marine salt. Salt mines in Poland. Timber does not decay in them. Rock- salt produced by evaporation from sea-water. Fossil shells in salt mines. Salt in hollow pyramids. In cubes. Sea-water contains about one- thirtieth of salt 119

Nitre, native in Bengal and Italy. Nitrous gas combined with vital air produces red clouds, and the two airs occupy less space than one of them before, and give out heat. Oxygene and azote produce nitrous acid 143

Iron from decomposed vegetables. Chalybeat springs. Fern-leaves in nodules of iron. Concentric spheres of iron nodules owing to polarity, like iron-filings arranged by a magnet. Great strata of the earth owing to their polarity 183

Hardness of steel for tools. Gave superiority to the European nations.
Welding of steel. Its magnetism. Uses of gold 192

Artificial magnets improved by Savery and Dr. Knight, perfected by Mr. Michel. How produced. Polarity owing to the earth's rotatory motion. The electric fluid, and the matter of heat, and magnetism gravitate on each other. Magnetism being the lightest is found nearest the axis of the motion. Electricity produces northern lights by its centrifugal motion 193

Acids from vegetable recrements. Flint has its acid from the new world. Its base in part from the old world, and in part from the new. Precious stones 215

Diamond. Its great refraction of light. Its volatibility by heat. If an inflammable body. 228

Fires of the new world from fermentation. Whence sulphur and bitumen by sublimation, the clay, coal, and flint remaining 275

Colours not distinguishable in the enamel-kiln, till a bit of dry wood is introduced 283

Etrurian pottery prior to the foundations of Rome. Excelled in fine forms, and in a non-vitreous encaustic painting, which was lost till restored by Mr. Wedgwood. Still influences the taste of the inhabitants 291

Mr. Wedgwood's cameo of a slave in chains, and of Hope 315

Basso-relievos of two or more colours not made by the antients. Invented by Mr. Wedgwood 342

Petroleum and naptha have been sublimed. Whence jet and amber. They absorb air. Attract straws when rubbed. Electricity from electron the greek name for amber 353

Clefts in granite rocks in which metals are found. Iron and manganese found in all vegetables. Manganese in limestone. Warm springs from steam rising up the clefts of granite and limestone. Ponderous earth in limestone clefts and in granite. Copper, lead, iron, from descending materials. High mountains of granite contain no ores near their summits. Transmutation of metals. Of lead into calamy. Into silver 398

Armies of Cambytes destroyed by famine, and by sand-storms 435

Whirling turrets of sand described and explained 478

Granite shews iron as it decomposes. Marble decomposes. Immense quantity of charcoal exists in limestone. Volcanic slags decompose, and become clay 523

Millstones raised by wooden pegs 524

Hannibal made a passage by fire over the Alps 534

Passed tense of many words twofold, as driven or drove, spoken or spoke.
A poetic licence 609

CANTO III.

Clouds consist of aqueous spheres, which do not easily unite, like globules of quicksilver, as may be seen in riding through water. Owing to electricity. Snow. Hailstones rounded by attrition and dissolution of their angles. Not from frozen drops of water 15

Dew on points and edges of grass, or hangs over cabbage-leaves, needle floats on water 18

Mists over rivers and on mountains. Halo round the moon. Shadow of a church-steeple upon a mist. Dry mist, or want of transparency of the air, a sign of fair-weather 20

Tides on both sides of the earth. Moon's tides should be much greater than the earth's tides. The ocean of the moon is frozen 61

Spiral form of shells saves calcareous matter. Serves them as an organ of hearing. Calcareous matter produced from inflamed membranes. Colours of shells, labradore-stone from mother-pearl. Fossil shells not now found recent 66

Sea-insects like flowers. Actinia 82

Production of pearls, not a disease of the fish. Crab's eyes. Reservoirs of pearly matter 84

Rocks of coral in the south-sea. Coralloid limestone at Linsel, and Coalbrook Dale 90

Rocks thrown from mountains, ice from glaciers, and portions of earth, or morasses, removed by columns of water. Earth-motion in Shropshire. Water of wells rising above the level of the ground. St. Alkmond's well near Derby might be raised many yards, so as to serve the town. Well at Sheerness, and at Hartford in Connecticut 116

Moonsoons attended with rain Overflowing of the Nile. Vortex of ascending air. Rising of the Dogstar announces the floods of the Nile. Anubis hung out upon their temples 129

Situations exempt from rain. At the Line in Lower Egypt. On the coast of Peru 138

Giesar, a boiling fountain in Iceland. Water with great degrees of heat dissolves siliceous matter. Earthquake from steam 150

Warm springs not from decomposed pyrites. From steam rising up fissures from great depths 166

Buxton bath possesses 82 degrees of heat. Is improperly called a warm bath. A chill at immersion, and then a sensation of warmth, like the eye in an obscure room owing to increased sensibility of the skin 184

Water compounded of pure air and inflammable air with as much matter of heat as preserves it fluid. Perpetually decomposed by vegetables in the sun's light, and recomposed in the atmosphere 204

Mythological interpretation of Jupiter and Juno designed as an emblem of the composition of water from two airs 260

Death of Mrs. French 308

Tomb of Mr. Brindley 341

Invention of the pump. The piston lifts the atmosphere above it. The surrounding atmosphere presses up the water into the vacuum. Manner in which a child sucks 366

Air-cell in engines for extinguishing fire. Water dispersed by the explosion of Gunpowder. Houses preserved from fire by earth on the floors, by a second ceiling of iron-plates or coarse mortar. Wood impregnated with alabaster or flint 406

Muscular actions and sensations of plants 460

River Achelous. Horn of Plenty 495

Flooding lands defends them from vernal frosts. Some springs deposit calcareous earth. Some contain azotic gas, which contributes to produce nitre. Snow water less serviceable 540

CANTO IV.

Cacalia produces much honey, that a part may be taken by insects without injury 2

Analysis of common air. Source of azote. Of Oxygene. Water decomposed by vegetable pores and the sun's light. Blood gives out phlogiston and receives vital air. Acquires heat and the vivifying principle 34

Cupid and Psyche 48

Simoom, a pestilential wind. Described. Owing to volcanic electricity. Not a whirlwind 65

Contagion either animal or vegetable 82

Thyrsis escapes the Plague 91

Barometer and air-pump, Dew on exhausting the receiver though the hygrometer points to dryness. Rare air will dissolve or acquire more heat, and more moisture, and more electricity 128

Sound propagated best by dense bodies, as wood, and water, and earth.
Fish in spiral shells all ear 164

Discoveries of Dr. Priestley. Green vegetable matter. Pure air contained in the calces of metals, as minium, manganese, calamy, ochre 166

Fable of Proserpine an antient chemical emblem 178

Diving balloons supplied with pure air from minium. Account of one by
Mr. Boyle 195

Mr. Day. Mr. Spalding 217

Captain Pierce and his daughters 219

Pestilential winds of volcanic origin. Jordan flows through a country of volcanos 294

Change of wind owing to small causes. If the wind could be governed, the products of the earth would be doubled, and its number of inhabitants increased 308

Mr. Kirwan's treatise on temperature of climates 342

Seeds of plants. Spawn of fish. Nutriment lodged in seeds. Their preservation in their seed-vessels 355

Fixed stars approach each other 369

Fable of the Phoenix 377

Plants visible within bulbs, and buds, and seeds 383

Great Egg of Night 406

Seeds shoot into the ground. Pith. Seed-lobes. Starch converted into sugar. Like animal chyle 411

Light occasions the actions of vegetable muscles. Keeps them awake 422

Vegetable love in Parnassia, Nigella. Vegetable adultery in Collinsonia 456

Strong vegetable shoots and roots bound with wire, in part debarked, whence leaf-buds converted into flower-buds. Theory of this curious fact 463

Branches bent to the horizon bear more fruit 466

Engrafting of a spotted passion-flower produced spots upon the stock.
Apple soft on one side and hard on the other 483

Cyprepedium assumes the form of a large spider to affright the humming- bird. Fly-ophris. Willow-wren sucks the honey of the crown-imperial 505

Diseases of plants four kinds. Honey-dew 511

Ergot a disease of rye 513

Glass unannealed. Its cracks owing to elasticity. One kind of lead-ore cracks into pieces. Prince Rupert's drops. Elastic balls 519

Sleep of plants. Their irritability, sensibility, and voluntary motions 538

ADDITIONAL NOTES.

NOTE I.—METEORS.

Etherial Forms! you chase the shooting stars, Or yoke the vollied lightnings to your cars.

CANTO I. l. 115.

There seem to be three concentric strata of our incumbent atmosphere; in which, or between them, are produced four kinds of meteors; lightning, shooting stars, fire-balls, and northern lights. First, the lower region of air, or that which is dense enough to resist by the adhesion of its particles the descent of condensed vapour, or clouds, which may extend from one to three or four miles high. In this region the common lightning is produced from the accumulation or defect of electric matter in those floating fields of vapour either in respect to each other, or in respect to the earth beneath them, or the dissolved vapour above them, which is constantly varying both with the change of the form of the clouds, which thus evolve a greater or less surface; and also with their ever-changing degree of condensation. As the lightning is thus produced in dense air, it proceeds but a short course on account of the greater resistance which it encounters, is attended with a loud explosion, and appears with a red light.

2. The second region of the atmosphere I suppose to be that which has too little tenacity to support condensed vapour or clouds; but which yet contains invisible vapour, or water in aerial solution. This aerial solution of water differs from that dissolved in the matter of heat, as it is supported by its adhesion to the particles of air, and is not precipitated by cold. In this stratum it seems probable that the meteors called shooting stars are produced; and that they consist of electric sparks, or lightning, passing from one region to another of these invisible fields of aero-aqueous solution. The height of these shooting stars has not yet been ascertained by sufficient observation; Dr. Blagden thinks their situation is lower down in the atmosphere than that of fireballs, which he conjectures from their swift apparent motion, and ascribes their smallness to the more minute division of the electric matter of which they are supposed to consist, owing to the greater resistance of the denser medium through which they pass, than that in which the fire-balls exist. Mr. Brydone observed that the shooting stars appeared to him to be as high in the atmosphere, when he was near the summit of mount Etna, as they do when observed from the plain. Phil. Tran. Vol. LXIII.

As the stratum of air, in which shooting stars are supposed to exist is much rarer than that in which lightning resides, and yet much denser than that in which fire-balls are produced, they will be attracted at a greater distance than the former, and at a less than the latter. From this rarity of the air so small a sound will be produced by their explosion, as not to reach the lower parts of the atmosphere; their quantity of light from their greater distance being small, is never seen through dense air at all, and thence does not appear red, like lightning or fire balls. There are no apparent clouds to emit or to attract them, because the constituent parts of these aero-aqueous regions may possess an abundance or deficiency of electric matter and yet be in perfect reciprocal solution. And lastly their apparent train of light is probably owing only to a continuance of their impression on the eye; as when a fire-stick is whirled in the dark it gives the appearance of a compleat circle of fire: for these white trains of shooting stars quickly vanish, and do not seem to set any thing on fire in their passage, as seems to happen in the transit of fire-balls.

3. The second region or stratum of air terminates I suppose where the twilight ceases to be refracted, that is, where the air is 3000 times rarer than at the surface of the earth; and where it seems probable that the common air ends, and is surrounded by an atmosphere of inflammable gas tenfold rarer than itself. In this region I believe fire-balls sometimes to pass, and at other times the northern lights to exist. One of these fire-balls or draco volans, was observed by Dr. Pringle and many others on Nov. 26, 1758, which was afterwards estimated to have been a mile and a half in circumference, to have been about one hundred miles high, and to have moved towards the north with a velocity of near thirty miles in a second of time. This meteor had a real tail many miles long, which threw off sparks in its course, and the whole exploded with a sound like distant thunder. Philos. Trans. Vol. LI.

Dr. Blagden has related the history of another large meteor, or fire- ball, which was seen the 18th of August, 1783, with many ingenious observations and conjectures. This was estimated to be between 60 and 70 miles high, and to travel 1000 miles at the rate of about twenty miles in a second. This fire-ball had likewise a real train of light left behind it in its passage, which varied in colour; and in some part of its course gave off sparks or explosions where it had been brightest; and a dusky red streak remained visible perhaps a minute. Philos. Trans. Vol. LXXIV.

These fire-balls differ from lightning, and from shooting stars in many remarkable circumstances; as their very great bulk, being a mile and a half in diameter; their travelling 1000 miles nearly horizontally; their throwing off sparks in their passage; and changing colours from bright blue to dusky red; and leaving a train of fire behind them, continuing about a minute. They differ from the northern lights in not being diffused, but passing from one point of the heavens to another in a defined line; and this in a region above the crepuscular atmosphere, where the air is 3000 tines rarer than at the surface

of the earth. There has not yet been even a conjecture which can account for these appearances!—One I shall therefore hazard; which, if it does not inform, may amuse the reader.

In the note on l. 123, it was shewn that there is probably a supernatant stratum of inflammable gas or hydrogene, over the common atmosphere; and whose density at the surface where they meet, must be at least ten times less than that upon which it swims; like chemical ether floating upon water, and perhaps without any real contact. 1. In this region, where the aerial atmosphere terminates and the inflammable one begins, the quantity of tenacity or resistance must be almost inconceivable; in which a ball of electricity might pass 1000 miles with greater ease than through a thousandth part of an inch of glass. 2. Such a ball of electricity passing between inflammable and common air would set fire to them in a line as it patted along; which would differ in colour according to the greater proportionate commixture of the two airs; and from the same cause there might occur greater degrees of inflammation, or branches of fire, in some parts of its course.

As these fire-balls travel in a defined line, it is pretty evident from the known laws of electricity, that they must be attracted; and as they are a mile or more in diameter, they must be emitted from a large surface of electric matter; because large nobs give larger sparks, less diffused, and more brightly luminous, than less ones or points, and resist more forceably the emission of the electric matter. What is there in nature can attract them at so great a distance as 1000 miles, and so forceably as to detach an electric spark of a mile diameter? Can volcanos at the time of their eruptions have this effect, as they are generally attended with lightning? Future observations must discover these secret operations of nature! As a stream of common air is carried along with the passage of electric aura from one body to another; it is easy to conceive, that the common air and the inflammable air between which the fire-ball is supposed to pass, will be partially intermixed by being thus agitated, and so far as it becomes intermixed it will take fire, and produce the linear flame and branching sparks above described. In this circumstance of their being attracted, and thence passing in a defined line, the fire-balls seem to differ from the coruscations of the aurora borealis, or northern lights, which probably take place in the same region of the atmosphere; where the common air exists in extreme tenuity, and is covered by a still rarer sphere of inflammable gas, ten times lighter than itself.

As the electric streams, which constitute these northern lights, seem to be repelled or radiated from an accumulation of that fluid in the north, and not attracted like the fireballs; this accounts for the diffusion of their light, as well as the silence of their passage; while their variety of colours, and the permanency of them, and even the breadth of them in different places, may depend on their setting on fire the mixture of inflammable and common air through which they pass; as seems to happen in the transit of the fire-balls.

It was observed by Dr. Priestley that the electric shock taken through inflammable air was red, in common air it is blueish; to these circumstances perhaps some of the colours of the northern lights may bear analogy; though the density of the medium through which light is seen must principally vary its colour, as is well explained by Mr. Morgan. Phil. Trans. Vol. LXXV. Hence lightning is red when seen through a dark cloud, or near the horizon; because the more refrangible rays cannot permeate so dense a medium. But the shooting stars consist of white light, as they are generally seen on clear nights, and nearly vertical: in other situations their light is probably too faint to come to us. But as in some remarkable appearances of the northern lights, as in March, 1716, all the prismatic colours were seen quickly to succeed each other, these appear to have been owing to real combustion; as the density of the interposed medium could not be supposed to change so frequently; and therefore these colours must have been owing to different degrees of heat according to Mr. Morgan's theory of combustion. In Smith's Optics, p. 69. the prismatic colours, and optical deceptions of the northern lights are described by Mr. Cotes.

The Torricellian vacuum, if perfectly free from air, is said by Mr. Morgan and others to be a perfect non-conductor. This circumstance therefore would preclude the electric streams from rising above the atmosphere. But as Mr. Morgan did not try to pass an electric shock through a vacuum, and as air, or something containing air, surrounding the transit of electricity may be necessary to the production of light, the conclusion may perhaps still be dubious. If however the streams of the northern lights were supposed to rise above our atmosphere, they would only be visible at each extremity of their course; where they emerge from, or are again immerged into the atmosphere; but not in their journey through the vacuum; for the absence of electric light in a vacuum is sufficiently proved by the common experiment of shaking a barometer in the dark; the electricity, produced by the friction of the mercury in the glass at its top, is luminous if the barometer has a little air in it; but there is no light if the vacuum be complete.

The aurora borealis, or northern dawn, is very ingeniously accounted for by Dr. Franklin on principles of electricity. He premises the following electric phenomena: 1. that all new fallen snow has much positive electricity standing on its surface. 2. That about twelve degrees of latitude round the poles are

covered with a crust of eternal ice, which is impervious to the electric fluid. 3. That the dense part of the atmosphere rises but a few miles high; and that in the rarer parts of it the electric fluid will pass to almost any distance.

Hence he supposes there must be a great accumulation of positive electric matter on the fresh fallen snow in the polar regions; which, not being able to pass through the crust of ice into the earth, must rise into the rare air of the upper parts of our atmosphere, which will the least resist its passage; and passing towards the equator descend again into the denser atmosphere, and thence into the earth in silent streams. And that many of the appearances attending these lights are optical deceptions, owing to the situation of the eye that beholds them; which makes all ascending parallel lines appear to converge to a point.

The idea, above explained in note on l. 123, of the existence of a sphere of inflammable gas over the aerial atmosphere would much favour this theory of Dr. Franklin; because in that case the dense aerial atmosphere would rise a much less height in the polar regions, diminishing almost to nothing at the pole itself; and thus give an easier passage to the ascent of the electric fluid. And from the great difference in the specific gravity of the two airs, and the velocity of the earth's rotation, there must be a place between the poles and the equator, where the superior atmosphere of inflammable gas would terminate; which would account for these streams of the aurora borealis not appearing near the equator; add to this that it is probable the electric fluid may be heavier than the magnetic one; and will thence by the rotation of the earth's surface ascend over the magnetic one by its centrifugal force; and may thus be induced to rise through the thin stratum of aerial atmosphere over the poles. See note on Canto II. l. 193. I shall have occasion again to mention this great accumulation of inflammable air over the poles; and to conjecture that these northern lights may be produced by the union of inflammable with common air, without the assistance of the electric spark to throw them into combustion.

The antiquity of the appearance of northern lights has been doubted; as none were recorded in our annals since the remarkable one on Nov. 14, 1574, till another remarkable one on March 6, 1716, and the three following nights, which were seen at the same time in Ireland, Russia, and Poland, extending near 30 degrees of longitude and from about the 50th degree of latitude over almost all the north of Europe. There is however reason to believe them of remote antiquity though inaccurately described; thus the following curious passage from the Book of Maccabees, (B. II. c. v.) is such a description of them, as might probably be given by an ignorant and alarmed people. "Through all the city, for the space of almost forty days, there were seen horsemen running in the air, in cloth of gold, and armed with lances, like a band of soldiers; and troops of horsemen in array encountering and running one against another, with shaking of shields and multitude of pikes, and drawing of swords, and casting of darts, and glittering of golden ornaments and harness."

NOTE II.—PRIMARY COLOURS.

Cling round the aerial bow with prisms bright, And pleased untwist the sevenfold threads of light.

CANTO I. l. 117.

The manner in which the rainbow is produced was in some measure understood before Sir Isaac Newton had discovered his theory of colours. The first person who expressly shewed the rainbow to be formed by the reflection of the sunbeams from drops of falling rain was Antonio de Dominis. This was afterwards more fully and distinctly explained by Des Cartes. But what caused the diversity of its colours was not then understood; it was reserved for the immortal Newton to discover that the rays of light consisted of seven combined colours of different refrangibility, which could be seperated at pleasure by a wedge of glass. Pemberton's View of Newton.

Sir Isaac Newton discovered that the prismatic spectrum was composed of seven colours in the following proportions, violet 80, indigo 40, blue 60, green 60, yellow 48, orange 27, red 45. If all these colours be painted on a circular card in the proportions above mentioned, and the card be rapidly whirled on its center, they produce in the eye the sensation of white. And any one of these colours may be imitated by painting a card with the two colours which are contiguous to it, in the same proportions as in the spectrum, and whirling them in the same manner. My ingenious friend, Mr. Galton of Birmingham, ascertained in this manner by a set of experiments the following propositions; the truth of

which he had preconceived from the above data.

1. Any colour in the prismatic spectrum may be imitated by a mixture of the two colours contiguous to it.

2. If any three successive colours in the prismatic spectrum are mixed, they compose only the second or middlemost colour.

3. If any four succesive colours in the prismatic spectrum be mixed, a tint similar to a mixture of the second and third colours will be produced, but not precisely the same, because they are not in the same proportion.

4. If beginning with any colour in the circular spectrum, you take of the second colour a quantity equal to the first, second, and third; and add to that the fifth colour, equal in quantity to the fourth, fifth, and sixth; and with these combine the seventh colour in the proportion it exists in the spectrum, white will be produced. Because the first, second, and third, compose only the second; and the fourth, fifth, and sixth, compose only the fifth; therefore if the seventh be added, the same effect is produced, as if all the seven were employed.

5. Beginning with any colour in the circular spectrum, if you take a tint composed of a certain proportion of the second and third, (equal in quantity to the first, second, third, and fourth,) and add to this the sixth colour equal in quantity to the fifth, sixth, and seventh, white will be produced.

From these curious experiments of Mr. Galton many phenomena in the chemical changes of colours may probably become better understood; especially if, as I suppose, the same theory must apply to transmitted colours, as to reflected ones. Thus it is well known, that if the glass of mangonese, which is a tint probably composed of violet and indigo, be mixed in a certain proportion with the glass of lead, which is yellow; that the mixture becomes transparent. Now from Mr. Galton's experiments it appears, that in reflected colours such a mixture would produce white, that is, the same as if all the colours were reflected. And therefore in transmitted colours the same circumstances must produce transparency, that is, the same as if all the colours were transmitted. For the particles, which constitute the glass of mangonese will transmit red, violet, indigo, and blue; and those of the glass of lead will transmit orange, yellow, and green; hence all the primary colours by a mixture of these glasses become transmitted, that is, the glass becomes transparent.

Mr. Galton has further observed that five successive prismatic colours may be combined in such proportions as to produce but one colour, a circumstance which might be of consequence in the art of painting. For if you begin at any part of the circular spectrum above described, and take the first, second, and third colours in the proportions in which they exist in the spectrum; these will compose only the second colour equal in quantity to the first, second, and third; add to these the third, fourth, and fifth in the proportion they exist in the spectrum, and these will produce the fourth colour equal in quantity to the third, fourth, and fifth. Consequently this is precisely the same thing, as mixing the second and fourth colours only; which mixture would only produce the third colour. Therefore if you combine the first, second, fourth, and fifth in the proportions in which they exist in the spectrum, with double the quantity of the third colour, this third colour will be produced. It is probable that many of the unexpected changes in mixing colours on a painter's easle, as well as in more fluid chemical mixtures, may depend on these principles rather than on a new arrangement or combination of their minute particles.

Mr. Galton further observes, that white may universally be produced by the combination of one prismatic colour, and a tint intermediate to two others. Which tint may be distinguished by a name compounded of the two colours, to which it is intermediate. Thus white is produced by a mixture of red with blue-green. Of orange with indigo-blue. Of Yellow with violet-indigo. Of green with red-violet. Of blue with Orange-red. Of indigo with yellow-orange. Of violet with green-yellow. Which he further remarks exactly coincides with the theory and facts mentioned by Dr. Robert Darwin of Shrewsbury in his account of ocular spectra; who has shewn that when one of these contrasted colours has been long viewed, a spectrum or appearance of the other becomes visible in the fatigued eye. Philos. Trans. Vol. LXXVI. for the year 1786.

These experiments of Mr. Galton might much assist the copper-plate printers of callicoes and papers in colours; as three colours or more might be produced by two copper-plates. Thus suppose some yellow figures were put on by the first plate, and upon some parts of these yellow figures and on other parts of the ground blue was laid on by another copper-plate. The three colours of yellow, blue, and green might be produced; as green leaves with yellow and blue flowers.

NOTE III.—COLOURED CLOUDS.

Eve's silken couch with gorgeous tints adorn, Or fire the arrowy throne of rising morn.

CANTO I. l. 119.

The rays from the rising and setting sun are refracted by our spherical atmosphere, hence the most refrangible rays, as the violet, indigo, and blue are reflected in greater quantities from the morning and evening skies; and the least refrangible ones, as red and orange, are last seen about the setting sun. Hence Mr. Beguelin observed that the shadow of his finger on his pocket-book was much bluer in the morning and evening, when the shadow was about eight times as long as the body from which it was projected. Mr. Melville observes, that the blue rays being more refrangible are bent down in the evenings by our atmosphere, while the red and orange being less refrangible continue to pass on and tinge the morning and evening clouds with their colours. See Priestley's History of Light and Colours, p. 440. But as the particles of air, like those of water, are themselves blue, a blue shadow may be seen at all times of the day, though much more beautifully in the mornings and evenings, or by means of a candle in the middle of the day. For if a shadow on a piece of white paper is produced by placing your finger between the paper and a candle in the day light, the shadow will appear very blue; the yellow light of the candle upon the other parts of the paper apparently deepens the blue by its contrast; these colours being opposite to each other, as explained in note II.

Colours are produced from clouds or mists by refraction, as well as by reflection. In riding in the night over an unequal country I observed a very beautiful coloured halo round the moon, whenever I was covered with a few feet of mist, as I ascended from the vallies; which ceased to appear when I rose above the mist. This I suppose was owing to the thinness of the stratum of mist, in which I was immersed; had it been thicker, the colours refracted by the small drops, of which a fog consists, would not have passed through it down to my eye.

There is a bright spot seen on the cornea of the eye, when we face a window, which is much attended to by portrait painters; this is the light reflected from the spherical surface of the polished cornea, and brought to a focus; if the observer is placed in this focus, he sees the image of the window; if he is placed before or behind the focus, he only sees a luminous spot, which is more luminous and of less extent, the nearer he approaches to the focus. The luminous appearance of the eyes of animals in the dusky corners of a room, or in holes in the earth, may arise in some instances from the same principle; viz. the reflection of the light from the spherical cornea; which will be coloured red or blue in some degree by the morning, evening, or meridian light; or by the objects from which that light is previously reflected. In the cavern at Colebrook Dale, where the mineral tar exsudes, the eyes of the horse, which was drawing a cart from within towards the mouth of it, appeared like two balls of phosphorus, when he was above 100 yards off, and for a long time before any other part of the animal was visible. In this case I suspect the luminous appearance to have been owing to the light, which had entered the eye, being reflected from the back surface of the vitreous humour, and thence emerging again in parallel rays from the animals eye, as it does from the back surface of the drops of the rainbow, and from the water-drops which lie, perhaps without contact, on cabbage-leaves, and have the brilliancy of quicksilver. This accounts for this luminous appearance being best seen in those animals which have large apertures in their iris, as in cats and horses, and is the only part visible in obscure places, because this is a better reflecting surface than any other part of the animal. If any of these emergent rays from the animals eye can be supposed to have been reflected from the choroid coat through the semi-transparent retina, this would account for the coloured glare of the eyes of dogs or cats and rabits in dark corners.

NOTE IV.—COMETS.

Alarm with comet-blaze the sapphire plain, The wan stars glimmering through its silver train.

CANTO I. l. 133.

There have been many theories invented to account for the tails of comets. Sir Isaac Newton thinks that they consist of rare vapours raised from the nucleus of the comet, and so rarefied by the sun's heat

as to have their general gravitation diminished, and that they in consequence ascend opposite to the sun, and from thence reflect the rays of light. Dr. Halley compares the light of the tails of comets to the streams of the aurora borealis, and other electric effluvia. Philos. Trans. No. 347.

Dr. Hamilton observes that the light of small stars are seen undiminished through both the light of the tails of comets, and of the aurora borealis, and has further illustrated their electric analogy, and adds that the tails of comets consist of a lucid self-shining substance which has not the power of refracting or reflecting the rays of light. Essays.

The tail of the comet of 1744 at one time appeared to extend above 16 degrees from its body, and must have thence been above twenty three millions of miles long. And the comet of 1680, according to the calculations of Dr. Halley on November the 11th, was not above one semi- diameter of the earth, or less than 4000 miles to the northward of the way of the earth; at which time had the earth been in that part of its orbit, what might have been the consequence! no one would probably have survived to have registered the tremendous effects.

The comet of 1531, 1607, and 1682 having returned in the year 1759, according to Dr. Halley's prediction in the Philos. Trans. for 1705, there seems no reason to doubt that all the other comets will return after their proper periods. Astronomers have in general acquiesced in the conjecture of Dr. Halley, that the comets of 1532, and 1661 are one and the same comet, from the similarity of the elements of their orbits, and were therefore induced to expect its return to its perihelium 1789. As this comet is liable to be disturbed in its ascent from the sun by the planets Jupiter and Saturn, Dr. Maskelyne expected its return to its perihelium in the beginning of the year 1789, or the latter end of the year 1788, and certainly sometime before the 27th of April, 1789, which prediction has not been fulfilled. Phil. Trans. Vol. LXXVI.

NOTE V.—SUN'S RAYS.

Or give the sun's phlogistic orb to roll.

CANTO I. l. 136.

The dispute among philosophers about phlogiston is not concerning the existence of an inflammable principle, but rather whether there be one or more inflammable principles. The disciples of Stahl, which till lately included the whole chemical world, believed in the identity of phlogiston in all bodies which would flame or calcine. The disciples of Lavoisier pay homage to a plurality of phlogistons under the various names of charcoal, sulphur, metals, &c. Whatever will unite with *pure* air, and thence compose an acid, is esteemed in this ingenious theory to be a different kind of phlogistic or inflammable body. At the same time there remains a doubt whether these inflammable bodies, as metals, sulphur, charcoal, &c. may not be compounded of the same phlogiston along with some other material yet undiscovered, and thus an unity of phlogiston exist, as in the theory of Stahl, though very differently applied in the explication of chemical phenomena.

Some modern philosophers are of opinion that the sun is the great fountain from which the earth and other planets derive all the phlogiston which they possess; and that this is formed by the combination of the solar rays with all opake bodies, but particularly with the leaves of vegetables, which they suppose to be organs adapted to absorb them. And that as animals receive their nourishment from vegetables they also obtain in a secondary manner their phlogiston from the sun. And lastly as great masses of the mineral kingdom, which have been found in the thin crust of the earth which human labour has penetrated, have evidently been formed from the recrements of animal and vegetable bodies, these also are supposed thus to have derived their phlogiston from the sun.

Another opinion concerning the sun's rays is, that they are not luminous till they arrive at our atmosphere; and that there uniting with some part of the air they produce combustion, and light is emitted, and that an etherial acid, yet undiscovered, is formed from this combustion.

The more probable opinion is perhaps, that the sun is a phlogistic mass of matter, whose surface is in a state of combustion, which like other burning bodies emits light with immense velocity in all directions; that these rays of light act upon all opake bodies, and combining with them either displace or produce their elementary heat, and become chemically combined with the phlogistic part of them; for light is given out when phlogistic bodies unite with the oxygenous principle of the air, as in

combustion, or in the reduction of metallic calxes; thus in presenting to the flame of a candle a letter-wafer, (if it be coloured with red- lead,) at the time the red-lead becomes a metallic drop, a flash of light is perceived. Dr. Alexander Wilson very ingeniously endeavours to prove that the sun is only in a state of combustion on its surface, and that the dark spots seen on the disk are excavations or caverns through the luminous crust, some of which are 4000 miles in diameter. Phil. Trans. 1774. Of this I shall have occasion to speak again.

NOTE VI.—CENTRAL FIRES.

Round her still centre tread the burning soil, And watch the billowy Lavas, as they boil.

CANTO I. l. 139.

M. de Mairan in a paper published in the Histoire de l'Academie de Sciences, 1765, has endeavoured to shew that the earth receives but a small part of the heat which it possesses, from the sun's rays, but is principally heated by fires within itself. He thinks the sun is the cause of the vicissitudes of our seasons of summer and winter by a very small quantity of heat in addition to that already residing in the earth, which by emanations from the centre to the circumference renders the surface habitable, and without which, though the sun was constantly to illuminate two thirds of the globe at once, with a heat equal to that at the equator, it would soon become a mass of solid ice. His reasonings and calculations on this subject are too long and too intricate to be inserted here, but are equally curious and ingenious and carry much conviction along with them.

The opinion that the center of the earth consists of a large mass of burning lava, has been espoused by Boyle, Boerhave, and many other philosophers. Some of whom considering its supposed effects on vegetation and the formation of minerals have called it a second sun. There are many arguments in support of this opinion, 1. Because the power of the sun does not extend much beyond ten feet deep into the earth, all below being in winter and summer always of the same degree of heat, viz. 48, which being much warmer than the mildest frost, is supposed to be sustained by some internal distant fire. Add to this however that from experiments made some years ago by Dr. Franklin the spring-water at Philadelphia appeared to be of 52° of heat, which seems further to confirm this opinion, since the climates in North America are supposed to be colder than those of Europe under similar degrees of latitude. 2. Mr. De Luc in going 1359 feet perpendicular into the mines of Hartz on July the 5th, 1778, on a very fine day found the air at the bottom a little warmer than at the top of the shaft. Phil. Trans. Vol. LXIX. p. 488. In the mines in Hungary, which are 500 cubits deep, the heat becomes very troublesome when the miners get below 480 feet depth. *Morinus de Locis subter*. p. 131. But as some other deep mines as mentioned by Mr. Kirwan are said to possess but the common heat of the earth; and as the crust of the globe thus penetrated by human labour is so thin compared with the whole, no certain deduction can be made from these facts on either side of the question. 3. The warm-springs in many parts of the earth at great distance from any Volcanos seem to originate from the condensation of vapours arising from water which is boiled by subterraneous fires, and cooled again in their passage through a certain length of the colder soil; for the theory of chemical solution will not explain the equality of their heat at all seasons and through so many centuries. See note on Fucus in Vol. II. See a letter on this subject in Mr. Pilkinton's View of Derbyshire from Dr. Darwin. 4. From the situations of volcanos which are always found upon the summit of the highest mountains. For as these mountains have been lifted up and lose several of their uppermost strata as they rise, the lowest strata of the earth yet known appear at the tops of the highest hills; and the beds of the Volcanos upon these hills must in consequence belong to the lowest strata of the earth, consisting perhaps of granite or basaltes, which were produced before the existance of animal or vegetable bodies, and might constitute the original nucleus of the earth, which I have supposed to have been projected from the sun, hence the volcanos themselves appear to be spiracula or chimneys belonging to great central fires. It is probably owing to the escape of the elastic vapours from these spiracula that the modern earthquakes are of such small extent compared with those of remote antiquity, of which the vestiges remain all over the globe. 5. The great size and height of the continents, and the great size and depth of the South-sea, Atlantic, and other oceans, evince that the first earthquakes, which produced these immense changes in the globe, must have been occasioned by central fires. 6. The very distant and expeditious communication of the shocks of some great earthquakes. The earthquake at Lisbon in 1755 was perceived in Scotland, in the Peak of Derbyshire, and in many other distant parts of Europe. The percussions of it travelled with about the velocity of sound, viz. about thirteen miles in a minute. The earthquake in 1693 extended 2600 leagues. (Goldsmith's History.) These phenomena are easily

explained if the central parts of the earth consist of a fluid lava, as a percussion on one part of such a fluid mass would be felt on other parts of its confining vault, like a stroke on a fluid contained in a bladder, which however gentle on one side is perceptible to the hand placed on the other; and the velocity with which such a concussion would travel would be that of sound, or thirteen miles in a minute. For further information on this part of the subject the reader is referred to Mr. Michell's excellent Treatise on Earthquakes in the Philos. Trans. Vol. LI. 7. That there is a cavity at the center of the earth is made probable by the late experiments on the attraction of mountains by Mr. Maskerlyne, who supposed from other considerations that the density of the earth near the surface should be five times less than its mean density. Phil. Trans. Vol. LXV. p. 498. But found from the attraction of the mountain Schehallien, that it is probable, the mean density of the earth is but double that of the hill. Ibid. p. 532. Hence if the first supposition be well founded there would appear to be a cavity at the centre of considerable magnitude, from whence the immense beds and mountains of lava, toadstone, basaltes, granite, &c. have been protruded. 8. The variation of the compass can only be accounted for by supposing the central parts of the earth to consist of a fluid mass, and that part of this fluid is iron, which requiring a greater degree of heat to bring it into fusion than glass or other metals, remains a solid, and the vis inertiae of this fluid mass with the iron in it, occasions it to perform fewer revolutions than the crust of solid earth over it, and thus it is gradually left behind, and the place where the floating iron resides is pointed to by the direct or retrograde motions of the magnetic needle. This seems to have been nearly the opinion of Dr. Halley and Mr. Euler.

NOTE VII.—ELEMENTARY HEAT.

> *Or sphere on sphere in widening waves expand, And glad with genial warmth the incumbent land.*

CANTO I. l. 143.

A certain quantity of heat seems to be combined with all bodies besides the sensible quantity which gravitates like the electric fluid amongst them. This combined heat or latent heat of Dr. Black, when set at liberty by fermentation, inflammation, crystallization, freezing, or other chemical attractions producing new *combinations*, passes as a fluid element into the surrounding bodies. And by thawing, diffusion of neutral salts in water, melting, and other chemical *solutions*, a portion of heat is attracted from the bodies in vicinity and enters into or becomes combined with the new solutions.

Hence a *combination* of metals with acids, of essential oils and acids, of alcohol and water, of acids and water, give out heat; whilst a *solution* of snow in water or in acids, and of neutral salts in water, attract heat from the surrounding bodies. So the acid of nitre mixed with oil of cloves unites with it and produces a most violent flame; the same acid of nitre poured on snow instantly dissolves it and produces the greatest degree of cold yet known, by which at Petersburgh quicksilver was first frozen in 1760.

Water may be cooled below 32° without being frozen, if it be placed on a solid floor and secured from agitation, but when thus cooled below the freezing point the least agitation turns part of it suddenly into ice, and when this sudden freezing takes place a thermometer placed in it instantly rises as some heat is given out in the act of congelation, and the ice is thus left with the same *sensible* degree of cold as the water had possessed before it was agitated, but is nevertheless now combined with less *latent* heat.

A cubic inch of water thus cooled down to 32° mixed with an equal quantity of boiling water at 212° will cool it to the middle number between these two, or to 122. But a cubic inch of ice whose sensible cold also is but 32, mixed with an equal quantity of boiling water, will cool it six times as much as the cubic inch of cold water above-mentioned, as the ice not only gains its share of the sensible or gravitating heat of the boiling water but attracts to itself also and combines with the quantity of latent heat which it had lost at the time of its congelation.

So boiling water will acquire but 212° of heat under the common pressure of the atmosphere, but the steam raised from it by its expansion or by its solution in the atmosphere combines with and carries away a prodigious quantity of heat which it again parts with on its condensation; as is seen in common distillation where the large quantity of water in the worm-tub is so soon heated. Hence the evaporation of ether on a thermometer soon sinks the mercury below freezing, and hence a warmth of the air in

winter frequently succeeds a shower.

When the matter of heat or calorique is set at liberty from its combinations, as by inflammation, it passes into the surrounding bodies, which possess different capacities of acquiring their share of the loose or sensible heat; thus a pint measure of cold water at 48° mixed with a pint of boiling water at 212° will cool it to the degree between these two numbers, or to 154°, but it requires two pint measures of quicksilver at 48° of heat to cool one pint of water as above. These and other curious experiments are adduced by Dr. Black to evince the existance of combined or latent heat in bodies, as has been explained by some of his pupils, and well illustrated by Dr. Crawford. The world has long been in expectation of an account of his discoveries on this subject by the celebrated author himself.

As this doctrine of elementary heat in its fluid and combined state is not yet universally received, I shall here add two arguments in support of it drawn from different sources, viz. from the heat given out or absorbed by the mechanical condensation or expansion of the air, and perhaps of other bodies, and from the analogy of the various phenomena of heat with those of electricity.

I. If a thermometer be placed in the receiver of an air-pump, and the air hastily exhausted, the thermometer will sink some degrees, and the glass become steamy; the same occurs in hastily admitting a part of the air again. This I suppose to be produced by the expansion of part of the air, both during the exhaustion and re-admission of it; and that the air so expanded becomes capable of attracting from the bodies in its vicinity a part of their heat, hence the vapours contained in it and the glass receiver are for a time colder and the steam is precipitated. That the air thus parts with its moisture from the cold occasioned by its rarefaction and not simply by the rarefaction itself is evident, because in a minute or two the same rarefied air will again take up the dew deposited on the receiver; and because water will evaporate sooner in rare than in dense air.

There is a curious phenomenon similar to this observed in the fountain of Hiero constructed on a large scale at the Chemnicensian mines in Hungary. In this machine the air in a large vessel is compressed by a column of water 260 feet high, a stop-cock is then opened, and as the air issues out with great vehemence, and thus becomes immediately greatly expanded, so much cold is produced that the moisture from this stream of air is precipitated in the form of snow, and ice is formed adhering to the nosel of the cock. This remarkable circumstance is described at large with a plate of the machine in Philos. Trans. Vol. LII. for 1761.

The following experiment is related by Dr. Darwin in the Philos. Trans. Vol. LXXVIII. Having charged an air-gun as forcibly as he well could the air-cell and syringe became exceedingly hot, much more so than could be ascribed to the friction in working it; it was then left about half an hour to cool down to the temperature of the air, and a thermometer having been previously fixed against a wall, the air was discharged in a continual stream on its bulb, and it sunk many degrees. From these three experiments of the steam in the exhausted receiver being deposited and re-absorbed, when a part of the air is exhausted or re-admitted, and the snow produced by the fountain of Hiero, and the extraordinary heat given out in charging, and the cold produced in discharging an air-gun, there is reason to conclude that when air is mechanically compressed the elementary fluid heat is pressed out of it, and that when it is mechanically expanded the same fluid heat is re-absorbed from the common mass.

It is probable all other bodies as well as air attract heat from their neighbours when they are mechanically expanded, and give it out when they are mechanically condensed. Thus when a vibration of the particles of hard bodies is excited by friction or by percussion, these particles mutually recede from and approach each other reciprocally; at the times of their recession from each other, the body becomes enlarged in bulk, and is then in a condition to attract heat from those in its vicinity with great and sudden power; at the times of their approach to each other this heat is again given out, but the bodies in contact having in the mean while received the heat they had thus lost, from other bodies behind them, do not so suddenly or so forcibly re-absorb the heat again from the body in vibration; hence it remains on its surface like the electric fluid on a rubbed glass globe, and for the same reason, because there is no good conductor to take it up again. Hence at every vibration more and more heat is acquired and stands loose upon the surface; as in filing metals or rubbing glass tubes; and thus a smith with a few strokes on a nail on his anvil can make it hot enough to light a brimstone-match; and hence in striking flint and steel together heat enough is produced to vitrify the parts thus strucken off, the quantity of which heat is again probably increased by the new chemical combination.

II. The analogy between the phenomena of the electric fluid and of heat furnishes another argument in support of the existence of heat as a gravitating fluid. 1. They are both accumulated by friction on the excited body. 2. They are propagated easily or with difficalty along the same classes of bodies; with ease by metals, with less ease by water; and with difficulty by resins, bees-wax, silk, air, and glass. Thus glass canes or canes of sealing-wax may be melted by a blow-pipe or a candle within a quarter of an inch of the fingers which hold them, without any inconvenient heat, while a pin or other metallic

substance applyed to the flame of a candle so readily conducts the heat as immediately to burn the fingers. Hence clothes of silk keep the body warmer than clothes of linen of equal thickness, by confining the heat upon the body. And hence plains are so much warmer than the summits of mountains by the greater density of the air confining the acquired heat upon them. 3. They both give out light in their passage through air, perhaps not in their passage through a vacuum. 4. They both of them fuse or vitrify metals. 5. Bodies after being electrized if they are mechanically extended will receive a greater quantity of electricity, as in Dr. Franklin's experiment of the chain in the tankard; the same seems true in respect to heat as explained above. 6. Both heat and electricity contribute to suspend steam in the atmosphere by producing or increasing the repulsion of its particles. 7. They both gravitate, when they have been accumulated, till they find their equilibrium.

If we add to the above the many chemical experiments which receive an easy and elegant explanation from the supposed matter of heat, as employed in the works of Bergman and Lavoisier, I think we may reasonably allow of its existence as an element, occasionally combined with other bodies, and occasionally existing as a fluid, like the electric fluid gravitating amongst them, and that hence it may be propagated from the central fires of the earth to the whole mass, and contribute to preserve the mean heat of the earth, which in this country is about 48 degrees but variable from the greater or less effect of the sun's heat in different climates, so well explained in Mr. Kirwan's Treatise on the Temperature of different Latitudes. 1787, Elmsly. London.

NOTE VIII.—MEMNON'S LYRE.

So to the sacred Sun in Memnon's fane Spontaneous concords quired the matin strain.

CANTO I. l. 183.

The gigantic statue of Memnon in his temple at Thebes had a lyre in his hands, which many credible writers assure us, sounded when the rising sun shone upon it. Some philosophers have supposed that the sun's light possesses a mechanical impulse, and that the sounds abovementioned might be thence produced. Mr. Michell constructed a very tender horizontal balance, as related by Dr. Priestley in his history of light and colours, for this purpose, but some experiments with this balance which I saw made by the late Dr. Powel, who threw the focus of a large reflector on one extremity of it, were not conclusive either way, as the copper leaf of the balance approached in one experiment and receded in another.

There are however methods by which either a rotative or alternating motion may be produced by very moderate degrees of heat. If a straight glass tube, such as are used for barometers, be suspended horizontally before a fire, like a roasting spit, it will revolve by intervals; for as glass is a bad conductor of heat the side next the fire becomes heated sooner than the opposite side, and the tube becomes bent into a bow with the external part of the curve towards the fire, this curve then falls down and produces a fourth part of a revolution of the glass tube, which thus revolves with intermediate pauses.

Another alternating motion I have seen produced by suspending a glass tube about eight inches long with bulbs at each end on a centre like a scale beam. This curious machine is filled about one third part with purest spirit of wine, the other two thirds being a vacuum, and is called a pulse-glass, if it be placed in a box before the fire, so that either bulb, as it rises, may become shaded from the fire, and exposed to it when it descends, an alternate libration of it is produced. For spirit of wine in vacuo emits steam by a very small degree of heat, and this steam forces the spirit beneath it up into the upper bulb, which therefore descends. It is probable such a machine on a larger scale might be of use to open the doors or windows of hot-houses or mellon- frames, when the air within them should become too much heated, or might be employed in more important mechanical purposes.

On travelling through a hot summer's day in a chaise with a box covered with leather on the fore-axle-tree, I observed, as the sun shone upon the black leather, the box began to open its lid, which at noon rose above a foot, and could not without great force be pressed down; and which gradually closed again as the sun declined in the evening. This I suppose might with still greater facility be applied to the purpose of opening melon-frames or the sashes of hot-houses.

The statue of Memnon was overthrown and sawed in two by Cambyses to discover its internal structure, and is said still to exist. See Savary's Letters on Egypt. The truncated statue is said for many centuries to have saluted the rising sun with chearful tones, and the setting sun with melancholy ones.

NOTE IX.—LUMINOUS INSECTS.

Star of the earth, and diamond of the night.

CANTO I. l. 196.

There are eighteen species of Lampyris or glow-worm, according to Linneus, some of which are found in almost every part of the world. In many of the species the females have no wings, and are supposed to be discovered by the winged males by their shining in the night. They become much more lucid when they put themselves in motion, which would seem to indicate that their light is owing to their respiration; in which process it is probable phosphoric acid is produced by the combination of vital air with some part of the blood, and that light is given out through their transparent bodies by this slow internal combustion.

There is a fire-fly of the beetle-kind described in the Dict. Raisonné under the name of Acudia, which is said to be two inches long, and inhabits the West-Indies and South America; the natives use them instead of candles, putting from one to three of them under a glass. Madam Merian says, that at Surinam the light of this fly is so great, that she saw sufficiently well by one of them to paint and finish one of the figures of them in her work on insects. The largest and oldest of them are said to become four inches long, and to shine like a shooting star as they fly, and are thence called Lantern-bearers. The use of this light to the insect itself seems to be that it may not fly against objects in the night; by which contrivance these insects are enabled to procure their sustenance either by night or day, as their wants may require, or their numerous enemies permit them; whereas some of our beetles have eyes adapted only to the night, and if they happen to come abroad too soon in the evening are so dazzled that they fly against every thing in their way. See note on Phosphorus, No. X.

In some seas, as particularly about the coast of Malabar, as a ship floats along, it seems during the night to be surrounded with fire, and to leave a long tract of light behind it. Whenever the sea is gently agitated it seems converted into little stars, every drop as it breaks emits light, like bodies electrified in the dark. Mr. Bomare says, that when he was at the port of Cettes in Languedoc, and bathing with a companion in the sea after a very hot day, they both appeared covered with fire after every immersion, and that laying his wet hand on the arm of his companion, who had not then dipped himself, the exact mark of his hand and fingers was seen in characters of fire. As numerous microscopic insects are found in this shining water, its light has been generally ascribed to them, though it seems probable that fish-slime in hot countries may become in such a state of incipient putrefaction as to give light, especially when by agitation it is more exposed to the air; otherwise it is not easy to explain why agitation should be necessary to produce this marine light. See note on Phosphorus No. X.

NOTE X.—PHOSPHORUS.

Or mark in shining letters Kunckel's name In the pale phosphor's self-consuming flame.

CANTO I. l. 231.

Kunckel, a native of Hamburgh, was the first who discovered to the world the process for producing phosphorus; though Brandt and Boyle were likewise said to have previously had the art of making it. It was obtained from sal microcosmicum by evaporation in the form of an acid, but has since been found in other animal substances, as in the ashes of bones, and even in some vegetables, as in wheat flour. Keir's chemical Dict. This phosphoric acid is like all other acids united with vital air, and requires to be treated with charcoal or phlogiston to deprive it of this air, it then becomes a kind of animal sulphur, but of so inflammable a nature, that on the access of air it takes fire spontaneously, and as it burns becomes again united with vital air, and re-assumes its form of phosphoric acid.

As animal respiration seems to be a kind of slow combustion, in which it is probable that phosphoric acid is produced by the union of phosphorus with the vital air, so it is also probable that phosphoric acid is produced in the excretory or respiratory vessels of luminous insects, as the glow-worm and fire-fly, and some marine insects. From the same principle I suppose the light from putrid fish, as from the heads of hadocks, and from putrid veal, and from rotten wood in a certain state of their putrefaction, is

produced, and phosphorus thus slowly combined with air is changed into phosphoric acid. The light from the Bolognian stone, and from calcined shells, and from white paper, and linen after having been exposed for a time to the sun's light, seem to produce either the phosphoric or some other kind of acid from the sulphurous or phlogistic matter which they contain. See note on Beccari's shells. l. 180.

There is another process seems similar to this slow combustion, and that is *bleaching*. By the warmth and light of the sun the water sprinkled upon linen or cotton cloth seems to be decomposed, (if we credit the theory of M. Lavoisier,) and a part of the vital air thus set at liberty and uncombined and not being in its elastic form, more easily dissolves the colouring or phlogistic matter of the cloth, and produces a new acid, which is itself colourless, or is washed out of the cloth by water. The new process of bleaching confirms a part of this theory, for by uniting much vital air to marine acid by distilling it from manganese, on dipping the cloth to be bleached in water repleat with this super-aerated marine acid, the colouring matter disappears immediately, sooner indeed in cotton than in linen. See note XXXIV.

There is another process which I suspect bears analogy to these above- mentioned, and that is the rancidity of animal fat, as of bacon; if bacon be hung up in a warm kitchen, with much salt adhering on the outside of it, the fat part of it soon becomes yellow and rancid; if it be washed with much cold water after it has imbibed the salt, and just before it is hung up, I am well informed, that it will not become rancid, or in very slight degrees. In the former case I imagine the salt on the surface of the bacon attracts water during the cold of the night, which is evaporated during the day, and that in this evaporation a part of the water becomes decomposed, as in bleaching, and its vital air uniting with greater facility in its unelastic state with the animal fat, produces an acid, perhaps of the phosphoric kind, which being of a fixed nature lies upon the bacon, giving it the yellow colour and rancid taste. It is remarkable that the super-aerated marine acid does not bleach living animal substances, at least it did not whiten a part of my hand which I for some minutes exposed to it.

NOTE XI.—STEAM-ENGINE.

> *Quick moves the balanced beam, of giant-birth, Wields his large limbs, and nodding shakes the earth.*

CANTO I. l. 261.

The expansive force of steam was known in some degree to the antients, Hero of Alexandria describes an application of it to produce a rotative motion by the re-action of steam issuing from a sphere mounted upon an axis, through two small tubes bent into tangents, and issuing from the opposite sides of the equatorial diameter of the sphere, the sphere was supplied with steam by a pipe communicating with a pan of boiling water, and entering the sphere at one of its poles.

A french writer about the year 1630 describes a method of raising water to the upper part of a house by filling a chamber with steam, and suffering it to condense of itself, but it seems to have been mere theory, as his method was scarcely practicable as he describes it. In 1655 the Marquis of Worcester mentions a method of raising water by fire in his Century of Inventions, but he seems only to have availed himself of the expansive force and not to have known the advantages arising from condensing the steam by an injection of cold water. This latter and most important improvement seems to have been made by Capt. Savery sometime prior to 1698, for in that year his patent for the use of that invention was confirmed by act of parliament. This gentleman appears to have been the first who reduced the machine to practice and exhibited it in an useful form. This method consisted only in expelling the air from a vessel by steam and condensing the steam by an injection of cold water, which making a vacuum, the pressure of the atmosphere forced the water to ascend into the steam-vessel through a pipe of 24 to 26 feet high, and by the admission of dense steam from the boiler, forcing the water in the steam-vessel to ascend to the height desired. This construction was defective because it required very strong vessels to resist the force of the steam, and because an enormous quantity of steam was condensed by coming in contact with the cold water in the steam-vessel.

About or soon after that time M. Papin attempted a steam-engine on similar principles but rather more defective in its construction.

The next improvement was made very soon afterwards by Messrs. Newcomen and Cawley of Dartmouth, it consisted in employing for the steam-vessel a hollow cylinder, shut at bottom and open at

top, furnished with a piston sliding easily up and down in it, and made tight by oakum or hemp, and covered with water. This piston is suspended by chains from one end of a beam, moveable upon an axis in the middle of its length, to the other end of this beam are suspended the pump-rods.

The danger of bursting the vessels was avoided in this machine, as however high the water was to be raised it was not necessary to increase the density of the steam but only to enlarge the diameter of the cylinder.

Another advantage was, that the cylinder not being made so cold as in Savary's method, much less steam was lost in filling it after each condensation.

The machine however still remained imperfect, for the cold water thrown into the cylinder acquired heat from the steam it condensed, and being in a vessel exhausted of air it produced steam itself, which in part resisted the action of the atmosphere on the piston; were this remedied by throwing in more cold water the destruction of steam in the next filling of the cylinder would be proportionally increased. It has therefore in practice been found adviseable not to load these engines with columns of water weighing more than seven pounds for each square inch of the area of the piston. The bulk of water when converted into steam remained unknown until Mr. J. Watt, then of Glasgow, in 1764, determined it to be about 1800 times more rare than water. It soon occurred to Mr. Watt that a perfect engine would be that in which no steam should be condensed in filling the cylinder, and in which the steam should be so perfectly cooled as to produce nearly a perfect vacuum.

Mr. Watt having ascertained the degree of heat in which water boiled in vacuo, and under progressive degrees of pressure, and instructed by Dr. Black's discovery of latent heat, having calculated the quantity of cold water necessary to condense certain quantities of steam so far as to produce the exhaustion required, he made a communication from the cylinder to a cold vessel previously exhausted of air and water, into which the steam rushed by its elasticity, and became immediately condensed. He then adapted a cover to the cylinder and admitted steam above the piston to press it down instead of air, and instead of applying water he used oil or grease to fill the pores of the oakum and to lubricate the cylinder.

He next applied a pump to extract the injection water, the condensed steam, and the air, from the condensing vessel, every stroke of the engine.

To prevent the cooling of the cylinder by the contact of the external air, he surrounded it with a case containing steam, which he again protected by a covering of matters which conduct heat slowly.

This construction presented an easy means of regulating the power of the engine, for the steam being the acting power, as the pipe which admits it from the boiler is more or less opened, a greater or smaller quantity can enter during the time of a stroke, and consequently the engine can act with exactly the necessary degree of energy.

Mr. Watt gained a patent for his engine in 1768, but the further persecution of his designs were delayed by other avocations till 1775, when in conjunction with Mr. Boulton of Soho near Birmingham, numerous experiments were made on a large scale by their united ingenuity, and great improvements added to the machinery, and an act of parliament obtained for the prolongation of their patent for twenty-five years, they have since that time drained many of the deep mines in Cornwall, which but for the happy union of such genius must immediately have ceased to work. One of these engines works a pump of eighteen inches diameter, and upwards of 100 fathom or 600 feet high, at the rate of ten to twelve strokes of seven feet long each, in a minute, and that with one fifth part of the coals which a common engine would have taken to do the same work. The power of this engine may be easier comprehended by saying that it raised a weight equal to 81000 pounds 80 feet high in a minute, which is equal to the combined action of 200 good horses. In Newcomen's engine this would have required a cylinder of the enormous diameter of 120 inches or ten feet, but as in this engine of Mr. Watt and Mr. Boulton the steam acts, and a vacuum is made, alternately above and below the piston, the power exerted is double to what the same cylinder would otherways produce, and is further augmented by an inequality in the length of the two ends of the lever.

These gentlemen have also by other contrivances applied their engines to the turning of mills for almost every purpose, of which that great pile of machinery the Albion Mill is a well known instance. Forges, slitting mills, and other great works are erected where nature has furnished no running water, and future times may boast that this grand and useful engine was invented and perfected in our own country.

Since the above article went to the press the Albion Mill is no more; it is supposed to have been set on fire by interested or malicious incendaries, and is burnt to the ground. Whence London has lost the credit and the advantage of possessing the most powerful machine in the world!

NOTE XII.—FROST.

In phalanx firm the fiend of Frost assail.

CANTO I. l. 439.

The cause of the expansion of water during its conversion into ice is not yet well ascertained, it was supposed to have been owing to the air being set at liberty in the act of congelation which was before dissolved in the water, and the many air bubbles in ice were thought to countenance this opinion. But the great force with which ice expands during its congelation, so as to burst iron bombs and coehorns, according to the experiments of Major Williams at Quebec, invalidates this idea of the cause of it, and may sometime be brought into use as a means of breaking rocks in mining, or projecting cannon-balls, or for other mechanical purposes, if the means of producing congelation should ever be discovered to be as easy as the means of producing combustion.

Mr. de Mairan attributes the increase of bulk of frozen water to the different arrangement of the particles of it in crystallization, as they are constantly joined at an angle of 60 degrees; and must by this disposition he thinks occupy a greater volume than if they were parallel. He found the augmentation of the water during freezing to amount to one-fourteenth, one-eighteenth, one-nineteenth, and when the water was previously purged of air to only one-twenty-second part. He adds that a piece of ice, which was at first only one-fourteenth part specifically lighter than water, on being exposed some days to the frost became one-twelfth lighter than water. Hence he thinks ice by being exposed to greater cold still increases in volume, and to this attributes the bursting of ice in ponds and on the glaciers. See Lewis's Commerce of Arts, p. 257. and the note on Muschus in the other volume of this work.

This expansion of ice well accounts for the greater mischief done by vernal frosts attended with moisture, (as by hoar-frosts,) than by the dry frosts called black frosts. Mr. Lawrence in a letter to Mr. Bradley complains that the dale-mist attended with a frost on may-day had destroyed all his tender fruits; though there was a sharper frost the night before without a mist, that did him no injury; and adds, that a garden not a stone's throw from his own on a higher situation, being above the dale-mist, had received no damage. Bradley, Vol. II. p. 232.

Mr. Hunter by very curious experiments discovered that the living principle in fish, in vegetables, and even in eggs and seeds, possesses a power of resisting congelation. Phil. Trans. There can be no doubt but that the exertions of animals to avoid the pain of cold may produce in them a greater quantity of heat, at least for a time, but that vegetables, eggs, or seeds, should possess such a quality is truly wonderful. Others have imagined that animals possess a power of preventing themselves from becoming much warmer than 98 degrees of heat, when immersed in an atmosphere above that degree of heat. It is true that the increased exhalation from their bodies will in some measure cool them, as much heat is carried off by the evaporation of fluids, but this is a chemical not an animal process. The experiments made by those who continued many minutes in the air of a room heated so much above any natural atmospheric heat, do not seem conclusive, as they remained in it a less time than would have been necessary to have heated a mass of beef of the same magnitude, and the circulation of the blood in living animals, by perpetually bringing new supplies of fluid to the skin, would prevent the external surface from becoming hot much sooner than the whole mass. And thirdly, there appears no power of animal bodies to produce cold in diseases, as in scarlet fever, in which the increased action of the vessels of the skin produces heat and contributes to exhaust the animal power already too much weakened.

It has been thought by many that frosts meliorate the ground, and that they are in general salubrious to mankind. In respect to the former it is now well known that ice or snow contain no nitrous particles, and though frost by enlarging the bulk of moist clay leaves it softer for a time after the thaw, yet as soon as the water exhales, the clay becomes as hard as before, being pressed together by the incumbent atmosphere, and by its self-attraction, called *setting* by the potters. Add to this that on the coasts of Africa, where frost is unknown, the fertility of the soil is almost beyond our conceptions of it. In respect to the general salubrity of frosty seasons the bills of mortality are an evidence in the negative, as in long frosts many weakly and old people perish from debility occasioned by the cold, and many classes of birds and other wild animals are benumbed by the cold or destroyed by the consequent scarcity of food, and many tender vegetables perish from the degree of cold.

I do not think it should be objected to this doctrine that there are moist days attended with a brisk cold wind when no visible ice appears, and which are yet more disagreeable and destructive than frosty weather. For on these days the cold moisture, which is deposited on the skin is there evaporated and

thus produces a degree of cold perhaps greater than the milder frosts. Whence even in such days both the disagreeable sensations and insalubrious effects belong to the cause abovementioned, viz. the intensity of the cold. Add to this that in these cold moist days as we pass along or as the wind blows upon us, a new sheet of cold water is as it were perpetually applied to us and hangs upon our bodies, now as water is 800 times denser than air and is a much better conductor of heat, we are starved with cold like those who go into a cold bath, both by the great number of particles in contact with the skin and their greater facility of receiving our heat.

It may nevertheless be true that snows of long duration in our winters may be less injurious to vegetation than great rains and shorter frosts, for two reasons. 1. Because great rains carry down many thousand pounds worth of the best part of the manure off the lands into the sea, whereas snow dissolves more gradually and thence carries away less from the land; any one may distinguish a snow-flood from a rain-flood by the transparency of the water. Hence hills or fields with considerable inclination of surface should be ploughed horizontally that the furrows may stay the water from showers till it deposits its mud. 2. Snow protects vegetables from the severity of the frost, since it is always in a state of thaw where it is in contact with the earth; as the earth's heat is about 48° and the heat of thawing snow is 32° the vegetables between them are kept in a degree of heat about 40, by which many of them are preserved. See note on Muschus, Vol. II. of this work.

NOTE XIII.—ELECTRICITY

Cold from each point cerulean lustres gleam.

CANTO I. l. 339.

ELECTRIC POINTS.

There was an idle dispute whether knobs or points were preferable on the top of conductors for the defence of houses. The design of these conductors is to permit the electric matter accumulated in the clouds to pass through them into the earth in a smaller continued stream as the cloud approaches, before it comes to what is termed striking distance; now as it is well known that accumulated electricity will pass to points at a much greater distance than it will to knobs there can be no doubt of their preference; and it would seem that the finer the point and the less liable to become rusty the better, as it would take off the lightening while it was still at a greater distance, and by that means preserve a greater extent of building; the very extremity of the point should be of pure silver or gold, and might be branched into a kind of brush, since one small point can not be supposed to receive so great a quantity as a thicker bar might conduct into the earth.

If an insulated metallic ball is armed with a point, like a needle, projecting from one part of it, the electric fluid will be seen in the dark to pass off from this point, so long as the ball is kept supplied with electricity. The reason of this is not difficult to comprehend, every part of the electric atmosphere which surrounds the insulated ball is attracted to that ball by a large surface of it, whereas the electric atmosphere which is near the extremity of the needle is attracted to it by only a single point, in consequence the particles of electric matter near the surface of the ball approach towards it and push off by their greater gravitation the particles of electric matter over the point of the needle in a continued stream.

Something like this happens in respect to the diffusion of oil on water from a pointed cork, an experiment which was many years ago shewn me by Dr. Franklin; he cut a piece of cork about the size of a letter-wafer and left on one edge of it a point about a sixth of an inch in length projecting as a tangent to the circumference. This was dipped in oil and thrown on a pond of water and continued to revolve as the oil left the point for a great many minutes. The oil descends from the floating cork upon the water being diffused upon it without friction and perhaps without contact; but its going off at the point so forcibly as to make the cork revolve in a contrary direction seems analogous to the departure of the electric fluid from points.

Can any thing similar to either of these happen in respect to the earth's atmosphere and give occasion to the breezes on the tops of mountains, which may be considered as points on the earths circumference?

FAIRY-RINGS.

There is a phenomenon supposed to be electric which is yet unaccounted for, I mean the Fairy-rings, as they are called, so often seen on the grass. The numerous flashes of lightning which occur every summer are, I believe, generally discharged on the earth, and but seldom (if ever) from one cloud to another. Moist trees are the most frequent conductors of these flashes of lightning, and I am informed by purchasers of wood that innumerable trees are thus cracked and injured. At other times larger parts or prominences of clouds gradually sinking as they move along, are discharged on the moisture parts of grassy plains. Now this knob or corner of a cloud in being attracted by the earth will become nearly cylindrical, as loose wool would do when drawn out into a thread, and will strike the earth with a stream of electricity perhaps two or ten yards in diameter. Now as a stream of electricity displaces the air it passes through, it is plain no part of the grass can be burnt by it, but just the external ring of this cylinder where the grass can have access to the air, since without air nothing can be calcined. This earth after having been so calcined becomes a richer soil, and either funguses or a bluer grass for many years mark the place. That lightning displaces the air in its passage is evinced by the loud crack that succeeds it, which is owing to the sides of the aerial vacuum clapping together when the lightning is withdrawn. That nothing will calcine without air is now well understood from the acids produced in the burning of phlogistic substances, and may be agreeably seen by suspending a paper on an iron prong and putting it into the centre of the blaze of an iron-furnace; it may be held there some seconds and may be again withdrawn without its being burnt, if it be passed quickly into the flame and out again through the external part of it which is in contact with the air. I know some circles of many yards diameter of this kind near Foremark in Derbyshire which annually produce large white funguses and stronger grass, and have done so, I am informed, above thirty years. This increased fertility of the ground by calcination or charring, and its continuing to operate so many years is well worth the attention of the farmer, and shews the use of paring and burning new turf in agriculture, which produces its effect not so much by the ashes of the vegetable fibres as by charring the soil which adheres to them.

These situations, whether from eminence or from moisture, which were proper once to attract and discharge a thunder-cloud, are more liable again to experience the same. Hence many fairy-rings are often seen near each other either without intersecting each other, as I saw this summer in a garden in Nottinghamshire, or intersecting each other as described on Arthur's seat near Edinburgh in the Edinb. Trans. Vol. II. p. 3.

NOTE XIV.—BUDS AND BULBS.

Where dwell my vegetative realms benumb'd In buds imprison'd, or in bulbs intomb'd.

CANTO I. l. 459.

A tree is properly speaking a family or swarm of buds, each bud being an individual plant, for if one of these buds be torn or cut out and planted in the earth with a glass cup inverted over it to prevent its exhalation from being at first greater than its power of absorption, it will produce a tree similar to its parent; each bud has a leaf, which is its lungs, appropriated to it, and the bark of the tree is a congeries of the roots of these individual buds, whence old hollow trees are often seen to have some branches flourish with vigour after the internal wood is almost intirely decayed and vanished. According to this idea Linneus has observed that trees and shrubs are roots above ground, for if a tree be inverted leaves will grow from the root-part and roots from the trunk-part. Phil. Bot p. 39. Hence it appears that vegetables have two methods of propagating themselves, the oviparous as by seeds, and the viviparous as by their buds and bulbs, and that the individual plants, whether from seeds or buds or bulbs, are all annual productions like many kinds of insects as the silk-worm, the parent perishing in the autumn after having produced an embryon, which lies in a torpid state during the winter, and is matured in the succeeding summer. Hence Linneus names buds and bulbs the winter-cradles of the plant or hybernacula, and might have given the same term to seeds. In warm climates few plants produce buds, as the vegetable life can be compleated in one summer, and hence the hybernacle is not wanted; in cold climates also some plants do not produce buds, as philadelphus, frangula, viburnum, ivy, heath, wood-nightshade, rue, geranium.

The bulbs of plants are another kind of winter-cradle, or hybernacle, adhering to the descending trunk, and are found in the perennial herbaceous plants which are too tender to bear the cold of the

winter. The production of these subterraneous winter lodges, is not yet perhaps clearly understood, they have been distributed by Linneus according to their forms into scaly, solid, coated, and jointed bulbs, which however does not elucidate their manner of production. As the buds of trees may be truly esteemed individual annual plants, their roots constituting the bark of the tree, it follows that these roots (viz. of each individual bud) spread themselves over the last years bark, making a new bark over the old one, and thence descending cover with a new bark the old roots also in the same manner. A similar circumstance I suppose to happen in some herbaceous plants, that is, a new bark is annually produced over the old root, and thus for some years at least the old root or caudex increases in size and puts up new stems. As these roots increase in size the central part I suppose changes like the internal wood of a tree and does not possess any vegetable life, and therefore gives out no fibres or rootlets, and hence appears bitten off, as in valerian, plantain, and devil's-bit. And this decay of the central part of the root I suppose has given occasion to the belief of the root-fibres drawing down the bulb so much insisted on by Mr. Milne in his Botanical Dictionary, Art. Bulb.

From the observations and drawings of various kinds of bulbous roots at different times of their growth, sent me by a young lady of nice observation, it appears probable that all bulbous roots properly so called perish annually in this climate: Bradley, Miller, and the Author of Spectacle de la Nature, observe that the tulip annually renews its bulb, for the stalk of the old flower is found under the old dry coat but on the outside of the new bulb. This large new bulb is the flowering bulb, but besides this there are other small new bulbs produced between the coats of this large one but from the same caudex, (or circle from which the root-fibres spring;) these small bulbs are leaf-bearing bulbs, and renew themselves annually with increasing size till they bear flowers.

Miss —— favoured me with the following curious experiment: She took a small tulip-root out of the earth when the green leaves were sufficiently high to show the flower, and placed it in a glass of water; the leaves and flower soon withered and the bulb became wrinkled and soft, but put out one small side bulb and three bulbs beneath descending an inch into the water by long processes from the caudex, the old bulb in some weeks intirely decayed; on dissecting this monster, the middle descending bulb was found by its process to adhere to the caudex and to the old flower-stem, and the side ones were separated from the flower- stem by a few shrivelled coats but adhered to the caudex. Whence she concludes that these last were off-sets or leaf-bulbs which should have been seen between the coats of the new flower-bulb if it had been left to grow in the earth, and that the middle one would have been the new flower-bulb. In some years (perhaps in wet seasons) the florists are said to lose many of their tulip-roots by a similar process, the new leaf-bulbs being produced beneath the old ones by an elongation of the caudex without any new flower-bulbs.

By repeated dissections she observes that the leaf-bulbs or off-sets of tulip, crocus, gladiolus, fritillary, are renewed in the same manner as the flowering-bulbs, contrary to the opinion of many writers; this new leaf-bulb is formed on the inside of the coats from whence the leaves grow, and is more or less advanced in size as the outer coats and leaves are more or less shrivelled. In examining tulip, iris, hyacinth, hare- bell, the new bulb was invariably found *between* the flower-stem and the base of the innermost leaf of those roots which had flowered, and *inclosed* by the base of the innermost leaf in those roots which had not flowered, in both cases adhering to the caudex or fleshy circle from which the root-fibres spring.

Hence it is probable that the bulbs of hyacinths are renewed annually, but that this is performed from the caudex within the old bulb, the outer coat of which does not so shrivel as in crocus and fritillary and hence this change is not so apparent. But I believe as soon as the flower is advanced the new bulbs may be seen on dissection, nor does the annual increase of the size of the root of cyclamen and of aletris capensis militate against this annual renewal of them, since the leaf- bulbs or off-sets, as described above, are increased in size as they are annually renewed. See note on orchis, and on anthoxanthum, in Vol. II. of this work.

NOTE XV.—SOLAR VOLCANOS.

From the deep craters of his realms of fire The whirling sun this ponderous planet hurld.

CANTO II. l. 14.

Dr. Alexander Wilson, Professor of Astronomy at Glasgow, published a paper in the Philosophical

Transactions for 1774, demonstrating that the spots in the sun's disk are real cavities, excavations through the luminous material, which covers the other parts of the sun's surface. One of these cavities he found to be about 4000 miles deep and many times as wide. Some objections were made to this doctrine by M. De la Laude in the Memoirs of the French Academy for the year 1776, which however have been ably answered by Professor Wilson in reply in the Philos. Trans. for 1783. Keil observes, in his Astronomical Lectures, p. 44, "We frequently see spots in the sun which are larger and broader not only than Europe or Africa, but which even equal, if they do not exceed, the surface of the whole terraqueous globe." Now that these cavities are made in the sun's body by a process of nature similar to our earthquakes does not seem improbable on several accounts. 1. Because from this discovery of Dr. Wilson it appears that the internal parts of the sun are not in a state of inflammation or of ejecting light, like the external part or luminous ocean which covers it; and hence that a greater degree of heat or inflammation and consequent expansion or explosion may occasionally be produced in its internal or dark nucleus. 2. Because the solar spots or cavities are frequently increased or diminished in size. 3. New ones are often produced. 4. And old ones vanish. 5. Because there are brighter or more luminous parts of the sun's disk, called faculae by Scheiner and Hevelius, which would seem to be volcanos in the sun, or, as Dr. Wilson calls them, "eructations of matter more luminous than that which covers the sun's surface." 6. To which may be added that all the planets added together with their satellites do not amount to more than one six hundred and fiftieth part of the mass of the sun according to Sir Isaac Newton.

Now if it could be supposed that the planets were originally thrown out of the sun by larger sun-quakes than those frequent ones which occasion these spots or excavations above-mentioned, what would happen? 1. According to the observations and opinion of Mr. Herschel the sun itself and all its planets are moving forwards round some other centre with an unknown velocity, which may be of opake matter corresponding with the very antient and general idea of a chaos. Whence if a ponderous planet, as Saturn, could be supposed to be projected from the sun by an explosion, the motion of the sun itself might be at the same time disturbed in such a manner as to prevent the planet from falling again into it. 2. As the sun revolves round its own axis its form must be that of an oblate spheroid like the earth, and therefore a body projected from its surface perpendicularly upwards from that surface would not rise perpendicularly from the sun's centre, unless it happened to be projected exactly from either of its poles or from its equator. Whence it may not be necessary that a planet if thus projected from the sun by explosion should again fall into the sun. 3. They would part from the sun's surface with the velocity with which that surface was moving, and with the velocity acquired by the explosion, and would therefore move round the sun in the same direction in which the sun rotates on its axis, and perform eliptic orbits. 4. All the planets would move the same way round the sun, from this first motion acquired at leaving its surface, but their orbits would be inclined to each other according to the distance of the part, where they were thrown out, from the sun's equator. Hence those which were ejected near the sun's equator would have orbits but little inclined to each other, as the primary planets; the plain of all whose orbits are inclined but seven degrees and a half from each other. Others which were ejected near the sun's poles would have much more eccentric orbits, as they would partake so much less of the sun's rotatory motion at the time they parted from his surface, and would therefore be carried further from the sun by the velocity they had gained by the explosion which ejected them, and become comets. 5. They would all obey the same laws of motion in their revolutions round the sun; this has been determined by astronomers, who have demonstrated that they move through equal areas in equal times. 6. As their annual periods would depend on the height they rose by the explosion, these would differ in them all. 7. As their diurnal revolutions would depend on one side of the exploded matter adhering more than the other at the time it was torn off by the explosion, these would also differ in the different planets, and not bear any proportion to their annual periods. Now as all these circumstances coincide with the known laws of the planetary system, they serve to strengthen this conjecture.

This coincidence of such a variety of circumstances induced M. de Buffon to suppose that the planets were all struck off from the sun's surface by the impact of a large comet, such as approached so near the sun's disk, and with such amazing velocity, in the year 1680, and is expected to return in 2255. But Mr. Buffon did not recollect that these comets themselves are only planets with more eccentric orbits, and that therefore it must be asked, what had previously struck off these comets from the sun's body? 2. That if all these planets were struck off from the sun at the same time, they must have been so near as to have attracted each other and have formed one mass: 3. That we shall want new causes for separating the secondary planets from the primary ones, and must therefore look out for some other agent, as it does not appear how the impulse of a comet could have made one planet roll round another at the time they both of them were driven off from the surface of the sun.

If it should be asked, why new planets are not frequently ejected from the sun? it may be answered, that after many large earthquakes many vents are left for the elastic vapours to escape, and hence, by the present appearance of the surface of our earth, earthquakes prodigiously larger than any recorded

in history have existed; the same circumstances may have affected the sun, on whose surface there are appearances of volcanos, as described above. Add to this, that some of the comets, and even the georgium sidus, may, for ought we know to the contrary, have been emitted from the sun in more modern days, and have been diverted from their course, and thus prevented from returning into the sun, by their approach to some of the older planets, which is somewhat countenanced by the opinion several philosophers have maintained, that the quantity of matter of the sun has decreased. Dr. Halley observed, that by comparing the proportion which the periodical time of the moon bore to that of the sun in former times, with the proportion between them at present, that the moon is found to be somewhat accelerated in respect to the sun. Pemberton's View of Sir Isaac Newton, p. 247. And so large is the body of this mighty luminary, that all the planets thus thrown out of it would make scarcely any perceptible diminution of it, as mentioned above. The cavity mentioned above, as measured by Dr. Wilson of 4000 miles in depth, not penetrating an hundredth part of the sun's semi-diameter; and yet, as its width was many times greater than its depth, was large enough to contain a greater body than our terrestrial world.

I do not mean to conceal, that from the laws of gravity unfolded by Sir Isaac Newton, supposing the sun to be a sphere and to have no progressive motion, and not liable itself to be disturbed by the supposed projection of the planets from it, that such planets must return into the sun. The late Rev. William Ludlam, of Leicester, whose genius never met with reward equal to its merits, in a letter to me, dated January, 1787, after having shewn, as mentioned above, that planets so projected from the sun would return to it, adds, "That a body as large as the moon so projected, would disturb the motion of the earth in its orbit, is certain; but the calculation of such disturbing forces is difficult. The body in some circumstances might become a satellite, and both move round their common centre of gravity, and that centre be carried in an annual orbit round the sun."

There are other circumstances which might have concurred at the time of such supposed explosions, which would render this idea not impossible. 1. The planets might be thrown out of the sun at the time the sun itself was rising from chaos, and be attracted by other suns in their vicinity rising at the same time out of chaos, which would prevent them from returning into the sun. 2. The new planet in its course or ascent from the sun, might explode and eject a satellite, or perhaps more than one, and thus by its course being affected might not return into the sun. 3. If more planets were ejected at the same time from the sun, they might attract and disturb each others course at the time they left the body of the sun, or very soon afterwards, when they would be so much nearer each other.

NOTE XVI.—CALCAREOUS EARTH.

While Ocean wrap'd it in his azure robe.

CANTO II. l. 34.

From having observed that many of the highest mountains of the world consist of lime-stone replete with shells, and that these mountains bear the marks of having been lifted up by subterraneous fires from the interior parts of the globe; and as lime-stone replete with shells is found at the bottom of many of our deepest mines some philosophers have concluded that the nucleus of the earth was for many ages covered with water which was peopled with its adapted animals; that the shells and bones of these animals in a long series of time produced solid strata in the ocean surrounding the original nucleus.

These strata consist of the accumulated exuviae of shell-fish, the animals perished age after age but their shells remained, and in progression of time produced the amazing quantities of lime-stone which almost cover the earth. Other marine animals called coralloids raised walls and even mountains by the congeries of their calcareous habitations, these perpendicular corralline rocks make some parts of the Southern Ocean highly dangerous, as appears in the journals of Capt. Cook. From contemplating the immense strata of lime-stone, both in respect to their extent and thickness, formed from these shells of animals, philosophers have been led to conclude that much of the water of the sea has been converted into calcareous earth by passing through their organs of digestion. The formation of calcareous earth seems more particularly to be an animal process as the formation of clay belongs to the vegetable economy; thus the shells of crabs and other testaceous fish are annually reproduced from the mucous membrane beneath them; the shells of eggs are first a mucous membrane, and the calculi of the kidneys and those found in all other parts of our system which sometimes contain calcareous earth, seem to originate from inflamed membranes; the bones themselves consist of calcareous earth united

with the phosphoric or animal acid, which may be separated by dissolving the ashes of calcined bones in the nitrous acid; the various secretions of animals, as their saliva and urine, abound likewise with calcareous earth, as appears by the incrustations about the teeth and the sediments of urine. It is probable that animal mucus is a previous process towards the formation of calcareous earth; and that all the calcareous earth in the world which is seen in lime-stones, marbles, spars, alabasters, marls, (which make up the greatest part of the earth's crust, as far as it has yet been penetrated,) have been formed originally by animal and vegetable bodies from the mass of water, and that by these means the solid part of the terraqueous globe has perpetually been in an increasing state and the water perpetually in a decreasing one.

After the mountains of shells and other recrements of aquatic animals were elevated above the water the upper heaps of them were gradually dissolved by rains and dews and oozing through were either perfectly crystallized in smaller cavities and formed calcareous spar, or were imperfectly crystallized on the roofs of larger cavities and produced stalactes; or mixing with other undissolved shells beneath them formed marbles, which were more or less crystallized and more or less pure; or lastly, after being dissolved, the water was exhaled from them in such a manner that the external parts became solid, and forming an arch prevented the internal parts from approaching each other so near as to become solid, and thus chalk was produced. I have specimens of chalk formed at the root of several stalactites, and in their central parts; and of other stalactites which are hollow like quills from a similar cause, viz. from the external part of the stalactite hardening first by its evaporation, and thus either attracting the internal dissolved particles to the crust, or preventing them from approaching each other so as to form a solid body. Of these I saw many hanging from the arched roof of a cellar under the high street in Edinburgh.

If this dissolved limestone met with vitriolic acid it was converted into alabaster, parting at the same time with its fixable air. If it met with the fluor acid it became fluor; if with the siliceous acid, flint; and when mixed with clay and sand, or either of them, acquires the name of marl. And under one or other of these forms composes a great part of the solid globe of the earth.

Another mode in which limestone appears is in the form of round granulated particles, but slightly cohering together; of this kind a bed extends over Lincoln heath, perhaps twenty miles long by ten wide. The form of this calcareous sand, its angles having been rubbed off, and the flatness of its bed, evinces that that part of the country was so formed under water, the particles of sand having thus been rounded, like all other rounded pebbles. This round form of calcareous sand and of other larger pebbles is produced under water, partly by their being more or less soluble in water, and hence the angular parts become dissolved, first, by their exposing a larger surface to the action of the menstruum, and secondly, from their attrition against each other by the streams or tides, for a great length of time, successively as they were collected, and perhaps when some of them had not acquired their hardest state.

This calcareous sand has generally been called ketton-stone and believed to resemble the spawn of fish, it has acquired a form so much rounder than siliceous sand from its being of so much softer a texture and also much more soluble in water. There are other soft calcareous stones called tupha which are deposited from water on mosses, as at Matlock, from which moss it is probable the water may receive something which induces it the readier to part with its earth.

In some lime-stones the living animals seem to have been buried as well as their shells during some great convulsion of nature, these shells contain a black coaly substance within them, in others some phlogiston or volatile alcali from the bodies of the dead animals remains mixed with the stone, which is then called liver-stone as it emits a sulphurous smell on being struck, and there is a stratum about six inches thick extends a considerable way over the iron ore at Wingerworth near Chesterfield in Derbyshire which seems evidently to have been formed from the shells of fresh-water muscles.

There is however another source of calcareous earth besides the aquatic one above described and that is from the recrements of land animals and vegetables as found in marls, which consist of various mixtures of calcareous earth, sand, and clay, all of them perhaps principally from vegetable origin.

Dr. Hutton is of opinion that the rocks of marble have been softened by fire into a fluid mass, which he thinks under immense pressure might be done without the escape of their carbonic acid or fixed air. Edinb. Transact. Vol. I. If this ingenious idea be allowed it might account for the purity of some white marbles, as during their fluid state there might be time for their partial impurities, whether from the bodies of the animals which produced the shells or from other extraneous matter, either to sublime to the uppermost part of the stratum or to subside to the lowermost part of it. As a confirmation of this theory of Dr. Hutton's it may be added that some calcareous stones are found mixed with lime, and have thence lost a part of their fixed air or carbonic gas, as the bath-stone, and on that account hardens on being exposed to the air, and mixed with sulphur produces calcareous liver of sulphur. Falconer on

Bath-water. Vol. I. p. 156. and p. 257. Mr. Monnet found lime in powder in the mountains of Auvergne, and suspected it of volcanic origin. Kirwan's Min. p. 22.

NOTE XVII.—MORASSES.

> *Gnomes! you then taught transuding dews to pass Through time-fallen woods, and root-inwove morass*.

CANTO II. l. 115.

Where woods have repeatedly grown and perished morasses are in process of time produced, and by their long roots fill up the interstices till the whole becomes for many yards deep a mass of vegetation. This fact is curiously verified by an account given many years ago by the Earl of Cromartie, of which the following is a short abstract.

In the year 1651 the EARL OF CROMARTIE being then nineteen years of age saw a plain in the parish of Lockburn covered over with a firm standing wood, which was so old that not only the trees had no green leaves upon them but the bark was totally thrown off, which he was there informed by the old countrymen was the universal manner in which fir-woods terminated, and that in twenty or thirty years the trees would cast themselves up by the roots. About fifteen years after he had occasion to travel the same way and observed that there was not a tree nor the appearance of a root of any of them; but in their place the whole plain where the wood stood was covered with a flat green moss or morass, and on asking the country people what was become of the wood he was informed that no one had been at the trouble to carry it away, but that it had all been overturned by the wind, that the trees lay thick over each other, and that the moss or bog had overgrown the whole timber, which they added was occasioned by the moisture which came down from the high hills above it and stagnated upon the plain, and that nobody could yet pass over it, which however his Lordship was so incautious as to attempt and slipt up to the arm-pits. Before the year 1699 that whole piece of ground was become a solid moss wherein the peasants then dug turf or peat, which however was not yet of the best sort. Philos. Trans. No. 330. Abridg. Vol. V. p. 272.

Morasses in great length of time undergo variety of changes, first by elutriation, and afterwards by fermentation, and the consequent heat. 1. By water perpetually oozing through them the most soluble parts are first washed away, as the essential salts, these together with the salts from animal recrements are carried down the rivers into the sea, where all of them seem to decompose each other except the marine salt. Hence the ashes of peat contain little or no vegetable alcali and are not used in the countries, where peat constitutes the fuel of the lower people, for the purpose of washing linen. The second thing which is always seen oozing from morasses is iron in solution, which produces chalybeate springs, from whence depositions of ochre and variety of iron ores. The third elutriation seems to consist of vegetable acid, which by means unknown appears to be converted into all other acids. 1. Into marine and nitrous acids as mentioned above. 2. Into vitriolic acid which is found in some morasses so plentifully as to preserve the bodies of animals from putrefaction which have been buried in them, and this acid carried away by rain and dews and meeting with calcareous earth produces gypsum or alabaster, with clay it produces alum, and deprived of its vital air produces sulphur. 3. Fluor acid which being washed away and meeting with calcareous earth produces fluor or cubic spar. 4. The siliceous acid which seems to have been disseminated in great quantity either by solution in water or by solution in air, and appears to have produced the sand in the sea uniting with calcareous earth previously dissolved in that element, from which were afterwards formed some of the grit- stone rocks by means of a siliceous or calcareous cement. By its union with the calcareous earth of the morass other strata of siliceous sand have been produced; and by the mixture of this with clay and lime arose the beds of marl.

In other circumstances, probably where less moisture has prevailed, morasses seem to have undergone a fermentation, as other vegetable matter, new hay for instance is liable to do from the great quantity of sugar it contains. From the great heat thus produced in the lower parts of immense beds of morass the phlogistic part, or oil, or asphaltum, becomes distilled, and rising into higher strata becomes again condensed forming coal-beds of greater or less purity according to their greater or less quantity of inflammable matter; at the same time the clay beds become purer or less so, as the phlogistic part is more or less completely exhaled from them. Though coal and clay are frequently produced in this manner, yet I have no doubt, but that they are likewise often produced by elutriation;

in situations on declivities the clay is washed away down into the valleys, and the phlogistic part or coal left behind; this circumstance is seen in many valleys near the beds of rivers, which are covered recently by a whitish impure clay, called water-clay. See note XIX. XX. and XXIII.

LORD CROMARTIE has furnished another curious observation on morasses in the paper above referred to. In a moss near the town of Eglin in Murray, though there is no river or water which communicates with the moss, yet for three or four feet of depth in the moss there are little shell-fish resembling oysters with living fish in them in great quantities, though no such fish are found in the adjacent rivers, nor even in the water pits in the moss, but only in the solid substance of the moss. This curious fact not only accounts for the shells sometimes found on the surface of coals, and in the clay above them; but also for a thin stratum of shells which sometimes exists over iron-ore.

NOTE XVIII.—IRON.

Cold waves, immerged, the glowing mass congeal, And turn to adamant the hissing Steel.

CANTO II. l. 191.

As iron is formed near the surface of the earth, it becomes exposed to streams of water and of air more than most other metallic bodies, and thence becomes combined with oxygene, or vital air, and appears very frequently in its calciform state, as in variety of ochres. Manganese, and zinc, and sometimes lead, are also found near the surface of the earth, and on that account become combined with vital air and are exhibited in their calciform state.

The avidity with which iron unites with oxygene, or vital air, in which process much heat is given out from the combining materials, is shewn by a curious experiment of M. Ingenhouz. A fine iron wire twisted spirally is fixed to a cork, on the point of the spire is fixed a match made of agaric dipped in solution of nitre; the match is then ignited, and the wire with the cork put immediately into a bottle full of vital air, the match first burns vividly, and the iron soon takes fire and consumes with brilliant sparks till it is reduced to small brittle globules, gaining an addition of about one third of its weight by its union, with vital air. Annales de Chymie. Traité de Chimie, per Lavoisier, c. iii.

STEEL.

It is probably owing to a total deprivation of vital air which it holds with so great avidity, that iron on being kept many hours or days in ignited charcoal becomes converted into steel, and thence acquires the faculty of being welded when red hot long before it melts, and also the power of becoming hard when immersed in cold water; both which I suppose depend on the same cause, that is, on its being a worse conductor of heat than other metals; and hence the surface both acquires heat much sooner, and loses it much sooner, than the internal parts of it, in this circumstance resembling glass.

When steel is made very hot, and suddenly immerged in very cold water, and moved about in it, the surface of the steel becomes cooled first, and thus producing a kind of case or arch over the internal part, prevents that internal part from contracting quite so much as it otherwise would do, whence it becomes brittler and harder, like the glass-drops called Prince Rupert's drops, which are made by dropping melted glass into cold water. This idea is countenanced by the circumstance that hardened steel is specifically lighter than steel which is more gradually cooled. (Nicholson's Chemistry, p. 313.) Why the brittleness and hardness of steel or glass should keep pace or be companions to each other may be difficult to conceive.

When a steel spring is forcibly bent till it break, it requires less power to bend it through the first inch than the second, and less through the second than the third; the same I suppose to happen if a wire be distended till it break by hanging weights to it; this shews that the particles may be forced from each other to a small distance by less power, than is necessary to make them recede to a greater distance; in this circumstance perhaps the attraction of cohesion differs from that of gravitation, which exerts its power inversely as the squares of the distance. Hence it appears that if the innermost particles of a steel bar, by cooling the external surface first, are kept from approaching each other so nearly as they otherwise would do, that they become in the situation of the particles on the convex side of a bent spring, and can not be forced further from each other except by a greater power than would have been necessary to have made them recede thus far. And secondly, that if they be forced a little

further from each other they separate; this may be exemplified by laying two magnetic needles parallel to each other, the contrary poles together, then drawing them longitudinally from each other, they will slide with small force till they begin to separate, and will then require a stronger force to really separate them. Hence it appears, that hardness and brittleness depend on the same circumstance, that the particles are removed to a greater distance from each other and thus resist any power more forcibly which is applied to displace them further, this constitutes hardness. And secondly, if they are displaced by such applied force they immediately separate, and this constitutes brittleness.

Steel may be thus rendered too brittle for many purposes, on which account artists have means of softening it again, by exposing it to certain degrees of heat, for the construction of different kinds of tools, which is called tempering it. Some artists plunge large tools in very cold water as soon as they are compleatly ignited, and moving it about, take it out as soon as it ceases to be luminous beneath the water; it is then rubbed quickly with a file or on sand to clean the surface, the heat which the metal still retains soon begins to produce a succession of colours; if a hard temper be required, the piece is dipped again and stirred about in cold water as soon as the yellow tinge appears, if it be cooled when the purple tinge appears it becomes fit for gravers' tools used in working upon metals; if cooled while blue it is proper for springs. Nicholson's Chemistry, p. 313. Keir's Chemical Dictionary.

MODERN PRODUCTION OF IRON.

The recent production of iron is evinced from the chalybeate waters which flow from morasses which lie upon gravel-beds, and which must therefore have produced iron after those gravel-beds were raised out of the sea. On the south side of the road between Cheadle and Okeymoor in Staffordshire, yellow stains of iron are seen to penetrate the gravel from a thin morass on its surface. There is a fissure eight or ten feet wide, in a gravel-bed on the eastern side of the hollow road ascending the hill about a mile from Trentham in Staffordshire, leading toward Drayton in Shropshire, which fissure is filled up with nodules of iron- ore. A bank of sods is now raised against this fissure to prevent the loose iron nodules from falling into the turnpike road, and thus this natural curiosity is at present concealed from travellers. A similar fissure in a bed of marl, and filled up with iron nodules and with some large pieces of flint, is seen on the eastern side of the hollow road ascending the hill from the turnpike house about a mile from Derby in the road towards Burton. And another such fissure filled with iron nodes, appears about half a mile from Newton-Solney in Derbyshire, in the road to Burton, near the summit of the hill. These collections of iron and of flint must have been produced posterior to the elevation of all those hills, and were thence evidently of vegetable or animal origin. To which should be added, that iron is found in general in beds either near the surface of the earth, or stratified with clay coals or argillaceous grit, which are themselves productions of the modern world, that is, from the recrements of vegetables and air-breathing animals.

Not only iron but manganese, calamy, and even copper and lead appear in some instances to have been of recent production. Iron and manganese are detected in all vegetable productions, and it is probable other metallic bodies might be found to exist in vegetable or animal matters, if we had tests to detect them in very minute quantities. Manganese and calamy are found in beds like iron near the surface of the earth, and in a calciform state, which countenances their modern production. The recent production of calamy, one of the ores of zinc, appears from its frequently incrusting calcareous spar in its descent from the surface of the earth into the uppermost fissures of the limestone mountains of Derbyshire. That the calamy has been carried by its solution or diffusion in water into these cavities, and not by its ascent from below in form of steam, is evinced from its not only forming a crust over the dogtooth spar, but by its afterwards dissolving or destroying the sparry crystal. I have specimens of calamy in the form of dogtooth spar, two inches high, which are hollow, and stand half an inch above the diminished sparry crystal on which they were formed, like a sheath a great deal too big for it; this seems to shew, that this process was carried on in water, otherwise after the calamy had incrusted its spar, and dissolved its surface, so as to form a hollow cavern over it, it could not act further upon it except by the interposition of some medium. As these spars and calamy are formed in the fissures of mountains they must both have been formed after the elevation of those mountains.

In respect to the recent production of copper, it was before observed in note on Canto II. l. 394, that the summit of the grit-stone mountain at Hawkstone in Shropshire, is tinged with copper, which from the appearance of the blue stains seems to have descended to the parts of the rock beneath. I have a calciform ore of copper consisting of the hollow crusts of cubic cells, which has evidently been formed on crystals of fluor, which it has eroded in the same manner as the calamy erodes the calcareous crystals, from whence may be deduced in the same manner, the aqueous solution or diffusion, as well as the recent production of this calciform ore of copper.

Lead in small quantities is sometimes found in the fissures of coal- beds, which fissures are previously covered with spar; and sometimes in nodules of iron-ore. Of the former I have a specimen from near

Caulk in Derbyshire, and of the latter from Colebrook Dale in Shropshire. Though all these facts shew that some metallic bodies are formed from vegetable or animal recrements, as iron, and perhaps manganese and calamy, all which are found near the surface of the earth; yet as the other metals are found only in fissures of rocks, which penetrate to unknown depths, they may be wholly or in part produced by ascending steams from subterraneous fires, as mentioned in note on Canto II. l. 398.

SEPTARIA OF IRON-STONE.

Over some lime works at Walsall in Staffordshire, I observed some years ago a stratum of iron earth about six inches thick, full of very large cavities; these cavities were evidently produced when the material passed from a semifluid state into a solid one; as the frit of the potters, or a mixture of clay and water is liable to crack in drying; which is owing to the further contraction of the internal part, after the crust is become hard. These hollows are liable to receive extraneous matter, as I believe gypsum, and sometimes spar, and even lead; a curious specimen of the last was presented to me by Mr. Darby of Colebrook Dale, which contains in its cavity some ounces of lead-ore. But there are other septaria of iron-stone which seem to have had a very different origin, their cavities having been formed in cooling or congealing from an ignited state, as is ingeniously deduced by Dr. Hutton from their internal structure. Edinb. Transact. Vol. I. p. 246. The volcanic origin of these curious septaria appears to me to be further evinced from their form and the places where they are found. They consist of oblate spheroids and are found in many parts of the earth totally detached from the beds in which they lie, as at East Lothian in Scotland. Two of these, which now lie before me, were found with many others immersed in argillaceous shale or shiver, surrounded by broken limestone mountains at Bradbourn near Ashbourn in Derbyshire, and were presented to me by Mr. Buxton, a gentleman of that town. One of these is about fifteen inches in its equatorial diameter, and about six inches in its polar one, and contains beautiful star-like septaria incrusted and in part filled with calcareous spar. The other is about eight inches in its equatorial diameter, and about four inches in its polar diameter, and is quite solid, but shews on its internal surface marks of different colours, as if a beginning separation had taken place. Now as these septaria contain fifty per cent, of iron, according to Dr. Hutton, they would soften or melt into a semifluid globule by subterraneous fire by less heat than the limestone in their vicinity; and if they were ejected through a hole or fissure would gain a circular motion along with their progressive one by their greater friction or adhesion to one side of the hole. This whirling motion would produce the oblate spheroidical form which they possess, and which as far as I know can not in any other way be accounted for. They would then harden in the air as they rose into the colder parts of the atmosphere; and as they descended into so soft a material as shale or shiver, their forms would not be injured in their fall; and their presence in materials so different from themselves becomes accounted for.

About the tropics of the large septarium above mentioned, are circular eminent lines, such as might have been left if it had been coarsely turned in a lathe. These lines seem to consist of a fluid matter, which seems to have exsuded in circular zones, as their edges appear blunted or retracted; and the septarium seems to have split easier in such sections parallel to its equator. Now as the crust would first begin to cool and harden after its ejection in a semifluid state, and the equatorial diameter would become gradually enlarged as it rose in the air; the internal parts being softer would slide beneath the polar crust, which might crack and permit part of the semifluid to exsude, and it is probable the adhesion would thus become less in sections parallel to the equator. Which further confirms this idea of the production of these curious septaria. A new-cast cannon ball red-hot with its crust only solid, if it were shot into the air would probably burst in its passage; as it would consist of a more fluid material than these septaria; and thus by discharging a shower of liquid iron would produce more dreadful combustion, if used in war, than could be effected by a ball, which had been cooled and was heated again: since in the latter case the ball could not have its internal parts made hotter than the crust of it, without first loosing its form.

NOTE XIX.—FLINT.

Transmute to glittering flints her chalky lands, Or sink on Ocean's bed in countless sands.

CANTO II. l. 217.

1. SILICEOUS ROCKS.

The great masses of siliceous sand which lie in rocks upon the beds of limestone, or which are stratified with clay, coal, and iron-ore, are evidently produced in the decomposition of vegetable or animal matters, as explained in the note on morasses. Hence the impressions of vegetable roots and even whole trees are often found in sand-stone, as well as in coals and iron-ore. In these sand-rocks both the siliceous acid and the calcareous base seem to be produced from the materials of the morass; for though the presence of a siliceous acid and of a calcareous base have not yet been separately exhibited from flints, yet from the analogy of flint to fluor, and gypsum, and marble, and from the conversion of the latter into flint, there can be little doubt of their existence.

These siliceous sand-rocks are either held together by a siliceous cement, or have a greater or less portion of clay in them, which in some acts as a cement to the siliceous crystals, but in others is in such great abundance that in burning them they become an imperfect porcelain and are then used to repair the roads, as at Chesterfield in Derbyshire; these are called argillaceous grit by Mr. Kirwan. In other places a calcareous matter cements the crystals together; and in other places the siliceous crystals lie in loose strata under the marl in the form of white sand; as at Normington about a mile from Derby.

The lowest beds of siliceous sand-stone produced from morasses seem to obtain their acid from the morass, and their calcareous base from the limestone on which it rests; These beds possess a siliceous cement, and from their greater purity and hardness are used for course grinding- stones and scyth stones, and are situated on the edges of limestone countries, having lost the other strata of coals, or clay, or iron, which were originally produced above them. Such are the sand-rocks incumbent on limestone near Matlock in Derbyshire. As these siliceous sand-rocks contain no marine productions scattered amongst them, they appear to have been elevated, torn to pieces, and many fragments of them scattered over the adjacent country by explosions, from fires within the morass from which they have been formed; and which dissipated every thing inflammable above and beneath them, except some stains of iron, with which they are in some places spotted. If these sand-rocks had been accumulated beneath the sea, and elevated along with the beds of limestone on which they rest, some vestiges of marine shells either in their siliceous or calcareous state must have been discerned amongst them.

2. SILICEOUS TREES.

In many of these sand-rocks are found the impressions of vegetable roots, which seem to have been the most unchangeable parts of the plant, as shells and shark's teeth are found in chalk-beds from their being the most unchangeable parts of the animal. In other instances the wood itself is penetrated, and whole trees converted into flint; specimens of which I have by me, from near Coventry, and from a gravel-pit in Shropshire near Child's Archal in the road to Drayton. Other polished specimens of vegetable flints abound in the cabinets of the curious, which evidently shew the concentric circles of woody fibres, and their interstices filled with whiter siliceous matter, with the branching off of the knots when cut horizontally, and the parallel lines of wood when cut longitudinally, with uncommon beauty and variety. Of these I possess some beautiful specimens, which were presented to me by the Earl of Uxbridge.

The colours of these siliceous vegetables are generally brown, from the iron, I suppose, or manganese, which induced them to crystallize or to fuse more easily. Some of the cracks of the wood in drying are filled with white flint or calcedony, and others of them remain hollow, lined with innumerable small crystals tinged with iron, which I suppose had a share in converting their calcareous matter into siliceous crystals, because the crystals called Peak-diamonds are always found bedded in an ochreous earth; and those called Bristol-stones are situated on limestone coloured with iron. Mr. F. French presented me with a congeries of siliceous crystals, which he gathered on the crater (as he supposes) of an extinguished volcano at Cromach Water in Cumberland. The crystals are about an inch high in the shape of dogtooth or calcareous spar, covered with a dark ferruginous matter. The bed on which they rest is about an inch in thickness, and is stained with iron on its undersurface. This curious fossil shews the transmutation of calcareous earth into siliceous, as much as the siliceous shells which abound in the cabinets of the curious. There may sometime be discovered in this age of science, a method of thus impregnating wood with liquid flint, which would produce pillars for the support, and tiles for the covering of houses, which would be uninflammable and endure as long as the earth beneath them.

That some siliceous productions have been in a fluid state without much heat at the time of their formation appears from the vegetable flints above described not having quite lost their organized appearance; from shells, and coralloids, and entrochi being converted into flint without loosing their form; from the bason of calcedony round Giesar in Iceland; and from the experiment of Mr. Bergman, who obtained thirteen regular formed crystals by suffering the powder of quartz to remain in a vessel

with fluor acid for two years; these crystals were about the size of small peas, and were not so hard as quartz. Opusc. de Terrâ Siliceâ, p. 33. Mr. Achard procured both calcareous and siliceous crystals, one from calcareous earth, and the other from the earth of alum, both dissolved in water impregnated with fixed air; the water filtrating very slowly through a porous bottom of baked clay. See Journal de Physique, for January, 1778.

3. AGATES, ONYXES, SCOTS-PEBBLES.

In small cavities of these sand-rocks, I am informed, the beautiful siliceous nodules are found which are called Scot's-pebbles; and which on being cut in different directions take the names of agates, onyxes, sardonyxes, &c. according to the colours of the lines or strata which they exhibit. Some of the nodules are hollow and filled with crystals, others have a nucleus of less compact siliceous matter which is generally white, surrounded with many concentric strata coloured with iron, and other alternate strata of white agate or calcedony, sometimes to the number of thirty.

I think these nodules bear evident marks of their having been in perfect fusion by either heat alone, or by water and heat, under great pressure, according to the ingenious theory of Dr. Hutton; but I do not imagine, that they were injected into cavities from materials from without, but that some vegetables or parts of vegetables containing more iron or manganese than others, facilitated the compleat fusion, thus destroying the vestiges of vegetable organization, which were conspicuous in the siliceous trees above mentioned. Some of these nodules being hollow and lined with crystals, and others containing a nucleus of white siliceous matter of a looser texture, shew they were composed of the materials then existing in the cavity; which consisting before of loose sand, must take up less space when fused into a solid mass.

These siliceous nodules resemble the nodules of iron-stone mentioned in note on Canto II. l. 183, in respect to their possessing a great number of concentric spheres coloured generally with iron, but they differ in this circumstance, that the concentric spheres generally obey the form of the external crust, and in their not possessing a chalybeate nucleus. The stalactites formed on the roofs of caverns are often coloured in concentric strata, by their coats being spread over each other at different times; and some of them, as the cupreous ones, possess great beauty from this formation; but as these are necessarily more or less of a cylindrical or conic form, the nodules or globular flints above described cannot have been constructed in this manner. To what law of nature then is to be referred the production of such numerous concentric spheres? I suspect to the law of congelation.

When salt and water are exposed to severe frosty air, the salt is said to be precipitated as the water freezes; that is, as the heat, in which it was dissolved, is withdrawn; where the experiment is tried in a bowl or bason, this may be true, as the surface freezes first, and the salt is found at the bottom. But in a fluid exposed in a thin phial, I found by experiment, that the extraneous matter previously dissolved by the heat in the mixture was not simply set at liberty to subside, but was detruded or pushed backward as the ice was produced. The experiment was this: about two ounces of a solution of blue vitriol were accidentally frozen in a thin phial, the glass was cracked and fallen to pieces, the ice was dissolved, and I found a pillar of blue vitriol standing erect on the bottom of the broken bottle. Nor is this power of congelation more extraordinary, than that by its powerful and sudden expansion it should burst iron shells and coehorns, or throw out the plugs with which the water was secured in them above one hundred and thirty yards, according to the experiments at Quebec by Major Williams. Edinb. Transact. Vol. II. p. 23.

In some siliceous nodules which now lie before me, the external crust for about the tenth of an inch consists of white agate, in others it is much thinner, and in some much thicker; corresponding with this crust there are from twenty to thirty superincumbent strata, of alternately darker and lighter colour; whence it appears, that the external crust as it cooled or froze, propelled from it the iron or manganese which was dissolved in it; this receded till it had formed an arch or vault strong enough to resist its further protrusion; then the next inner sphere or stratum as it cooled or froze, propelled forwards its colouring matter in the same manner, till another arch or sphere produced sufficient resistance to this frigoriscent expulsion. Some of them have detruded their colouring matter quite to the centre, the rings continuing to become darker as they are nearer it; in others the chalybeate arch seems to have stopped half an inch from the centre, and become thicker by having attracted to itself the irony matter from the white nucleus, owing probably to its cooling less precipitately in the central parts than at the surface of the pebble.

A similar detrusion of a marly matter in circular arches or vaults obtains in the salt mines in Cheshire; from whence Dr. Hutton very ingeniously concludes, that the salt must have been liquified by heat; which would seem to be much confirmed by the above theory. Edinb. Transact. Vol. I. p. 244.

I cannot conclude this account of Scots-pebbles without observing that some of them on being sawed

longitudinally asunder, seem still to possess some vestiges of the cylindrical organization of vegetables; others possess a nucleus of white agate much resembling some bulbous roots with their concentric coats, or the knots in elm-roots or crab- trees; some of these I suppose were formed in the manner above explained, during the congelation of masses of melted flint and iron; others may have been formed from a vegetable nucleus, and retain some vestiges of the organization of the plant.

4. SAND OF THE SEA.

The great abundance of siliceous sand at the bottom of the ocean may in part be washed down from the siliceous rocks above described, but in general I suppose it derives its acid only from the vegetable and animal matter of morasses, which is carried down by floods or by the atmosphere, and becomes united in the sea with its calcareous base from shells and coralloids, and thus assumes its crystalline form at the bottom of the ocean, and is there intermixed with gravel or other matters washed from the mountains in its vicinity.

5. CHERT, OR PETROSILEX.

The rocks of marble are often alternately intermixed with strata of chert, or coarse flint, and this in beds from one to three feet thick, as at Ham and Matlock, or of less than the tenth of an inch in thickness, as a mile or two from Bakewell in the road to Buxton. It is difficult to conceive in what manner ten or twenty strata of either limestone or flint, of different shades of white and black, could be laid quite regularly over each other from sediments or precipitations from the sea; it appears to me much easier to comprehend, by supposing with Dr. Hutton, that both the solid rocks of marble and the flint had been fused by great heat, (or by heat and water,) under immense pressure; by its cooling or congealing the colouring matter might be detruded, and form parallel or curvilinean strata, as above explained.

The colouring matter both of limestone and flint was probably owing to the flesh of peculiar animals, as well as the siliceous acid, which converted some of the limestone into flint; or to some strata of shell-fish having been overwhelmed when alive with new materials, while others dying in their natural situations would lose their fleshy parts, either by its putrid solution in the water or by its being eaten by other sea- insects. I have some calcareous fossil shells which contain a black coaly matter in them, which was evidently the body of the animal, and others of the same kind filled with spar instead of it. The Labradore stone has I suppose its colours from the nacre or mother-pearl shells, from which it was probably produced. And there is a stratum of calcareous matter about six or eight inches thick at Wingerworth in Derbyshire over the iron-beds, which is replete with shells of fresh- water muscles, and evidently obtains its dark colour from them, as mentioned in note XVI. Many nodules of flint resemble in colour as well as in form the shell of the echinus or sea-urchin; others resemble some coralloids both in form and colour; and M. Arduini found in the Monte de Pancrasio, red flints branching like corals, from whence they seem to have obtained both their form and their colour. Ferber's Travels in Italy, p. 42.

6. NODULES OF FLINT IN CHALK-BEDS.

As the nodules of flint found in chalk-beds possess no marks of having been rounded by attrition or solution, I conclude that they have gained their form as well as their dark colour from the flesh of the shell-fish from which they had their origin; but which have been so compleatly fused by heat, or heat and water, as to obliterate all vestiges of the shell, in the same manner as the nodules of agate and onyx were produced from parts of vegetables, but which had been so completely fused as to obliterate all marks of their organization, or as many iron-nodules have obtained their form and origin from peculiar vegetables.

Some nodules in chalk-beds consist of shells of echini filled up with chalk, the animal having been dissolved away by putrescence in water, or eaten by other sea-insects; other shells of echini, in which I suppose the animal's body remained, are converted into flint but still retain the form of the shell. Others, I suppose as above, being more completely fused, have become flint coloured by the animal flesh, but without the exact form either of the flesh or shell of the animal. Many of these are hollow within and lined with crystals, like the Scot's-pebbles above described; but as the colouring matter of animal bodies differs but little from each other compared with those of vegetables, these flints vary less in their colours than those above mentioned. At the same time as they cooled in concentric spheres like the Scot's-pebbles, they often possess faint rings of colours, and always break in conchoide forms like them.

This idea of the production of nodules of flint in chalk-beds is countenanced from the iron which

generally appears as these flints become decomposed by the air; which by uniting with the iron in their composition reduces it from a vitrescent state to that of calx, and thus renders it visible. And secondly, by there being no appearance in chalk- beds of a string or pipe of siliceous matter connecting one nodule with another, which must have happened if the siliceous matter, or its acid, had been injected from without according to the idea of Dr. Hutton. And thirdly, because many of them have very large cavities at their centres, which should not have happened had they been formed by the injection of a material from without.

When shells or chalk are thus converted from calcareous to siliceous matter by the flesh of the animal, the new flint being heavier than the shell or chalk occupies less space than the materials it was produced from; this is the cause of frequent cavities within them, where the whole mass has not been completely fused and pressed together. In Derbyshire there are masses of coralloid and other shells which have become siliceous, and are thus left with large vacuities sometimes within and sometimes on the outside of the remaining form of the shell, like the French millstones, and I suppose might serve the same purpose; the gravel of the Derwent is full of specimens of this kind.

Since writing the above I have received a very ingenious account of chalk-beds from Dr. MENISH of Chelmsford. He distinguishes chalk-beds into three kinds; such as have been raised from the sea with little disturbance of their strata, as the cliffs of Dover and Margate, which he terms *intire* chalk. Another state of chalk is where it has suffered much derangement, as the banks of the Thames at Gravesend and Dartford. And a third state where fragments of chalk have been rounded by water, which he terms *alluvial* chalk. In the first of these situations of chalk he observes, that the flint lies in strata horizontally, generally in distinct nodules, but that he has observed two instances of solid plates or strata of flint, from an inch to two inches in thickness, interposed between the chalk-beds; one of these is in a chalk-bank by the road side at Berkhamstead, the other in a bank on the road from Chatham leading to Canterbury. Dr. Menish has further observed, that many of the echini are crushed in their form, and yet filled with flint, which has taken the form of the crushed shell, and that though many flint nodules are hollow, yet that in some echini the siliceum seems to have enlarged, as it passed from a fluid to a solid state, as it swells out in a protuberance at the mouth and anus of the shell, and that though these shells are so filled with flint yet that in many places the shell itself remains calcareous. These strata of nodules and plates of flint seem to countenance their origin from the flesh of a stratum of animals which perished by some natural violence, and were buried in their shells.

7. ANGLES OF SILICEOUS SAND.

In many rocks of siliceous sand the particles retain their angular form, and in some beds of loose sand, of which there is one of considerable purity a few yards beneath the marl at Normington about a mile south of Derby. Other siliceous sands have had their angles rounded off, like the pebbles in gravel-beds. These seem to owe their globular form to two causes; one to their attrition against each other, when they may for centuries have lain at the bottom of the sea, or of rivers; where they may have been progressively accumulated, and thus progressively at the same time rubbed upon each other by the dashing of the water, and where they would be more easily rolled over each other by their gravity being so much less than in air. This is evidently now going on in the river Derwent, for though there are no limestone rocks for ten or fifteen miles above Derby, yet a great part of the river-gravel at Derby consists of limestone nodules, whose angles are quite worn off in their descent down the stream.

There is however another cause which must have contributed to round the angles both of calcareous and siliceous fragments; and that is, their solubility in water; calcareous earth is perpetually found suspended in the waters which pass over it; and the earth of flints was observed by Bergman to be contained in water in the proportion of one grain to a gallon. Kirwan's Mineralogy, p. 107. In boiling water, however, it is soluble in much greater proportion, as appears from the siliceous earth sublimed in the distillation of fluor acid in glass vessels; and from the basons of calcedony which surrounded the jets of hot water near mount Heccla in Iceland. Troil on Iceland. It is probable most siliceous sands or pebbles have at some ages of the world been long exposed to aqueous steams raised by subterranean fires. And if fragments of stone were long immersed in a fluid menstrum, their angular parts would be first dissolved, on account of their greater surface.

Many beds of siliceous gravel are cemented together by a siliceous cement, and are called breccia; as the plumb-pudding stones of Hartfordshire, and the walls of a subterraneous temple excavated by Mr. Curzon, at Hagley near Rugely in Staffordfshire; these may have been exposed to great heat as they were immersed in water; which water under great pressure of superincumbent materials may have been rendered red- hot, as in Papin's digester; and have thus possessed powers of solution with which we are unacquainted.

8. BASALTES AND GRANITES.

Another source of siliceous stones is from the granite, or basaltes, or porphyries, which are of different hardnesses according to the materials of their composition, or to the fire they have undergone; such are the stones of Arthur's-hill near Edinburgh, of the Giant's Causway in Ireland, and of Charnwood Forest in Leicestershire; the uppermost stratum of which last seems to have been cracked either by its elevation, or by its hastily cooling after ignition by the contact of dews or snows, and thus breaks into angular fragments, such as the streets of London are paved with; or have had their angles rounded by attrition or by partial solution; and have thus formed the common paving stones or bowlers; as well as the gravel, which is often rolled into strata amid the siliceous sand-beds, which are either formed or collected in the sea.

In what manner such a mass of crystallized matter as the Giant's Causway and similar columns of basaltes, could have been raised without other volcanic appearances, may be a matter not easy to comprehend; but there is another power in nature besides that of expansile vapour which may have raised some materials which have previously been in igneous or aqueous solution; and that is the act of congelation. When the water in the experiments above related of Major Williams had by congelation thrown out the plugs from the bomb-shells, a column of ice rose from the hole of the bomb six or eight inches high. Other bodies I suspect increase in bulk which crystallize in cooling, as iron and type-metal. I remember pouring eight or ten pounds of melted brimstone into a pot to cool and was surprized to see after a little time a part of the fluid beneath break a hole in the congealed crust above it, and gradually rise into a promontory several inches high; the basaltes has many marks of fusion and of crystallization and may thence, as well as many other kinds of rocks, as of spar, marble, petrosilex, jasper, &c. have been raised by the power of congelation, a power whose quantity has not yet been ascertained, and perhaps greater and more universal than that of vapours expanded by heat. These basaltic columns rise sometimes out of mountains of granite itself, as mentioned by Dr. Beddoes, (Phil. Transact. Vol. LXXX.) and as they seem to consist of similar materials more completely fused, there is still greater reason to believe them to have been elevated in the cooling or crystallization of the mass. See note XXIV.

NOTE XX.—CLAY.

Whence ductile Clays in wide expansion spread, Soft as the Cygnet's down, their snow-white bed.

CANTO II. l. 277.

The philosophers, who have attended to the formation of the earth, have acknowledged two great agents in producing the various changes which the terraqueous globe has undergone, and these are water and fire. Some of them have perhaps ascribed too much to one of these great agents of nature, and some to the other. They have generally agreed that the stratification of materials could only be produced from sediments or precipitations, which were previously mixed or dissolved in the sea; and that whatever effects were produced by fire were performed afterwards.

There is however great difficulty in accounting for the universal stratification of the solid globe of the earth in this manner, since many of the materials, which appear in strata, could not have been suspended in water; as the nodules of flint in chalk-beds, the extensive beds of shells, and lastly the strata of coal, clay, sand, and iron-ore, which in most coal-countries lie from five to seven times alternately stratified over each other, and none of them are soluble in water. Add to this if a solution of them or a mixture of them in water could be supposed, the cause of that solution must cease before a precipitation could commence.

1. The great masses of lava, under the various names of granite, porphyry, toadstone, moor-stone, rag, and slate, which constitute the old world, may have acquired the stratification, which some of them appear to possess, by their having been formed by successive eruptions of a fluid mass, which at different periods of antient time arose from volcanic shafts and covered each other, the surface of the interior mass of lava would cool and become solid before the superincumbent stratum was poured over it; to the same cause may be ascribed their different compositions and textures, which are scarcely the same in any two parts of the world.

2. The stratifications of the great masses of limestone, which were produced from sea-shells, seem to have been formed by the different times at which the innumerable shells were produced and deposited. A colony of echini, or madrepores, or cornua ammonis, lived and perished in one period of time; in

another a new colony of either similar or different shells lived and died over the former ones, producing a stratum of more recent shell over a stratum of others which had began to petrify or to become marble; and thus from unknown depths to what are now the summits of mountains the limestone is disposed in strata of varying solidity and colour. These have afterwards undergone variety of changes by their solution and deposition from the water in which they were immersed, or from having been exposed to great heat under great pressure, according to the ingenious theory of Dr. Hutton. Edinb. Transact. Vol. I. See Note XVI.

3. In most of the coal-countries of this island there are from five to seven beds of coal stratified with an equal number of beds, though of much greater thickness, of clay and sandstone, and occasionally of iron- ores. In what manner to account for the stratification of these materials seems to be a problem of greater difficulty. Philosophers have generally supposed that they have been arranged by the currents of the sea; but considering their insolubility in water, and their almost similar specific gravity, an accumulation of them in such distinct beds from this cause is altogether inconceiveable, though some coal-countries bear marks of having been at some time immersed beneath the waves and raised again by subterranean fires.

The higher and lower parts of morasses were necessarily produced at different periods of time, see Note XVII. and would thus originally be formed in strata of different ages. For when an old wood perished, and produced a morass, many centuries would elapse before another wood could grow and perish again upon the same ground, which would thus produce a new stratum of morass over the other, differing indeed principally in its age, and perhaps, as the timber might be different, in the proportions of its component parts.

Now if we suppose the lowermost stratum of a morass become ignited, like fermenting hay, (after whatever could be carried away by solution in water was gone,) what would happen? Certainly the inflammable part, the oil, sulphur, or bitumen, would burn away, and be evaporated in air; and the fixed parts would be left, as clay, lime, and iron; while some of the calcareous earth would join with the siliceous acid, and produce sand, or with the argillaceous earth, and produce marl. Thence after many centuries another bed would take fire, but with less degree of ignition, and with a greater body of morass over it, what then would happen? The bitumen and sulphur would rise and might become condensed under an impervious stratum, which might not be ignited, and there form coal of different purities according to its degree of fluidity, which would permit some of the clay to subside through it into the place from which it was sublimed.

Some centuries afterwards another similar process might take place, and either thicken the coal-bed, or produce a new clay-bed, or marl, or sand, or deposit iron upon it, according to the concomitant circumstances above mentioned.

I do not mean to contend that a few masses of some materials may not have been rolled together by currents, when the mountains were much more elevated than at present, and in consequence the rivers broader and more rapid, and the storms of rain and wind greater both in quantity and force. Some gravel-beds may have been thus washed from the mountains; and some white clay washed from morasses into valleys beneath them; and some ochres of iron dissolved and again deposited by water; and some calcareous depositions from water, (as the bank for instance on which stand the houses at Matlock-bath;) but these are of small extent or consequence compared to the primitive rocks of granite or porpyhry which form the nucleus of the earth, or to the immense strata of limestone which crust over the greatest part of this granite or porphyry; or lastly to the very extensive beds of clay, marl, sandstone, coal, and iron, which were probably for many millions of years the only parts of our continents and islands, which were then elevated above the level of the sea, and which on that account became covered with vegetation, and thence acquired their later or superincumbent strata, which constitute, what some have termed, the new world.

There is another source of clay, and that of the finest kind, from decomposed granite, this is of a snowy white and mixed with mining particles of mica, of this kind is an earth from the country of Cherokees. Other kinds are from less pure lavas; Mr. Ferber asserts that the sulphurous steams from Mount Vesuvius convert the lava into clay.

"The lavas of the antient Solfatara volcano have been undoubtedly of a vitreous nature, and these appear at present argillaceous. Some fragments of this lava are but half or at one side changed into clay, which either is viscid or ductile, or hard and stoney. Clays by fire are deprived of their coherent quality, which cannot be restored to them by pulverization, nor by humectation. But the sulphureous Solfatara steams restore it, as may be easily observed on the broken pots wherein they gather the sal ammoniac; though very well baked and burnt at Naples they are mollified again by the acid steams into a viscid clay which keeps the former fire-burnt colour." Travels in Italy, p. 156.

NOTE XXI.—ENAMELS.

Smear'd her huge dragons with metallic hues, With golden purples, and cobaltic blues;

CANTO II. l. 287.

The fine bright purples or rose colours which we see on china cups are not producible with any other material except gold, manganese indeed gives a purple but of a very different kind.

In Europe the application of gold to these purposes appears to be of modern invention. Cassius's discovery of the precipitate of gold by tin, and the use of that precipitate for colouring glass and enamels, are now generally known, but though the precipitate with tin be more successful in producing the ruby glass, or the colourless glass which becomes red by subsequent ignition, the tin probably contributing to prevent the gold from separating, (which it is very liable to do during the fusion; yet, for enamels, the precipitates made by alcaline salts answer equally well, and give a finer red, the colour produced by the tin precipitate being a bluish purple, but with the others a rose red. I am informed that some of our best artists prefer aurum fulminans, mixing it, before it has become dry, with the white composition or enamel flux; when once it is divided by the other matter, it is ground with great safety, and without the least danger of explosion, whether moist or dry. The colour is remarkably improved and brought forth by long grinding, which accordingly makes an essential circumstance in the process.

The precipitates of gold, and the colcothar or other red preparations of iron, are called *tender* colours. The heat must be no greater than is just sufficient to make the enamel run upon the piece, for if greater, the colours will be destroyed or changed to a different kind. When the vitreous matter has just become fluid it seems as if the coloured metallic calx remained barely *intermixed* with it, like a coloured powder of exquisite tenuity suspended in water: but by stronger fire the calx is *dissolved*, and metallic colours are altered by *solution* in glass as well as in acids or alcalies.

The Saxon mines have till very lately almost exclusively supplied the rest of Europe with cobalt, or rather with its preparations, zaffre and smalt, for the exportation of the ore itself is there a capital crime. Hungary, Spain, Sweden, and some other parts of the continent, are now said to afford cobalts equal to the Saxon, and specimens have been discovered in our own island, both in Cornwall and in Scotland; but hitherto in no great quantity.

Calces of cobalt and of copper differ very materially from those above mentioned in their application for colouring enamels. In those the calx has previously acquired the intended colour, a colour which bears a red heat without injury, and all that remains is to fix it on the piece by a vitreous flux. But the blue colour of cobalt, and the green or bluish green of copper, are *produced* by vitrification, that is, by *solution* in the glass, and a strong fire is necessary for their perfection. These calces therefore, when mixed with the enamel flux, are melted in crucibles, once or oftener, and the deep coloured opake glass, thence resulting, is ground into unpalpable powder, and used for enamel. One part of either of these calces is put to ten, sixteen, or twenty parts of the flux, according to the depth of colour required. The heat of the enamel kiln is only a full red, such as is marked on Mr. Wedgwood's thermometer 6 degrees. It is therefore necessary that the flux be so adjusted as to melt in that low heat. The usual materials are flint, or flint-glass, with a due proportion of red-led, or borax, or both, and sometimes a little tin calx to give opacity.

Ka-o-lin is the name given by the Chinese to their porcelain clay, and *pe-tun-tse* to the other ingredient in their China ware. Specimens of both these have been brought into England, and found to agree in quality with some of our own materials. Kaolin is the very same with the clay called in Cornwall [Transcriber's note: word missing] and the petuntse is a granite similar to the Cornish moorstone. There are differences, both in the Chinese petuntses, and the English moorstones; all of them contain micaceous and quartzy particles, in greater or less quantity, along with feltspat, which last is the essential ingredient for the porcelain manufactory. The only injurious material commonly found in them is iron, which discolours the ware in proportion to its quantity, and which our moorstones are perhaps more frequently tainted with than the Chinese. Very fine porcelain has been made from English materials but the nature of the manufacture renders the process precarious and the profit hazardous; for the semivitrification, which constitutes porcelain, is necessarily accompanied with a degree of softness, or semifusion, so that the vessels are liable to have their forms altered in the kiln, or to run together with any accidental augmentations of the fire.

NOTE XXII.—PORTLAND VASE.

Or bid Mortality rejoice or mourn O'er the fine forms of Portland's mystic urn.

CANTO II. l. 319.

The celebrated funereal vase, long in possession of the Barberini family, and lately purchased by the Duke of Portland for a thousand guineas, is about ten inches high and six in diameter in the broadest part. The figures are of most exquisite workmanship in bas relief of white opake glass, raised on a ground of deep blue glass, which appears black except when held against the light. Mr. Wedgwood is of opinion from many circumstances that the figures have been made by cutting away the external crust of white opake glass, in the manner the finest cameo's have been produced, and that it must thence have been the labour of a great many years. Some antiquarians have placed the time of its production many centuries before the christian aera; as sculpture was said to have been declining in respect to its excellence in the time of Alexander the Great. See an account of the Barberini or Portland vase by M. D'Hancarville, and by Mr. Wedgwood.

Many opinions and conjectures have been published concerning the figures on this celebrated vase. Having carefully examined one of Mr. Wedgwood's beautiful copies of this wonderful production of art, I shall add one more conjecture to the number.

Mr. Wedgwood has well observed that it does not seem probable that the Portland vase was purposely made for the ashes of any particular person deceased, because many years must have been necessary for its production. Hence it may be concluded, that the subject of its embellishments is not private history but of a general nature. This subject appears to me to be well chosen, and the story to be finely told; and that it represents what in antient times engaged the attention of philosophers, poets, and heroes, I mean a part of the Eleusinian mysteries.

These mysteries were invented in Aegypt, and afterwards transferred to Greece, and flourished more particularly at Athens, which was at the same time the seat of the fine arts. They consisted of scenical exhibitions representing and inculcating the expectation of a future life after death, and on this account were encouraged by the government, insomuch that the Athenian laws punished a discovery of their secrets with death. Dr. Warburton has with great learning and ingenuity shewn that the descent of Aeneas into hell, described in the Sixth Book of Virgil, is a poetical account of the representations of the future state in the Eleusinian mysteries. Divine Legation, Vol. I. p. 210.

And though some writers have differed in opinion from Dr. Warburton on this subject, because Virgil has introduced some of his own heroes into the Elysian fields, as Deiphobus, Palinurus, and Dido, in the same manner as Homer had done before him, yet it is agreed that the received notions about a future state were exhibited in these mysteries, and as these poets described those received notions, they may be said, as far as these religious doctrines were concerned, to have described the mysteries.

Now as these were emblematic exhibitions they must have been as well adapted to the purposes of sculpture as of poetry, which indeed does not seem to have been uncommon, since one compartment of figures in the sheild of Aeneas represented the regions of Tartarus. Aen. Lib. X. The procession of torches, which according to M. De St. Croix was exhibited in these mysteries, is still to be seen in basso relievo, discovered by Spon and Wheler. Memoires sur le Mysteres par De St. Croix. 1784. And it is very probable that the beautiful gem representing the marriage of Cupid and Psyche, as described by Apuleus, was originally descriptive of another part of the exhibitions in these mysteries, though afterwards it became a common subject of antient art. See Divine Legat. Vol. I. p. 323. What subject could have been imagined so sublime for the ornaments of a funereal urn as the mortality of all things and their resuscitation? Where could the designer be supplied with emblems for this purpose, before the Christian era, but from the Eleusinian mysteries?

1. The exhibitions of the mysteries were of two kinds, those which the people were permitted to see, and those which were only shewn to the initiated. Concerning the latter, Aristides calls them "the most shocking and most ravishing representations." And Stoboeus asserts that the initiation into the grand mysteries exactly resembles death. Divine Legat. Vol. I. p. 280, and p. 272. And Virgil in his entrance to the shades below, amongst other things of terrible form, mentions death. Aen. VI. This part of the exhibition seems to be represented in one of the compartments of the Portland vase.

Three figures of exquisite workmanship are placed by the side of a ruined column whose capital is fallen off, and lies at their feet with other disjointed stones, they sit on loose piles of stone beneath a tree, which has not the leaves of any evergreen of this climate, but may be supposed to be an elm, which Virgil places near the entrance of the infernal regions, and adds, that a dream was believed to

dwell under every leaf of it. Aen. VI. l. 281. In the midst of this group reclines a female figure in a dying attitude, in which extreme languor is beautifully represented, in her hand is an inverted torch, an antient emblem of extinguished life, the elbow of the same arm resting on a stone supports her as she sinks, while the other hand is raised and thrown over her drooping head, in some measure sustaining it and gives with great art the idea of fainting lassitude. On the right of her sits a man, and on the left a woman, both supporting themselves on their arms, as people are liable to do when they are thinking intensely. They have their backs towards the dying figure, yet with their faces turned towards her, as if seriously contemplating her situation, but without stretching out their hands to assist her.

This central figure then appears to me to be an hieroglyphic or Eleusinian emblem of MORTAL LIFE, that is, the lethum, or death, mentioned by Virgil amongst the terrible things exhibited at the beginning of the mysteries. The inverted torch shews the figure to be emblematic, if it had been designed to represent a real person in the act of dying there had been no necessity for the expiring torch, as the dying figure alone would have been sufficiently intelligible;—it would have been as absurd as to have put an inverted torch into the hand of a real person at the time of his expiring. Besides if this figure had represented a real dying person would not the other figures, or one of them at least, have stretched out a hand to support her, to have eased her fall among loose stones, or to have smoothed her pillow? These circumstances evince that the figure is an emblem, and therefore could not be a representation of the private history of any particular family or event.

The man and woman on each side of the dying figure must be considered as emblems, both from their similarity of situation and dress to the middle figure, and their being grouped along with it. These I think are hieroglyphic or Eleusinian emblems of HUMANKIND, with their backs toward the dying figure of MORTAL LIFE, unwilling to associate with her, yet turning back their serious and attentive countenances, curious indeed to behold, yet sorry to contemplate their latter end. These figures bring strongly to one's mind the Adam and Eve of sacred writ, whom some have supposed to have been allegorical or hieroglyphic persons of Aegyptian origin, but of more antient date, amongst whom I think is Dr. Warburton. According to this opinion Adam and Eve were the names of two hieroglyphic figures representing the early state of mankind; Abel was the name of an hieroglyphic figure representing the age of pasturage, and Cain the name of another hieroglyphic symbol representing the age of agriculture, at which time the uses of iron were discovered. And as the people who cultivated the earth and built houses would increase in numbers much faster by their greater production of food, they would readily conquer or destroy the people who were sustained by pasturage, which was typified by Cain slaying Abel.

2. On the other compartment of this celebrated vase is exhibited an emblem of immortality, the representation of which was well known to constitute a very principal part of the shews at the Eleusinian mysteries, as Dr. Warburton has proved by variety of authority. The habitation of spirits or ghosts after death was supposed by the antients to be placed beneath the earth, where Pluto reigned, and dispensed rewards or punishments. Hence the first figure in this group is of the MANES or GHOST, who having passed through an open portal is descending into a dusky region, pointing his toe with timid and unsteady step, feeling as it were his way in the gloom. This portal Aeneas enters, which is described by Virgil,—patet atri janua ditis, Aen. VI. l. 126; as well as the easy descent,—facilis descensus Averni. Ib. The darkness at the entrance to the shades is humorously described by Lucian. Div. Legat. Vol. I. p. 241. And the horror of the gates of hell was in the time of Homer become a proverb; Achilles says to Ulysses, "I hate a liar worse than the gates of hell;" the same expression is used in Isaiah, ch. xxxviii. v. 10. The MANES or GHOST appears lingering and fearful, and wishes to drag after him a part of his mortal garment, which however adheres to the side of the portal through which he has passed. The beauty of this allegory would have been expressed by Mr. Pope, by "We feel the ruling passion strong in death."

A little lower down in the group the manes or ghost is received by a beautiful female, a symbol of IMMORTAL LIFE. This is evinced by her fondling between her knees a large and playful serpent, which from its annually renewing its external skin has from great antiquity, even as early as the fable of Prometheus, been esteemed an emblem of renovated youth. The story of the serpent acquiring immortal life from the ass of Prometheus, who carried it on his back, is told in Bacon's Works, Vol. V. p. 462. Quarto edit. Lond. 1778. For a similar purpose a serpent was wrapped round the large hieroglyphic egg in the temple of Dioscuri, as an emblem of the renewal of life from a state of death. Bryant's Mythology, Vol II. p. 359. sec. edit. On this account also the serpent was an attendant on Aesculapius, which seems to have been the name of the hieroglyphic figure of medicine. This serpent shews this figure to be an emblem, as the torch shewed the central figure of the other compartment to be an emblem, hence they agreeably correspond, and explain each other, one representing MORTAL LIFE, and the other IMMORTAL LIFE.

This emblematic figure of immortal life sits down with her feet towards the figure of Pluto, but, turning back her face towards the timid ghost, she stretches forth her hand, and taking hold of his

elbow, supports his tottering steps, as well as encourages him to advance, both which circumstances are thus with wonderful ingenuity brought to the eye. At the same time the spirit loosely lays his hand upon her arm, as one walking in the dark would naturally do for the greater certainty of following his conductress, while the general part of the symbol of IMMORTAL LIFE, being turned toward the figure of Pluto, shews that she is leading the phantom to his realms.

In the Pamphili gardens at Rome, Perseus in assisting Andromeda to descend from the rock takes hold of her elbow to steady or support her step, and she lays her hand loosely on his arm as in this figure. Admir. Roman. Antiq.

The figure of PLUTO can not be mistaken, as is agreed by most of the writers who have mentioned this vase; his grisley beard, and his having one foot buried in the earth, denotes the infernal monarch. He is placed at the lowest part of the group, and resting his chin on his hand, and his arm upon his knee, receives the stranger-spirit with inquisitive attention; it was before observed that when people think attentively they naturally rest their bodies in some easy attitude, that more animal power may be employed on the thinking faculty. In this group of figures there is great art shewn in giving an idea of a descending plain, viz. from earth to Elysium, and yet all the figures are in reality on an horizontal one. This wonderful deception is produced first by the descending step of the manes or ghost; secondly, by the arm of the sitting figure of immortal life being raised up to receive him as he descends; and lastly, by Pluto having one foot sunk into the earth.

There is yet another figure which is concerned in conducing the manes or ghost to the realms of Pluto, and this is LOVE. He precedes the descending spirit on expanded wings, lights him with his torch, and turning back his beautiful countenance beckons him to advance. The antient God of love was of much higher dignity than the modern Cupid. He was the first that came out of the great egg of night, (Hesiod. Theog. V. CXX. Bryant's Mythol. Vol. II. p. 348.) and is said to possess the keys of the sky, sea, and earth. As he therefore led the way into this life, he seems to constitute proper emblem for leading the way to a future life. See Bacon's works. Vol. I. p. 568. and Vol. III. p. 582. Quarto edit.

The introduction of love into this part of the mysteries requires a little further explanation. The Psyche of the Aegyptians was one of their most favourite emblems, and represented the soul, or a future life; it was originally no other than the aurelia, or butterfly, but in after times was represented by a lovely female child with the beautiful wings of that insect. The aurelia, after its first stage as an eruca or caterpillar, lies for a season in a manner dead, and is inclosed in a sort of coffin, in this state of darkness it remains all the winter, but at the return of spring it bursts its bonds and comes out with new life, and in the most beautiful attire. The Aegyptians thought this a very proper picture of the soul of man, and of the immortality to which it aspired. But as this was all owing to divine Love, of which EROS was an emblem, we find this person frequently introduced as a concomitant of the soul in general or Psyche. (Bryant's Mythol. Vol. II. p. 386.) EROS, or divine Love, is for the same reason a proper attendant on the manes or soul after death, and much contributes to tell the story, that is, to shew that a soul or manes is designed by the descending figure. From this figure of Love M. D'Hancarville imagines that Orpheus and Eurydice are typified under the figure of the manes and immortal life as above described. It may be sufficient to answer, first, that Orpheus is always represented with a lyre, of which there are prints of four different gems in Spence's Polymetis, and Virgil so describes him, Aen. VI. cytharâ fretus. And secondly, that it is absurd to suppose that Eurydice was fondling and playing with a serpent that had slain her. Add to this that Love seems to have been an inhabitant of the infernal regions, as exhibited in the mysteries, for Claudian, who treats more openly of the Eleusinian mysteries, when they were held in less veneration, invokes the deities to disclose to him their secrets, and amongst other things by what torch Love softens Pluto.

Dii, quibus in numerum, &c.
Vos mihi sacrarum penetralia pandite rerum,
Et vestri secreta poli, quâ lampade Ditem
Flexit amor.

In this compartment there are two trees, whose branches spread over the figures, one of them has smoother leaves like some evergreens, and might thence be supposed to have some allusion to immortality, but they may perhaps have been designed only as ornaments, or to relieve the figures, or because it was in groves, where these mysteries were originally celebrated. Thus Homer speaks of the woods of Proserpine, and mentions many trees in Tartarus, as presenting their fruits to Tantalus; Virgil speaks of the pleasant groves of Elysium; and in Spence's Polymetis there are prints of two antient gems, one of Orpheus charming Cerberus with his lyre, and the other of Hercules binding him in a cord, each of them standing by a tree. Polymet. p. 284. As however these trees have all different foliage so clearly marked by the artist, they may have had specific meanings in the exhibitions of the mysteries, which have not reached posterity, of this kind seem to have been the tree of knowledge of good and evil, and the tree of life, in sacred writ, both which must have been emblematic or allegorical.

The masks, hanging to the handles of the vase, seem to indicate that there is a concealed meaning in the figures besides their general appearance. And the priestess at the bottom, which I come now to describe, seems to shew this concealed meaning to be of the sacred or Eleusinian kind.

3. The figure on the bottom of the vase is on a larger scale than the others, and less finely finished, and less elevated, and as this bottom part was afterwards cemented to the upper part, it might be executed by another artist for the sake of expedition, but there seems no reason to suppose that it was not originally designed for the upper part of it as some have conjectured. As the mysteries of Ceres were celebrated by female priests, for Porphyrius says the antients called the priestesses of Ceres, Melissai, or bees, which were emblems of chastity. Div. Leg. Vol. I. p. 235. And as, in his Satire against the sex, Juvenal says, that few women are worthy to be priestesses of Ceres. Sat. VI. the figure at the bottom of the vase would seem to represent a PRIESTESS or HIEROPHANT, whose office it was to introduce the initiated, and point out to them, and explain the exhibitions in the mysteries, and to exclude the uninitiated, calling out to them, "Far, far retire, ye profane!" and to guard the secrets of the temple. Thus the introductory hymn sung by the hierophant, according to Eusebius, begins, "I will declare a secret to the initiated, but let the doors be shut against the profane." Div. Leg. Vol. I. p. 177. The priestess or hierophant appears in this figure with a close hood, and dressed in linen, which fits close about her; except a light cloak, which flutters in the wind. Wool, as taken from slaughtered animals, was esteemed profane by the priests of Aegypt, who were always dressed in linen. Apuleus, p. 64. Div. Leg. Vol. I. p. 318. Thus Eli made for Samuel a linen ephod. Samuel i. 3.

Secrecy was the foundation on which all mysteries rested, when publicly known they ceased to be mysteries; hence a discovery of them was not only punished with death by the Athenian law; but in other countries a disgrace attended the breach of a solemn oath. The priestess in the figure before us has her finger pointing to her lips as an emblem of silence. There is a figure of Harpocrates, who was of Aegyptian origin, the same as Orus, with the lotus on his head, and with his finger pointing to his lips not pressed upon them, in Bryant's Mythol. Vol. II. p. 398, and another female figure standing on a lotus, as if just risen from the Nile, with her finger in the same attitude, these seem to have been representations or emblems of male and female priests of the secret mysteries. As these sort of emblems were frequently changed by artists for their more elegant exhibition, it is possible the foliage over the head of this figure may bear some analogy to the lotus above mentioned.

This figure of secrecy seems to be here placed, with great ingenuity, as a caution to the initiated, who might understand the meaning of the emblems round the vase, not to divulge it. And this circumstance seems to account for there being no written explanation extant, and no tradition concerning these beautiful figures handed down to us along with them.

Another explanation of this figure at the bottom of the vase would seem to confirm the idea that the basso relievos round its sides are representations of a part of the mysteries, I mean that it is the head of ATIS. Lucian says that Atis was a young man of Phrygia, of uncommon beauty, that he dedicated a temple in Syria to Rhea, or Cybele, and first taught her mysteries to the Lydians, Phrygians, and Samothracians, which mysteries he brought from India. He was afterwards made an eunuch by Rhea, and lived like a woman, and assumed a feminine habit, and in that garb went over the world teaching her ceremonies and mysteries. Dict. par M. Danet, art. Atis. As this figure is covered with clothes, while those on the sides of the vase are naked, and has a Phrygian cap on the head, and as the form and features are so soft, that it is difficult to say whether it be a male or female figure, there is reason to conclude, 1. that it has reference to some particular person of some particular country; 2. that this person is Atis, the first great hierophant, or teacher of mysteries, to whom M. De la Chausse says the figure itself bears a resemblance. Museo. Capitol. Tom. IV. p. 402.

In the Museum Etruscum, Vol. I. plate 96, there is the head of Atis with feminine features, clothed with a Phrygian cap, and rising from very broad foliage, placed on a kind of term supported by the paw of a lion. Goreus in his explanation of the figure says that it is placed on a lion's foot because that animal was sacred to Cybele, and that it rises from very broad leaves because after he became an eunuch he determined to dwell in the groves. Thus the foliage, as well as the cap and feminine features, confirm the idea of this figure at the bottom of the vase representing the head of Atis the first great hierophant, and that the figures on the sides of the vase are emblems from the antient mysteries.

I beg leave to add that it does not appear to have been uncommon amongst the antients to put allegorical figures on funeral vases. In the Pamphili palace at Rome there is an elaborate representation of Life and of Death, on an antient sarcophagus. In the first Prometheus is represented making man, and Minerva is placing a butterfly, or the soul, upon his head. In the other compartment Love extinguishes his torch in the bosom of the dying figure, and is receiving the butterfly, or Psyche, from him, with a great number of complicated emblematic figures grouped in very bad taste. Admir. Roman. Antiq.

NOTE XXIII.—COAL

Whence sable Coal his massy couch extends, And stars of gold the sparkling Pyrite blends.

CANTO II. l. 349.

To elucidate the formation of coal-beds I shall here describe a fountain of fossil tar, or petroleum, discovered lately near Colebrook Dale in Shropshire, the particulars of which were sent me by Dr. Robert Darwin of Shrewsbury.

About a mile and a half below the celebrated iron-bridge, constructed by the late Mr. DARBY near Colebrook Dale, on the east side of the river Severn, as the workmen in October 1786 were making a subterranean canal into the mountain, for the more easy acquisition and conveyance of the coals which lie under it, they found an oozing of liquid bitumen, or petroleum; and as they proceeded further cut through small cavities of different sizes from which the bitumen issued. From ten to fifteen barrels of this fossil tar, each barrel containing thirty-two gallons, were at first collected in a day, which has since however gradually diminished in quantity, so that at present the product is about seven barrels in fourteen days.

The mountain, into which this canal enters, consists of siliceous sand, in which however a few marine productions, apparently in their recent state, have been found, and are now in the possession of Mr. WILLIAM REYNOLDS of Ketly Bank. About three hundred yards from the entrance into the mountain, and about twenty-eight yards below the surface of it, the tar is found oozing from the sand-rock above into the top and sides of the canal.

Beneath the level of this canal a shaft has been sunk through a grey argillaceous substance, called in this country clunch, which is said to be a pretty certain indication of coal; beneath this lies a stratum of coal, about two or three inches thick, of an inferior kind, yielding little flame in burning, and leaving much ashes; below this is a rock of a harder texture; and beneath this are found coals of an excellent quality; for the purpose of procuring which with greater facility the canal, or horizontal aperture, is now making into the mountain. July, 1788.

Beneath these coals in some places is found salt water, in other parts of the adjacent country there are beds of iron-stone, which also contain some bitumen in a less fluid state, and which are about on a level with the new canal, into which the fossil tar oozes, as above described.

There are many interesting circumstances attending the situation and accompaniments of this fountain of fossil tar, tending to develop the manner of its production. 1. As the canal passing into the mountain runs over the beds of coals, and under the reservoir of petroleum, it appears that a *natural distillation* of this fossil in the bowels of the earth must have taken place at some early period of the world, similar to the artificial distillation of coal, which has many years been carried on in this place on a smaller scale above ground. When this reservoir of petroleum was cut into, the slowness of its exsudation into the canal was not only owing to its viscidity, but to the pressure of the atmosphere, or to the necessity there was that air should at the same time insinuate itself into the small cavities from which the petroleum descended. The existence of such a distillation at some antient time is confirmed by the thin stratum of coal beneath the canal, (which covers the hard rock,) having been deprived of its fossil oil, so as to burn without flame, and thus to have become a natural coak, or fossil charcoal, while the petroleum distilled from it is found in the cavities of the rock above it.

There are appearances in other places, which favour this idea of the natural distillation of petroleum, thus at Matlock in Derbyshire a hard bitumen is found adhering to the spar in the clefts of the lime-rocks in the form of round drops about the size of peas; which could perhaps only be deposited there in that form by sublimation.

2. The second deduction, which offers itself, is, that these beds of coal have been *exposed to a considerable degree of heat*, since the petroleum above could not be separated, as far as we know, by any other means, and that the good quality of the coals beneath the hard rock was owing to the impermeability of this rock to the bituminous vapour, and to its pressure being too great to permit its being removed by the elasticity of that vapour. Thus from the degree of heat, the degree of pressure, and the permeability of the superincumbent strata, many of the phenomena attending coal-beds receive an easy explanation, which much accords with the ingenious theory of the earth by Dr. Hutton, Trans. of Edinb. Vol. I.

In some coal works the fusion of the strata of coal has been so slight, that there remains the appearance of ligneus fibres, and the impression of leaves, as at Bovey near Exeter, and even seeds of

vegetables, of which I have had specimens from the collieries near Polesworth in Warwickshire. In some, where the heat was not very intense and the incumbent stratum not permeable to vapour, the fossil oil has only risen to the upper part of the coal-bed, and has rendered that much more inflammable than the lower parts of it, as in the collieries near Beaudesert, the seat of the EARL OF UXBRIDGE in Staffordshire, where the upper stratum is a perfect cannel, or candle-coal, and the lower one of an inferior quality. Over the coal-beds near Sir H. HARPUR'S house in Derbyshire a thin lamina of asphaltum is found in some places near the surface of the earth, which would seem to be from a distillation of petroleum from the coals below, the more fluid part of which had in process of time exhaled, or been consolidated by its absorption of air. In other coal-works the upper part of the stratum is of a worse kind than the lower one, as at Alfreton and Denbigh in Derbyshire, owing to the supercumbent stratum having permitted the exhalation of a great part of the petroleum; whilst at Widdrington in Northumberland there is first a seam of coal about six inches thick of no value, which lies under about four fathom of clay, beneath this is a white freestone, then a hard stone, which the workmen there call a whin, then two fathoms of clay, then another white stone, and under that a vein of coals three feet nine inches thick, of a similar nature to the Newcastle coal. Phil. Trans. Abridg. Vol. VI. plate II. p. 192. The similitude between the circumstances of this colliery, and of the coal beneath the fountain of tar above described, renders it highly probable that this upper thin seam of coal has suffered a similar distillation, and that the inflammable part of it had either been received into the clay above in the form of sulphur, which when burnt in the open air would produce alum; or had been dissipated for want of a receiver, where it could be condensed. The former opinion is perhaps in this case more probable as in some other coal-beds, of which I have procured accounts, the surface of the coal beneath clunch or clay is of an inferior quality, as at West Hallum in Nottinghamshire. The clunch probably from hence acquires its inflammable part, which on calcination becomes vitriolic acid. I gathered pieces of clunch converted partially into alum at a colliery near Bilston, where the ground was still on fire a few years ago.

The heat, which has thus pervaded the beds of morass, seems to have been the effect of the fermentation of their vegetable materials; as new hay sometimes takes fire even in such very small masses from the sugar it contains, and seems hence not to have been attended with any expulsion of lava, like the deeper craters of volcanos situated in beds of granite.

3. The marine shells found in the loose sand-rock above this reservoir of petroleum, and the coal-beds beneath it, together with the existence of sea-salt beneath these coals, prove that these coal beds have been *at the bottom of the sea*, during some remote period of time, and were afterwards raised into their present situation by subterraneous expansions of vapour. This doctrine is further supported by the marks of violence, which some coal-beds received at the time they were raised out of the sea, as in the collieries at Mendip in Somersetshire. In these there are seven strata of coals, equitant upon each other, with beds of clay and stone intervening; amongst which clay are found shells and fern branches. In one part of this hill the strata are disjoined, and a quantity of heterogeneous substances fill up the chasm which disjoins them, on one side of this chasm the seven strata of coal are seen corresponding in respect to their reciprocal thickness and goodness with the seven strata on the other side of the cavity, except that they have been elevated several yards higher. Phil. Trans. No. 360. abridg. Vol. V. p. 237.

The cracks in the coal-bed near Ticknall in Derbyshire, and in the sand- stone rock over it, in both of which specimens of lead-ore and spar are found, confirm this opinion of their having been forcibly raised up by subterraneous fires. Over the colliery at Brown-hills near Lichfield, there is a stratum of gravel on the surface of the ground; which may be adduced as another proof to shew that those coals had some time been beneath the sea, or the bed of a river. Nevertheless, these arguments only apply to the collieries above mentioned, which are few compared with those which bear no marks of having been immersed in the sea.

On the other hand the production of coals from morasses, as described in note XX. is evinced from the vegetable matters frequently found in them, and in the strata over them; as fern-leaves in nodules of iron-ore, and from the bog-shells or fresh water muscles sometimes found over them, of both which I have what I believe to be specimens; and is further proved from some parts of these beds being only in part transformed to coal; and the other part still retaining not only the form, but some of the properties of wood; specimens of which are not unfrequent in the cabinets of the curious, procured from Loch Neigh in Ireland, from Bovey near Exeter, and other places; and from a famous cavern called the Temple of the Devil, near the town of Altorf in Franconia, at the foot of a mountain covered with pine and savine, in which are found large coals resembling trees of ebony; which are so far mineralized as to be heavy and compact; and so to effloresce with pyrites in some parts as to crumble to pieces; yet from other parts white ashes are produced on calcination, from which *fixed alcali* is procured; which evinces their vegetable origin. (Dict. Raisonné, art. Charbon.) To these may be added another argument from the oil which is distilled from coals, and which is analogous to vegetable oil, and does not exist in any bodies truly mineral. Keir's Chemical Dictionary, art. Bitumen.

Whence it would appear, that though most collieries with their attendant strata of clay, sand-stone, and iron, were formed on the places where the vegetables grew, from which they had their origin; yet that other collections of vegetable matter were washed down from eminences by currents of waters into the beds of rivers, or the neighbouring seas, and were there accumulated at different periods of time, and underwent a great degree of heat from their fermentation, in the same manner as those beds of morass which had continued on the plains where they were produced. And that by this fermentation many of them had been raised from the ocean with sand and sea-shells over them; and others from the beds of rivers with accumulations of gravel upon them.

4. For the purpose of bringing this history of the products of morasses more distinctly to the eye of the reader, I shall here subjoin two or three accounts of sinking or boring for coals, out of above twenty which I have procured from various places, though the terms are not very intelligible, being the language of the overseers of coal-works.

1. *Whitfield mine* near the Pottery in Staffordshire. Soil 1 foot. brick-clay 3 feet. shale 4. metal which is hard brown and falls in the weather 42. coal 3. warrant clay 6. brown gritstone 36. coal 31/2. warrant clay 31/2. bass and metal 531/2. hardstone 4. shaly bass 11/2. coal 4. warrant clay, depth unknown. in all about 55 yards.

2. *Coal-mine at Alfreton* in Derbyshire. Soil and clay 7 feet. fragments of stone 9. bind 13. stone 6. bind 34. stone 5. bind 2. stone 2. bind 10. coal 11/2. bind 11/2. stone 37. bind 7. soft coal 3. bind 3. stone 20. bind 16. coal 71/2. in all about 61 yards.

3. *A basset coal-mine at Woolarton* in Nottinghamshire. Sand and gravel 6 feet. bind 21. stone 10. smut or effete coal 1. clunch 4. bind 21. stone 18. bind 18. stone-bind 15. soft coal 2. clunch and bind 21. coal 7. in all about 48 yards.

4. *Coal-mine at West-Hallam* in Nottinghamshire. Soil and clay 7 feet. bind 48. smut 11/2. clunch 4. bind 3. stone 2. bind 1. stone 1. bind 3. stone 1. bind 16. shale 2. bind 12. shale 3. clunch, stone, and a bed of cank 54. soft coal 4. clay and dun 1. soft coal 41/2. clunch and bind 21. coal 1. broad bind 26. hard coal 6. in all about 74 yards.

As these strata generally lie inclined, I suppose parallel with the limestone on which they rest, the upper edges of them all come out to day, which is termed bassetting; when the whole mass was ignited by its fermentation, it is probable that the inflammable part of some strata might thus more easily escape than of others in the form of vapour; as dews are known to slide between such strata in the production of springs; which accounts for some coal-beds being so much worse than others. See note XX.

From this account of the production of coals from morasses it would appear, that coal-beds are not to be expected beneath masses of lime- stone. Nevertheless I have been lately informed by my friend Mr. Michell of Thornhill, who I hope will soon favour the public with his geological investigations, that the beds of chalk are the uppermost of all the limestones; and that they rest on the granulated limestone, called ketton-stone; which I suppose is similar to that which covers the whole country from Leadenham to Sleaford, and from Sleaford to Lincoln; and that, thirdly, coal-delphs are frequently found beneath these two uppermost beds of limestone.

Now as the beds of chalk and of granulated limestone may have been formed by alluviation, on or beneath the shores of the sea, or in vallies of the land; it would seem, that some coal countries, which in the great commotions of the earth had been sunk beneath the water, were thus covered with alluvial limestone, as well as others with alluvial basaltes, or common gravel-beds. Very extensive plains which now consist of alluvial materials, were in the early times covered with water; which has since diminished as the solid parts of the earth have increased. For the solid parts of the earth consisting chiefly of animal and vegetable recrements must have originally been formed or produced from the water by animal and vegetable processes; and as the solid parts of the earth may be supposed to be thrice as heavy as water, it follows that thrice the quantity of water must have vanished compared with the quantity of earth thus produced. This may account for many immense beds of alluvial materials, as gravel, rounded sand granulated limestone, and chalk, covering such extensive plains as Lincoln-heath, having become dry without the supposition of their having been again elevated from the ocean. At the same time we acquire the knowledge of one of the uses or final causes of the organized world, not indeed very flattering to our vanity, that it converts water into earth, forming islands and continents by its recrements or exuviae.

NOTE XXIV.—GRANITE.

Climb the rude steeps, the Granite-cliffs surround.

CANTO II. l. 523.

The lowest stratum of the earth which human labour has arrived to, is granite; and of this likewise consists the highest mountains of the world. It is known under variety of names according to some difference in its appearance or composition, but is now generally considered by philosophers as a species of lava; if it contains quartz, feltspat, and mica in distinct crystals, it is called granite; which is found in Cornwall in rocks; and in loose stones in the gravel near Drayton in Shropshire, in the road towards Newcastle. If these parts of the composition be less distinct, or if only two of them be visible to the eye, it is termed porphyry, trap, whinstone, moorstone, slate. And if it appears in a regular angular form, it is called basaltes. The affinity of these bodies has lately been further well established by Dr. Beddoes in the Phil. Trans. Vol. LXXX.

These are all esteemed to have been volcanic productions that have undergone different degrees of heat; it is well known that in Papin's digester water may be made red hot by confinement, and will then dissolve many bodies which otherwise are little or not at all acted upon by it. From hence it may be conceived, that under immense pressure of superincumbent materials, and by great heat, these masses of lava may have undergone a kind of aqueous solution, without any tendency to vitrification, and might thence have a power of crystallization, whence all the varieties above mentioned from the different proportion of the materials, or the different degrees of heat they may have undergone in this aqueous solution. And that the uniformity of the mixture of the original earths, as of lime, argil, silex, magnesia, and barytes, which they contain, was owing to their boiling together a longer or shorter time before their elevation into mountains. See note XIX. art. 8.

The seat of volcanos seems to be principally, if not entirely, in these strata of granite; as many of them are situated on granite mountains, and throw up from time to time sheets of lava which run down over the proceeding strata from the same origin; and in this they seem to differ from the heat which has separated the clay, coal, and sand in morasses, which would appear to have risen from a kind of fermentation, and thus to have pervaded the whole mass without any expuition of lava.

[Illustration: *Section of the Earth. A sketch of a supposed Section of the Earth in respect to the disposition of the Strata over each other without regard to their proportions or number. London Published Dec'r 1st 1791 by J. Johnson St Paul's Church Yard.*]

All the lavas from Vesuvius contain one fourth part of iron, (Kirwan's Min.) and all the five primitive earths, viz. calcareous, argillaceous, siliceous, barytic, and magnesian earths, which are also evidently produced now daily from the recrements of animal and vegetable bodies. What is to be thence concluded? Has the granite stratum in very antient times been produced like the present calcareous and siliceous masses, according to the ingenious theory of Dr. Hutton, who says new continents are now forming at the bottom of the sea to rise in their turn, and that thus the terraqueous globe has been, and will be, eternal? Or shall we suppose that this internal heated mass of granite, which forms the nucleus of the earth, was a part of the body of the sun before it was separated by an explosion? Or was the sun originally a planet, inhabited like ours, and a satellite to some other greater sun, which has long been extinguished by diffusion of its light, and around which the present sun continues to revolve, according to a conjecture of the celebrated Mr. Herschell, and which conveys to the mind a most sublime idea of the progressive and increasing excellence of the works of the Creator of all things?

For the more easy comprehension of the facts and conjectures concerning the situation and production of the various strata of the earth, I shall here subjoin a supposed section of the globe, but without any attempt to give the proportions of the parts, or the number of them, but only their respective situation over each other, and a geological recapitulation.

GEOLOGICAL RECAPITULATION.

1. The earth was projected along with the other primary planets from the sun, which is supposed to be on fire only on its surface, emitting light without much internal heat like a ball of burning camphor.

2. The rotation of the earth round its axis was occasioned by its greater friction or adhesion to one side of the cavity from which it was ejected; and from this rotation it acquired its spheroidical form. As it cooled in its ascent from the sun its nucleus became harder; and its attendant vapours were condensed, forming the ocean.

3. The masses or mountains of granite, porphery, basalt, and stones of similar structure, were a part of the original nucleus of the earth; or consist of volcanic productions since formed.

4. On this nucleus of granite and basaltes, thus covered by the ocean, were formed the calcareous beds of limestone, marble, chalk, spar, from the exuviae of marine animals; with the flints, or chertz, which accompany them. And were stratified by their having been formed at different and very distant periods of time.

5. The whole terraqueous globe was burst by central fires; islands and continents were raised, consisting of granite or lava in some parts, and of limestone in others; and great vallies were sunk, into which the ocean retired.

6. During these central earthquakes the moon was ejected from the earth, causing new tides; and the earth's axis suffered some change in its inclination, and its rotatory motion was retarded.

7. On some parts of these islands and continents of granite or limestone were gradually produced extensive morasses from the recrements of vegetables and of land animals; and from these morasses, heated by fermentation, were produced clay, marle, sandstone, coal, iron, (with the bases of variety of acids;) all which were stratified by their having been formed at different, and very distant periods of time.

8. In the elevation of the mountains very numerous and deep fissures necessarily were produced. In these fissures many of the metals are formed partly from descending materials, and partly from ascending ones raised in vapour by subterraneous fires. In the fissures of granite or porphery quartz is formed; in the fissures of limestone calcareous spar is produced.

9. During these first great volcanic fires it is probable the atmosphere was either produced, or much increased; a process which is perhaps now going on in the moon; Mr. Herschell having discovered a volcanic crater three miles broad burning on her disk.

10. The summits of the new mountains were cracked into innumerable lozenges by the cold dews or snows falling upon them when red hot. From these summits, which were then twice as high as at present, cubes and lozenges of granite, and basalt, and quartz in some countries, and of marble and flints in others, descended gradually into the valleys, and were rolled together in the beds of rivers, (which were then so large as to occupy the whole valleys, which they now only intersect;) and produced the great beds of gravel, of which many valleys consist.

11. In several parts of the earth's surface subsequent earthquakes, from the fermentation of morasses, have at different periods of time deranged the position of the matters above described. Hence the gravel, which was before in the beds of rivers, has in some places been raised into mountains, along with clay and coal strata which were formed from morasses and washed down from eminences into the beds of rivers or the neighbouring seas, and in part raised again with gravel or marine shells over them; but this has only obtained in few places compared with the general distribution of such materials. Hence there seem to have existed two sources of earthquakes, which have occurred at great distance of time from each other; one from the granite beds in the central parts of the earth, and the other from the morasses on its surface. All the subsequent earthquakes and volcanos of modern days compared with these are of small extent and insignificant effect.

12. Besides the argillaceous sand-stone produced from morasses, which is stratified with clay, and coal, and iron, other great beds of siliceous sand have been formed in the sea by the combination of an unknown acid from morasses, and the calcareous matters of the ocean.

13. The warm waters which are found in many countries, are owing to steam arising from great depths through the fissures of limestone or lava, elevated by subterranean fires, and condensed between the strata of the hills over them; and not from any decomposition of pyrites or manganese near the surface of the earth.

14. The columns of basaltes have been raised by the congelation or expansion of granite beds in the act of cooling from their semi-vitreous fusion.

NOTE XXV.—EVAPORATION.

Aquatic nymphs! you lead with viewless march The winged vapour up the aerial arch.

CANTO III. l. 13.

I. The atmosphere will dissolve a certain quantity of moisture as a chemical menstruum, even when it is much below the freezing point, as appears from the diminution of ice suspended in frosty air, but a much greater quantity of water is evaporated and suspended in the air by means of heat, which is perhaps the universal cause of fluidity, for water is known to boil with less heat in vacuo, which is a proof that it will evaporate faster in vacuo, and that the air therefore rather hinders than promotes its evaporation in higher degrees of heat. The quick evaporation occasioned in vacuo by a small degree of heat is agreeably seen in what is termed a pulse-glass, which consists of an exhausted tube of glass with a bulb at each end of it and with about two thirds of the cavity filled with alcohol, in which the spirit is instantly seen to boil by the heat of the finger-end applied on a bubble of steam in the lower bulb, and is condensed again in the upper bulb by the least conceivable comparative coldness.

2. Another circumstance evincing that heat is the principal cause of evaporation is that at the time of water being converted into steam, a great quantity of heat is taken away from the neighbouring bodies. If a thermometer be repeatedly dipped in ether, or in rectified spirit of wine, and exposed to a blast of air, to expedite the evaporation by perpetually removing the saturated air from it, the thermometer will presently sink below freezing. This warmth, taken from the ambient bodies at the time of evaporation by the steam, is again given out when the steam is condensed into water. Hence the water in a worm-tub during distillation so soon becomes hot; and hence the warmth accompanying the descent of rain in cold weather.

3. The third circumstance, shewing that heat is the principal cause of evaporation, is, that some of the steam becomes again condensed when any part of the heat is withdrawn. Thus when warmer south-west winds replete with moisture succeed the colder north-east winds all bodies that are dense and substantial, as stone walls, brick floors, &c. absorb some of the heat from the passing air, and its moisture becomes precipitated on them, while the north-east winds become warmer on their arrival in this latitude, and are thence disposed to take up more moisture, and are termed drying winds.

4. Heat seems to be the principal cause of the solution of many other bodies, as common salt, or blue vitriol dissolved in water, which when exposed to severe cold are precipitated, or carried, to the part of the water last frozen; this I observed in a phial filled with a solution of blue vitriol which was frozen; the phial was burst, the ice thawed, and a blue column of cupreous vitriol was left standing upright on the bottom of the broken glass, as described in note XIX.

II. Hence water may either be dissolved in air, and may then be called an aerial solution of water; or it may be dissolved in the fluid matter of heat, according to the theory of M. Lavoisier, and may then be called steam. In the former case it is probable there are many other vapours which may precipitate it, as marine acid gas, or fluor acid gas. So alcaline gas and acid gas dissolved in air precipitate each other, nitrous gas precipitates vital air from its azote, and inflammable gas mixed with vital air ignited by an electric spark either produces or precipitates the water in both of them. Are there any subtle exhalations occasionally diffused in the atmosphere which may thus cause rain?

1. But as water is perhaps many hundred times more soluble in the fluid matter of heat than in air, I suppose the eduction of this heat, by whatever means it is occasioned, is the principal cause of devaporation. Thus if a region of air is brought from a warmer climate, as the S.W. winds, it becomes cooled by its contact with the earth in this latitude, and parts with so much of its moisture as was dissolved in the quantity of calorique, or heat, which it now looses, but retains that part which was suspended by its attraction to the particles of air, or by aerial solution, even in the most severe frosts.

2. A second immediate cause of rain is a stream of N.E. wind descending from a superior current of air, and mixing with the warmer S.W. wind below; or the reverse of this, viz. a superior current of S.W. wind mixing with an inferior one of N.E. wind; in both these cases the whole heaven becomes instantly clouded, and the moisture contained in the S.W. current is precipitated. This cause of devaporation has been ingeniously explained by Dr. Hutton in the Transact. of Edinburgh, Vol. I, and seems to arise from this circumstance; the particles of air of the N.E. wind educe part of the heat from the S.W. wind, and therefore the water which was dissolved by that quantity of *heat* is precipitated; all the other part of the water, which was suspended by its attraction to the particles of air, or dissolved in the remainder of the heat, continues unprecipitated.

3. A third method by which a region of air becomes cooled, and in consequence deposits much of its moisture, is from the mechanical expansion of air, when part of the pressure is taken off. In this case the expanded air becomes capable of receiving or attracting more of the matter of heat into its interstices, and the vapour, which was previously dissolved in this heat, is deposited, as is seen in the

receiver of an air-pump, which becomes dewy, as the air within becomes expanded by the eduction of part of it. See note VII. Hence when the mercury in the barometer sinks without a change of the wind the air generally becomes colder. See note VII. on Elementary Heat. And it is probably from the varying pressure of the incumbent air that in summer days small black clouds are often thus suddenly produced, and again soon vanish. See a paper in Philos. Trans. Vol. LXXVIII. intitled Frigorific Experiments on the Mechanical Expansion of Air.

4. Another portion of atmospheric water may possibly be held in solution by the electric fluid, since in thunder storms a precipitation of the water seems to be either the cause or the consequence of the eduction of the electricity. But it appears more probable that the water is condensed into clouds by the eduction of its heat, and that then the surplus of electricity prevents their coalescence into larger drops, which immediately succeeds the departure of the lightning.

5. The immediate cause why the barometer sinks before rain is, first, because a region of warm air, brought to us in the place of the cold air which it had displaced, must weigh lighter, both specifically and absolutely, if the height of the warm atmosphere be supposed to be equal to that of the preceeding cold one. And secondly, after the drops of rain begin to fall in any column of air, that column becomes lighter, the falling drops only adding to the pressure of the air in proportion to the resistance which they meet with in passing through that fluid.

If we could suppose water to be dissolved in air without heat, or in very low degrees of heat, I suppose the air would become heavier, as happens in many chemical solutions, but if water dissolved in the matter of heat, or calorique, be mixed with an aerial solution of water, there can be no doubt but an atmosphere consisting of such a mixture must become lighter in proportion to the quantity of calorique. On the same circumstance depends the visible vapour produced from the breath of animals in cold weather, or from a boiling kettle; the particles of cold air, with which it is mixed, steal a part of its heat, and become themselves raised in temperature, whence part of the water is precipitated in visible vapour, which, if in great quantity sinks to the ground; if in small quantity, and the surrounding air is not previously saturated, it spreads itself till it becomes again dissolved.

NOTE XXVI.—SPRINGS

Your lucid bands condense with fingers chill The blue mist hovering round the gelid hill.

CANTO III. l. 19.

The surface of the earth consists of strata many of which were formed originally beneath the sea, the mountains were afterwards forced up by subterraneous fires, as appears from the fissures in the rocks of which they consist, the quantity of volcanic productions all over the world, and the numerous remains of craters of volcanos in mountainous countries. Hence the strata which compose the sides of mountains lie slanting downwards, and one or two or more of the external strata not reaching to the summit when the mountain was raised up, the second or third stratum or a more inferior one is there exposed to day; this may be well represented by forceably thrusting a blunt instrument through several sheets of paper, a bur will stand up with the lowermost sheet standing highest in the center of it. On this uppermost stratum, which is colder as it is more elevated, the dews are condensed in large quantities; and sliding down pass under the first or second or third stratum which compose the sides of the hill; and either form a morass below, or a weeping rock, by oozing out in numerous places, or many of these less currents meeting together burst out in a more copious rill.

The summits of mountains are much colder than the plains in their vicinity, owing to several causes; 1. Their being in a manner insulated or cut off from the common heat of the earth, which is always of 48 degrees, and perpetually counteracts the effects of external cold beneath that degree. 2. From their surfaces being larger in proportion to their solid contents, and hence their heat more expeditiously carried away by the ever-moving atmosphere. 3. The increasing rarity of the air as the mountain rises. All those bodies which conduct electricity well or ill, conduct the matter of heat likewise well or ill. See note VII. Atmospheric air is a bad conductor of electricity and thence confines it on the body where it is accumulated, but when it is made very rare, as in the exhausted receiver, the electric aura passes away immediately to any distance. The same circumstance probably happens in respect to heat, which is thus kept by the denser air on the plains from escaping, but is dissipated on the hills where the air is thinner. 4. As the currents of air rise up the sides of mountains they become mechanically rarefied, the

pressure of the incumbent column lessening as they ascend. Hence the expanding air absorbs heat from the mountain as it ascends, as explained in note VII. 5. There is another, and perhaps more powerful cause, I suspect, which may occasion the great cold on mountains, and in the higher parts of the atmosphere, and which has not yet been attended to; I mean that the fluid matter of heat may probably gravitate round the earth, and form an atmosphere on its surface, mixed with the aerial atmosphere, which may diminish or become rarer, as it recedes from the earth's surface, in a greater proportion than the air diminishes.

6. The great condensation of moisture on the summits of hills has another cause, which is the dashing of moving clouds against them, in misty days this is often seen to have great effect on plains, where an eminent tree by obstructing the mist as it moves along shall have a much greater quantity of moisture drop from its leaves than falls at the same time on the ground in its vicinity. Mr. White, in his History of Selborne gives an account of a large tree so situated, from which a stream flowed during a moving mist so as to fill the cart-ruts in a lane otherwise not very moist, and ingeniously adds, that trees planted about ponds of stagnant water contribute much by these means to supply the reservoir. The spherules which constitute a mist or cloud are kept from uniting by so small a power that a little agitation against the leaves of a tree, or the greater attraction of a flat moist surface, condenses or precipitates them.

If a leaf has its surface moistened and particles of water separate from each other as in a mist be brought near the moistened surface of a leaf, each particle will be attracted more by that plain surface of water on the leaf than it can be by the surrounding particles of the mist, because globules only attract each other in one point, whereas a plain attracts a globule by a greater extent of its surface.

The common cold springs are thus formed on elevated grounds by the condensed vapours, and hence are stronger when the nights are cold after hot days in spring, than even in the wet days of winter. For the warm atmosphere during the day has dissolved much more water than it can support in solution during the cold of the night, which is thus deposited in large quantities on the hills, and yet so gradually as to soak in between the strata of them, rather than to slide off over their surfaces like showers of rain. The common heat of the internal parts of the earth is ascertained by springs which arise from strata of earth too deep to be affected by the heat of summer or the frosts of winter. Those in this country are of 48 degrees of heat, those about Philidelphia were said by Dr. Franklin to be 52; whether this variation is to be accounted for by the difference of the sun's heat on that country, according to the ingenious theory of Mr. Kirwan, or to the vicinity of subterranean fires is not yet, I think, decided. There are however subterraneous streams of water not exactly produced in this manner, as streams issuing from fissures in the earth, communicating with the craters of old volcanoes; in the Peak of Derbyshire are many hollows, called swallows, where the land floods sink into the earth, and come out at some miles distant, as at Ilam near Ashborne. See note on Fica, Vol. II.

Other streams of cold water arise from beneath the snow on the Alps and Andes, and other high mountains, which is perpetualy thawing at its under surface by the common heat of the earth, and gives rise to large rivers. For the origin of warm springs see note on Fucus, Vol. II.

NOTE XXVII.—SHELL FISH.

You round Echinus ray his arrowy mail,
Give the keel'd Nautilus his oar and sail.
Firm to his rock with silver cords suspend
The anchored Pinna, and his Cancer-friend.

CANTO III. l. 67.

The armour of the Echinus, or Sea-hedge Hog, consists generally of moveable spines; (*Linnei System. Nat.* Vol. I. p. 1102.) and in that respect resembles the armour of the land animal of the same name. The irregular protuberances on other sea-shells, as on some species of the Purpura, and Murex, serve them as a fortification against the attacks of their enemies.

It is said that this animal foresees tempestuous weather, and sinking to the bottom of the sea adheres firmly to sea-plants, or other bodies by means of a substance which resembles the horns of snails. Above twelve hundred of these fillets have been counted by which this animal fixes itself; and when afloat, it contracts these fillets between the bases of its points, the number of which often amounts to two thousand. Dict raisonne. art. Oursin. de mer.

There is a kind of Nautilus, called by Linneus, Argonauta, whose shell has but one cell; of this animal Pliny affirms, that having exonerated its shell by throwing out the water, it swims upon the surface, extending a web of wonderful tenuity, and bending back two of its arms and rowing with the rest, makes a sail, and at length receiving the water dives again. Plin. IX. 29. Linneus adds to his description of this animal, that like the Crab Diogenes or Bernhard, it occupies a house not its own, as it is not connected to its shell, and is therefore foreign to it; who could have given credit to this if it had not been attested by so many who have with their own eyes seen this argonaut in the act of sailing? Syst. Nat p. 1161.

The Nautilus, properly so named by Linneus, has a shell consisting of many chambers, of which cups are made in the East with beautiful painting and carving on the mother-pearl. The animal is said to inhabit only the uppermost or open chamber, which is larger than the rest; and that the rest remain empty except that the pipe, or siphunculus, which communicates from one to the other of them is filled with an appendage of the animal like a gut or string. Mr. Hook in his Philos. Exper. p. 306, imagines this to be a dilatable or compressible tube, like the air- bladders of fish, and that by contracting or permitting it to expand, it renders its shell boyant or the contrary. See Note on Ulva, Vol. II.

The Pinna, or Sea-wing, is contained in a two-valve shell, weighing sometimes fifteen pounds, and emits a beard of fine long glossy silk- like fibres, by which it is suspended to the rocks twenty or thirty feet beneath the surface of the sea. In this situation it is so successfully attacked by the eight-footed Polypus, that the species perhaps could not exist but for the exertions of the Cancer Pinnotheris, who lives in the same shell as a guard and companion. Amoen. Academ. Vol. II. p. 48. Lin. Syst. Nat. Vol. I. p. 1159, and p. 1040.

The Pinnotheris, or Pinnophylax, is a small crab naked like Bernard the Hermit, but is furnished with good eyes, and lives in the same shell with the Pinna; when they want food the Pinna opens its shell, and sends its faithful ally to forage; but if the Cancer sees the Polypus, he returns suddenly to the arms of his blind hostess, who by closing the shell avoids the fury of her enemy; otherwise, when it has procured a booty, it brings it to the opening of the shell, where it is admitted, and they divide the prey. This was observed by Haslequist in his voyage to Palestine.

The Byssus of the antients, according to Aristotle, was the beard of the Pinna above mentioned, but seems to have been used by other writers indiscriminately for any spun material, which was esteemed finer or more valuable than wool. Reaumur says the threads of this Byssus are not less fine or less beautiful than the silk, as it is spun by the silk-worm; the Pinna on the coasts of Italy and Provence (where it is fished up by iron-hooks fixed on long poles) is called the silk-worm of the sea. The stockings and gloves manufactured from it, are of exquisite fineness, but too warm for common wear, and are thence esteemed useful in rhumatism and gout. Dict. raisonné art. Pinne-marine. The warmth of the Byssus, like that of silk, is probably owing to their being bad conductors of heat, as well as of electricity. When these fibres are broken by violence, this animal as well as the muscle has the power to reproduce them like the common spiders, as was observed by M. Adanson. As raw silk, and raw cobwebs, when swallowed, are liable to produce great sickness (as I am informed) it is probable the part of muscles, which sometimes disagrees with the people who eat them, may be this silky web, by which they attach themselves to stones. The large kind of Pinna contains some mother-pearl of a reddish tinge, according to M. d'Argenville. The substance sold under the name of Indian weed, and used at the bottom of fish-lines, is probably a production of this kind; which however is scarcely to be distinguished by the eye from the tendons of a rat's tail, after they have been separated by putrefaction in water, and well cleaned and rubbed; a production, which I was once shewn as a great curiosity; it had the uppermost bone of the tail adhering to it, and was said to have been used as an ornament in a lady's hair.

NOTE XXVIII.—STURGEON.

> *With worm-like hard his toothless lips array, And teach the unweildy Sturgeon to betray.*

CANTO III. l. 71.

The Sturgeon, *Acipenser, Strurio.* Lin. Syst. Nat. Vol. I. p. 403. is a fish of great curiosity as well as of great importance; his mouth is placed under the head, without teeth, like the opening of a purse, which

he has the power to push suddenly out or retract. Before this mouth under the beak or nose hang four tendrils some inches long, and which so resemble earth-worms that at first sight they may be mistaken for them. This clumsy toothless fish is supposed by this contrivance to keep himself in good condition, the solidity of his flesh evidently shewing him to be a fish of prey. He is said to hide his large body amongst the weeds near the sea-coast, or at the mouths of large rivers, only exposing his cirrhi or tendrils, which small fish or sea-insects mistaking for real worms approach for plunder, and are sucked into the jaws of their enemy. He has been supposed by some to root into the soil at the bottom of the sea or rivers; but the cirrhi, or tendrills abovementioned, which hang from his snout over his mouth, must themselves be very inconvenient for this purpose, and as it has no jaws it evidently lives by suction, and during its residence in the sea a quantity of sea-insects are found in its stomach.

The flesh was so valued in the time of the Emperor Severus, that it was brought to table by servants with coronets on their heads, and preceded by music, which might give rise to its being in our country presented by the Lord Mayor to the King. At present it is caught in the Danube, and the Walga, the Don, and other large rivers for various purposes. The skin makes the best covering for carriages; isinglass is prepared from parts of the skin; cavear from the spawn; and the flesh is pickled or salted, and sent all over Europe.

NOTE XXIX.—OIL ON WATER.

Who with fine films, suspended o'er the deep, Of Oil effusive lull the waves to sleep.

CANTO III. l. 87.

There is reason to believe that when oil is poured upon water, the two surfaces do not touch each other, but that the oil is suspended over the water by their mutual repulsion. This seems to be rendered probable by the following experiment: if one drop of oil be droped on a bason of water, it will immediately diffuse itself over the whole, for there being no friction between the two surfaces, there is nothing to prevent its spreading itself by the gravity of the upper part of it, except its own tenacity, into a pellicle of the greatest tenuity. But if a second drop of oil be put upon the former, it does not spread itself, but remains in the form of a drop, as the other already occupied the whole surface of the bason, and there is friction in oil passing over oil, though none in oil passing over water.

Hence when oil is diffused on the surface of water gentle breezes have no influence in raising waves upon it; for a small quantity of oil will cover a very great surface of water, (I suppose a spoonful will diffuse itself over some acres) and the wind blowing upon this carries it gradually forwards; and there being no friction between the two surfaces the water is not affected. On which account oil has no effect in stilling the agitation of the water after the wind ceases, as was found by the experiments of Dr. Franklin.

This circumstance lately brought into notice by Dr. Franklin had been mentioned by Pliny, and is said to be in use by the divers for pearls, who in windy weather take down with them a little oil in their mouths, which they occasionally give out when the inequality of the supernatant waves prevents them from seeing sufficiently distinctly for their purpose.

The wonderful tenuity with which oil can be spread upon water is evinced by a few drops projected from a bridge, where the eye is properly placed over it, passing through all the prismatic colours as it diffuses itself. And also from another curious experiment of Dr. Franklin's: he cut a piece of cork to about the size of a letter-wafer, leaving a point standing off like a tangent at one edge of the circle. This piece of cork was then dipped in oil and thrown into a large pond of water, and as the oil flowed off at the point, the cork-wafer continued to revolve in a contrary direction for several minutes. The oil flowing off all that time at the pointed tangent in coloured streams. In a small pond of water this experiment does not so well succeed, as the circulation of the cork stops as soon as the water becomes covered with the pellicle of oil. See Additional Note, No. XIII. and Note on Fucus, Vol. II.

The ease with which oil and water slide over each other is agreeably seen if a phial be about half filled with equal parts of oil and water, and made to oscillate suspended by a string, the upper surface of the oil and the lower one of the water will always keep smooth; but the agitation of the surfaces where the oil and water meet, is curious; for their specific gravities being not very different, and their friction on each other nothing, the highest side of the water, as the phial descends in its oscillation, having acquired a greater momentum than the lowest side (from its having descended further) would

rise the highest on the ascending side of the oscillation, and thence pushes the then uppermost part of the water amongst the oil.

NOTE XXX.—SHIP-WORM.

Meet fell Teredo, as he mines the keel With beaked head, and break his lips of steel.

CANTO III. l. 91.

The Teredo, or ship-worm, has two calcareous jaws, hemispherical, flat before, and angular behind. The shell is taper, winding, penetrating ships and submarine wood, and was brought from India into Europe, Linnei System. Nat. p. 1267. The Tarieres, or sea-worms, attack and erode ships with such fury, and in such numbers, as often greatly to endanger them. It is said that our vessels have not known this new enemy above fifty years, that they were brought from the sea about the Antilles to our parts of the ocean, where they have increased prodigiously. They bore their passage in the direction of the fibres of the wood, which is their nourishment, and cannot return or pass obliquely, and thence when they come to a knot in the wood, or when two of them meet together with their stony mouths, they perish for want of food.

In the years 1731 and 1732 the United Provinces were under a dreadful alarm concerning these insects, which had made great depredation on the piles which support the banks of Zeland, but it was happily discovered a few years afterwards that these insects had totally abandoned that island, (Dict Raisonné, art, Vers Rongeurs,) which might have been occasioned by their not being able to live in that latitude when the winter was rather severer than usual.

NOTE XXXI.—MAELSTROM.

Turn the broad helm, the fluttering canvas urge From Maelstrom's fierce innavigable surge.

CANTO III. l. 93.

On the coast of Norway there is an extensive vortex, or eddy, which lies between the islands of Moskoe and Moskenas, and is called Moskoestrom, or Maelstrom; it occupies some leagues in circumference, and is said to be very dangerous and often destructive to vessels navigating these seas. It is not easy to understand the existence of a constant descending stream without supposing it must pass through a subterranean cavity to some other part of the earth or ocean which may lie beneath its level; as the Mediterranean seems to lie beneath the level of the Atlantic ocean, which therefore constantly flows into it through the Straits; and the waters of the Gulph of Mexico lie much above the level of the sea about the Floridas and further northward, which gives rise to the Gulph-stream, as described in note on Cassia in Vol. II.

The Maelstrom is said to be still twice in about twenty-four hours when the tide is up, and most violent at the opposite times of the day. This is not difficult to account for, since when so much water is brought over the subterraneous passage, if such exists, as compleatly to fill it and stand many feet above it, less disturbance must appear on the surface. The Maelstrom is described in the Memoires of the Swedish Academy of Sciences, and Pontoppiden's Hist. of Norway, and in Universal Museum for 1763, p. 131.

The reason why eddies of water become hollow in the middle is because the water immediately over the centre of the well, or cavity, falls faster, having less friction to oppose its descent, than the water over the circumference or edges of the well. The circular motion or gyration of eddies depends on the obliquity of the course of the stream, or to the friction or opposition to it being greater on one side of the well than the other; I have observed in water passing through a hole in the bottom of a trough, which was always kept full, the gyration of the stream might be turned either way by increasing the

opposition of one side of the eddy with ones finger, or by turning the spout, through which the water was introduced, a little more obliquely to the hole on one side or on the other. Lighter bodies are liable to be retained long in eddies of water, while those rather heavier than water are soon thrown out beyond the circumference by their acquired momentum becoming greater than that of the water. Thus if equal portions of oil and water be put into a phial, and by means of a string be whirled in a circle round the hand, the water will always keep at the greater distance from the centre, whence in the eddies formed in rivers during a flood a person who endeavours to keep above water or to swim is liable to be detained in them, but on suffering himself to sink or dive he is said readily to escape. This circulation of water in descending through a hole in a vessel Dr. Franklin has ingeniously applied to the explanation of hurricanes or eddies of air.

NOTE XXXII.—GLACIERS.

While round dark crags imprison'd waters bend Through rifted ice, in ivory veins descend.

CANTO III. l. 113.

The common heat of the interior parts of the earth being always 48 degrees, both in winter and summer, the snow which lies in contact with it is always in a thawing state; Hence in ice-houses the external parts of the collection of ice is perpetually thawing and thus preserves the internal part of it; so that it is necessary to lay up many tons for the preservation of one ton. Hence in Italy considerable rivers have their source from beneath the eternal glaciers, or mountains of snow and ice.

In our country when the air in the course of a frost continues a day or two at very near 32 degrees, the common heat of the earth thaws the ice on its surface, while the thermometer remains at the freezing point. This circumstance is often observable in the rimy mornings of spring; the thermometer shall continue at the freezing point, yet all the rime will vanish, except that which happens to lie on a bridge, a board, or on a cake of cow-dung, which being thus as it were insulated or cut off from so free a communication with the common heat of the earth by means of the air under the bridge, or wood, or dung, which are bad conductors of heat, continues some time longer unthawed. Hence when the ground is covered thick with snow, though the frost continues, and the sun does not shine, yet the snow is observed to decrease very sensibly. For the common heat of the earth melts the under surface of it, and the upper one evaporates by its solution in the air. The great evaporation of ice was observed by Mr. Boyle, which experiment I repeated some time ago. Having suspended a piece of ice by a wire and weighed it with care without touching it with my hand, I hung it out the whole of a clear frosty night, and found in the morning it had lost nearly a fifth of its weight. Mr. N. Wallerius has since observed that ice at the time of its congelation evaporates faster than water in its fluid form; which may be accounted for from the heat given out at the instant of freezing; (Saussure's Essais sur Hygromet. p. 249.) but this effect is only momentary.

Thus the vegetables that are covered with snow are seldom injured; since, as they lie between the thawing snow, which has 32 degrees of heat, and the covered earth which has 48, they are preserved in a degree of heat between these; viz. in 40 degrees of heat. Whence the moss on which the rein-deer feed in the northern latitudes vegetates beneath the snow; (See note on Muschus, Vol. II.) and hence many Lapland and Alpine plants perished through cold in the botanic garden at Upsal, for in their native situations, though the cold is much more intense, yet at its very commencement they are covered deep with snow, which remains till late in the spring. For this fact see Amaenit. Academ. Vol. I. No. 48. In our climate such plants do well covered with dried fern, under which they will grow, and even flower, till the severe vernal frosts cease. For the increase of glaciers see Note on Canto I. l. 529.

NOTE XXXIII.—WINDS.

While southern gales o'er western oceans roll, And Eurus steals his ice-winds from the pole.

The theory of the winds is yet very imperfect, in part perhaps owing to the want of observations sufficiently numerous of the exact times and places where they begin and cease to blow, but chiefly to our yet imperfect knowledge of the means by which great regions of air are either suddenly produced or suddenly destroyed.

The air is perpetually subject to increase or diminution from its combination with other bodies, or its evolution from them. The vital part of the air, called oxygene, is continually produced in this climate from the perspiration of vegetables in the sunshine, and probably from the action of light on clouds or on water in the tropical climates, where the sun has greater power, and may exert some yet unknown laws of luminous combination. Another part of the atmosphere, which is called azote, is perpetually set at liberty from animal and vegetable bodies by putrefaction or combustion, from many springs of water, from volatile alcali, and probably from fixed alcali, of which there is an exhaustless source in the water of the ocean. Both these component parts of the air are perpetually again diminished by their contact with the soil, which covers the surface of the earth, producing nitre. The oxygene is diminished in the production of all acids, of which the carbonic and muriatic exist in great abundance. The azote is diminished in the growth of animal bodies, of which it constitutes an important part, and in its combinations with many other natural productions.

They are both probably diminished in immense quantities by uniting with the inflammable air, which arises from the mud of rivers and lakes at some seasons, when the atmosphere is light: the oxygene of the air producing water, and the azote producing volatile alcali by their combinations with this inflammable air. At other seasons of the year these principles may again change their combinations, and the atmospheric air be reproduced.

Mr. Lavoisier found that one pound of charcoal in burning consumed two pounds nine ounces of vital air, or oxygene. The consumption of vital air in the process of making red lead may readily be reduced to calculation; a small barrel contains about twelve hundred weight of this commodity, 1200 pounds of lead by calcination absorb about 144 pounds of vital air; now as a cubic foot of water weighs 1000 averdupois ounces, and as vital air is above 800 times lighter than water, it follows that every barrel of red lead contains nearly 2000 cubic feet of vital air. If this can be performed in miniature in a small oven, what may not be done in the immense elaboratories of nature!

These great elaboratories of nature include almost all her fossil as well as her animal and vegetable productions. Dr. Priestley obtained air of greater or less purity, both vital and azotic, from almost all the fossil substances he subjected to experiment. Four ounce-weight of lava from Iceland heated in an earthen retort yielded twenty ounce-measures of air.

4 ounce-weight of lava gave 20 ounce measures of air. 7 ..... basaltes .... 104 ..... 2 ..... toadstone .... 40 ..... 11/2 ..... granite .... 20 ..... 1 ..... elvain .... 30 ..... 7 ..... gypsum .... 230 ..... 4 ..... blue slate .... 230 ..... 4 ..... clay .... 20 ..... 4 ..... limestone-spar .... 830 ..... 5 ..... limestone .... 1160 ..... 3 ..... chalk .... 630 ..... 31/2 ..... white iron-ore .... 560 ..... 4 ..... dark iron-ore .... 410 ..... 1/2 ..... molybdena .... 25 ..... 1/2 ..... stream tin .... 20 ..... 2 ..... steatites .... 40 ..... 2 ..... barytes .... 26 ..... 2 ..... black wad .... 80 ..... 4 ..... sand stone .... 75 ..... 3 ..... coal .... 700 .....

In this account the fixed air was previously extracted from the limestones by acids, and the heat applied was much less than was necessary to extract all the air from the bodies employed. Add to this the known quantities of air which are combined with the calciform ores, as the ochres of iron, manganese, calamy, grey ore of lead, and some idea may be formed of the great production of air in volcanic eruptions, as mentioned in note on Chunda, Vol. II. and of the perpetual absorptions and evolutions of whole oceans of air from every part of the earth.

But there would seem to be an officina aeris, a shop where air is both manufactured and destroyed in the greatest abundance within the polar circles, as will hereafter be spoken of. Can this be effected by some yet unknown law of the congelation of aqueous or saline fluids, which may set at liberty their combined heat, and convert a part both of the acid and alcali of sea-water into their component airs? Or on the contrary can the electricity of the northern lights convert inflammable air and oxygene into water, whilst the great degree of cold at the poles unites the azote with some other base? Another officina aeris, or manufacture of air, would seem to exist within the tropics or at the line, though in a much less quantity than at the poles, owing perhaps to the action of the sun's light on the moisture suspended in the air, as will also be spoken of hereafter; but in all other parts of the earth these

absorptions and evolutions of air in a greater or less degree are perpetually going on in inconceivable abundance; increased probably, and diminished at different seasons of the year by the approach or retrocession of the sun's light; future discoveries must elucidate this part of the subject. To this should be added that as heat and electricity, and perhaps magnetism, are known to displace air, that it is not impossible but that the increased or diminished quantities of these fluids diffused in the atmosphere may increase its weight a well as its bulk; since their specific attractions or affinities to matter are very strong, they probably also possess general gravitation to the earth; a subject which wants further investigation. See Note XXVI.

SOUTH-WEST WINDS.

The velocity of the surface of the earth in moving round its axis diminishes from the equator to the poles. Whence if a region of air in this country should be suddenly removed a few degrees towards the north it must constitute a western wind, because from the velocity it had previously acquired in this climate by its friction with the earth it would for a time move quicker than the surface of the country it was removed to; the contrary must ensue when a region of air is transported from this country a few degrees southward, because the velocity it had acquired in this climate would be less than that of the earth's surface where it was removed to, whence it would appear to constitute a wind from the east, while in reality the eminent parts of the earth would be carried against the too slow air. But if this transportation of air from south to north be performed gradually, the motion of the wind will blow in the diagonal between south and west. And on the contrary if a region of air be gradually removed from north to south it would also blow diagonally between the north and east, from whence we may safely conclude that all our winds in this country which blow from the north or east, or any point between them, consist of regions of air brought from the north; and that all our winds blowing from the south or west, or from any point between them, are regions of air brought from the south.

It frequently happens during the vernal months that after a north-east wind has passed over us for several weeks, during which time the barometer has flood at above 301/2 inches, it becomes suddenly succeeded by a south-west wind, which also continues several weeks, and the barometer sinks to nearly 281/2 inches. Now as two inches of the mercury in the barometer balance one-fifteenth part of the whole atmosphere, an important question here presents itself, *what is become of all this air*.

1. This great quantity of air can not be carried in a superior current towards the line, while the inferior current slows towards the poles, because then it would equally affect the barometer, which should not therefore subside from 301/2 inches to 281/2 for six weeks together.

2. It cannot be owing to the air having lost all the moisture which was previously dissolved in it, because these warm south-west winds are replete with moisture, and the cold north-east winds, which weigh up the mercury in the barometer to 31 inches, consist of dry air.

3. It can not be carried over the polar regions and be accumulated on the meridian, opposite to us in its passage towards the line, as such an accumulation would equal one-fifteenth of the whole atmosphere, and can not be supposed to remain in that situation for six weeks together.

4. It can not depend on the existence of tides in the atmosphere, since it must then correspond to lunar periods. Nor to accumulations of air from the specific levity of the upper regions of the atmosphere, since its degree of fluidity must correspond with its tenuity, and consequently such great mountains of air can not be supposed to exist for so many weeks together as the south west winds sometimes continue.

5. It remains therefore that there must be at this time a great and sudden absorption of air in the polar circle by some unknown operation of nature, and that the south wind runs in to supply the deficiency. Now as this south wind consists of air brought from a part of the earth's surface which moves faster than it does in this climate it must have at the same time a direction from the west by retaining part of the velocity it had previously acquired. These south-west winds coming from a warmer country, and becoming colder by their contact with the earth of this climate, and by their expansion, (so great a part of the superincumbent atmosphere having vanished,) precipitate their moisture; and as they continue for several weeks to be absorbed in the polar circle would seem to receive a perpetual supply from the tropical regions, especially over the line, as will hereafter be spoken of.

It may sometimes happen that a north-east wind having passed over us may be bent down and driven back before it has acquired any heat from the climate, and may thus for a few hours or a day have a south-west direction, and from its descending from a higher region of the atmosphere may possess a greater degree of cold than an inferior north east current of air.

The extreme cold of Jan. 13, 1709, at Paris came on with a gentle south wind, and was diminished

when the wind changed to the north, which is accounted for by Mr. Homberg from a reflux of air which had been flowing for some time from the north. Chemical Essays by R. Watson, Vol. V. p. 182.

It may happen that a north-east current may for a day or two pass over us and produce incessant rain by mixing with the inferior south-west current; but this as well as the former is of short duration, as its friction will soon carry the inferior current along with it, and dry or frosty weather will then succeed.

NORTH-EAST WINDS.

The north-east winds of this country consist of regions of air from the north, travelling sometimes at the rate of about a mile in two minutes during the vernal months for several weeks together from the polar regions toward the south, the mercury in the barometer standing above 30. These winds consist of air greatly cooled by the evaporation of the ice and snow over which it passes, and as they become warmer by their contact with the earth of this climate are capable of dissolving more moisture as they pass along, and are thence attended with frosts in winter and with dry hot weather in summer.

1. This great quantity of air can not be supplied by superior currents passing in a contrary direction from south to north, because such currents must as they arise into the atmosphere a mile or two high become exposed to so great cold as to occasion them to deposit their moisture, which would fall through the inferior current upon the earth in some part of their passage.

2. The whole atmosphere must have increased in quantity, because it appears by the barometer that there exists one-fifteenth part more air over us for many weeks together, which could not be thus accumulated by difference of temperature in respect to heat, or by any aerostatic laws at present known, or by any lunar influence.

From whence it would appear that immense masses of air were set at liberty from their combinations with solid bodies, along with a sufficient quantity of combined heat, within the polar circle, or in some region to the north of us; and that they thus perpetually increase the quantity of the atmosphere; and that this is again at certain times re-absorbed, or enters into new combinations at the line or tropical regions. By which wonderful contrivance the atmosphere is perpetually renewed and rendered fit for the support of animal and vegetable life.

SOUTH-EAST WINDS.

The south-east winds of this country consist of air from the north which had passed by us, or over us, and before it had obtained the velocity of the earth's surface in this climate had been driven back, owing to a deficiency of air now commencing at the polar regions. Hence these are generally dry or freezing winds, and if they succeed north-east winds should prognosticate a change of wind from north-east to south-west; the barometer is generally about 30. They are sometimes attended with cloudy weather, or rain, owing to their having acquired an increased degree of warmth and moisture before they became retrograde; or to their being mixed with air from the south.

2. Sometimes these south-east winds consist of a vertical eddy of north- east air, without any mixture of south-west air; in that case the barometer continues above 30, and the weather is dry or frosty for four or five days together.

It should here be observed, that air being an elastic fluid must be more liable to eddies than water, and that these eddies must extend into cylinders or vortexes of greater diameter, and that if a vertical eddy of north-east air be of small diameter or has passed but a little way to the south of us before its return, it will not have gained the velocity of the earth's surface to the south of us, and will in consequence become a south-east wind.—But if the vertical eddy be of large diameter, or has passed much to the south of us, it will have acquired velocity from its friction with the earth's surface to the south of us, and will in consequence on its return become a south-west wind, producing great cold.

NORTH-WEST WINDS.

There seem to be three sources of the north-west winds of this hemisphere of the earth. 1. When a portion of southern air, which was passing over us, is driven back by accumulation of new air in the polar regions. In this case I suppose they are generally moist or rainy winds, with the barometer under 30, and if the wind had previously been in the south-west, it would seem to prognosticate a change to the north-east.

2. If a current of north wind is passing over us but a few miles high, without any easterly direction; and is bent down upon us, it must immediately possess a westerly direction, because it will now move

faster than the surface of the earth where it arrives; and thus becomes changed from a north-east to a north-west wind. This descent of a north- east current of air producing a north-west wind may continue some days with clear or freezing weather, as it may be simply owing to a vertical eddy of north-east air, as will be spoken of below. It may otherwise be forced down by a current of south-west wind passing over it, and in this case it will be attended with rain for a few days by the mixture of the two airs of different degrees of heat; and will prognosticate a change of wind from north-east to south-west if the wind was previously in the north-east quarter.

3. On the eastern coast of North America the north-west winds bring frost, as the north-east winds do in this country, as appears from variety of testimony. This seems to happen from a vertical spiral eddy made in the atmosphere between the shore and the ridge of mountains which form the spine or back-bone of that continent. If a current of water runs along the hypothenuse of a triangle an eddy will be made in the included angle, which will turn round like a water-wheel as the stream passes in contact with one edge of it. The same must happen when a sheet of air flowing along from the north-east rises from the shore in a straight line to the summit of the Apalachian mountains, a part of the stream of north-east air will flow over the mountains, another part will revert and circulate spirally between the summit of the country and the eastern shore, continuing to move toward the south; and thus be changed from a north-east to a north-west wind.

This vertical spiral eddy having been in contact with the cold summits of these mountains, and descending from higher parts of the atmosphere will lose part of its heat, and thus constitute one cause of the greater coldness of the eastern sides of North America than of the European shores opposite to them, which is said to be equal to twelve degrees of north latitude, which is a wonderful fact, not otherwise easy to be explained, since the heat of the springs at Philadelphia is said to be 50, which is greater than the medium heat of the earth in this country.

The existence of vertical eddies, or great cylinders of air rolling on the surface of the earth, is agreeable to the observations of the constructors of windmills; who on this idea place the area of the sails leaning backwards, inclined to the horizon; and believe that then they have greater power than when they are placed quite perpendicularly. The same kind of rolling cylinders of water obtain in rivers owing to the friction of the water against the earth at their bottoms; as is known by bodies having been observed to float upon their surfaces quicker than when immersed to a certain depth. These vertical eddies of air probably exist all over the earth's surface, but particularly at the bottom or sides of mountains; and more so probably in the course of the south-west than of the north-east winds; because the former fall from an eminence, as it were, on a part of the earth where there is a deficiency of the quantity of air; as is shewn by the sinking of the barometer: whereas the latter are pushed or squeezed forward by an addition to the atmosphere behind them, as appears by the rising of the barometer.

TRADE-WINDS.

A column of heated air becomes lighter than before, and will therefore ascend, by the pressure of the cold air which surrounds it, like a cork in water, or like heated smoke in a chimney.

Now as the sun passes twice over the equator for once over either tropic, the equator has not time to become cool; and on this account it is in general hotter at the line than at the tropics; and therefore the air over the line, except in some few instances hereafter to be mentioned, continues to ascend at all seasons of the year, pressed upwards by regions of air brought from the tropics.

This air thus brought from the tropics to the equator, would constitute a north wind on one side of the equator, and a south wind on the other; but as the surface of the earth at the equator moves quicker than the surface of the earth at the tropics, it is evident that a region of air brought from either tropic to the equator, and which had previously only acquired the velocity of the earth's surface at the tropics, will now move too slow for the earth's surface at the equator, and will thence appear to move in a direction contrary to the motion of the earth. Hence the trade-winds, though they consist of regions of air brought from the north on one side of the line, and from the south on the other, will appear to have the diagonal direction of north-east and south-west winds.

Now it is commonly believed that there are superior currents of air passing over these north-east and south-west currents in a contrary direction, and which descending near the tropics produce vertical whirlpools of air. An important question here again presents itself, *What becomes of the moisture which this heated air ought to deposit, as it cools in the upper regions of the atmosphere in its journey to the tropics?* It has been shewn by Dr. Priestley and Mr. Ingenhouz that the green matter at the bottom of cisterns, and the fresh leaves of plants immersed in water, give out considerable quantities of vital air in the sun-shine; that is, the perspirable matter of plants (which is water much divided in its egress from their minute pores) becomes decomposed by the sun's light, and converted into two kinds of air, the vital and inflammable airs. The moisture contained or dissolved in the ascending heated air

at the line must exist in great tenuity; and by being exposed to the great light of the sun in that climate, the water may be decomposed, and the new airs spread on the atmosphere from the line to the poles.

1. From there being no constant deposition of rains in the usual course of the trade-winds, it would appear that the water rising at the line is decomposed in its ascent.

2. From the observations of M. Bougner on the mountain Pinchinca, one of the Cordelieres immediately under the line, there appears to be no condensible vapour above three or four miles high. Now though the atmosphere at that height may be cold to a very considerable degree; yet its total deprivation of condensible vapour would seem to shew, that its water was decomposed; as there are no experiments to evince that any degree of cold hitherto known has been able to deprive air of its moisture; and great abundance of snow is deposited from the air that flows to the polar regions, though it is exposed to no greater degrees of cold in its journey thither than probably exists at four miles height in the atmosphere at the line.

3. The hygrometer of Mr. Sauffure also pointed to dryness as he ascended into rarer air; the single hair of which it was constructed, contracting from deficiency of moisture. Essais sur l'Hygromet. p. 143.

From these observations it appears either that rare and cold air requires more moisture to saturate it than dense air; or that the moisture becomes decomposed and converted into air, as it ascends into these cold and rare regions of the atmosphere.

4. There seems some analogy between the circumstance of air being produced or generated in the cold parts of the atmosphere both at the line and at the poles.

MONSOONS AND TORNADOES.

1. In the Arabian and Indian seas are winds, which blow six months one way, and six months the other, and are called Monsoons; by the accidental dispositions of land and sea it happens, that in some places the air near the tropic is supposed to become warmer when the sun is vertical over it, than at the line. The air in these places consequently ascends pressed upon one side by the north-east regions of air, and on the other side by the south-west regions of air. For as the air brought from the south has previously obtained the velocity of the earth's surface at the line, it moves faster than the earth's surface near the tropic where it now arrives, and becomes a south-west wind, while the air from the north becomes a north-east wind as before explained. These two winds do not so quietly join and ascend as the north-east and south-east winds, which meet at the line with equal warmth and velocity and form the trade-winds; but as they meet in contrary directions before they ascend, and cannot be supposed accurately to balance each other, a rotatory motion will be produced as they ascend like water falling through a hole, and an horizontal or spiral eddy is the consequence; these eddies are more or less rapid, and are called Tornadoes in their most violent state, raising water from the ocean in the west or sand from the deserts of the east, in less violent degrees they only mix together the two currents of north-east and south- west air, and produce by this means incessant rains, as the air of the north-east acquires some of the heat from the south-west wind, as explained in Note XXV. This circumstance of the eddies produced by the monsoon-winds was seen by Mr. Bruce in Abyssinia; he relates that for many successive mornings at the commencement of the rainy monsoon, he observed a cloud of apparently small dimensions whirling round with great rapidity, and in few minutes the heavens became covered with dark clouds with consequent great rains. See Note on Canto III. l. 129.

2. But it is not only at the place where the air ascends at the northern extremity of the rainy monsoon, and where it forms tornadoes, as observed above by Mr. Bruce, but over a great tract of country several degrees in length in certain parts as in the Arabian sea, a perpetual rain for several months descends, similar to what happens for weeks together in our own climate in a less degree during the south-west winds. Another important question presents itself here, *if the climate to which this south-west wind arrives, it not colder than that it comes from, why should it deposit its moisture during its whole journey? if it be a colder climate, why does it come thither?* The tornadoes of air above described can extend but a little way, and it is not easy to conceive that a superior cold current of air can mix with an inferior one, and thus produce showers over ten degrees of country, since at about three miles high there is perpetual frost; and what can induce these narrow and shallow currents to flow over each other so many hundred miles?

Though the earth at the northren extremity of this monsoon may be more heated by certain circumstances of situation than at the line, yet it seems probable that the intermediate country between that and the line, may continue colder than the line (as in other parts of the earth) and hence that the air coming from the line to supply this ascent or destruction of air at the northern extremity of the monsoon will be cooled all the way in its approach, and in consequence deposit its water. It seems

probable that at the northern extremity of this monsoon, where the tornadoes or hurricanes exist, that the air not only ascends but is in part converted into water, or otherwise diminished in quantity, as no account is given of the existence of any superior currents of it.

As the south-west winds are always attended with a light atmosphere, an incipient vacancy, or a great diminution of air must have taken place to the northward of them in all parts of the earth wherever they exist, and a deposition of their moisture succeeds their being cooled by the climate they arrive at, and not by a contrary current of cold air over them, since in that case the barometer would not sink. They may thus in our own country be termed monsoons without very regular periods.

3. Another cause of TORNADOES independent of the monsoons is ingeniously explained by Dr. Franklin, when in the tropical countries a stratum of inferior air becomes so heated by its contact with the warm earth, that its expansion is increased more than is equivalent to the pressure of the stratum of air over it; or when the superior stratum becomes more condensed by cold than the inferior one by pressure, the upper region will descend and the lower one ascend. In this situation if one part of the atmosphere be hotter from some fortuitous circumstances, or, has less pressure over it, the lower stratum will begin to ascend at this part, and resemble water falling through a hole as mentioned above. If the lower region of air was going forwards with considerable velocity, it will gain an eddy by riling up this hole in the incumbent heavy air, so that the whirlpool or tornado has not only its progressive velocity, but its circular one also, which thus lifts up or overturns every thing within its spiral whirl. By the weaker whirlwinds in this country the trees are sometimes thrown down in a line of only twenty or forty yards in breadth, making a kind of avenue through a country. In the West Indies the sea rises like a cone in the whirl, and is met by black clouds produced by the cold upper air and the warm lower air being rapidly mixed; whence are produced the great and sudden rains called water-spouts; while the upper and lower airs exchange their plus or minus electricity in perpetual lightenings.

LAND AND SEA-BREEZES.

The sea being a transparent mass is less heated at its surface by the sun's rays than the land, and its continual change of surface contributes to preserve a greater uniformity in the heat of the air which hangs over it. Hence the surface of the tropical islands is more heated during the day than the sea that surrounds them, and cools more in the night by its greater elevation: whence in the afternoon when the lands of the tropical islands have been much heated by the sun, the air over them ascends pressed upwards by the cooler air of the incircling ocean, in the morning again the land becoming cooled more than the sea, the air over it descends by its increased gravity, and blows over the ocean near its shores.

CONCLUSION.

1. There are various irregular winds besides those above described, which consist of horizontal or vertical eddies of air owing to the inequality of the earth's surface, or the juxtaposition of the sea. Other irregular winds have their origin from increased evaporation of water, or its sudden devaporation and descent in showers; others from the partial expansion and condensation of air by heat and cold; by the accumulation or defect of electric fluid, or to the air's new production or absorption occasioned by local causes not yet discovered. See Notes VII. and XXV.

2. There seem to exist only two original winds: one consisting of air brought from the north, and the other of air brought from the south. The former of these winds has also generally an apparent direction from the east, and the latter from the west, arising from the different velocities of the earth's surface. All the other winds above described are deflections or retrogressions of some parts of these currents of air from the north or south.

3. One fifteenth part of the atmosphere is occasionally destroyed, and occasionally reproduced by unknown causes. These causes are brought into immediate activity over a great part of the surface of the earth at nearly the same time, but always act more powerful to the northward than to the southward of any given place; and would hence seem to have their principal effect in the polar circles, existing nevertheless though with less power toward the tropics or at the line.

For when the north-east wind blows the barometer rises, sometimes from 281/2 inches to 301/2, which shews a great new generation of air in the north; and when the south-west wind blows the barometer sinks as much, which shews a great destruction of air in the north. But as the north- east winds sometimes continue for five or six weeks, the newly-generated air must be destroyed at those times in the warmer climates to the south of us, or circulate in superior currents, which has been shewn to be improbable from its not depositing its water. And as the south-west winds sometimes continue for some weeks, there must be a generation of air to the south at those times, or superior currents, which last has been shewn to be improbable.

4. The north-east winds being generated about the poles are pushed forwards towards the tropics or line, by the pressure from behind, and hence they become warmer, as explained in Note VII. as well as by their coming into contact with a warmer part of the earth which contributes to make these winds greedily absorb moisture in their passage. On the contrary, the south-west winds, as the atmosphere is suddenly diminished in the polar regions, are drawn as it were into an incipient vacancy, and become therefore expanded in their passage, and thus generate cold, as explained in Note VII. and are thus induced to part with their moisture, as well as by their contact with a colder part of the earth's surface. Add to this, that the difference in the sound of the north-east and south-west winds may depend on the former being pushed forwards by a pressure behind, and the latter falling as it were into a partial or incipient vacancy before; whence the former becomes more condensed, and the latter more rarefied as it passes. There is a whistle, termed a lark-call, which consists of a hollow cylinder of tin-plate, closed at each end, about half an inch in diameter and a quarter of an inch high, with opposite holes about the size of a goose-quill through the centre of each end; if this lark-whistle be held between the lips the sound of it is manifestly different when the breath is forceably blown through it from within outwards, and when it is sucked from without inwards. Perhaps this might be worthy the attention of organ-builders.

5. A stop is put to this new generation of air, when about a fifteenth of the whole is produced, by its increasing pressure; and a similar boundary is fixed to its absorption or destruction by the decrease of atmospheric pressure. As water requires more heat to convert it into vapour under a heavy atmosphere than under a light one, so in letting off the water from muddy fish-ponds great quantities of air-bubbles are seen to ascend from the bottom, which were previously confined there by the pressure of the water. Similar bubbles of inflammable air are seen to arise from lakes in many seasons of the year, when the atmosphere suddenly becomes light.

6. The increased absorptions and evolutions of air must, like its simple expansions, depend much on the presence or absence of heat and light, and will hence, in respect to the times and places of its production and destruction, be governed by the approach or retrocession of the sun, and on the temperature, in regard to heat, of various latitudes, and parts of the same latitude, so well explained by Mr. Kirwan.

7. Though the immediate cause of the destruction or reproduction of great masses of air at certain times, when the wind changes from north to south, or from south to north can not yet be ascertained; yet as there appears greater difficulty in accounting for this change of wind for any other known causes, we may still suspect that there exists in the arctic and antarctic circles a BEAR or DRAGON yet unknown to philosophers, which at times suddenly drinks up, and as suddenly at other times vomits out one-fifteenth part of the atmosphere: and hope that this or some future age will learn how to govern and domesticate a monster which might be rendered of such important service to mankind.

INSTRUMENTS.

If along with the usual registers of the weather observations were made on the winds in many parts of the earth with the three following instruments, which might be constructed at no great expence, some useful information might be acquired.

1. To mark the hour when the wind changes from north-east to south-west, and the contrary. This might be managed by making a communication from the vane of a weathercock to a clock; in such a manner, that if the vane mould revolve quite round, a tooth on its revolving axis should stop the clock, or put back a small bolt on the edge of a wheel revolving once in twenty-four hours.

2. To discover whether in a year more air passed from north to south, or the contrary. This might be effected by placing a windmill-sail of copper about nine inches diameter in a hollow cylinder about six inches long, open at both ends, and fixed on an eminent situation exactly north and south. Thence only a part of the north-east and south-west currents would affect the sail so as to turn it; and if its revolutions were counted by an adapted machinery, as the sail would turn one way with the north currents of air, and the contrary one with the south currents, the advance of the counting finger either way would shew which wind had prevailed most at the end of the year.

3. To discover the rolling cylinders of air, the vane of a weathercock might be so suspended as to dip or rise vertically, as well as to have its horizontal rotation.

RECAPITULATION.

NORTH-EAST WINDS consist of air flowing from the north, where it seems to be occasionally produced; has an apparent direction from the east owing to its not having acquired in its journey the

increasing velocity of the earth's surface; these winds are analogous to the trade-winds between the tropics, and frequently continue in the vernal months for four and six weeks together, with a high barometer, and fair or frosty weather. 2. They sometimes consist of south-west air, which had passed by us or over us, driven back by a new accumulation of air in the north, These continue but a day or two, and are attended with rain. See Note XXV.

SOUTH-WEST WIND consists of air flowing from the south, and seems occasionally absorbed at its arrival to the more northern latitudes. It has a real direction from the west owing to its not having lost in its journey the greater velocity it had acquired from the earth's surface from whence it came. These winds are analogous to the monsoons between the tropics, and frequently continue for four or six weeks together, with a low barometer and rainy weather. 2. They sometimes consist of north-east air, which had passed by us or over us, which becomes retrograde by a commencing deficiency of air in the north. These winds continue but a day or two, attended with severer frost with a sinking barometer; their cold being increased by their expansion, as they return, into an incipient vacancy.

NORTH-WEST WINDS consist, first, of south-west winds, which have passed over us, bent down and driven back towards the south by newly generated northern air. They continue but a day or two, and are attended with rain or clouds. 2. They consist of north-east winds bent down from the higher parts of the atmosphere, and having there acquired a greater velocity than, the earth's surface; are frosty or fair. 3. They consist of north- east winds formed into a vertical spiral eddy, as on the eastern coasts of North America, and bring severe frost.

SOUTH-EAST WINDS consist, first, of north-east winds become retrograde, continue for a day or two, frosty or fair, sinking barometer. 2. They consist of north-east winds formed into a vertical eddy not a spiral one, frost or fair.

NORTH WINDS consist, first, of air flowing slowly from the north, so that they acquire the velocity of the earth's surface as they approach, are fair or frosty, seldom occur. 2. They consist of retrograde south winds; these continue but a day or two, are preceded by south-west winds; and are generally succeeded by north-east winds, cloudy or rainy, barometer rising.

SOUTH WINDS consist, first, of air flowing slowly from the south, loosing their previous western velocity by the friction of the earth's surface as they approach, moist, seldom occur, 2. They consist of retrograde north winds; these continue but a day or two, are preceded by north-east winds, and generally succeeded by south-west winds, colder, barometer sinking.

EAST WINDS consist of air brought hastily from the north, and not impelled farther southward, owing to a sudden beginning absorption of air in the northern regions, very cold, barometer high, generally succeeded by south-west wind.

WEST WINDS consist of air brought hastily from the south, and checked from proceeding further to the north by a beginning production of air in the northern regions, warm and moist, generally succeeded by north-east wind. 2. They consist of air bent down from the higher regions of the atmosphere, if this air be from the south, and brought hastily it becomes a wind of great velocity, moving perhaps 60 miles an hour, is warm and rainy; if it consists of northern air bent down it is of less velocity and colder.

Application of the preceding Theory to Some Extracts from a Journal of the Weather.

Dec. 1, 1790. The barometer sunk suddenly, and the wind, which had been some days north-east with frost, changed to south-east with an incessant though moderate fall of snow. A part of the northern air, which had passed by us I suppose, now became retrograde before it had acquired the velocity of the earth's surface to the south of us, and being attended by some of the southern air in its journey, the moisture of the latter became condensed and frozen by its mixture mith the former.

Dec. 2, 3. The wind changed to north-west and thawed the snow. A part of the southern air, which had passed by us or over us, with the retrograde northern air above described, was now in its turn driven back, before it had lost the velocity of the surface of the earth to the south of us, and consequently became a north-west wind; and not having lost the warmth it brought from the south produced a thaw.

Dec. 4, 5. Wind changed to north-east with frost and a rising barometer. The air from the north continuing to blow, after it had driven back the southern air as above described, became a north-east wind, having less velocity than the surface of the earth in this climate, and produced frost from its coldness.

Dec. 6, 7. Wind now changed to the south-west with incessant rain and a sinking barometer. From unknown causes I suppose the quantity of air to be diminished in the polar regions, and the southern air cooled by the earth's surface, which was previously frozen, deposits its moisture for a day or two; afterwards the wind continued south-west without rain, as the surface of the earth became warmer.

March 18, 1785. There has been a long frost; a few days ago the barometer sunk to 291/2, and the frost became more severe. Because the air being expanded by a part of the pressure being taken off became colder. This day the mercury rose to 30, and the frost ceased, the wind continuing as before between north and east. *March 19.* Mercury above 30, weather still milder, no frost, wind north-east. *March 20.* The same, for the mercury rising shews that the air becomes more compressed by the weight above, and in consequence gives out warmth.

April 4, 5. Frost, wind north-east, the wind changed in the middle of the day to the north-west without rain, and has done so for three or four days, becoming again north-east at night. For the sun now giving greater degrees of heat, the air ascends as the sun passes the zenith, and is supplied below by the air on the western side as well as on the eastern side of the zenith during the hot part of the day; whence for a few hours, on the approach of the hot part of the day, the air acquires a westerly direction in this longitude. If the north-west wind had been caused by a retrograde motion of some southern air, which had passed over us, it would have been attended with rain or clouds.

April 10. It rained all day yesterday, the wind north-west, this morning there was a sharp frost. The evaporation of the moisture, (which fell yesterday) occasioned by the continuance of the wind, produced so much cold as to freeze the dew.

May 12. Frequent showers with a current of colder wind preceding every shower. The sinking of the rain or cloud pressed away the air from beneath it in its descent, which having been for a time shaded from the sun by the floating cloud, became cooled in some degree.

June 20. The barometer sunk, the wind became south-west, and the whole heaven was instantly covered with clouds. A part of the incumbent atmosphere having vanished, as appeared by the sinking of the barometer, the remainder became expanded by its elasticity, and thence attracted some of the matter of heat from the vapour intermixed with it, and thus in a few minutes a total devaporation took place, as in exhausting the receiver of an air-pump. See note XXV. At the place where the air is destroyed, currents both from the north and south flow in to supply the deficiency, (for it has been shewn that there are no other proper winds but these two) and the mixture of these winds produces so sudden condensation of the moisture, both by the coldness of the northern air and the expansion of both of them, that lightning is given out, and an incipient tornado takes place; whence thunder is said frequently to approach against the wind.

August 28, 1732. Barometer was at 31, and *Dec. 30*, in the same year, it was at 28 2-tenths. Medical Essays, Edinburgh, Vol. II. p. 7. It appears from these journals that the mercury at Edinburgh varies sometimes nearly three inches, or one tenth of the whole atmosphere. From the journals kept by the Royal Society at London it appears seldom to vary more than two inches, or one-fifteenth of the whole atmosphere. The quantity of the variation is said still to decrease nearer the line, and to increase in the more northern latitudes; which much confirms the idea that there exists at certain times a great destruction or production of air within the polar circle.

July 2, 1732. The westerly winds in the journal in the Medical Essays, Vol. II. above referred to, are frequently marked with the number three to shew their greater velocity, whereas the easterly winds seldom approach to the number two. The greater velocity of the westerly winds than the easterly ones is well known I believe in every climate of the world; which may be thus explained from the theory above delivered. 1. When the air is still, the higher parts of the atmosphere move quicker than those parts which touch the earth, because they are at a greater distance from the axis of motion. 2. The part of the atmosphere where the north or south wind comes from is higher than the part of it where it comes to, hence the more elevated parts of the atmosphere continue to descend towards the earth as either of those winds approach. 3. When southern air is brought to us it possesses a westerly direction also, owing to the velocity it had previously acquired from the earth's surface; and if it consists of air from the higher parts of the atmosphere descending nearer the earth, this westerly velocity becomes increased. But when northern air is brought to us, it possesses an apparent easterly direction also, owing to the velocity which it had previously acquired from the earth's surface being less than that of the earth's surface in this latitude; now if the north-east wind consists of air descending from higher parts of the atmosphere, this deficiency of velocity will be less, in consequence of the same cause, viz. The higher parts of the atmosphere descending, as the wind approaches, increases the real velocity of the western winds, and decreases the apparent velocity of the eastern ones.

October 22. Wind changed from south-east to south-west. There is a popular prognostication that if the wind changes from the north towards the south passing through the east, it is more likely to

continue in the south, than if it passes through the west, which may be thus accounted for. If the north-east wind changes to a north-west wind, it shews either that a part of the northern air descends upon us in a spiral eddy, or that a superior current of southern air is driven back; but if a north-east wind be changed into a south-east wind it shews that the northern air is become retrograde, and that in a day or two, as soon as that part of it has passed, which has not gained the velocity of the earth's surface in this latitude, it will become a south wind for a few hours, and then a south-west wind.

The writer of this imperfect sketch of anemology wishes it may incite some person of greater leizure and ability to attend to this subject, and by comparing the various meteorological journals and observations already published, to construct a more accurate and methodical treatise on this interesting branch of philosophy.

NOTE XXXIV.—VEGETABLE PERSPIRATION.

And wed the enamoured Oxygene to Light.

CANTO IV. l. 34.

When points or hairs are put into spring-water, as in the experiments of Sir B. Thompson, (Philos. Trans. Vol. LXXVII.) and exposed to the light of the sun, much air, which loosely adhered to the water, rises in bubbles, as explained in note on Fucus, Vol. II. A still greater quantity of air, and of a purer kind, is emitted by Dr. Priestley's green matter, and by vegetable leaves growing in water in the sun-shine, according to Mr. Ingenhouze's experiments; both which I suspect to be owing to a decomposition of the water perspired by the plant, for the edge of a capillary tube of great tenuity may be considered as a circle of points, and as the oxygene, or principle of vital air, may be expanded into a gas by the sun's light; the hydrogene or inflammable air may be detained in the pores of the vegetable.

Hence plants growing in the shade are white, and become green by being exposed to the sun's light; for their natural colour being blue, the addition of hydrogene adds yellow to this blue, and *tans* them green. I suppose a similar circumstance takes place in animal bodies; their perspirable matter as it escapes in the sun-shine becomes decomposed by the edges of their pores as in vegetables, though in less quantity, as their perspiration is less, and by the hydrogene being retained the skin becomes *tanned* yellow. In proof of this it must be observed that both vegetable and animal substances become bleached white by the sun-beams when they are dead, as cabbage-stalks, bones, ivory, tallow, bees-wax, linen and cotton cloth; and hence I suppose the copper-coloured natives of sunny countries might become etiolated or blanched by being kept from their infancy in the dark, or removed for a few generations to more northerly climates.

It is probable that on a sunny morning much pure air becomes separated from the dew by means of the points of vegetables on which it adheres, and much inflammable air imbibed by the vegetable, or combined with it; and by the sun's light thus decomposing water the effects of it in bleaching linen seems to depend (as described in Note X.): the water is decomposed by the light at the ends or points of the cotton or thread, and the vital air unites with the phlogistic or colouring matters of the cloth, and produces a new acid, which is either itself colourless or washes out, at the same time the inflammable part of the water escapes. Hence there seems a reason why cotton bleaches so much sooner than linen, viz. because its fibres are three or four times shorter, and therefore protrude so many more points, which seem to facilitate the liberation of the vital air from the inflammable part of the water.

Bee's wax becomes bleached by exposure to the sun and dews in a similar manner as metals become calcined or rusty, viz. by the water on their surface being decomposed; and hence the inflammable material which caused the colour becomes united with vital air forming a new acid, and is washed away.

Oil close stopped in a phial not full, and exposed long to the sun's light, becomes bleached, as I suppose, by the decomposition of the water it contains; the inflammable air rising above the surface, and the vital air uniting with the colouring matter of the oil. For it is remarkable, that by shutting up a phial of bleached oil in a dark drawer, it in a little time becomes coloured again.

The following experiment shews the power of light in separating vital air from another basis, viz. from azote. Mr. Scheel inverted a glass vessel filled with colourless nitrous acid into another glass containing the same acid, and on exposing them to the sun's light, the inverted glass became partly

filled with pure air, and the acid at the same time became coloured. Scheel in Crell's Annal. 1786. But if the vessel of colourless nitrous acid be quite full and stopped, so that no space is left for the air produced to expand itself into, no change of colour takes place. Priestley's Exp. VI. p. 344. See Keir's very excellent Chemical Dictionary, p. 99. new edition.

A sun-flower three feet and half high according to the experiment of Dr. Hales, perspired two pints in one day (Vegetable Statics.) which is many times as much in proportion to its surface, as is perspired from the surface and lungs of animal bodies; it follows that the vital air liberated from the surfaces of plants by the sunshine must much exceed the quantity of it absorbed by their respiration, and that hence they improve the air in which they live during the light part of the day, and thus blanched vegetables will sooner become *tanned into green* by the sun's light, than etiolated animal bodies will become *tanned yellow* by the same means.

It is hence evident, that the curious discovery of Dr. Priestley, that his green vegetable matter and other aquatic plants gave out vital air when the sun shone upon them, and the leaves of other plants did the same when immersed in water, as observed by Mr. Ingenhouze, refer to the perspiration of vegetables not to their respiration. Because Dr. Priestley observed the pure air to come from both sides of the leaves and even from the stalks of a water-flag, whereas one side of the leaf only serves the office of lungs, and certainly not the stalks. Exper. on Air, Vol. III. And thus in respect to the circumstance in which plants and animals seemed the furtherest removed from each other, I mean in their supposed mode of respiration, by which one was believed to purify the air which the other had injured, they seem to differ only in degree, and the analogy between them remains unbroken.

Plants are said by many writers to grow much faster in the night than in the day; as is particularly observable in seedlings at their rising out of the ground. This probably is a consequence of their sleep rather than of the absence of light; and in this I suppose they also resemble animal bodies.

NOTE XXXV.—VEGETABLE PLACENTATION.

_While in bright veins the silvery sap ascends.

CANTO IV. l. 419.

As buds are the viviparous offspring of vegetables, it becomes necessary that they should be furnished with placental vessels for their nourishment, till they acquire lungs or leaves for the purpose of elaborating the common juices of the earth into nutriment. These vessels exist in bulbs and in seeds, and supply the young plant with a sweet juice till it acquires leaves, as is seen in converting barley into malt, and appears from the sweet taste of onions and potatoes, when they begin to grow.

The placental vessels belonging to the buds of trees are placed about the roots of most, as the vine; so many roots are furnished with sweet or mealy matter as fern-root, bryony, carrot, turnip, potatoe, or in the alburnum or sap-wood as in those trees which produce manna, which is deposited about the month of August, or in the joints of sugar cane, and grasses; early in the spring the absorbent mouths of these vessels drink up moisture from the earth, with a saccharine matter lodged for that purpose during the preceding autumn, and push this nutritive fluid up the vessels of the alburnum to every individual bud, as is evinced by the experiments of Dr. Hales, and of Mr. Walker in the Edinburgh Philosophical Transact. The former observed that the sap from the stump of a vine, which he had cut off in the beginning of April, arose twenty- one feet high in tubes affixed to it for that purpose, but in a few weeks it ceased to bleed at all, and Dr. Walker marked the progress of the ascending sap, and found likewise that as soon as the leaves became expanded the sap ceased to rise; the ascending juice of some trees is so copious and so sweet during the sap-season that it is used to make wine, as the birch, betula, and sycamore, acer pseudo-platinus, and particularly the palm.

During this ascent of the sap-juice each individual leaf-bud expands its new leaves, and shoots down new roots, covering by their intertexture the old bark with a new one; and as soon as these new roots (or bark) are capable of absorbing sufficient juices from the earth for the support of each bud, and the new leaves are capable of performing their office of exposing these juices to the influence of the air; the placental vessels cease to act, coalesce, and are transformed from sap- wood, or alburnum, into inert wood; serving only for the support of the new tree, which grows over them.

Thus from the pith of the new bud of the horse-chesnut five vessels pass out through the circle of the

placental vessels above described, and carry with them a minuter circle of those vessels; these five bundles of vessels unite after their exit, and form the footstalk or petiole of the new five-fingered leaf, to be spoken of hereafter. This structure is well seen by cutting off a leaf of the horse-chesnut (Aesculus Hippocastanum) in September before it falls, as the buds of this tree are so large that the flower may be seen in them with the naked eye.

After a time, perhaps about midsummer, another bundle of vessels passes from the pith through the alburnum or sap-vessels in the bosom of each leaf, and unites by the new bark with the leaf, which becomes either a flower-bud or a leaf-bud to be expanded in the ensuing spring, for which purpose an apparatus of placental vessels are produced with proper nutriment during the progress of the summer and autumn, and thus the vegetable becomes annually increased, ten thousand buds often existing on one tree, according to the estimate of Linneus. Phil. Bot.

The vascular connection of vegetable buds with the leaves in whose bosoms they are formed is confirmed by the following experiment, (Oct. 20, 1781.) On the extremity of a young bud of the Mimosa (sensitive plant) a small drop of acid of vitriol was put by means of a pen, and, after a few seconds, the leaf in whose axilla it dwelt closed and opened no more, though the drop of vitriolic acid was so small as apparently only to injure the summit of the bud. Does not this seem to shew that the leaf and its bud have connecting vessels though they arise at different times and from different parts of the medulla or pith? And, as it exists previously to it, that the leaf is the parent of the bud?

This placentation of vegetable buds is clearly evinced from the sweetness of the rising sap, and from its ceasing to rise as soon as the leaves are expanded, and thus compleats the analogy between buds and bulbs. Nor need we wonder at the length of the umbilical cords of buds since that must correspond with their situation on the tree, in the same manner as their lymphatics and arteries are proportionally elongated.

It does not appear probable that any umbilical artery attends these placental absorbents, since, as there seems to be no system of veins in vegetables to bring back the blood from the extremities of their arteries, (except their pulmonary veins,) there could not be any vegetable fluids to be returned to their placenta, which in vegetables seems to be simply an organ for nutrition, whereas the placenta of the animal foetus seems likewise to serve as a respiratory organ like the gills of fishes.

NOTE XXXVI—VEGETABLE CIRCULATION.

And refluent blood in milky eddies bends.

CANTO IV. l. 420.

The individuality of vegetable buds was spoken of before, and is confirmed by the method of raising all kinds of trees by Mr. Barnes. (Method of propagating Fruit Trees. 1759. Lond. Baldwin.) He cut a branch into as many pieces as there were buds or leaves upon it, and wiping the two wounded ends dry he quickly applied to each a cement, previously warmed a little, which consisted principally of pitch, and planted them in the earth. The use of this cement I suppose to consist in its preventing the bud from bleeding to death, though the author ascribes it to its antisceptic quality.

These buds of plants, which are thus each an individual vegetable, in many circumstances resemble individual animals, but as animal bodies are detached from the earth, and move from place to place in search of food, and take that food at considerable intervals of time, and prepare it for their nourishiment within their own bodies after it is taken, it is evident they must require many organs and powers which are not necessary to a stationary bud. As vegetables are immoveably fixed to the soil from whence they draw their nourishment ready prepared, and this uniformly not at returning intervals, it follows that in examining their anatome we are not to look for muscles of locomotion, as arms and legs; nor for organs to receive and prepare their nourishment, as a stomach and bowels; nor for a reservoir for it after it is prepared, as a general system of veins, which in locomotive animals contains and returns the superfluous blood which is left after the various organs of secretion have been supplied, by which contrivance they are enabled to live a long time without new supplies of food.

The parts which we may expert to find in the anatome of vegetables correspondent to those in the animal economy are, 1. A system of absorbent vessels to imbibe the moisture of the earth similar to the lacteal vessels, as in the roots of plants; and another system of absorbents similar to the lymphatics of

animal bodies, opening its mouths on the internal cells and external surfaces of vegetables; and a third system of absorbent vessels correspondent with those of the placentation of the animal foetus. 2. A pulmonary system correspondent to the lungs or gills of quadrupeds and fish, by which the fluid absorbed by the lacteals and lymphatics may be exposed to the influence of the air, this is done by the green leaves of plants, those in the air resembling lungs, and those in the water resembling gills; and by the petals of flowers. 3. Arterial systems to convey the fluid thus elaborated to the various glands of the vegetable for the purposes of its growth, nutrition, and various secretions. 4. The various glands which separate from the vegetable blood the honey, wax, gum, resin, starch, sugar, essential oil, &c. 5. The organs adapted for their propagation or reproduction. 6. Muscles to perform several motions of their parts.

I. The existence of that branch of the absorbent vessels of vegetables which resembles the lacteals of animal bodies, and imbibes their nutriment from the moist earth, is evinced by their growth so long as moisture is applied to their roots, and their quickly withering when it is withdrawn.

Besides these absorbents in the roots of plants there are others which open their mouths on the external surfaces of the bark and leaves, and on the internal surfaces of all the cells, and between the bark and the alburnum or sap-wood; the existence of these is shewn, because a leaf plucked off and laid with its under side on water will not wither so soon as if left in the dry air,—the same if the bark alone of a branch which is separated from a tree be kept moist with water,—and lastly, by moistening the alburnum or sap-wood alone of a branch detached from a tree it will not so soon wither as if left in the dry air. By the following experiment these vessels were agreeably visible by a common magnifying glass, I placed in the summer of 1781 the footstalks of some large fig-leaves about an inch deep in a decoction of madder, (rubia tinctorum,) and others in a decoction of logwood, (haematoxylum campechense,) along with some sprigs cut off from a plant of picris, these plants were chosen because their blood is white, after some hours, and on the next day, on taking out either of these and cutting off from its bottom about a quarter of an inch of the stalk an internal circle of red points appeared, which were the ends of absorbent vessels coloured red with the decoction, while an external ring of arteries was seen to bleed out hastily a milky juice, and at once evinced both the absorbent and arterial system. These absorbent vessels have been called by Grew, and Malphigi, and some other philosophers, bronchi, and erroneously supposed to be air-vessels. It is probable that these vessels, when cut through, may effuse their fluids, and receive air, their sides being too stiff to collapse; since dry wood emits air-bubles in the exhausted receiver in the same manner as moist wood.

The structure of these vegetable absorbents consists of a spiral line, and not of a vessel interrupted with valves like the animal lymphatics, since on breaking almost any tender leaf and drawing out some of the fibres which adhere longest this spiral structure becomes visible even to the naked eye, and distinctly so by the use of a common lens. See Grew, Plate 51.

In such a structure it is easy to conceive how a vermicular or peristaltic motion of the vessel beginning at the lowest part of it, each spiral ring successively contracting itself till it fills up the tube, must forcibly push forwards its contents, as from the roots of vines in the bleeding season; and if this vermicular motion should begin at the upper end of the vessel it is as easy to see how it must carry its contained fluid in a contrary direction. The retrograde motion of the vegetable absorbent vessels is shewn by cutting a forked branch from a tree, and immersing a part of one of the forks in water, which will for many days prevent the other from withering; or it is shewn by planting a willow branch with the wrong end upwards. This structure in some degree obtains in the esophagus or throat of cows, who by similar means convey their food first downwards and afterward upwards by a retrograde motion of the annular muscles or cartilages for the purpose of a second mastication of it.

II. The fluids thus drank up by the vegetable absorbent vessels from the earth, or from the atmosphere, or from their own cells and interfaces, are carried to the foot-stalk of every leaf, where the absorbents belonging to each leaf unite into branches, forming so many pulmonary arteries, and are thence dispersed to the extremities of the leaf, as may be seen in cutting away slice after slice the footstalk of a horse- chesnut in September before the leaf falls. There is then a compleat circulation in the leaf; a pulmonary vein receiving the blood from the extremities of each artery on the upper side of the leaf, and joining again in the footstalk of the leaf these veins produce so many arteries, or aortas, which disperse the new blood over the new bark, elongating its vessels, or producing its secretions; but as a reservoir of blood could not be wanted by a vegetable bud which takes in its nutriment at all times, I imagine there is no venous system, no veins properly so called, which receive the blood which was to spare, and return it into the pulmonary or arterial system.

The want of a system of veins was countenanced by the following experiment; I cut off several stems of tall spurge, (Euphorbia helioscopia) in autumn, about the centre of the plant, and observed tenfold the quantity of milky juice ooze from the upper than from the lower extremity, which could hardly have happened if there had been a venous system of vessels to return the blood from the roots to the leaves.

Thus the vegetable circulation, complete in the lungs, but probably in the other part of the system deficient in respect to a system of returning veins, is carried forwards without a heart, like the circulation through the livers of animals where the blood brought from the intestines and mesentery by one vein is dispersed through the liver by the vena portarum, which assumes the office of an artery. See Note XXXVII.

At the same time so minute are the vessels in the intertexture of the barks of plants, which belong to each individual bud, that a general circulation may possibly exist, though we have not yet been able to discover the venous part of it.

There is however another part of the circulation of vegetable juices visible to the naked eye, and that is in the corol or petals of flowers, in which a part of the blood of the plant is exposed to the influence of the air and light in the same manner as in the foliage, as will be mentioned more at large in Notes XXXVII and XXXIX.

These circulations of their respective fluids seem to be carried on in the vessels of plants precisely as in animal bodies by their irritability to the stimulus of their adapted fluids, and not by any mechanical or chemical attraction, for their absorbent vessels propel the juice upwards, which they drink up from the earth, with great violence; I suppose with much greater than is exerted by the lacteals of animals, probably owing to the greater minuteness of these vessels in vegetables and the greater rigidity of their coats. Dr. Hales in the spring season cut off a vine near the ground, and by fixing tubes on the remaining stump of it, found the sap to rise twenty-one feet in the tube by the propulsive power of these absorbents of the roots of it. Veget. Stat. p. 102. Such a power can not be produced by capillary attraction, as that could only raise a fluid nearly to the upper edge of the attracting cylinder, but not enable it to flow over that edge, and much less to rise 21 feet above it. What then can this power be owing to? Doubtless to the living activity of the absorbent vessels, and to their increased vivacity from the influence of the warmth of the spring succeeding the winter's cold, and their thence greater susceptibility to irritation from the juices which they absorb, resembling in all circumstances the action of the living vessels of animals.

NOTE XXXVII—VEGETABLE RESPIRATION.

While spread in air the leaves respiring play.

CANTO IV. l. 421.

I. There have been various opinions concerning the use of the leaves of plants in the vegetable oeconomy. Some have contended that they are perspiratory organs; this does not seem probable from an experiment of Dr. Hales, Veg. Stat. p. 30. He found by cutting off branches of trees with apples on them, and taking off the leaves, that an apple exhaled about as much as two leaves, the surfaces of which were nearly equal to the apple; whence it would appear that apples have as good a claim to be termed perspiratory organs as leaves. Others have believed them excretory organs of excrementious juices; but as the vapour exhaled from vegetables has no taste, this idea is no more probable than the other; add to this that in moist weather, they do not appear to perspire or exhale at all.

The internal surface of the lungs or air-vessels in men, are said to be equal to the external surface of the whole body, or about fifteen square feet; on this surface the blood is exposed to the influence of the respired air through the medium however of a thin pellicle; by this exposure to the air it has its colour changed from deep red to bright scarlet, and acquires something so necessary to the existence of life, that we can live scarcely a minute without this wonderful process.

The analogy between the leaves of plants and the lungs or gills of animals seems to embrace so many circumstances, that we can scarcely withhold our assent to their performing similar offices.

I. The great surface of the leaves compared to that of the trunk and branches of trees is such, that it would seem to be an organ well adapted for the purpose of exposing the vegetable juices to the influence of the air; this however we shall see afterwards is probably performed only by their upper surfaces, yet even in this case the surface of the leaves in general bear a greater proportion to the surface of the tree, than the lungs of animals to their external surfaces.

2. In the lungs of animal, the blood after having been exposed to the air in the extremities of

pulmonary artery, is changed in colour from deep red to bright scarlet, and certainly in some of its essential properties; it is then collected by the pulmonary vein and returned to the heart. To shew a similarity of circumstance in the leaves of plants the following experiment was made, June 24, 1781: A stalk with leaves and seed-vessels of large spurge (Euphorbia helioscopia) had been several days placed in a decoction of madder (Rubia tinctorum) so that the lower part of the stem, and two of the undermost leaves were immersed in it. After having washed the immersed leaves in clear water, I could readily discern the colour of the madder passing along the middle rib of each leaf. This red artery was beautifully visible both on the under and upper surface of the leaf; but on the upper side many red branches were seen going from it to the extremities of the leaf, which on the other side were not visible except by looking through it against the light. On this under side a system of branching vessels carrying a pale milky fluid were seen coming from the extremities of the leaf, and covering the whole underside of it, and joining into two large veins, one on each side of the red artery in the middle rib of the leaf, and along with it descending to the footstalk or petiole. On slitting one of these leaves with scissars, and having a common magnifying lens ready, the milky blood was seen oozing out of the returning veins on each side of the red artery in the middle rib, but none of the red fluid from the artery.

All these appearances were more easily seen in a leaf of Picris treated in the same manner; for in this milky plant the stems and middle rib of the leaves are sometimes naturally coloured reddish, and hence the colour of the madder seemed to pass further into the ramifications of their leaf-arteries, and was there beautifully visible with the returning branches of milky veins on each side.

3. From these experiments the upper surface of the leaf appeared to be the immediate organ of respiration, because the coloured fluid was carried to the extremities of the leaf by vessels most conspicuous on the upper surface, and there changed into a milky fluid, which is the blood of the plant, and then returned by concomitant veins on the under surface, which were seen to ooze when divided with scissars, and which in Picris, particularly render the under surface of the leaves greatly whiter than the upper one.

4. As the upper surface of leaves constitutes the organ of respiration, on which the sap is exposed in the terminations of arteries beneath a thin pellicle to the action of the atmosphere, these surfaces in many plants strongly repel moisture, as cabbage-leaves, whence the particles of rain lying over their surfaces without touching them, as observed by Mr. Melville (Essays Literary and Philosop. Edinburgh) have the appearance of globules of quicksilver. And hence leaves laid with the upper surfaces on water, wither as soon as in the dry air, but continue green many days, if placed with the under surfaces on water, as appears in the experiments of Mons. Bonnet (Usage des Fevilles.) Hence some aquatic plants, as the Water-lily (Nymphoea) have the lower sides of their leaves floating on the water, while the upper surfaces remain dry in the air.

5. As those insects, which have many spiracula, or breathing apertures, as wasps and flies, are immediately suffocated by pouring oil upon them, I carefully covered with oil the surfaces of several leaves of Phlomis, of Portugal Laurel, and Balsams, and though it would not regularly adhere, I found them all die in a day or two.

Of aquatic leaves, see Note on Trapa and on Fucus, in Vol. II. to which must be added that many leaves are furnished with muscles about their footstalks, to turn their upper surfaces to the air or light, as Mimosa and Hedysarum gyrans. From all these analogies I think there can be no doubt but that leaves of trees are their lungs, giving out a phlogistic material to the atmosphere, and absorbing oxygene or vital air.

6. The great use of light to vegetation would appear from this theory to be by disengaging vital air from the water which they perspire, and thence to facilitate its union with their blood exposed beneath the thin surface of their leaves; since when pure air is thus applied, it is probable, that it can be more readily absorbed. Hence in the curious experiments of Dr. Priestley and Mr. Ingenhouze, some plants purified air less than others, that is, they perspired less in the sunshine; and Mr. Scheele found that by putting peas into water, which about half- covered them, that they converted the vital air into fixed air, or carbonic acid gas, in the same manner as in animal respiration. See Note XXXIV.

7. The circulation in the lungs or leaves of plants is very similar to that of fish. In fish the blood after having passed through their gills does not return to the heart as from the lungs of air-breathing animals, but the pulmonary vein taking the structure of an artery after having received the blood from the gills, which there gains a more florrid colour, distributes it to the other parts of their bodies. The same structure occurs in the livers of fish, whence we see in those animals two circulations independent of the power of the heart, viz. that beginning at the termination of the veins of the gills, and branching through the muscles; and that which passes through the liver; both which are carried on by the action of those respective arteries and veins. Monro's Physiology of Fish, p. 19.

The course of the fluids in the roots, leaves, and buds of vegetables seems to be performed in a manner similar to both these. First the absorbent vessels of the roots and surfaces unite at the footstalk of the leaf; and then, like the Vena Portarum, an artery commences without the intervention of a heart, and spreads the sap in its numerous ramifications on the upper surface of the leaf; here it changes its colour and properties, and becomes vegetable blood; and is again collected by a pulmonary vein on the under surface of the leaf. This vein, like that which receives the blood from the gills of fish, assumes the office and name of an artery, and branching again disperses the blood upward to the bud from the footstalk of the leaf, and downward to the roots; where it is all expended in the various secretions, the nourishment and growth of the plant, as fast as it is prepared.

II. The organ of respiration already spoken of belongs particularly to the shoots or buds, but there is another pulmonary system, perhaps totally independent of the green foliage, which belongs to the fructification only, I mean the corol or petals. In this there is an artery belonging to each petal, which conveys the vegetable blood to its extremities, exposing it to the light and air under a delicate membrane covering the internal surface of the petal, where it often changes its colour, as is beautifully seen in some party-coloured poppies; though it is probable some of the iridescent colours of flowers may be owing to the different degrees of tenuity of the exterior membrane of the leaf refracting the light like soap-bubbles, the vegetable blood is then returned by correspondent vegetable veins, exactly as in the green foliage; for the purposes of the important secretions of honey, wax, the finer essential oil, and the prolific dust of the anthers.

1. The vascular structure of the corol as above described, and which is visible to the naked eye, and its exposing the vegetable juices to the air and light during the day, evinces that it is a pulmonary organ.

2. As the glands which produce the prolific dust of the anthers, the honey, wax, and frequently some odoriferous essential oil, are generally attached to the corol, and always fall off and perish with it, it is evident that the blood is elaborated or oxygenated in this pulmonary system for the purpose of these important secretions.

3. Many flowers, as the Colchicum, and Hamamelis arise naked in autumn, no green leaves appearing till the ensuing spring; and many others put forth their flowers and complete their impregnation early in the spring before the green foliage appears, as Mezereon, cherries, pears, which shews that these corols are the lungs belonging to the fructification.

4. This organ does not seem to have been necessary for the defence of the stamens and pistils, since the calyx of many flowers, as Tragopogon, performs this office; and in many flowers these petals themselves are so tender as to require being shut up in the calyx during the night, for what other use then can such an apparatus of vessels be designed?

5. In the Helleborus-niger, Christmas-rose, after the seeds are grown to a certain size, the nectaries and stamens drop off, and the beautiful large white petals change their colour to a deep green, and gradually thus become a calyx inclosing and defending the ripening seeds, hence it would seem that the white vessels of the corol served the office of exposing the blood to the action of the air, for the purposes of separating or producing the honey, wax, and prolific dust, and when these were no longer wanted, that these vessels coalesced like the placental vessels of animals after their birth, and thus ceased to perform that office and lost at the same time their white colour. Why should they loose their white colour, unless they at the same time lost some other property besides that of defending the seed-vessel, which they still continue to defend?

6. From these observations I am led to doubt whether green leaves be absolutely necessary to the progress of the fruit-bud after the last year's leaves are fallen off. The green leaves serve as lungs to the shoots and foster the new buds in their bosoms, whether these buds be leaf-buds or fruit-buds; but in the early spring the fruit-buds expand their corols, which are their lungs, and seem no longer to require green leaves; hence the vine bears fruit at one joint without leaves, and puts out a leaf-bud at another joint without fruit. And I suppose the green leaves which rise out of the earth in the spring from the Colchicum are for the purpose of producing the new bulb, and its placenta, and not for the giving maturity to the seed. When currant or goosberry trees lose their leaves by the depredation of insects the fruit continues to be formed, though less sweet and less in size.

7. From these facts it appears that the flower-bud after the corol falls off, (which is its lungs,) and the stamens and nectary along with it, becomes simply an uterus for the purpose of supplying the growing embryon with nourishment, together with a system of absorbent vessels which bring the juices of the earth to the footstalk of the fruit, and which there changes into an artery for the purpose of distributing the sap for the secretion of the saccharine or farinaceous or acescent materials for the use of the embryon. At the same time as all the vessels of the different buds of trees inosculate or communicate with each other, the fruit becomes sweeter and larger when the green leaves continue on the tree, but

the mature flowers themselves, (the succeeding fruit not considered) perhaps suffer little injury from the green leaves being taken off, as some florists have observed.

8. That the vessels of different vegetable buds inosculate in various parts of their circulation is rendered probable by the increased growth of one bud, when others in its vicinity are cut away; as it thus seems to receive the nourishment which was before divided amongst many.

NOTE XXXVIII.—VEGETABLE IMPREGNATION.

Love out their hour and leave their lives in air.

CANTO IV. l. 456.

From the accurate experiments and observations of Spallanzani it appears that in the Spartium Junceum, rush-broom, the very minute seeds were discerned in the pod at least twenty days before the flower is in full bloom, that is twenty days before fecundation. At this time also the powder of the anthers was visible, but glued fast to their summits. The seeds however at this time, and for ten days after the blossom had fallen off, appeared to consist of a gelatinous substance. On the eleventh day after the falling of the blossom the seeds became heart- shape, with the basis attached by an appendage to the pod, and a white point at the apex; this white point was on pressure found to be a cavity including a drop of liquor.

On the 25th day the cavity which at first appeared at the apex was much enlarged and still full of liquor, it also contained a very small semi- transparent body, of a yellowish colour, gelatinous, and fixed by its two opposite ends to the sides of the cavity.

In a month the seed was much enlarged and its shape changed from a heart to a kidney, the little body contained in the cavity was increased in bulk and was less transparent, and gelatinous, but there yet appeared no organization.

On the 40th day the cavity now grown larger was quite filled with the body, which was covered with a thin membrane; after this membrane was removed the body appeared of a bright green, and was easily divided by the point of a needle into two portions, which manifestly formed the two lobes, and within these attached to the lower part the exceedingly small plantule was easily perceived.

The foregoing observations evince, 1. That the seeds exist in the ovarium many days before fecundation. 2. That they remain for some time solid, and then a cavity containing a liquid is formed in them. 3. That after fecundation a body begins to appear within the cavity fixed by two points to the sides, which in process of time proves to be two lobes containing a plantule. 4. That the ripe seed consists of two lobes adhering to a plantule, and surrounded by a thin membrane which is itself covered with a husk or cuticle. Spalanzani's Dissertations, Vol. II. p. 253.

The analogy between seeds and eggs has long been observed, and is confirmed by the mode of their production. The egg is known to be formed within the hen long before its impregnation; C.F. Wolf asserts that the yolk of the egg is nourished by the vessels of the mother, and that it has from those its arterial and venous branches, but that after impregnation these vessels gradually become impervious and obliterated, and that new ones are produced from the fetus and dispersed into the yolk. Haller's Physiolog. Tom. VIII. p. 94. The young seed after fecundation, I suppose, is nourished in a similar manner from the gelatinous liquor, which is previously deposited for that purpose; the uterus of the plant producing or secreting it into a reservoir or amnios in which the embryon is lodged, and that the young embryon is furnished with vessels to absorb a part of it, as in the very early embryon in the animal uterus.

The spawn of frogs and of fish is delivered from the female before its impregnation. M. Bonnet says that the male salamander darts his semen into the water, where it forms a little whitish cloud which is afterwards received by the swoln anus of the female, and she is fecundated.—He adds that marine plants approach near to these animals, as the male does not project a fine powder but a liquor which in like manner forms a little cloud in the water.—And further adds, who knows but the powder of the stamina of certain plants may not make some impression on certain germs belonging to the animal kingdom! Letter XLIII. to Spalanzani, Oevres Philos.

Spalanzani found that the seminal fluid of frogs and dogs even when diluted with much water retained its prolific quality. Whether this quality be simply a stimulus exciting the egg into animal action, which may be called a vivifying principle, or whether part of it be actually conjoined with the egg is not yet determined, though the latter seems more probable from the frequent resemblance of the fetus to the male parent. A conjunction however of both the male and female influence seems necessary for the purpose of reproduction throughout all organized nature, as well in hermaphrodite insects, microscopic animals, and polypi, and exists as well in the formation of the buds of vegetables as in the production of their seeds, which is ingeniously conceived and explained by Linneus. After having compared the flower to the larva of a butterfly, confining of petals instead of wings, calyxes instead of wing-sheaths, with the organs of reproduction, and having shewn the use of the farina in fecundating the egg or seed, he proceeds to explain the production of the bud. The calyx of a flower, he says, is an expansion of the outer bark, the petals proceed from the inner bark or rind, the stamens from the alburnum or woody circle, and the style from the pith. In the production and impregnation of the seed a commixture of the secretions of the stamens and style are necessary; and for the production of a bud he thinks the medulla or pith bursts its integuments and mixes with the woody part or alburnum, and these forcing their passage through the rind and bark constitute the bud or viviparous progeny of the vegetable. System of Vegetables translated from Linneus, p. 8.

It has been supposed that the embryon vegetable after fecundation, by its living activity or stimulus exerted on the vessels of the parent plant, may produce the fruit or seed-lobes, as the animal fetus produces its placenta, and as vegetable buds may be supposed to produce their umbilical vessels or roots down the bark of the tree. This in respect to the production of the fruit surrounding the seeds of trees has been assimilated to the gall-nuts on oak-leaves, and to the bedeguar on briars, but there is a powerful objection to this doctrine, viz. that the fruit of figs, all which are female in this country, grow nearly as large without fecundation, and therefore the embryon has in them no self-living principle.

NOTE XXXIX.—VEGETABLE GLANDULATION.

Seeks, where fine pores their dulcet balm distil.

CANTO IV. l. 503.

The glands of vegetables which separate from their blood the mucilage, starch, or sugar for the placentation or support of their seeds, bulbs, and buds; or those which deposit their bitter, acrid, or narcotic juices for their defence from depredations of insects or larger animals; or those which secrete resins or wax for their protection from moisture or frosts, consist of vessels too fine for the injection or absorption of coloured fluids, and have not therefore yet been exhibited to the inspection even of our glasses, and can therefore only be known by their effects, but one of the most curious and important of all vegetable secretions, that of honey, is apparent to our naked eyes, though before the discoveries of Linneus the nectary or honey-gland had not even acquired a name.

The odoriferous essential oils of several flowers seem to have been designed for their defence against the depredations of insects, while their beautiful colours were a necessary consequence of the size of the particles of their blood, or of the tenuity of the exterior membrane of the petal. The use of the prolific dust is now well ascertained, the wax which covers the anthers prevents this dust from receiving moisture, which would make it burst prematurely and thence prevent its application to the stigma, as sometimes happens in moist years and is the cause of deficient fecundation both of our fields and orchards.

The universality of the production of honey in the vegetable world, and the very complicated apparatus which nature has constructed in many flowers, as well as the acrid or deleterious juices she has furnished those flowers with (as in the Aconite) to protect this honey from rain and from the depredations of insects, seem to imply that this fluid is of very great importance in the vegetable economy; and also that it was necessary to expose it to the open air previous to its reabsorption into the vegetable vessels.

In the animal system the lachrymal gland separates its fluid into the open air for the purpose of moistening the eye, of this fluid the part which does not exhale it absorbed by the puncta lachrymalia and carried into the nostrils; but as this is not a nutritive fluid the analogy goes no further than its secretion into the open air and its reabsorption into the system; every other secreted fluid in the animal

body is in part absorbed again into the system, even those which are esteemed excrementitious, as the urine and perspirable matter, of which the latter is secreted, like the honey, into the external air. That the honey is a nutritious fluid, perhaps the most so of any vegetable production, appears from its great similarity to sugar, and from its affording sustenance to such numbers of insects, which live upon it solely during summer, and lay it up for their winter provision. These proofs of its nutritive nature evince the necessity of its reabsorption into the vegetable system for some useful purpose.

This purpose however has as yet escaped the researches of philosophical botanists. M. Pontedera believes it designed to lubricate the vegetable uterus, and compares the horn-like nectaries of some flowers to the appendicle of the caecum intestinum of animals. (Antholog. p. 49.) Others have supposed that the honey, when reabsorbed, might serve the purpose of the liquor amnii, or white of the egg, as a nutriment for the young embryon or fecundated seed in its early state of existence. But as the nectary is found equally general in male flowers as in female ones; and as the young embryon or seed grows before the petals and nectary are expanded, and after they fall off; and, thirdly, as the nectary so soon falls off after the fecundation of the pistillum; these seem to be insurmountable objections to both the above-mentioned opinions.

In this state of uncertainty conjectures may be of use so far as they lead to further experiment and investigation. In many tribes of insects, as the silk-worm, and perhaps in all the moths and butterflies, the male and female parents die as soon as the eggs are impregnated and excluded; the eggs remaining to be perfected and hatched at some future time. The same thing happens in regard to the male and female parts of flowers; the anthers and filaments, which constitute the male parts of the flower, and the stigma and style, which constitute the female part of the flower, fall off and die as soon as the seeds are impregnated, and along with these the petals and nectary. Now the moths and butterflies above-mentioned, as soon as they acquire the passion and the apparatus for the reproduction of their species, loose the power of feeding upon leaves as they did before, and become nourished by what?—by honey alone.

Hence we acquire a strong analogy for the use of the nectary or secretion of honey in the vegetable economy, which is, that the male parts of flowers, and the female parts, as soon as they leave their fetus-state, expanding their petals, (which constitute their lungs,) become sensible to the passion, and gain the apparatus for the reproduction of their species, and are fed and nourished with honey like the insects above described; and that hence the nectary begins its office of producing honey, and dies or ceases to produce honey at the same time with the birth and death of the stamens and the pistils; which, whether existing in the same or in different flowers, are separate and distinct animated beings.

Previous to this time the anthers with their filaments, and the stigmas with their styles, are in their fetus-state sustained by their placental vessels, like the unexpanded leaf-bud; with the seeds existing in the vegetable womb yet unimpregnated, and the dust yet unripe in the cells of the anthers. After this period they expand their petals, which have been shewn above to constitute the lungs of the flower; the placental vessels, which before nourished the anthers and the stigmas, coalesce or cease to nourish them; and they now acquire blood more oxygenated by the air, obtain the passion and power of reproduction, are sensible to heat, and cold, and moisture, and to mechanic stimulus, and become in reality insects fed with honey, similar in every respect except their being attached to the tree on which they were produced.

Some experiments I have made this summer by cutting out the nectaries of several flowers of the aconites before the petals were open, or had become much coloured, some of these flowers near the summit of the plants produced no seeds, others lower down produced seeds; but they were not sufficiently guarded from the farina of the flowers in their vicinity; nor have I had opportunity to try if these seeds would vegetate.

I am acquainted with a philosopher, who contemplating this subject thinks it not impossible, that the first insects were the anthers or stigmas of flowers; which had by some means loosed themselves from their parent plant, like the male flowers of Vallisneria; and that many other insects have gradually in long process of time been formed from these; some acquiring wings, others fins, and others claws, from their ceaseless efforts to procure their food, or to secure themselves from injury. He contends, that none of these changes are more incomprehensible than the transformation of tadpoles into frogs, and caterpillars into butterflies.

There are parts of animal bodies, which do not require oxygenated blood for the purpose of their secretions, as the liver; which for the production of bile takes its blood from the mesenteric veins, after it must have lost the whole or a great part of its oxygenation, which it had acquired in its passage through the lungs. In like manner the pericarpium, or womb of the flower, continues to secrete its proper juices for the present nourishment of the newly animated embryon-seed; and the saccharine, acescent, or starchy matter of the fruit or seed- lobes for its future growth; in the same manner as

these things went on before fecundation; that is, without any circulation of juices in the petals, or production of honey in the nectary; these having perished and fallen off with the male and female apparatus for impregnation.

It is probable that the depredations of insects on this nutritious fluid must be injurious to the products of vegetation, and would be much more so, but that the plants have either acquired means to defend their honey in part, or have learned to make more than is absolutely necessary for their own economy. In the same manner the honey-dew on trees is very injurious to them; in which disease the nutritive fluid, the vegetable- sap-juice, seems to be exsuded by a retrograde motion of the cutaneous lymphatics, as in the sweating sickness of the last century. To prevent the depredation of insects on honey a wealthy man in Italy is said to have poisoned his neighbour's bees perhaps by mixing arsnic with honey, against which there is a most flowery declamation in Quintilian. No. XIII. As the use of the wax is to preserve the dust of the anthers from moisture, which would prematurely burst them, the bees which collect this for the construction of the combs or cells, must on this account also injure the vegetation of a country where they too much abound.

It is not easy to conjecture why it was necessary that this secretion of honey should be exposed to the open air in the nectary or honey-cup, for which purpose so great an apparatus for its defence from insects and from showers became necessary. This difficulty increases when we recollect that the sugar in the joints of grass, in the sugar-cane, and in the roots of beets, and in ripe fruits is produced without the exposure to the air. On supposition of its serving for nutriment to the anthers and stigmas it may thus acquire greater oxygenation for the purpose of producing greater powers of sensibility, according to a doctrine lately advanced by a French philosopher, who has endeavoured to shew that the oxygene, or base of vital air, is the constituent principle of our power of sensibility.

From this provision of honey for the male and female parts of flowers, and from the provision of sugar, starch, oil, and mucilage, in the fruits, seed-cotyledons, roots, and buds of plants laid up for the nutriment of the expanding fetus, not only a very numerous class of insects, but a great part of the larger animals procure their food; and thus enjoy life and pleasure without producing pain to others, for these seeds or eggs with the nutriment laid up in them are not yet endued with sensitive life.

The secretions from various vegetable glands hardened in the air produce gums, resins, and various kinds of saccharine, saponaceous, and wax-like substances, as the gum of cherry or plumb-trees, gum tragacanth from the astragalus tragacantha, camphor from the laurus camphora, elemi from amyris elemifera, aneme from hymenoea courbaril, turpentine from pistacia terebinthus, balsam of Mecca from the buds of amyris opobalsamum, branches of which are placed in the temples of the East on account of their fragrance, the wood is called xylobalsamum, and the fruit carpobalsamum; aloe from a plant of the same name; myrrh from a plant not yet described; the remarkably elastic resin is brought into Europe principally in the form of flasks, which look like black leather, and are wonderfully elastic, and not penetrable by water, rectified ether dissolves it; its flexibility is encreased by warmth and destroyed by cold; the tree which yields this juice is the jatropha elastica, it grows in Guaiana and the neighbouring tracts of America; its juice is said to resemble wax in becoming soft by heat, but that it acquires no elasticity till that property is communicated to it by a secret art, after which it is poured into moulds and well dried and can no longer be rendered fluid by heat. Mr. de la Borde physician at Cayenne has given this account. Manna is obtained at Naples from the fraxinus ornus, or manna-ash, it partly issues spontaneously, which is preferred, and partly exsudes from wounds made purposely in the month of August, many other plants yield manna more sparingly; sugar is properly made from the saccharum officinale, or sugar-cane, but is found in the roots of beet and many other plants; American wax is obtained from the myrica cerifera, candle-berry myrtle, the berries are boiled in water and a green wax separates, with luke-warm water the wax is yellow: the seed of croton sebiferum are lodged in tallow; there are many other vegetable exsudations used in the various arts of dyeing, varnishing, tanning, lacquering, and which supply the shop of the druggist with medicines and with poisons.

There is another analogy, which would seem to associate plants with animals, and which perhaps belongs to this Note on Glandulation, I mean the similarity of their digestive powers. In the roots of growing vegetables, as in the process of making malt, the farinaceous part of the seed is converted into sugar by the vegetable power of digestion in the same manner as the farinaceous matter of seeds are converted into sweet chyle by the animal digestion. The sap-juice which rises in the vernal months from the roots of trees through the alburnum or sap-wood, owes its sweetness I suppose to a similar digestive power of the absorbent system of the young buds. This exists in many vegetables in great abundance as in vines, sycamore, birch, and most abundantly in the palm-tree, (Isert's Voyage to Guinea,) and seems to be a similar fluid in all plants, as chyle is similar in all animals.

Hence as the digested food of vegetables consists principally of sugar, and from that is produced again their mucilage, starch, and oil, and since animals are sustained by these vegetable productions, it would seem that the sugar-making process carried on in vegetable vessels was the great source of life

to all organized beings. And that if our improved chemistry should ever discover the art of making sugar from fossile or aerial matter without the assistance of vegetation, food for animals would then become as plentiful as water, and mankind might live upon the earth as thick as blades of grass, with no restraint to their numbers but the want of local room.

It would seem that roots fixed in the earth, and leaves innumerable waving in the air were necessary for the decomposition of water, and the conversion of it into saccharine matter, which would have been not only cumberous but totally incompatible with the locomotion of animal bodies. For how could a man or quadruped have carried on his head or back a forest of leaves, or have had long branching lacteal or absorbent vessels terminating in the earth? Animals therefore subsist on vegetables; that is, they take the matter so far prepared, and have organs to prepare it further for the purposes of higher animation, and greater sensibility. In the same manner the apparatus of green leaves and long roots were found inconvenient for the more animated and sensitive parts of vegetable-flowers, I mean the anthers and stigmas, which are therefore separate beings, endued with the passion and power of reproduction, with lungs of their own, and fed with honey, a food ready prepared by the long roots and green leaves of the plant, and presented to their absorbent mouths.

From this outline a philosopher may catch a glimpse of the general economy of nature; and like the mariner cast upon an unknown shore, who rejoiced when he saw the print of a human foot upon the sand, he may cry out with rapture, "A GOD DWELLS HERE."

CONTENTS

Dispute about phlogiston; the sun the fountain from whence all phlogiston is derived; its rays not luminous till they arrive at our atmosphere; light owing to their combustion with air, whence an unknown acid; the sun is on fire only on its surface; the dark spots on it are excavations through its luminous crust.

NOTE VI ... CENTRAL FIRES.

Sun's heat much less than that from the fire at the earth's centre; sun's heat penetrates but a few feet in summer; some mines are warm; warm springs owing to subterraneous fire; situations of volcanos on high mountains; original nucleus of the earth; deep vallies of the ocean; distant perception of earthquakes; great attraction of mountains; variation of the compass; countenance the existence of a cavity or fluid lava within the earth.

NOTE VII ... ELEMENTARY HEAT.

Combined and sensible heat; chemical combinations attract heat, solutions reject heat; ice cools boiling water six times as much as cold water cools it; cold produced by evaporation; heat by devaporation; capacities of bodies in respect to heat, 1. Existence of the matter of heat shewn from the mechanical condensation and rarefaction of air, from the steam produced in exhausting a receiver, snow from rarefied air, cold from discharging an air-gun, heat from vibration or friction; 2. Matter of heat analogous to the electric fluid in many circumstances, explains many chemical phenomena.

NOTE VIII ... MEMNON'S LYRE.

Mechanical impulse of light dubious; a glass tube laid horizontally before a fire revolves; pulse-glass suspended on a centre; black leather contracts in the sunshine; Memnon's statue broken by Cambyses.

NOTE IX ... LUMINOUS INSECTS.

Eighteen species of glow-worm, their light owing to their respiration in transparent lungs; Acudia of Surinam gives light enough to read and draw by, use of its light to the insect; luminous sea-insects adhere to the skin of those who bathe in the ports of Languedoc, the light may arise from putrescent slime.

NOTE X ... PHOSPHORUS.

Discovered by Kunkel, Brandt, and Boyle; produced in respiration, and by luminous insects, decayed wood, and calcined shells; bleaching a slow combustion in which the water is decomposed; rancidity of animal fat owing to the decomposition of water on its surface; aerated marine acid does not whiten or bleach the hand.

NOTE XI ... STEAM-ENGINE.

Hero of Alexandria first applied steam to machinery, next a French writer in 1630, the Marquis of Worcester in 1655, Capt. Savery in 1689, Newcomen and Cawley added the piston; the improvements of Watt and Boulton; power of one of their large engines equal to two hundred horses.

NOTE XII ... FROST.

Expansion of water in freezing; injury done by vernal frosts; fish, eggs, seeds, resist congelation; animals do not resist the increase of heat; frosts do not meliorate the ground, nor are in general salubrious; damp air produces cold on the skin by evaporation; snow less pernicious to agriculture than heavy rains for two reasons.

NOTE XIII ... ELECTRICITY.

1. *Points* preferable to knobs for defence of buildings; why points emit the electric fluid; diffusion of oil on water; mountains are points on the earth's globe; do they produce ascending currents of air? 2. *Fairy-rings* explained; advantage of paring and burning ground.

NOTE XIV ... BUDS AND BULBS.

A tree is a swarm of individual plants; vegetables are either oviparous or viviparous; are all annual productions like many kinds of insects? Hybernacula, a new bark annually produced over the old one in trees and in some herbaceous plants, whence their roots seem end-bitten; all bulbous roots perish annually; experiment on a tulip-root; both the leaf-bulbs and the flower-bulbs are annually renewed.

NOTE XV ... SOLAR VOLCANOS.

The spots in the sun are cavities, some of them four thousand miles deep and many times as broad; internal parts of the sun are not in a state of combustion; volcanos visible in the sun; all the planets together are less than one six hundred and fiftieth part of the sun; planets were ejected from the sun by volcanos; many reasons shewing the probability of this hypothesis; Mr. Buffon's hypothesis that planets were struck off from the sun by comets; why no new planets are ejected from the sun; some comets and the georgium sidus may be of later date; Sun's matter decreased; Mr. Ludlam's opinion, that it is possible the moon might be projected from the earth.

NOTE XVI ... CALCAREOUS EARTH.

High mountains and deep mines replete with shells; the earth's nucleus covered with limestone; animals convert water into limestone; all the calcareous earth in the world formed in animal and vegetable bodies; solid parts of the earth increase; the water decreases; tops of calcareous mountains dissolved; whence spar, marbles, chalk, stalactites; whence alabaster, fluor, flint, granulated limestone, from solution of their angles, and by attrition; tupha deposited on moss; limestones from shells with animals in them; liver-stone from fresh- water muscles; calcareous earth from land-animals and vegetables, as marl; beds of marble softened by fire; whence Bath-stone contains lime as well as limestone.

NOTE XVII ... MORASSES.

The production of morasses from fallen woods; account by the Earl Cromartie of a new morass; morasses lose their salts by solution in water; then their iron; their vegetable acid is converted into marine, nitrous, and vitriolic acids; whence gypsum, alum, sulphur; into fluor- acid, whence fluor; into siliceous acid, whence flint, the sand of the sea, and other strata of siliceous sand and marl; some morasses ferment like new hay, and, subliming their phlogistic part, form coal-beds above and clay below, which are also produced by elutriation; shell-fish in some morasses, hence shells sometimes found on coals and over iron- stone.

NOTE XVIII ... IRON

Calciform ores; combustion of iron in vital air; steel from deprivation of vital air; welding; hardness; brittleness like Rupert's drops; specific levity; hardness and brittleness compared; steel tempered by its colours; modern production of iron, manganese, calamy; septaria of iron-stone ejected from volcanos; red-hot cannon balls.

NOTE XIX ... FLINT.

1. *Siliceous rocks* from morasses; their cements. 2. *Siliceous trees*; coloured by iron or manganese; Peak-diamonds; Bristol-stones; flint in form of calcareous spar; has been fluid without much heat; obtained from powdered quartz and fluor-acid by Bergman and by Achard. 3. *Agates and onyxes* found in sand-rocks; of vegetable origin; have been in complete fusion; their concentric coloured circles not from superinduction but from congelation; experiment of freezing a solution of blue vitriol; iron and manganese repelled in spheres as the nodule of flint cooled; circular stains of marl in salt-mines; some flint nodules resemble knots of wood or roots. 4. *Sand of the sea*; its acid from morasses; its base from shells. 5. *Chert or petrosilex* stratified in cooling; their colour and their acid from sea-animals; labradore-stone from mother- pearl. 6. *Flints in chalk-beds*; their form, colour, and acid, from the flesh of sea-animals; some are hollow and lined with crystals; contain iron; not produced by injection from without; coralloids converted to flint; French-millstones; flints sometimes found in solid strata. 7. *Angles of sand* destroyed by attrition and solution in steam; siliceous breccia cemented by solution in red-hot water. 8. *Basaltes and granites* are antient lavas; basaltes raised by its congelation not by subterraneous fire.

NOTE XX ... CLAY.

Fire and water two great agents; stratification from precipitation; many stratified materials not soluble in water. 1. Stratification of lava from successive accumulation. 2. Stratifications of limestone from the different periods of time in which the shells were deposited. 3. Stratifications of coal, and clay, and sandstone, and iron-ores, not from currents of water, but from the production of morass-beds at different periods of time; morass-beds become ignited; their bitumen and sulphur is sublimed; the clay, lime, and iron remain; whence sand, marle, coal, white clay in valleys, and gravel-beds, and some ochres, and some calcareous depositions owing to alluviation; clay from decomposed granite; from the lava of Vesuvius; from vitreous lavas.

NOTE XXI ... ENAMELS.

Rose-colour and purple from gold; precipitates of gold by alcaline salt preferable to those by tin; aurum fulminans long ground; tender colours from gold or iron not dissolved but suspended in the glass; cobalts; calces of cobalt and copper require a strong fire; Ka-o-lin and Pe-tun-tse the same as our own materials.

NOTE XXII ... PORTLAND VASE.

Its figures do not allude to private history; they represent a part of the Elusinian mysteries; marriage of Cupid and Psyche; procession of torches; the figures in one compartment represent MORTAL LIFE in the act of expiring, and HUMANKIND attending to her with concern; Adam and Eve hyeroglyphic figures; Abel and Cain other hyeroglyphic figures; on the other compartment is represented IMMORTAL LIFE, the Manes or Ghost descending into Elisium is led on by DIVINE LOVE, and received by IMMORTAL LIFE, and conducted to Pluto; Tree of Life and Knowledge are emblematical; the figure at the bottom is of Atis, the first great Hierophant, or teacher of mysteries.

NOTE XXIII ... COAL.

1. A fountain of fossile tar in Shropshire; has been distilled from the coal-beds beneath, and condensed in the cavities of a sand-rock; the coal beneath is deprived of its bitumen in part; bitumen sublimed at Matlock into cavities lined with spar. 2. Coal has been exposed to heat; woody fibres and vegetable seeds in coal at Bovey and Polesworth; upper part of coal-beds more bituminous at Beaudesert; thin stratum of asphaltum near Caulk; upper part of coal-bed worse at Alfreton; upper stratum of no value at Widdrington; alum at West-Hallum; at Bilston. 3. Coal at Coalbrooke-Dale has been immersed in the sea, shewn by sea- shells; marks of violence in the colliery at Mendip and at Ticknal; Lead-ore and spar in coal-beds; gravel over coal near Lichfield; Coal produced from morasses shewn by fern-leaves, and bog-shells, and muscle- shells; by some parts of coal being still woody; from Lock Neagh and Bovey, and the Temple of the devil; fixed alcali; oil.

NOTE XXIV ... GRANITE.

Granite the lowest stratum of the earth yet known; porphory, trap, Moor- stone, Whin-stone, slate, basaltes, all volcanic productions dissolved in red-hot water; volcanos in granite strata; differ from the heat of morasses from fermentation; the nucleus of the earth ejected from the sun? was the sun originally a planet? supposed section of the globe.

NOTE XXV ... EVAPORATION.

I. Solution of water in air; in the matter of heat; pulse-glass. 2. Heat is the principal cause of evaporation; thermometer cooled by evaporation of ether; heat given from steam to the worm-tub; warmth accompanying rain. 3. Steam condensed on the eduction of heat; moisture on cold walls; south-west and north-east winds. 4. Solution of salt and of blue vitriol in the matter of heat. II. Other vapours may precipitate steam and form rain. 1. Cold the principal cause of devaporation; hence the steam dissolved in heat is precipitated, but that dissolved in air remains even in frosts; south-west wind. 2. North-east winds mixing with south-west winds produce rain; because the cold particles of air of the north-east acquire some of the matter of heat from the south-west winds. 3. Devaporation from mechanical expansion of air, as in the receiver of an air-pump; summer-clouds appear and vanish; when the barometers sink without change of wind the weather becomes colder. 4. Solution of water in electric fluid dubious. 5. Barometer sinks from the lessened gravity of the air, and from the rain having less pressure as it falls; a mixture of a solution of water in calorique with an aerial solution of water is lighter than dry air; breath of animals in cold weather why condensed into visible vapour and dissolved again.

NOTE XXVI ... SPRINGS.

Lowest strata of the earth appear on the highest hills; springs from dews sliding between them; mountains are colder than plains; 1. from their being insulated in the air; 2. from their enlarged surface; 3. from the rarety of the air it becomes a better conductor of heat; 4. by the air on mountains being mechanically rarefied as it ascends; 5. gravitation of the matter of heat; 6. the dashing of clouds against hills; of fogs against trees; springs stronger in hot days with cold nights; streams from subterranean caverns; from beneath the snow on the Alps.

NOTE XXVII ... SHELL-FISH.

The armour of the Echinus moveable; holds itself in storms to stones by 1200 or 2000 strings: Nautilus rows and sails; renders its shell buoyant: Pinna and Cancer; Byssus of the antients was the beard of the Pinna; as fine as the silk is spun by the silk-worm; gloves made of it; the beard of muscles produces sickness; Indian weed; tendons of rats tails.

NOTE XXVIII ... STURGEON.

Sturgeon's mouth like a purse; without teeth; tendrils like worms hang before his lips, which entice small fish and sea-insects mistaking them for worms; his skin used for covering carriages; isinglass made from it; cavear from the spawn.

NOTE XXIX ... OIL ON WATER.

Oil and water do not touch; a second drop of oil will not diffuse itself on the preceeding one; hence it stills the waves; divers for pearl carry oil in their mouths; oil on water produces prismatic colours; oiled cork circulates on water; a phial of oil and water made to oscillate.

NOTE XXX ... SHIP-WORM.

The Teredo has calcareous jaws; a new enemy; they perish when they meet together in their ligneous canals; United Provinces alarmed for the piles of the banks of Zeland; were destroyed by a severe winter.

NOTE XXXI ... MAELSTROM.

A whirlpool on the coast of Norway; passes through a subterraneous cavity; less violent when the tide is up; eddies become hollow in the middle; heavy bodies are thrown out by eddies; light ones retained; oil and water whirled in a phial; hurricanes explained.

NOTE XXXII ... GLACIERS.

Snow in contact with the earth is in a state of thaw; ice-houses; rivers from beneath the snow; rime in spring vanishes by its contact with the earth; and snow by its evaporation and contact with the earth; moss vegetates beneath the snow; and Alpine plants perish at Upsal for want of show.

NOTE XXXIII ... WINDS.

Air is perpetually subject to increase and to diminution; Oxygene is perpetually produced from vegetables in the sunshine, and from clouds in the light, and from water; Azote is perpetually produced from animal and vegetable putrefaction, or combustion; from springs of water; volatile alcali; fixed alcali; sea-water; they are both perpetually diminished by their contact with the soil, producing nitre; Oxygene is diminished in the production of all acids; Azote by the growth of animal bodies; charcoal in burning consumes double its weight of pure air; every barrel of red-lead absorbes 2000 cubic feet of vital air; air obtained from variety of substances by Dr. Priestley; Officina aeris in the polar circle, and at the Line. *South-west winds*; their westerly direction from the less velocity of the earth's surface; the contrary in respect to north-east winds; South-west winds consist of regions of air from the south; and north-east winds of regions of air from the north; when the south-west prevails for weeks and the barometer sinks to 28, what becomes of above one fifteenth part of the atmosphere; 1. It is not carried back by superior currents; 2. Not from its loss of moisture; 3. Not carried over the pole; 4. Not owing to atmospheric tides or mountains; 5. It is absorbed at the polar circle; hence south-west winds and rain; south-west sometimes cold. *North-east winds* consist of air from the north; cold by the evaporation of

ice; are dry winds; 1. Not supplied by superior current; 2. The whole atmosphere increased in quantity by air set at liberty from its combinations in the polar circles. *South-east winds* consist of north winds driven back. *North- west winds* consist of south-west winds driven back; north-west winds of America bring frost; owing to a vertical spiral eddy of air between the eastern coast and the Apalachian mountains; hence the greater cold of North America. *Trade-winds*; air over the Line always hotter than at the tropics; trade-winds gain their easterly direction from the greater velocity of the earth's surface at the line; not supplied by superior currents; supplied by decomposed water in the sun's great light; 1. Because there are no constant rains in the tract of the trade-winds; 2. Because there is no condensible vapour above three or four miles high at the line. *Monsoons and tornadoes*; some places at the tropic become warmer when the sun is vertical than at the line; hence the air ascends, supplied on one side by the north-east winds, and on the other by the south-west; whence an ascending eddy or tornado, raising water from the sea, or sand from the desert, and incessant rains; air diminished to the northward produces south-west winds; tornadoes from heavier air above sinking through lighter air below, which rises through a perforation; hence trees are thrown down in a narrow line of twenty or forty yards broad, the sea rises like a cone, with great rain and lightning. *Land and sea breezes*; sea less heated than land; tropical islands more heated in the day than the sea, and are cooled more in the night. *Conclusion*; irregular winds from other causes; only two original winds north and south; different sounds of north-east and south-west winds; a Bear or Dragon in the arctic circle that swallows at times and disembogues again above one fifteenth part of the atmosphere; wind- instruments; recapitulation.

NOTE XXXIV ... VEGETABLE PERSPIRATION.

Pure air from Dr. Priestley's vegetable matter, and from vegetable leaves, owing to decomposition of water; the hydrogene retained by the vegetables; plants in the shade are *tanned* green by the sun's light; animal skins are *tanned* yellow by the retention of hydrogene; much pure air from dew on a sunny morning; bleaching why sooner performed on cotton than linen; bees wax bleached; metals calcined by decomposition of water; oil bleached in the light becomes yellow again in the dark; nitrous acid coloured by being exposed to the sun; vegetables perspire more than animals, hence in the sun-shine they purify air more by their perspiration than they injure it by their respiration; they grow fastest in their sleep.

NOTE XXXV ... VEGETABLE PLACENTATION.

Buds the viviparous offspring of vegetables; placentation in bulbs and seeds; placentation of buds in the roots, hence the rising of sap in the spring, as in vines, birch, which ceases as soon as the leaves expand; production of the leaf of Horse-chesnut, and of its new bud; oil of vitriol on the bud of Mimosa killed the leaf also; placentation shewn from the sweetness of the sap; no umbilical artery in vegetables.

NOTE XXXVI ... VEGETABLE CIRCULATION.

Buds set in the ground will grow if prevented from bleeding to death by a cement; vegetables require no muscles of locomotion, no stomach or bowels, no general system of veins; they have, 1. Three systems of absorbent vessels; 2. Two pulmonary systems; 3. Arterial systems; 4. Glands; 5. Organs of reproduction; 6. muscles. I. Absorbent system evinced by experiments by coloured absorptions in fig-tree and picris; called air-vessels erroneously; spiral structure of absorbent vessels; retrograde motion of them like the throats of cows. II. Pulmonary arteries in the leaves, and pulmonary veins; no general system of veins shewn by experiment; no heart; the arteries act like the vena portarum of the liver; pulmonary system in the petals of flowers; circulation owing to living irritability; vegetable absorption more powerful than animal, as in vines; not by capillary attraction.

NOTE XXXVII ... VEGETABLE RESPIRATION.

I. Leaves not perspiratory organs, nor excretory ones; lungs of animals. 1. Great surfaces of leaves. 2. Vegetable blood changes colour in the leaves; experiment with spurge; with picris. 3. Upper surface of the leaf only acts as a respiratory organ. 4. Upper surface repels moisture; leaves laid on water. 5. Leaves killed by oil like insects; muscles at the foot-stalks of leaves. 6. Use of light to vegetable leaves; experiments of Priestley, Ingenhouze, and Scheel. 7. Vegetable circulation similar to that of fish. II. Another pulmonary system belongs to flowers; colours of flowers. 1. Vascular structure of the corol. 2. Glands producing honey, wax, &c. perish with the corol. 3. Many flowers have no green leaves attending them, as Colchicum. 4. Corols not for the defence of the stamens. 5. Corol of Helleborus Niger changes to a calyx. 6. Green leaves not necessary to the fruit-bud; green leaves of Colchicum belong to the new bulb not to the flower. 7. Flower-bud after the corol falls is simply an uterus; mature

flowers not injured by taking of the green leaves. 8. Inosculation of vegetable vessels.

NOTE XXXVIII ... VEGETABLE IMPREGNATION.

Seeds in broom discovered twenty days before the flower opens; progress of the seed after impregnation; seeds exist before fecundation; analogy between seeds and eggs; progress of the egg within the hen; spawn of frogs and of fish; male Salamander; marine plants project a liquor not a powder; seminal fluid diluted with water, if a stimulus only? Male and female influence necessary in animals, insects, and vegetables, both in production of seeds and buds; does the embryon seed produce the surrounding fruit, like insects in gall-nuts?

NOTE XXXIX ... VEGETABLE GLANDULATION.

Vegetable glands cannot be injected with coloured fluids; essential oil; wax; honey; nectary, its complicate apparatus; exposes the honey to the air like the lacrymal gland; honey is nutritious; the male and female parts of flowers copulate and die like moths and butterflies, and are fed like them with honey; anthers supposed to become insects; depredation of the honey and wax injurious to plants; honey-dew; honey oxygenated by exposure to air; necessary for the production of sensibility; the provision for the embryon plant of honey, sugar, starch, &c. supplies food to numerous classes of animals; various vegetable secretions as gum tragacanth, camphor, elemi, anime, turpentine, balsam of Mecca, aloe, myrrh, elastic resin, manna, sugar, wax, tallow, and many other concrete juices; vegetable digestion; chemical production of sugar would multiply mankind; economy of nature.

THE END

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