THE

SCIENCE OF MIND;

OR,

PNEUMATOLOGY.

"The proper study of mankind is man." — POPE.

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CONTENTS.

Of Sensations of Smell.

Of Sensations of Sound.

Of Sensations of Colour.

Of Inorganic Sensations.

THE INFLUENCE OF MIND UPON MATTER PRODUCING HUMAN ACTION.

THE

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INTRODUCTION.

The materials of the Science of Mind have been in existence from the creation of man. We have in the Pentateuch a rich record of these materials from the earliest ages. Many individuals have successively arisen, who in their several generations have been celebrated amongst their contemporaries for their knowledge of human nature, for their sayings and counsels of wisdom, which in general have been founded on an extensive observance of man, his capabilities, his susceptibilities, his motives to action. Why then is the science of mind to this day so philosophically incomplete? why is it in so unsatisfactory a state, so far behind, in its parts and its structure, the other sciences? The answer is, first, because, unlike other sciences, it is still unorganised, it is still treated of in a desultory manner —

the great want is arrangement of materials and of parts. No man has yet arisen to perform satisfactorily for this interesting, this pre-eminent science — metaphysics — what Euclid did for geometry, so that additions may be made, but neither the sub-strata be again disturbed, nor the organisation be pulled to pieces, and the parts readjusted. Next there is yet imperfect discrimination. This important process of intellect has not been carried sufficiently far, as I hope to show hereafter. So long as this continues, confusion and inaccuracy must prevail. Again, terms are not confined to their proper uses, as is done in other sciences, but are employed in an indefinite manner, are used too much for one another, as if that were of no moment, instead of being, as it is, of vast importance to stability and progress.

Having given my mind for very many years to this most valuable science, and having devoted my spare hours principally to it, I feel impelled to offer to those who, by constitution of intellect, are especially interested in the subject, an arrangement of pneumatology, which, so far as it may go, I cannot avoid thinking will be a scientific or philosophical arrangement in the strictest sense of those terms. If, on the contrary, I am deceiving myself, and am guilty of great errors, either in respect to the elements of the science, or to the order and connection of its parts, my labours, like those of many others before me, will have been nought; the desideratum still remains unsatisfied.

With these slight preliminary remarks I at once proceed. Dr. Thomas Reid, in his great work "On the Powers of the Human Mind," virtually begins with "Sensation;" the treatment whereof occupies the second essay, the first being introductory only. The same is more especially the case in his "Inquiry into the Human Mind," chapters ii., iii., and iv. Believing this to be the true beginning of the science, and never to be displaced by any other department, I commence with it also, remarking, nevertheless, at the outset, that that most eminent philosopher was in error in classing sensation as a power of the mind: the capacity of experiencing sensation is an attribute of mind, but not properly a power of mind.

THE INFLUENCE AND ACTION OF MATTER UPON MIND, OCCASIONING SENSATION.

OF SENSATIONS OF TASTE.

SECTION THE FIRST.

Of the several Varieties of Animal Matter as Causes or Occasions of Sensations of Taste.

If a piece of flesh be placed in the mouth, and we proceed to masticate it, there is experienced what is termed a sensation.

Different kinds of animal matter produce different sensations.

The flesh of one animal has, as is well known to all persons, a different flavour from the flesh of other animals, and the diversity of sensations occasioned by animal matter is very great.

An arrangement is needed of the numerous sensations of taste which are produced by animal matter.

The arrangement would most correctly be founded upon this basis. The scientific appellations of animals ought to be taken in their most approved order, alphabetically or otherwise, and the flavour of the flesh of each, raw, roasted, and boiled, described. But this plan cannot yet be followed out, because of the multiplicity and exceeding variety of the brute creation, and because there are no terms to describe animal flavours with any approach to accuracy.

In zoological works, amongst other characters of each variety of animal, the taste of the flesh is usually in some measure described, particularly in such works as are of a less scientific complexion, but are rather descriptive of the habits of animals. Yet in all such works on natural history, the descriptions of the flavours are very loose and general, and perhaps cannot be otherwise. Notwithstanding, every attempt ought to be made to discriminate and to classify the innumerable diversities of flavour.

I confine myself to a few common animals as indications of the suggested arrangement, using their familiar names.

The ox or bullock.—The flesh of this animal is called beef; it is in large consumption amongst the modern civilised nations of Europe and America. Bruce makes, on several occasions, a statement that the Abyssinians eat the raw flesh. The soldiers cut it from the buttock of the animal whilst alive. At their brinde feasts it was eaten by the higher classes. The flavour must to them, therefore, have been agreeable. What the taste of raw beef may be, is utterly unknown to nearly every civilised person. The flavour of beef, when roasted or baked, stewed or boiled, is known to us familiarly as pleasant, but how to describe it is the difficulty. There are, I apprehend, no terms by which these flavours can be discriminated from the flavours of other kinds of meat. The flesh of the young of the cow, which is called veal, is more insipid. The beef of the wild bull, a species which I suppose is still preserved in Chillingham Park, is said in Goldsmith's "Animated Nature," to be of excellent flavour.

The sheep. — Mutton, the name of the flesh of sheep, is of more delicate flavour than the flesh of the bullock. Both roasted and boiled it is in general consumption by flesh-eaters in the temperate regions. The actual flavour is, however, in the present state of science, indescribable. Lamb, the flesh of the young sheep, is, like veal, more tasteless.

Swine.—The flesh of swine, which is called pork, is, except by Jews, Mahomedans, and some other people, eaten in the cooler seasons of the year. Its flavour is considered to be higher than the flavour of either beef or mutton, but there are no means of describing it. Pork is eaten roasted, baked, or boiled. It also undergoes a process of smoking, &c., by which it becomes bacon and ham, which are eaten broiled or boiled. The flesh of a sucking-pig is much relished by many.

Deer.—The flesh of deer, entitled venison, is in flavour esteemed by epicures superior to that of mutton, but much allied to it in character; it is usually eaten roasted. Not a few men, however, have been heard to declare, to the disgust of high-feeders, that a fine haunch of mutton is superior to a haunch of venison. Some prefer venison and mutton after it has hung a long while. The flavour of flesh after it has undergone in part the process of putrefaction, so as to become offensive to the smell, is materially altered—it becomes more poignant, or much stronger. To the uninitiated the new taste is excessively nauseous. Isaac, when he thought himself to be on his death-bed, desired Esau to go and take a wild deer and make him savoury meat, such as his soul desired, preparatory to giving his last blessing.

The goat. — Its flesh is in general consumed as food only by the inhabitants of mountainous lands, where these animals are more numerously kept, or are the search of the hunter. The flesh of the full-grown animal is not, I believe, considered agreeable in flavour. A kid by the Oriental nations in early times, and, may be, in modern also, was much delighted in: instance the savoury meat that Rebecca made for Isaac; also, "Thou never gavest me a kid, that I might make merry with my friends."

The hare, the rabbit, and some other quadrupeds, are pursued by the sportsman, and the flavour of their flesh is esteemed. Each kind somewhat differently affects the organ of taste, but these varieties of flavour we have no phraseology whatever to mark.

In countries where wild animals are not extinguished, many are hunted for one reason or another, and the flesh of some, or portions of the body, are eaten. The flavour in each case is distinct and peculiar, but cannot be described.

The flesh of beasts of prey is represented by those travellers and others who have been compelled to eat it, as in general very strong, coarse, and nauseous. In works of natural history these flavours are described in the lax expressions which are only in use.

Having slightly alluded to domestic quadrupeds, and those wild ones which are articles of food, we may proceed to notice the large class of domestic fowls and wild birds, which are eaten with much satisfaction by most persons.

Each variety of poultry has its peculiar flavour, in all cases very agreeable, but in no way describable.

This being the case, there needs only a slight enumeration of some few of these.

The commoner varieties of poultry are the duck, the goose, the common fowl, the turkey, the pea-fowl, the guinea-fowl. These all have peculiarity of flavour; and the flavour of the wild birds of the same species differs somewhat markedly from that of the tame or farm-yard ones.

Besides domestic birds, there are many varieties of wild birds which are shot by the sportsman or fowler, and are considered to be delicious food. In this country are the pheasant, the partridge, the woodcock, and such like. These are eaten by some in their fresh state, by others after being hung for a time. The flavour in each case, and as to each species, varies; but there are no means of describing them, no standards to which they may be assimilated or referred.

The flavour of the flesh of any bird of prey, or rapacious bird, is described by those who have tasted it as in every case to be nauseous, offensive, disagreeable, being very rank.

Some carnivorous birds have their flesh tainted with the taste of the food on which they subsist. Those which feed upon carrion or corrupted flesh taste, it is said, very disgustingly; whilst those which subsist upon fish acquire a very fishy flavour — such are the gull, petrel, pelican, &c.

Another great class of animals, the flavour of whose flesh is in numerous instances much approved, but which flavour differs widely in character from both that of quadrupeds and that of birds, is the fish tribe.

Each fish eaten as food has its peculiar flavour, which can readily be discriminated by the palate, though it cannot be described in language.

Some few varieties of fish are by civilised beings eaten raw; these are almost exclusively shell-fish, of which the oyster is perhaps the chief. I have heard that in Sweden the salmon is eaten raw.

Nearly all kinds of fish, including shell-fish, are either boiled or broiled, mostly the former.

Amongst common edible fish, those with which we are most familiar are the salmon, cod, sole, turbot, trout, eel, shrimp, and prawn; and of shell-fish, the lobster, crab, turtle, &c.

Some of the smaller fish, having a fine strong flavour, are employed as sauces to relish the more delicately-tasted fishes — such are the anchovy, the lobster, the shrimp, the oyster.

"All flesh is not the same flesh; there is one kind of flesh of birds, another of fishes, another of beasts."

Next in order to a collection of instances, scientifically arranged, of *animals* as producers of sensations of taste, ought to come the consideration of the *parts* of animals as causing such sensations.

Animal bodies are made up of various parts — muscle, blood, secreted liquids, &c. These vary somewhat in their constituent elements, and somewhat differently affect the human organ of taste.

In books on organic chemistry the flavours of the different parts of animals are, or ought to be, described with as much accuracy as practicable. Dr. Thomas Thomson, in the fourth volume of his "Elements of Chemistry," characterises the flavours of the several parts of the animal body.

In any attempted arrangement of the flavours of the parts of animals it would be advisable to start with the article "muscle, or flesh." I will select as examples a few of the more common.

The muscles.—The flesh of animals is a main-stay as an article of food of mankind. In general it is made to undergo the direct action of fire by roasting, broiling, or baking; and no doubt the various flavours of flesh are greatly modified thereby. In numerous cases flesh indirectly undergoes the like action by the mediation of heated water. By the action of warm water muscle or flesh is resolvable into certain proximate principles; viz., extractive, gelatin, albumen, fibrin.

Extracts or decoctions. — A consideration of these naturally follows that of muscle. By means of long stewing, the juices or soluble parts of meat or flesh can be all removed, carrying with them the particles which occasion sensations of taste. These decoctions are ordinarily termed broths or soups.

Milk. — The milk of several of the larger animals is grateful to the human palate, it affects most agreeably but mildly the organ of taste. The milk of the cow, being given out plentifully and continuously, is very largely in use amongst civilised nations. Dr. Thomson describes it as "having a pleasant, sweetish taste." The Tartar and other Asiatic tribes use mare's milk. The milk of the goat is considered strengthening for sickly persons, and is, I suppose, pleasant to the taste. "Woman's milk," Dr. Thomson says, "has a much sweeter taste than cow's milk." "Asses' milk, before the cream separates, has," he says, "an agreeable sweetish taste, and contains more sugar of milk than cows' milk." Besides these are the milk of the reindeer, the camel, and others.

Cows' milk, and, to a less extent, the milk of other animals, after being left some time, resolves itself into two parts, cream and thinner milk; from the latter, by a moderate application of heat, more cream can be separated. The flavour of cream is richer than that of milk.

From cream, by agitation, the oily portion is separated; this is called butter, and has a pleasant, peculiar flavour.

From milk is also obtained, by certain appliances, curd. From curd cheese is obtained. The fluid remaining from milk after the curd is separated is termed whey. "Filtered whey," Dr. Thomson says, "is of a pleasant, sweetish taste, in which the flavour of milk may be distinguished."

Eggs.—The eggs of nearly all kinds of birds are eaten, and their flavour is appreciated and approved by some people or other. Most of us like the eggs of poultry and of wild-fowl. Negroes, Goldsmith records, are fond of crocodiles' eggs, the flavour being agreeable to their palate. The shell of eggs contains two substances, the white and the yolk. The white is "albumen," but not pure, and is insipid; the yolk has a mild, oily taste.

The brain. — The brain, when acted upon by heat, has generally a peculiar flavour, distinguishing it from other parts of the same animal.

Marrow. — A considerable degree of flavour, and that peculiar, is found in the nervous substance of animals which occupies the middle of the larger bones. "This, however, seems chiefly attributable," Dr. Thomson says, "to a substance which, by boiling and filtration, may be separated. Pure marrow is insipid and sweetish."

Bile is a liquid of a bitter taste. Ox-bile is very bitter, but at the same time sweetish. The bile of the carp and eel is very bitter. The taste of human bile is said to be not very bitter. In animals are found biliary concretions and calculi. The bitter taste of bile appertains, I apprehend, to these. From bile a substance is obtained which is named picromel.

Urine. — Healthy human urine has in general a disagreeable, bitter taste. The urine of the larger animals, the carnivori especially, is, I presume, even more bitter and nauseous. From urine a substance called urea is separable, to which the taste of urine is owing. In inflammatory diseases the urine is peculiarly acrid. In diabetes the urine is sweet-tasted, and yields a considerable quantity of sweet matter, which is termed "sugar of diabetic urine."

Fæces.—The taste of human fæces is sweetish bitter. The excrementitious matter of cattle fed at the stall has little taste. That of the larger and fouler carnivori must, I suppose, be very acrid and bitter. From fæces, by filtration and evaporation, is obtained a matter of a bitterish taste.

Blood. — The taste of blood is slightly saline. The serum of blood has the taste of blood. The cruor or clot has, I apprehend, little or no taste. The colouring matter of blood is tasteless.

Cerumen of the ear has a bitter taste.

Fat has, I presume, a very slight flavour, if any, in its raw state. When dressed it has a somewhat agreeable, mild flavour. Purified fat is tasteless, or nearly so. Animal fixed oils are obtained from the fat chiefly. They have a mild taste, sweetish or nearly insipid. Fat and animal oils are separable into two substances, one of which is solid and called *stearine,* the other is fluid, and is termed *elain.*

Musk. — Its taste is bitter. Many animals amongst quadrupeds and birds have a musky flavour; see arts. "Musk-ox," "Muscovy Duck," "Crocodile," &c.

Castor. — Its taste is bitter and acrid.

Honey is perhaps rather a vegetable than an animal matter. It is collected by the bee from flowers; nevertheless it may in some degree be animalised by the collector; its taste is sweet. From honey sugar of honey is obtained.

Some animal parts are tasteless, or are so nearly so as to be termed insipid. This is the case with bone, shell, horn, nail, scale, hair, feather. The skin, both the epidermis or cuticle and the inner layer, called the cutis, has not, I apprehend, any taste. Purified spermaceti has scarcely any taste. Human saliva has no taste. Vipers' poison is tasteless. Healthy pus is insipid. Ambergris is insipid.

Animal Matter is reducible into several proximate principles, albumen, gluten, &c., by which different sensations of taste are occasioned, excepting those which affect not that organ.

Albumen.—The white of an egg is albumen in an impure state. Albumen is obtained from muscle and other parts of animals. Albumen in its natural state, or uncoagulated, has little taste. Coagulated albumen is of a sweetish, mucilaginous taste. To acquire this flavour it must, I apprehend, have undergone some chemical action.

Fibre or *fibrin* is obtained from the muscles of animals, from the clotted part of blood, &c. It has no taste.

Gelatin is obtained from the skin and other parts of animals. In its soft unpurified state it is called *jelly*, and when hard and unpurified *glue*. Jelly is nearly insipid. Glues differ from one another in taste; the best glue is without taste. Purified jelly, or glue, or gelatin, is insipid.

Stearin is tasteless.

Elain retains, I presume, somewhat of the flavour of that oil, in its pure state, from which it is obtained.

Sugar of milk is obtained in crystals by slowly evaporating whey; it has a sweetish taste.

Sugar of diabetic urine is a sweet-tasted extract, like honey; it is nearer in its properties, according to Dr. Thomson, to common sugar than to sugar of milk.

Sugar of honey is most probably a vegetable saccharine matter.

Picromel has an intensely bitter taste, followed by some sweetness.

Mucus obtained from saliva and from oyster has little taste.

Urea.—The taste of urea is strong and acrid, resembling that of ammoniacal salts.

Animal acids.—There are certain acids obtainable from animal matter by peculiar processes. In these processes the animal matter undergoes, I consider, a chemical change, imbibing probably oxygen from the atmosphere.

Margaric acid, from stearin, elain, and animal tallow, is tasteless.

Of *oleic acid,* from the same substances, I know not the taste.

Cetic acid, procured from spermaceti, is destitute of taste.

Lactic acid has a sharp, sour taste.

Amniotic acid has a very slight degree of sourness.

Uric acid is destitute of taste.

Laccic acid, from *stick-lac.*—Perhaps this is a vegetable acid rather than animal; its taste is acid.

Animal matter is farther resolvable into those ultimate principles—carbon, oxygen, hydrogen, and azote—which, so far from being peculiar to animal matter, are found abundantly in every kingdom of the material world.

Thus certain parts and proximate principles of animal bodies are distinguishable by their tastes or flavours. These flavours, in the present state of animal chemistry, admit of only partial classification. We have—

Animal sours or acid tastes.—Sour milk, or lactic acid, amniotic acid, laccic acid, and formic acid, have a sour taste; but these acids seem to be products by the action of oxygen upon certain animal matters, and not to be found naturally in animal bodies. Chyle and a few other animal fluids and solids have perhaps a slight acidity.

Sweet tastes. — Animal substances having a sweet taste are milk, whey, and sugar of milk, diabetic urine, and sugar of diabetic urine, honey, and sugar of honey, if honey be animalised matter.

Several other solid parts and fluids of animals have naturally a sweetish taste, such as chyle, coagulated albumen, &c.; most probably the saccharine portion is separable by chemical means.

Bitter tastes.—Bile, biliary concretions, calculi, picromel, the cerumen of the ear, healthy human urine, human fæces, and the fæces of certain animals, castor, musk, the liquor amnii of the cow, one class of resinous concretions, concentrated extractive of muscle, all occasion in various degrees a sensation of bitterness. In most of these enumerated instances the bitter matter might no doubt be separated, leaving the mass free from a bitter flavour.

Acrid tastes.—Rancid fat and oils, rancid spermaceti, rancid cream and butter, a matter yielded by the bile of certain fishes, the poison of the scorpion, human semen, human urine in inflammatory diseases, castor, extractive of muscle, the picromel of certain birds, urea, have all an acrid taste. The acrid matter of most of these animal substances might no doubt, by chemical processes, be also separated.

There are other varieties of flavour in animal matter, but the terms employed in describing them are not sufficiently definite for scientific use.

Many of the parts of animal bodies produce no action whatever upon the organ of taste; they occasion in that respect no sensation. The following are amongst these varieties of animal matter:—bones, shells and crusts, horns, nails and scales, hair and feathers, silk, the skin outward and inward, the colouring matter of blood, human saliva, vipers' poison, healthy pus, ambergris, albumen, fibrin, stearin, elain, margaric acid, cetic acid, mucus.

SECTION THE SECOND.

Of the several Varieties of Vegetable Matter as Causes or Occasions of Sensations of Taste.

VEGETABLE chemistry being in a more advanced state than animal chemistry, we have the opportunity of adopting a more perfect arrangement. There cannot, as appears to me, be a more scientific mode than to consider plants separately under their botanic names and in alphabetical order.

It is manifest that here can be particularised a very few of the numerous plants, the parts of which affect even strongly the organ of taste, and those only in the way of specimen.

Amygdalus communis.— Almonds, the fruit or seed of this plant, are of two kinds, the bitter and the sweet. Bitter almonds probably contain a portion of bitter principle.

Atropa belladonna, Deadly nightshade. — From the leaves of this plant has been obtained a bitter, nauseous substance, which is the narcotic part of the plant.

Aloe perfoliata.—Aloes is the dried juice of the leaves of one variety of this plant. Aloes has a powerfully bitter taste.

Artemisia absynthium, Absynthium vulgare.—Wormwood comprises the leaves, stalks, and flower-tops of the plant. Wormwood has an intensely bitter taste.

Anthemis nobilis, Chamomile.—The flowers and leaves have a bitter taste.

Arundo saccharifera, Sugar-cane. — The juice of the unripe sugar-cane contains a quantity of acid; whether unripe cane-juice has altogether a sour flavour I do not know. The juice of the ripe sugar-cane has, I believe, a very sweet flavour. In making sugar it is necessary first to neutralise by lime a quantity of acid which is usually in the juice. By certain processes of boiling, &c., the saccharine matter of the juice is obtained in a dry state, in crystals large and well formed or minute. The various kinds of sugar in use are muscovado, crystallised, lump or loaf, and candy. Molasses is the uncrystallisable or liquid portion of the juice, which is also very sweet. The drainings of sugar ferment and produce a wash from which a spirit is distilled called rum, the flavour of which spirit is peculiar. The oil to which the flavour is attributable cannot be discharged.

Allium sativum.—The bulbous part of the root is garlic. Garlic is remarkable for its peculiar taste. By distillation with water garlic yields a volatile oil: its taste is very acrid.

Allium cepa.—Onion is the bulbous part of this root. When onion is reduced to a pulp, a viscous juice may be expressed. In this juice the taste of onion chiefly, I believe, resides. By much boiling and change of water the strong taste of onion may be discharged, and the bulk reduced to a comparatively mild state.

Beta vulgaris and cicla.—From the root of the beet sugar is largely obtained in France and Germany. Sugar of beet is the same or nearly so as cane sugar.

Cassia senna.—The leaves, which are the senna of medicine, have a bitter taste. The infusion of senna in water has the bitter taste, and the leaves become comparatively, I believe, tasteless.

Cinchona floribunda.—The bark is bitter and disagreeable. The decoction has an extremely bitter taste. A brownish matter is separable: to it the peculiar qualities of the decoction are ascribed. The taste of this brownish matter is very bitter.

Cinchona officinalis. — The three kinds of Peruvian bark, the red, pale, and yellow, have all, but in different degrees, a bitter disagreeable taste. From Peruvian bark the bitter principle is separable, and is called quinine.

Coffea arabica.—The seeds or berries being roasted, grounded, and boiled, the liquor so much in use, coffee, is obtained, the flavour of which is rather a pleasant bitter. From unburnt coffee, digested in water or alcohol, a bitter matter, called caffein, is obtained.

Cucumis colocynthis. — The fruit, colocynth, has a bitter taste. From it a bitter principle is extracted, having the properties of the bitter principle of quassia.

Callicocca ipecacuanha.—From the root, ipecacuanha, emetin is obtained. The taste is bitter, and a little acrid, but not in the least nauseous.

Crocus sativus. — The pistils are called saffron : it has a pungent and somewhat bitter taste.

Curcuma longa.—The root of this plant, turmeric, has an aromatic bitter taste.

Convolvulus scammonia.—Scammony is the hardened milky expressed juice of the roots. The taste is bitter and acrid.

Convolvulus jalappa. — The root is called jalap. It has a weak acrid taste.

Hordeum vulgare. — When the grain of this plant, barley, is made to germinate, it becomes malt; the starch acquires a sweetish taste. When malt is infused in water the liquid is called wort; it has a luscious, sweet taste. Wort, by a fermenting process and admixture with hops, becomes beer, a liquid of a peculiar flavour, and generally agreeable to the palate. Distillers' wort is sometimes obtained from pure malt, but chiefly from barley. By fermentation it is converted into wash. Wash, by distillation, yields a spirit, which is gin and whisky. Gin is usually flavoured by juniper berries, &c. Whisky acquires its smoky taste from the fuel.

Humulus lupilus, or Hop.—The leaves of the flower have a somewhat pleasant bitter taste, and are employed in imparting flavour to, and in preserving, beer. Hops contain an oil, in which the flavour seems to reside. The bitter principle of hops is either kindred to, or the same as, quassia.

Laurus cinnamomum.—The inner bark is cinnamon. Cinnamon has a pungent but agreeable taste; by infusing the bark in alcohol and distilling a volatile oil may be separated. The oil has an extremely pungent but agreeable taste: to this oil the properties of cinnamon are owing. Cinnamon is used to flavour chocolate, &c.

Laurus camphora.—When the wood is distilled with water, camphor sublimes. Camphor has a strong but acrid taste. By distilling nitric acid off camphor, camphoric acid is obtained. Camphoric acid has a slightly acid, bitter taste.

Menispermum cocculus.—The fruit of this plant is Cocculus indicus. Cocculus indicus has a very bitter taste. From Cocculus indicus is obtained a bitter principle in crystals. This principle is named picrotoxin, being both poisonous and intensely bitter.

Myristica moschata.—Nutmeg is the seed, mace is the covering of the nut; both are strong-flavoured spices, and are used in seasoning vegetable food. From nutmeg an oil is extracted, to which it owes its peculiar taste.

Vitis vinifera, the Vine.—The taste of the sap is sweetish, but not rough. Grapes, when unripe, have a sour taste; when ripe they are sweet. In the process of making wine the juice of the grapes is expressed.

The liquor is termed must; it has a sweet taste. Must contains tartaric acid and saccharine matter. Tartaric acid is very sour. The sugar of grapes is obtainable by crystallisation; it is not so sweet as cane sugar: refined grape sugar is very similar to sugar of honey. Must contains also a considerable portion of syrup or liquid uncrystallisable sugar. Must, by fermentation, becomes wine. Wines are exceedingly various in their flavours, according to the species and country of the plant; they are universally agreeable to the human palate. Wines contain a certain portion of bi-tartrate of potash, or tartar. Tartar has an acid and rather unpleasant taste. Every wine has also a volatile oil, to which its peculiarity of flavour is perhaps attributable. From wines a spirituous liquor is obtained by distillation; this spirit is called brandy. Brandy, like other alcohols, owes its peculiar flavour to a small quantity of essential oil. Wines, by exposure to the air, imbibe oxygen, and become sour. This powerful acid liquor is known by the name of vinegar.

Wood forms a large portion, even the basis, of all plants. In large trees the trunk and principal limbs are known by the name of timber. Wood is either tasteless, or the sapid juices which it contains are easily removable. When wood is distilled in a retort an acid liquor of a peculiar taste comes over, which is termed pyroligneous acid; from it, by purification, an inferior vinegar is obtained.

In very many cases the power or property of affecting the organ of taste in the peculiar manner of each plant appertains to a portion of the plant which is separable from it, leaving the mass without flavour, or with greatly weakened flavour. This process is carried to a great extent by pharmaceutical chemists; inasmuch as it seems that the medicinal powers of plants carry with them very frequently the sapid power, medicines being for the most part strongly and disagreeably tasted. Such proximate vegetable principles require arrangement. I proceed to enumerate some few of them.

Jelly. — From numbers of ripe fruits the juice, when pressed out and allowed to rest, partially coagulates, and becomes jelly. Pure jelly has a pleasant taste. It is customary to preserve many jellies by boiling them with sugar to a higher consistency.

Oils. — Oil is a liquid portion of very many fruits, seeds, leaves, &c., which can be easily separated by expression, distillation, &c. Some oils are fat, or expressed oils; others volatile, or essential. Essential, or volatile oils, are in general obtainable only by distillation. They are distinguished by an acrid, hot, and exceedingly unpleasant taste; they are obtained from all parts of plants. Fixed, or fat oils, are obtained only from the seeds of bicotyledonous plants, and are procured by expression. Fixed oils are either sweetish, or nearly insipid.

Gums. — Gum exudes from certain species of trees; it is liquid at the time of flow, but becomes more viscid, and hardens afterwards. Few gums have the slightest taste.

Gum resins. — Gum resins exude from trees in a liquid state, but become harder than gums. Their taste is always acrid, and is always much stronger than that of gums.

Resins. — Some flow spontaneously from trees, others are obtained from wounds made in trees. The taste of resins is more or less acrid, and not unlike that of volatile oils.

Alcohol. — Spirit is obtained by distillation from wine, fermented malt, barley, sugar wash, milk, &c., and is known by the names of brandy, gin, rum, arrack, &c.

Each spirit has its peculiar flavour, which is attributed to a volatile or essential oil, that, in some cases, cannot be discharged. Alcohol, spirits of wine, or pure spirit, is that which is deprived of the oil, and so becomes nearly devoid of peculiar flavour, but is of a strong, penetrating, agreeable taste.

Ethers are obtained by distilling alcohol with various acids. Sulphuric ether has a hot, pungent taste. Nitric ether has its taste strong and quite peculiar. Muriatic ether has a sweetish taste. Acetic ether has a peculiar taste, bearing a resemblance to that of alcohol.

Starch, or farina. — The seeds of the Triticum hybernum and other plants consist, with the exception of the outer skin or case, of flour or meal. Wheat flour and other flour are separable into starch, or farina, and gluten. Starch of wheat has very little taste.

Gluten. — Gluten of wheat has very little taste. Gluten is obtained from many seeds, roots, &c.

Woody fibre. — If well-dried wood be digested first in water and then in alcohol, all matters soluble in these liquids are extracted, and there remains only woody fibre: woody fibre is perfectly tasteless.

Thus vegetable matter, in its varieties, affects, like animal matter, the organ of taste, exciting sensations, which sensations, in the present state of vegetable chemistry, may, to some extent, be classified.

Of vegetable acid, or sour tastes. — In Dr. Thomson's Chemistry, vol. iv. p. 3., is an enumeration of plants in which acids are found ready formed; there is likewise a list of the acids. Not every one, however, of the so-called acids which are found in plants has a sour taste. In many plants and parts of plants, which indicate, by their taste, the presence of an acid as an ingredient, the acid is not unfrequently in combination with a base; thus sorrel is very sour, but contains super-salt.

The sour-tasted acids, which are found ready formed in vegetables, or which are vegetable products, are the acetic and acetous, boletic, camphoric, citric, &c. Certain parts of many plants have a sour flavour, or yield, by fermentation, distillation, treatment with alcohol, and other processes, acids, the nature of which is not accurately ascertained. The juices of fruits whilst in an unripe state are very generally sour; as the fruits ripen the flavour alters from acidity to sweetness. In very many cases, if not quite in all, the acid or sour matter of plants can be separated from the other vegetable matter, and exhibited apart.

Of that vegetable taste which is denominated sweet, or saccharine. — Saccharine matter exists in numerous plants, — Amygdalus communis, Arundo saccharifera, Acer saccharinum, Acer campestre, &c. Dr. Thomson, vol. iv. p. 31. of his "Chemistry," gives a list of the chief plants from which saccharine matter has been extracted by chemists. From the ripe fruits of numerous plants, or rather from the expressed juices thereof, saccharine matter is obtainable: from a variety of fruits and vegetable juices the saccharine matter which may be extracted will not crystallise, but remains liquid, or syrup; the cause of this is not understood.

Of that vegetable taste which is known by the term bitter. —The bitter principle of plants or parts of plants may in general be separated. These bitter principles are quassin, picrotoxin, scillitin, caffein, daphnin, &c. Parts of numerous plants have a bitter taste, but the peculiarities of the bitter principle have not been ascertained. See *Amygdalus communis, Atropa belladonna, Aloe perfoliata, &c.*

Of other tastes occasioned by vegetable matter, termed acridity, astringency, &c. — *Acridity.* — For plants and parts of plants having an acrid taste, see *Amyris gilead-*

ensis, Allium sativum, Bubon galbanum, Convolvulus jalappa, &c.

Astringency.—For plants and parts of plants having an astringent taste, see *Acarois resinifera, Amyris gileadensis, Cinchona officinalis, &c.*

There are other flavours not sufficiently particularised for separate classification. For plants or parts of plants having such flavours, see *Atropa belladonna, Æsculus hippocastanum, Amyris elemifera, Allium sativum, &c.*

Many hot-tasted and other varieties of vegetable substances are used as condiments or seasonings to flavour animal food and make it more stimulating and grateful to the palate. The more insipid kinds of vegetable food and liquids are flavoured also by saccharine, acid, spicy, and other vegetable matters. The art of cookery materially consists in the due admixture of these.

Many varieties of vegetable matter are tasteless or nearly so, *id est* are insipid. For plants and parts of plants which do not or very slightly affect the organ of taste, see *Astralagus tragacantha, Calamus draco, Gossypium, Guaiacum officinale, Helianthus annuus, &c.* The woody or fibrous portion of plants, and that portion from which the sapid matter has been extracted, is almost wholly tasteless. Plants when made to vegetate in the dark have scarcely any taste. Culinary vegetables and fruits which are forced in hot-houses for the purpose of being conveyed early to the table or the market, are notoriously very inferior in flavour to those which are matured in their proper season by the sun. Caloric and light thus seem to have much to do with the proper action of vegetable matter upon the organ of taste.

In regard to sensations of taste, we are not so variously and powerfully affected by animal as by vegetable matter; this is proved by the universal use of vegetable substances as condiments to flavour animal food.

Carbon, hydrogen, oxygen, and in part azote, are almost the only elements out of which all the immense varieties of vegetable matter are formed. The great distinction between animal and vegetable substance, is that azote is an essential element of the former, whilst from the latter it is nearly excluded.

SECTION THE THIRD.

Of the several Varieties of Mineral Matter as Causes or Occasions of Sensations of Taste.

One of the characters by which minerals are distinguished and classified is their taste.

A vast number of minerals occasion no taste of any consideration. In mineralogical works, such as Dr. Jameson's "System of Mineralogy," under the head of each mineral, the taste is usually indicated.

Ores of antimony.—Antimony, when rubbed upon the fingers, communicates to them a peculiar taste.

Alum slate, alum stone. — The taste of alum is sweetish and very astringent. Alumina, the earth of alum, has little taste.

Borax. — The taste of purified borax is sweet and somewhat acrid. Boracic acid has a sourish taste at first, then makes a bitterish cooling impression, and at last leaves an agreeable sweetness. Boron is without taste.

Ores of copper. — The taste of copper is styptic and nauseous.

Iron ores. — Iron has a styptic taste.

Ponderous spar. — Barytes has a harsh and a more caustic taste than lime.

Common salt. — Its taste is universally known, and is what is, strictly speaking, denominated *salt.*

Sulphate of magnesia, Epsom salts. — The taste is intensely bitter. Magnesia has very little taste.

Prismatic Glauber salt. — Its taste is first cooling, then saline and bitter.

Mascagnine, or sulphate of ammonia. — Its taste is sharp and bitter.

Natron. — Both common and radiated have an urinous and saline taste.

Prismatic nitre. — Its taste is cooling and saline.

Sal ammoniac. — Its taste is pungent and urinous.

Earthy minerals are tasteless. Saline minerals, if solid, have a sensible taste. Metalliferous minerals are tasteless. Inflammable minerals, if solid, have no taste.

Minerals, metals, &c. which have any taste admit of a very imperfect classification in regard to the sensations they produce. Under the heads of sourness, sweetness, bitterness, astringency, acridity, &c. very few will arrange themselves.

SECTION THE FOURTH.

Of Water, Atmospheric Air, the simple Gases, and certain other simple Substances as Causes or Occasions of Sensations of Taste.

The waters, which exist in such abundance in almost every part of the earth, differ considerably from each other in their taste. Rain water owes its taste to the presence of air, carbonic acid gas, and in part perhaps to ammonia. Spring water, well, lake, and marsh waters, take their taste from the animal and vegetable remains and the mineral substances which they contain. Sea water differs materially from common water in its taste; when pure it is only saline; its bitterness is derived from the animal and vegetable substances which are mixed with it. Mineral waters are distinguished by peculiar tastes, according to the mineral matter which predominates. Good water has scarcely any taste. Distilled, that is water in its pure state, is tasteless.

Atmospheric air has no taste.

Oxygen has no sensible taste.

Chlorine.—Its taste is astringent.

Iodine.—Its taste is acrid and hot, and continues for a long time in the mouth.

Azote, hydrogen, and *carbon* have no taste.

Phosphorus.—Has it any taste?

Sulphur and *boron* are insipid.

SECTION THE FIFTH.

Of artificial or chemical Combinations of Two, Three, or more simple Substances as Causes or Occasions of Sensations of Taste.

THESE chemical combinations admit of a very perfect arrangement. (See Dr. Thomson's and other chemical works.) First may be taken the combinations of oxygen with the simple bases, almost all of which combinations rather strongly affect the palate; then the several combinations of chlorine with a simple base, iodine and a base, azote and a base, hydrogen and a base, carbon and a base, sulphur and a base.

Combinations of oxygen with another simple substance.

— *Deutoxide of chlorine.*—Its solution in water has an astringent and corrosive taste, leaving a disagreeable and lasting impression upon the tongue.

Chloric acid has a very acrid taste.

Iodic acid has a strong, astringent, sour taste.

The *nitric* and *nitrous acids* have an exceedingly acid taste.

Protoxide of azote.—Water absorbs this gas and acquires a sweetish taste.

Carbonic acid gas.—When water is saturated with this gas it acquires an agreeable acidity.

Phosphoric acid has a very acid taste.

Sulphurous acid gas.—Its taste is intensely acid and sulphurous. The taste of liquid sulphuric acid is intensely sour.

Arsenious acid has a sharp, acrid taste, leaving at last a sensation of sweetness. Arsenic acid when dissolved in water has an exceedingly sour taste.

The *oxides of iron, nickel, zinc, lead, tin, bismuth, gold,* are tasteless.

Protoxide of mercury has a coppery taste; the peroxide has an acrid and disagreeable taste.

Chromic acid has a sharp and metallic taste.

Chlorine and another simple substance.—*Chlorine* and *hydrogen* or *muriatic acid gas* has a very sour taste.

Protochloride of phosphorus has an acid and caustic taste.

Chloride of sulphur.—Its taste is acid, hot, and bitter.

Chloride of potassium.—Its taste is somewhat similar to that of common salt, but more inclined to bitter.

Chloride of sodium is pure common salt.

Chloride of calcium is of very bitter and pungent taste.

Combinations of two other simple substances.—*Iodine* and *hydrogen* or *hydriotic acid gas* has a very acid taste.

Fluorine and *boron*, or *fluoboric acid*, has an exceedingly acid taste.

Azote and *hydrogen*, or *ammonia*, has an acrid and caustic taste, like that of potash and soda, but not nearly so strong.

Hydrogen and *carbon*, or *olefiant gas*, or *carbureted hydrogen*, has no taste.

Phosphureted hydrogen gas has an exceedingly bitter taste. Water with 2 per cent. only of this gas acquires an intensely bitter taste.

Sulphureted hydrogen gas. — Water impregnated with it has a sweetish nauseous taste.

Combinations of three simple substances.—*Chlorate of potash.*—Its taste is cooling, austere, and disagreeably analogous to that of nitre.

Chlorate of soda.—Its taste is very sharp and cooling.

Chlorate of lime. — Its taste is very sharp and bitter.

Nitrate of potash, saltpetre, or nitre.—Its taste is very sharp and cooling.

Nitrate of soda, or *cubic nitre*, has a cool sharp taste, and is somewhat more bitter than nitre.

Carbonate of potash has a stronger alkaline taste than the bi-carbonate.

Carbonate of soda.—Its taste is precisely the same as that of carbonate of potash.

And so on through the salts, nearly all of which are triple compounds, are exceedingly numerous, have in general decided action upon the organ of taste, and are readily arrangeable as chlorates, nitrates, carbonates, sulphates, phosphates, &c.

Besides these there are numerous compounds of four simple substances, and even five, most of which have tastes peculiar to themselves, and by which they may be discriminated. To enumerate in order all these would require a considerable volume. The ammoniacal salts, the acetates, the camphorates, the citrates, oxalates, tartrates, &c., are such compounds.

SECTION THE SIXTH.

Of Substances generally as Causes or Occasions of Sensations of Taste. Of the Sensations themselves generally. Of the Organ of these Sensations. Of the Nerves and the Brain in connection with Sensations of Taste. Of the Sensibility of the Soul in respect to Sensations of Taste. Of the Spiritual Principle in Man in regard to Sensations of Taste.

Thus we see that numerous substances, animal, vegetable, mineral, &c. when placed in contact with the organ of taste, affect it, each occasioning what is known by the term *a sensation.*

Substances under ordinary circumstances are impure, and the sensations of taste are modified accordingly. In such cases the modified sensation is strictly compound, as it arises from the united action upon the organ of two or more mingled substances.

Diluted substances occasion sensations of taste which somewhat vary according to the extent of dilution. When water is the diluent the difference is that of intensity only, water having no action upon the organ; but when a fluid which is itself sapid is the diluent, the sensation is properly compound.

Substances not diluted or not impure excite powerfully or weakly according to the quantity brought to bear at once upon the organ.

It is highly probable, indeed we may say certain, that a given quantity of a substance in a pure state ever operates alike upon the organ, whilst the latter is sound or unaltered; and that sensations of the same kind are always, as to intensity, in proportion to the quantities which are made to act at one time upon the organ.

Substances, to occasion sensations of taste, must be in immediate contact with the organ of taste, they cannot affect at the smallest absolute distance.

Solution in the saliva, that is the liquid secreted by the glands of the mouth, seems to be essential to sensations of taste; and very probably all substances which will not mingle with, or in some degree chemically unite with the saliva, are on that account incapable of exciting sensation.

Perhaps in different conditions of the physical system, the state of the saliva especially, a given substance does not occasion the same sensation; but this does not evidence that the power of the substance to occasion sensation ever varies, but proves the variation to be in the human organ or its appendages.

Mr. Locke's doctrine was, that sensation of taste is a result of the configuration, &c. of the parts of the sapid body, but for this notion there never has been the slightest evidence. In vol. i. bk. ii. ch. viii. § 10. of the "Essay on Human Understanding," we meet with this language: "Powers to produce various sensations in us by their various qualities; *i. e.* by the bulk, figure, texture, and motion of their several parts, as colours, sounds, tastes, &c." See also the immediately succeeding sections. Democritus had taught this before: Enfield, in his "History of Philosophy," bk. ii. ch. xiii. p. 428., describes Democritus' doctrine thus: "The qualities of bodies (*some of them*) are not essential to their nature, but the casual effect of arrangement, and to this cause is to be ascribed the different impressions which they make upon the senses. Bitterness and sweetness, for example, are not properties essential to bodies, but effects produced upon the senses (*sense*) in consequence of the various arrangement of atoms." Now this is an assumption which is not borne out by modern investigation. The power of producing organic sensation is one which in general appertains to the atoms themselves, not to arrangement of atoms.

It is not certain that the same substance affords to every individual human being the same taste: still less certain is it that a substance affects an animal with the same taste that it does a human being. Although we cannot be certain that sensations of taste occasioned in different human individuals by equal quantities of a pure substance are altogether alike, inasmuch as there may be in men particular differences arising from physical constitution; yet these differences are, we have ground for belief, not sufficiently strong to prevent specific agreement. The flavour of a ripe green-gage may not be precisely the same in two persons' mouths, but both will describe it to be sweet; both will declare also sorrel to be sour, though they have not the means of ascertaining whether or not the peculiar acidity of that plant is in both of them identical sensation.

That substances are the causes or occasions of sensations of taste is indubitable. No metaphysical acuteness or sophistry can upset the mass of physical and chemical evidence which has been brought together or alluded to in the preceding sections.

Notwithstanding the certainty of our knowledge that substances are the causes of sensations of taste, the well-known proposition of the Bishop of Cloyne, Dr. Berkeley, remains undisturbed. Sensations of taste do not *alone* give the information which we unquestionably possess respecting their sources or origin. Could we feel, that is were we subject to sensation only, we could not possibly ascertain or determine whether the causes of our sensations of taste be material or spiritual.

How we attain to a knowledge of the materiality of the causes of sensations of taste is a problem which has long been mooted, and which still requires most careful investigation.

Our sensations of taste enable us to infer philosophically that there is some thing, or there are some things, in existence capable of affecting us. We infer the reality and the externality of the cause or causes of the sensations because we are wholly unconscious of originating or being ourselves in any way the cause of our sensations of taste.

From the diversity of our sensations of taste we have good reason to infer also a diversity in the causes or occasions of them. By induction we satisfactorily attain to the knowledge or conviction that there is more than one existence or reality concerned in producing in us the sensations of taste which we experience.

We may farther infer that the existences or realities which occasion our sensations of taste, possess a power or powers, a property or properties, of so affecting us.

Also, although a flavour by itself might not and would not be able to give us any insight into the nature of its cause, yet as we should, when again experiencing the flavour, recognise it, we should be justified in attributing it to the same origin or identical cause.

When the human mind has, with other assistance than its sensations of taste, ascertained that substances are the authors or originators of those sensations, it then proceeds to distinguish substances by means of the sensations which they severally occasion. We can as clearly determine by means of sensations of taste that sulphuric acid and potass are different substances, as we can by means of the different chemical combinations which those two substances form with other substances. Chemists, mineralogists, and medical men, in discriminating bodies, adopt for a character sensations of taste, and do so with strict propriety, because disagreement in taste of two bodies as perfectly demonstrates difference of nature as do discordance of other effects, or of operations, or of properties.

In several departments of trade tasting commodities is an important discriminative operation; it is so with the wine merchant, the spirit dealer, the tea taster, traders in several kinds of provisions, professed cooks, and others. The consideration of the use or employment of Tasting, as an instrument of investigation, belongs, however, to a subsequent part of the Science of Mind.

Many substances, compound as well as simple, affect not, we have shown, the organ of taste, so as to occasion sensations of taste; but as the far greater number of both simple and compound substances do, we conclude or infer that there is a power or property possessed by substances, though not universally, nor even perhaps may it correctly be said generally, of producing sensations of taste.

Sensations of taste give occasion to the exercise of the mental power or faculty of memory. Without memory we could not recognise flavours; we should be ignorant of having before been the subjects of the identical sensation at any moment experienced. To be enabled to recognise them, there must have been some kind of memorial impression upon the mind, when the sensation was first or formerly experienced.

The classification of sensations of taste is an important mental operation. Much remains to be effected in respect to a good arrangement of them in sub-classes.

These sensations are called by mental philosophers sensations of taste, but as the word "*taste*" has more than one meaning, a more definite term is desirable; they might be called glossian sensations, from *γλωσσα*, the tongue, or stomatian sensations, from *στομα*, the mouth. Altogether, the phraseology of this department of sensation demands much more precision than has hitherto been given to it.

The mind not only experiences sensations of taste, but distinguishes them as it distinguishes substances, by means of these sensations. I taste first a mulberry, then a nectarine, and so become the subject of two sensations; but beyond experiencing these sensations I discriminate them, I know that they differ.

Sensations of taste give rise to the exercise of the faculty of imagination, and of other powers of intellect. "The tastes of natural bodies," says Hartley, "suggest the visible appearances of the bodies to the fancy." The taste of a medicine palatable or nauseous, suggests to the imagination the effects also of that medicine.

The sensation occasioned by a particular substance is not invariably grateful or disagreeable. To the same individual a certain flavour is at one time pleasant, and at another the contrary; and amongst several persons what will be gratifying to one will be disliked by another. There are flavours which are naturally agreeable to the generality of mankind, and there are others which are not, but which become so to individuals by usage; such are the flavours of olives, tobacco, opium, &c. If a flavour be at one period of life disliked, at another extravagantly desired, the change does not arise from any alteration in the flavour itself,—that continues invariably the same; nor does it seem to be always occasioned by a variation in the organ of taste; the change is within, and is usually brought about by a variety of circumstances. What a prudent man considers will do him injury he refrains from taking, and sometimes gets to dislike; what he supposes will be beneficial he often ceases to find distasteful; the association of interesting events, the recollection of offensive concomitants and consequences, the wish and expectation of beneficial, or the apprehension of hurtful results, all operate to strengthen or discourage the simple inartificial impression. The desirableness or otherwise of sensation is affected by the influence of other feelings and principles of the soul, as these in return are modified by sensations. An emotion or sensation not in itself exactly pleasurable, is in many cases kept alive solely for the purpose of overwhelming or depressing some other sensation or feeling decidedly distressing. Many an one endeavours to correct the corrosive action of grief by exciting that sensation which accompanies the drinking of spirituous liquors, the immediate but temporary consequence being hilarity; and when the baneful indulgence becomes a habit, the nervous coat of the stomach is made so morbidly sensitive, there is such a twinging, gnawing, craving sensation generated, that the man is uncomfortable until he has stupified himself, and made himself nearly callous to sensations of all kinds. The disposition to one or other of the appetites of gluttony and drunkenness seems to be uncontrollable in some persons; they are unable to refrain indulging to excess whenever opportunity serves; they cannot check or restrain their inclination. The circumstances which in an individual have given force to an acquired inclination for a particular flavour, or class of flavours, would often, if closely investigated, prove curiously interesting and illustrative of some of the more delicate phenomena of feeling, and perhaps also of opinion and action.

A special organ is essential to the development of sensations of taste. By means of no other part of the human body can like sensation be experienced. This organ is commonly called by metaphysicians the organ of taste.

Mr. Locke says that the tongue and palate are the organs of taste. — "Elements of Natural Philosophy," p. 437. Dr. Reid represents Dr. Nehemiah Grew to state that the lips, the tip of the tongue, the root of the tongue, the fauces of the uvula and the throat are affected. — "Inquiry," p. 85. Dr. Roget describes the surface of the tongue to be the organ. — "Bridgewater Treatise," vol. ii. p. 393. Dr. Good adduces instances wherein the loss of the tongue and the uvula did not prevent taste.—"Book of Nature," vol. ii. pp. 233. 235, 236. Dr. G. Gregory describes the tongue to be the organ. — "Economy of Nature," vol. iii. 411.

There is undoubtedly considerable diversity amongst mankind in regard to the physical sensibility of the organ of taste; one person's taste is more acute than that of another, and one derives gratification from a class of sensations for which another has no relish, which difference is partly organic.

Constant subjection of the organ of taste to the action of a particular substance, or class of substances, sometimes makes agreeable that which had before been offensive; and, on the other hand, the taste frequently palls and becomes disgusted by being confined to particular meats, &c., however agreeable in themselves. In these cases perhaps the organ itself becomes, in some degree, altered, and adapted to the special action.

The organ of taste is liable to be affected by disease. Derangement in the organic parts does, as is well known, cause a complete change in the character of the sensations experienced.

This organ is, in some individuals, occasionally, and in others, habitually, in a state of morbid sensibility.

The knowledge of the existence and construction of the organ of taste is not obtained by means of the sensations of taste. These sensations do not of themselves tell us anything about the organ by means of which they have their existence: had we no other mode of information we should be ignorant of the necessity of physical organisation to the production of sensations of taste.

The organ of taste has in connection with it a certain portion of the nervous system. The nerves which are termed the ninth pair, are those, I presume, upon which sensations of taste depend.

The nerves appended to the organ of sensation are as essential to sensation as the organ itself; if they be destroyed, or seriously injured, sensations of taste are effectually prevented.

The organisation and course of the nerves which have especial connection with the organ of taste, and even their existence, are not ascertained by means of the sensations of taste.

These nerves terminate in the brain, which is a nervous mass, or conglomeration, immediately in connection with the mind, or spiritual principle, and, in some incomprehensible manner, the brain, and through that the mind, is affected when the organ of taste is acted upon by suitable material.

The lingual, or ninth pair of nerves, proceed from the tongue to that part of the brain which is termed the corpora pyramidalia. The corpora pyramidalia forms, I imagine, a part of the cerebellum, or lower part of the brain.

The brain may be so injured that sensations of taste cannot be experienced.

The necessity of the brain to sensations of taste, and its existence, are not made known to us by sensation alone.

By means of this order of sensations—sensations of taste—we come to know that the spiritual part of our system is endued with a *susceptibility* for such sensation.

There seems no natural necessity for the existence of such susceptibility; we can easily conceive the possibility of the existence of the human spirit without such an attribute.

That within us which is endowed with sensibility, in manner so described, to external material impressions or impulses, we term the mind, or soul, or spirit.

OF SENSATIONS OF SMELL.

SECTION THE FIRST.

Of Animal Matter in its several Varieties as Causes or Occasions of Sensations of Smell.

MANY brute animals have a powerful odour, which is not, in general, agreeable to the human organ of smell, an organ entirely dissimilar from the organ of taste, but placed in the human face just above it. As a few specimens of smell occasioned by animals I enumerate—

The human race. — The odour which proceeds from the negro is represented as very disagreeable to fastidious Europeans. The exhalations from some persons are unpleasant, especially from the feet. Persons who are uncleanly in their habits, and those who, when on military service, or whilst travelling, are deprived of the means of ablution, retain an odour which is repulsive.

The babyroussa, or *Indian hog,* when followed in the chase, has a very strong scent.

The badger scents pretty strongly; the smell proceeds from a gland under the tail.

The buffalo. — The smell of its flesh is said to be disagreeable.

The wild boar leaves, in the chase, a very strong scent; this proceeds from a certain gland, which the hunters cut off immediately.

The civet. — This animal smells very strongly of its well-known perfume; its fur is impregnated with it. The perfume is generated in a pouch, having a number of small glands, and is obtained therefrom. All of the same class of animals — the weazel kind — have a strong odour.

The crocodile has a very strong musky smell.

The ermine, or stoat. — Its scent is fetid, particularly when in a state of irritation.

The genet has an agreeable odour, not so powerful as the civet.

The lion. — His breath is very offensive, his urine still more so.

The moschus, or *musk-animal*, has a bag or pouch in which the musk is secreted. Musk is used as a perfume to the clothes of a person. See descriptions in zoological works; Goldsmith gives a long popular account; another may be found in "Chambers' Journal," No. 265.

The musk-ox. — The flesh has a strong, disagreeable, musky odour.

The peccary has a strong and offensive smell, which proceeds from a glandular lump on its back.

The polecat has a most offensive and powerful odour, which cannot even be discharged from the fur, which otherwise would be more valuable.

The stinkard and the squash. — These animals have a most horrible stench.

The cormorant has a rank smell, more fetid than carrion.

The eagle. — Its breath is said to be as strong and offensive as that of the lion.

The vulture retains a strong carrion smell after death.

The bug. — The disgusting smell which proceeds from this little animal when crushed is well known.

The cantharis. — When they swarm in the atmosphere, it is said their disagreeable smell spreads for some distance.

Serpents. — Some serpents are said to have proceeding from them a very offensive fetor, and all smell strongly.

Fish, in general, have an odour which is known by the term, a fishy smell. There is, in general, nothing distinguishing in the scent put forth by the fish family.

The peculiar scent of an animal proceeds usually from a particular part—the breath, the urine, the fæces, a special gland for the secretion of an odorous matter, &c. Apart from these, the animal itself may but moderately affect the human organ of smell.

The breath.—That of all the larger carnivori, birds as well as quadrupeds, especially those which feed in preference upon tainted flesh and garbage, is powerfully offensive, is fetid. That of the graminivori is, I believe, in all or nearly all cases, quite free from disagreeable odour. The breath of the cow is often remarked as peculiarly sweet.

Blood has a peculiar smell. Serum has the smell of the blood. The colouring matter of the blood is destitute of smell.

Bile has a peculiar smell. The smell of ox-bile is feeble, but peculiar and unpleasant.

The cutis, when fresh, retains in general somewhat, I apprehend, of the odour of the animal from whom taken.

Fat and blubber.—When fresh they are generally of rather an inoffensive smell; the fat of some animals, the unclean ones and those which are not used for human food, is, I suppose, somewhat stronger and more peculiar; though the carnivori are, from their habits, mostly destitute of any quantity of fat. Fat, when heated, exhales a strong odour.

Chyle, when drawn from the thoracic duct about five hours after an animal has taken food, is without smell.

Fæces.—The smell of human fæces is fetid and peculiar; after some time it changes to a sourish odour. The fæces of graminivorous animals is in general milder, but that of each kind of animal is peculiar. The carnivori have a disgusting, sickening odour attaching to their fæces.

Milk.—The milk of the cow and of most domestic animals is of a slight but pleasing smell; the milk of each animal is, I apprehend, somewhat peculiar. Cream has rather a stronger smell, but more fragrant than milk. Butter, when fresh, has a very slight smell. Good cheese has its smell from the oil of the cream which it retains. When milk is distilled, water comes over, which has the peculiar odour of the milk. Sugar of milk, when pure, has no smell.

Oil.—Animal oils, when fresh, are not in general strongly odorous. Train oil and the common animal oils in use smell the strongest. The mucilaginous matter, which deposits from train-oil on standing, has a disagreeable smell. The solid oil distilled over from marrow has a disagreeable smell.

Muscle.—The flesh of many animals has a strong smell, that of others is mild and inoffensive; the first applies generally to the carnivori and those animals which secrete scents or perfumes. The carcases of the graminivori which are articles of human food have, whilst fresh, faint and non-distinguishing smell; after being cooked, each kind can, in general, be determined by the speciality of its smell.

Pus.—Healthy pus, when cold, has no smell. The matter which runs from foul ulcers or sores has usually a fetid smell.

Sweat. — The fluid exhalations which proceed from the skin diffuse an odour around. Each animal has a peculiar smell arising from this cause alone. The matter emitted is probably of an oily character.

Shells have naturally in all, or nearly all, cases no smell. When exposed to heat, many throw out a strong smell of horn.

Saliva. — Human saliva has no smell. The saliva of the horse has a weak disagreeable smell.

Urine. — Healthy human urine has in general, when newly discharged, an aromatic odour; this, when the urine cools, leaves it, and is succeeded by another known by the name of urinous smell. When stale, there exhales a fetid, alkaline odour. The fresh urine of the horse, cow, and camel is rather strong and peculiar. The urine of the carnivorous beasts, the larger kind especially, is very offensive. Urea has a fetid smell, somewhat resembling that of garlic or arsenic. Urinary calculi, when sawed, exhale an odour like that of semen.

Castor has an aromatic odour and is strong.

Civet is so powerful as to require, to be made agreeable, a mixture with other substances.

Musk is aromatic and intensely strong.

These form part of a class of animal odours which are in use for perfumes, and they are considered to be odoriferous, or pleasant and desirable scents.

Albumen, in its natural state, has no smell.

Fibrin is destitute of smell.

Gelatin is scentless.

Stearin is without smell.

Elain is in general with little smell. In the case of some animals, the elain retains some peculiarity of smell.

Margaric acid has a weak smell.

Oleic acid, when pure, is destitute of smell.

Lactic acid has no smell while cold.

Putrid matter.—All dead animal matter, save the bones, nails, &c., is quickly acted upon by the heat, atmosphere, &c., decomposes, and emits most offensive and deleterious fumes. (See accounts of the putrefactive process in Thomson's "Chemistry," and other similar works.) Sulphuretted and phosphuretted hydrogen, and other gaseous compounds, are liberated, to which the stench is chiefly attributable.

After life in an animal is extinct, the parts of the body are no longer held together, and the elements thereof hasten, with the assistance of caloric, moisture, and air, to sever themselves and form new combinations. The effects upon the organ of smell are, then, more properly produced by the action of inorganic matter than of animal matter; nevertheless, the first developments occasioned by disintegration are very different from the ultimate exhibitions of gases, which result from the putrefactive process.

Animal chemistry is not in that advanced state, nor are the terms employed to describe odours sufficiently definite, to allow of anything like a satisfactory arrangement of scents, as has been partially attempted with animal flavours. There are a few terms which might be used as means of classification, viz., aromatic, alliaceous, fetid, &c.

Odour, like flavour, seems to be attached to particular portions of animal matter, and these portions are frequently entirely separable from the mass, leaving the latter scentless. The odorous portions of animal matter are in no degree identical with the sapid portions.

Numerous animal substances, or varieties of animal matter, occasion no smell or are scentless; they have no action upon the organ of smell, they seem destitute of the power of affecting that organ.

SECTION THE SECOND.

Of Vegetable Matter in its several Varieties as Causes or Occasions of Sensations of Smell.

Allium sativum.—The bulbous part of the root—garlic—is remarkable for its strong smell. The volatile oil which comes over when garlic is distilled with water has a very strong smell.

Allium cepa.—Onion, which is the root of this plant, has a powerful smell. The juice, when expressed, carries with it the greater portion of the scent. When the juice is distilled, that which does not pass over deposits a sediment having a strong oniony odour. Dr. Thomson says: "We do not know the substance which gives the alliaceous tribe their peculiar smell, a substance amazingly penetrating, which is dissipated by the heat of boiling water."—*Chemistry*, vol. iv.

Amyris elemifera.—The smell of elemi is at first strong and fragrant, but it gradually diminishes. A fragrant oil comes over when elemi is distilled with water.

Amyris gileadensis.—Opobalsum has a strong aromatic smell.

Artemisia absynthium.—The leaves, stalks, and flower-tops—wormwood—have a strong and rather disagreeable smell. A volatile oil is obtainable from wormwood, in which the smell inheres.

Cassia senna. — The leaves, senna, have an aromatic and somewhat disagreeable odour. Senna communicates to water its peculiar aromatic smell.

Cinchona floribunda. — The odour of the bark is strong and unpleasant.

Coffea arabica. — When an infusion of raw coffee is made, or when water is distilled from coffee, the infusion and what comes over have an aromatic smell. When coffee is roasted a peculiar agreeable smell is developed. The infusion of ground roasted coffee, made by heated water, diffuses this pleasant smell.

Convolvolus scammonia. — The smell of scammony is peculiar and nauseous.

Cystus creticus. — Labdanum has a fragrant odour.

Ferula assafœtida. — The smell of assafœtida is alliaceous and fetid. It yields a volatile oil, which takes with it, I apprehend, the odorous principle.

Hordeum vulgare. — In the process of malting, whilst the grain is sweating, it exhales an agreeable odour. Wort has a peculiar smell. Beer has a pleasant smell.

Laurus camphora. — Camphor has a strong smell. It communicates to water a portion of its peculiar odour. Camphoric acid has a smell like that of saffron.

Laurus cinnamomum. — The bark — cinnamon — has a very pleasant aromatic smell. Oil of cinnamon has an extremely pungent smell.

Myrica cerifera. — Myrtle wax, whilst burning, emits an agreeable aromatic odour.

Myroxolon Peruiferum. — Balsam of Peru has an agreeable smell.

Nicotiana tabacum or *latifolia.* — The leaves — tobacco — when properly cured, have a strong and rather unpleasant smell. The fumes of tobacco are powerful, and to some persons agreeable. Nicotin has the peculiar smell which distinguishes tobacco. The solutions of nicotin, both in water and alcohol, have its peculiar smell.

Piper nigrum.—The seeds—pepper—have a strong spicy smell. When pepper is macerated in cold water, the infusion acquires the odour of pepper. The oil of pepper is the source of the odour of pepper. When this oil is dissolved in alcohol, and diluted with water, its smell is extremely pleasant.

Pistacea lentiscus.—Mastich, when heated, exhales a fragrant odour.

Rubia tinctoria.—The root—madder—has a strong smell.

Styrax bensoc.—Benzoin has a very agreeable smell. When heated, its scent is given forth more strongly. Benzoic acid is distinguished by its aromatic odour.

Styrax officinalis.—Storax is the most fragrant of all the balsams.

Toluifera balsamum.—The smell of balsum of tolu is fragrant. When distilled with water, the water becomes strongly impregnated with the smell. When dissolved in the smallest quantity of lixivium of potash, it loses its own odour, and assumes a most fragrant smell, somewhat resembling the clove pink.

Valeriana officinalis.—The root, valerian.—Its odour is strong and camphoric. The expressed juice has a strong odour.

Vitis vinifera.—Every wine is distinguished by a peculiar odour, which probably depends upon the presence of a volatile oil, so small in quantity that it cannot be separated.

Acetic acid owes its peculiar odour to an empyreumatic oil.

Alcohol.—The various kinds of spirits have each some peculiarity of smell. Pure alcohol is a liquor of a pleasant smell.

Ethers are fragrant and very volatile liquids, somewhat differing according to the acid employed in their production.

Flowers.—Most flowers give forth a scent; the greater part agreeable, some unpleasant. They contain a peculiar volatile oil, to which they owe their smell.

Balsams. — The term balsam, or balm, was originally confined to a thick fragrant juice, obtained from the Amyris gileadensis, and afterwards applied by chemists to all substances possessing the same degree of consistence, and a strong smell. See *Amyris gileadensis, Calamus draco, Copaifera officinalis, Liquidambar styraciflua, Myoxylon Peruiferum, Styrax benzoe, Styrax officinalis, Toluifera balsamum, &c.*

Gum Resins have almost always a strong smell, which in several instances is alliaceous. See *Aloe perfoliata, Bubon Galbanum, Convolvulus scammonia, Euphorbia officinalis, Ferula assafœtida, Pastinaca opoponax, Stalagmatis gambogioides;* also *Ammoniac, Myrrh, Olibanum, Sagapenum.*

Mucilaginous juices. — The peculiar juices of some plants are not distinguished by any strong smell. In these mucilage seems to be the predominating matter.

Oils. — Fixed vegetable oils have no smell. Almost every plant, which is distinguished by a peculiar odour, contains a volatile oil, to which it is indebted for that odour. Volatile oils have a strong fragrant odour; they are numberless. All the fragrance of the vegetable kingdom resides in the volatile oils. Whenever, therefore, a volatile oil can be obtained from a plant, the scent of that plant is separated from it and the mass becomes inodorous. Heat applied to a volatile oil, causes evaporation, and a diffusion of its peculiar odour in the atmosphere. The greater number of volatile oils communicate to water their peculiar odour. Very many of the volatile oils are employed as perfumes.

Putrid vegetable matter. — When vegetable matter is decomposing, the gases given forth diffuse themselves in the atmosphere, and affect the organ of smell. These gases are for the most part excessively offensive to the human nasal organ. When dead vegetable substance, in process of decomposition, or resolution into its gaseous elements, affects strongly the organ of smell, the sensations are perhaps occasioned rather by gaseous than by vegetable matter; yet, often a peculiarity of odour accompanies the decomposition of each kind of plant, which evinces somewhat more than ordinary combination or development of gases.

Plants, in a state of vitality, throw off their odours mostly through the flower and the leaves. Both of these emissions are, I apprehend, of the nature of excretions; the former, whilst the plant is in the condition to propagate its species. The effluvium expired by the leaves is perhaps analogous to the used-up and vitiated air expired by animals, and as necessary to the welfare of the plant, in carrying off useless and hurtful gaseous matter. That these odours are essentially of a gaseous nature is evident, and in connection with them an excess probably of carbonaceous gas, of hydrogen, and of oxygen, beyond the wants of the plant, is got rid of. The giving forth of odours by the leaves may be taken as evidence that leaves are expiratory organs.

The phraseology of olfactory sensation is too indefinite to allow of an arrangement of vegetable substances according to the kind of smell produced. Almost the only terms employed which in the least affect precision, are sour, alliaceous, fetid, aromatic.

When by organic analysis the odoriferous principles of plants have been extensively abstracted, and the smell of each accurately ascertained, and by some means marked, there will then be opportunity to arrange vegetable bodies agreeably to a scale of scents; but until vegetable analysis has been sufficiently prosecuted, no arrangement is possible. In the last ten or fifteen years very great progress has been made.

Many varieties of vegetable matter excite no sensation of smell. A list of these might be usefully constructed: thus, pure sugar (Arundo saccharifera) has no smell; the juice evaporated to dryness of the Carica papaya has no smell; emetin (Cephaelis ipecacuanha) has no smell, &c. When the volatile oil of plants, or parts of plants, is extracted, the remainder of the plant becomes scentless. Woody fibre has no smell.

The odorous particles of numerous vegetable bodies appear to rise with the vapour of the water in which they are soluble, and through that medium are brought into contact with, and operate upon, the organ of smell.

The vapour of alcohol seems to be another medium through which such kinds of odorous vegetable matter as are soluble in that fluid frequently act upon the organ of smell.

Volatile vegetable oils are either constantly parting with a portion of their odour, or more probably under the ordinary temperature of the atmosphere are slowly, but constantly, volatilising, and the oleaceous vapour, like the vapour of water, and the vapour of alcohol, becomes the medium of intercourse between the odorous principle and the organ of smell.

Many vegetable odours can be transferred to scentless, pure vegetable oils, and can be extracted from plants by the agency of such oils, with the application of moderate heat. This extraction, or transference of delicate scents, is a branch of the art of the perfumer. So, again, many scents can be extracted by water and distillation: thus there are orange-water, rose-water, &c.

Camphor, assafœtida, and some other powerful scents, seem to act upon the organ of smell in the dry way. In these cases caloric is perhaps the direct medium of application, as, in fact, it is in all the other cases enumerated, the indirect medium; minute particles of the odorous body separately, or in conjunction with vapour, are carried off by heat, are diffused by it through the atmosphere, and conveyed to the nostrils.

A curious branch of chemical art has lately sprung up. Means have been found to impart to suitable compositions the flavour and scent of certain fruits, such flavours and scents not being extracted from the fruits themselves, but obtained by chemical combinations. Thus imitations of crystallised raspberries, strawberries, &c., are now exhibited and sold in the shops where sweets are obtainable.

The extraction of animal and vegetable odours, or their combination with convenient media, constitutes an important art in fashionable civilised society, — the art of the perfumer.

There appears to be an important distinction between vegetable and animal matter as causes or occasions of sensations of smell. Animal matter in its organised and vital state very slightly affects the olfactory organ, and that, for the most part, disagreeably; but plants in the height, in the strength, of their vital energy pour forth a profusion of odours which, in general, are grateful to the human organ of smell.

SECTION THE THIRD.

Of Mineral Matter in its several Varieties as occasioning Sensations of Smell.

Yellow Amber, when rubbed, gives out an agreeable smell; it burns with a fragrant odour.

Native arsenic, before the blowpipe, diffuses an arsenical odour, which is like that of garlic.

Felspar gives out a peculiar odour when rubbed.

Flint.—When two pieces of flint are rubbed together they emit a peculiar smell.

Common hornblende, when moistened, exhales a bitter smell.

Fetid, straight, lamellar spar, or hepatite, when rubbed or heated, gives out a fetid sulphurous odour.

Indurated lithomarge.—Some varieties, when moistened with water, afford an agreeable smell like that of nuts.

Common compact Lucullite, or black marble.—When two pieces are rubbed together a fetid urinous odour is exhaled, the intensity of which is increased when we breathe on them. The other Lucullites emit the same odour.

Retinite or retin-asphalt, when placed on a hot iron, gives out a fragrant odour.

Stink quartz, when broken, exhales a disagreeable smell, somewhat resembling that of sulphuretted or carburetted hydrogen.

Stink stone or swine stone.—When rubbed, it emits a fetid urinous odour.

Many minerals emit, when rubbed or heated, a sulphureous smell, others an arsenical smell, some a bituminous smell, &c. This smell oftentimes appertains, I take it, not so much to the minerals themselves as to the sulphureous and arsenical gases, bitumen, &c., with which they are accidentally mingled.

In mineralogy smell is one of the characters, or rather is one of the modes of discrimination. There never has been an attempt, I believe, to arrange minerals according to their smell.

Mineral smells are very insignificant in comparison with animal and vegetable odours.

Contagious Matter.—The nature of contagious matter has not yet been ascertained; it may be animal, vegetable, or mineral, all or either, diffused through the atmosphere, perhaps more likely one or other of the two former. Contagious matter is sometimes detected by its smell; but much contagion is undoubtedly at times in the atmosphere, which is not discernible by the nasal organ.

Miasmata.—Miasmata from vegetation are not, I think, in general so strong-scented as the putrid exhalations from either decayed animal or vegetable bodies whilst in process of decomposition, or as the offensive gases which are liberated during various processes of art. Perhaps the more insidious and dangerous vegetable miasmata are not to be detected by the olfactory organ. Armies encamped in the neighbourhood of marshy exhalations, do not generally, or perhaps ever, discover the dangerous error of position by means of unpleasant smells; it makes itself known by the ill effects upon the health of the troops. The destructive miasmata of the west coast of Africa, at the mouths of the Danube and other large rivers, after the rains and at the commencement of the hot season, are not, I apprehend, offensive to the smell.

SECTION THE FOURTH.

Water, Atmospheric Air, the simple Gases, and certain other simple Substances, considered as Causes or Occasions of Sensations of Smell.

Water. — Pure water is entirely destitute of smell. As water is exceedingly difficult of decomposition, and is itself free from odour, it offers a most convenient medium for the transference of other odours; its facility of imbibence is very considerable. Artificial odorous waters are numerous. Lake and marsh waters contain the remains of animal and vegetable matter, and give forth the odours thereof. Mineral waters smell according to their predominant contents. Hepatic waters have a sulphureous smell. When the sea remains stagnant for a considerable time, it becomes fetid. The fetor arises from the putrid animal, vegetable, and, in some cases, perhaps, mineral matter therein.

Atmospheric air has no smell.

Oxygen gas is destitute of smell.

Chlorine.—Its odour is exceedingly strong and suffocating. Water absorbs that gas, and acquires its disagreeable smell.

Iodine. — Its smell is disagreeable, and very similar to that of chlorine, though not nearly so strong. Water into which iodine is thrown acquires the peculiar smell of that substance.

Azote. — Azotic gas has no smell.

Hydrogen has no smell.

Boron and *sulphur*, and, I believe, *phosphorus*, are without smell.

Arsenic, when heated, emits a strong odour of garlic, which is very characteristic.

Iron emits a smell when rubbed.

Cobalt has scarcely any smell.

Manganese has no smell.

Zinc, lead, and *tin,* when rubbed, have slight, peculiar smells.

Copper, when rubbed on the hands, imparts to them a peculiar and disagreeable smell.

Antimony also communicates to them a peculiar smell.

Bismuth, mercury, silver, and *gold* are destitute of smell.

The electric fluid. — The electric fluid does not, I apprehend, act upon the organ of smell any more than it acts upon the organ of taste, or than light and caloric act upon either organ; any sensorial effect is produced by some of the bodies acted upon by the fluid, or by some of the resulting new combinations.

SECTION THE FIFTH.

Of Combinations of Two or more simple Substances not already described, as Causes or Occasions of Sensations of Smell.

Protoxide of chlorine. — The smell resembles that of burnt sugar mixed with that of chlorine. Deutoxide of chlorine. — The smell of this gas is peculiar and aromatic, without any mixture of the smell of chlorine. Chloric acid has no sensible smell.

Iodic acid is destitute of smell.

Fluoric acid gives out fumes, and a smell similar to that of muriatic acid, but much stronger.

Protoxide of azote is without odour. The fumes of nitric acid have an acrid and disagreeable odour.

Carbonic acid, boracic acid, and *silica,* have no smell.

Phosphorous acid fumes have an odour somewhat resembling garlic. Phosphoric acid has no smell.

Sulphurous acid gas, produced by burning sulphur, has a very strong suffocating odour. Sulphuric acid is inodorous.

Arsenious acid has an alliaceous smell.

Oxide of tellurium emits the odour of horse-radish.

The oxides of calcium, potassium, and *sodium,* or the fixed alkalies, have that smell which is sensible during the slaking of lime.

Barytes, magnesia, alumina, yttria, glucina, have no smell.

All the metallic oxides are inodorous, except that of *osmium,* which is remarkable for a peculiar smell, somewhat similar to that of chlorine.

Tungstic acid and *columbic acid* are inodorous.

Chloride of azote has a peculiar and strong smell, but not so disagreeable as that of chlorine.

Hydro-chloric acid, or *muriatic acid gas,* has a peculiar odour. Water which has absorbed muriatic acid gas has a strong pungent smell, similar to the gas.

Hydriodic acid, fluoboric acid, fluosilicic acid, have a smell similar to that of muriatic acid.

Azote and hydrogen. — Ammonia is known by its lively, pungent odour, by which it is distinguished.

Azote and carbon. — The smell of cyanogen is quite peculiar, and exceedingly strong.

Hydrogen and carbon. — Olefiant gas is destitute of smell. Pure carbureted hydrogen has no smell.

Phosphureted hydrogen gas has a smell similar to that of onions.

Sulphureted hydrogen gas has a strong, fetid smell, not unlike that of rotten eggs. Water impregnated with it has the same smell.

Arsenuretted hydrogen gas has a nauseous odour.

Telluretted hydrogen gas has a fetid odour, resembling that of sulphuretted hydrogen.

No substances act more powerfully upon the organ of smell than the hydroguretted gases; and I suspect, for various reasons, that hydrogen, although scentless itself, is the substratum of most odours.

Sulphuretted carbon is nauseous and fetid, although quite peculiar.

Sulphuret of potash, when moist, exhales the odour of sulphuretted hydrogen.

Phosgene gas has a strong smell.

Chlorocyanic acid has a strong and peculiar odour.

Many of the gases, simple and compound, are thus seen to be inodorous.

SECTION THE SIXTH.

Of Substances generally as Causes or Occasions of Sensations of Smell. Of the Sensations, &c.

SUBSTANCES act not in mass upon the organ of smell; they must be in a state of minute division.

Numerous bodies throw off, as we have seen, minute particles, which have the property of affecting the nostrils, so as to produce sensations of smell.

The particles which are thus thrown off by bodies are called effluvia, or odours. Philosophers are sadly ignorant of the nature of effluvia, and of their mode of action upon the nasal organ.

Odorous particles seem not to be, in all cases, essential to the bodies from which they emanate. Many plants, and other odoriferous substances, will lose their scent without any discoverable alteration in weight, texture, &c.

I have already remarked, I think, that effluvia are either gaseous themselves, or as ethereal as, or more so than, atmospheric air. Were there no atmosphere, and could we possibly live without it, bodies might give forth their odours, and our organ of smell might be affected just as it now is. Calorie is, I apprehend, necessary as an accompaniment, or perhaps vehicle, of scent; to it an odour owes, in great measure, if not entirely, its volatility, because, in cold weather, smells rarely arise from any source, and in severe cold never, from either living or dead animal or vegetable matter. Whether caloric be chemically united with scent-bases or not, is not perhaps determinable.

Odours, when concentrated, and when diluted, act with very different force upon the olfactory organ: dilution is, in many cases, agreeable or disagreeable according to the strength of the odour.

When substances occasioning sensation of smell are diluted or impure, the resulting sensation is perhaps less a sensation of degree than a compound sensation. Degree of sensation may depend entirely upon the quantity of a given odorous substance in a state of purity acting at once upon the nasal organ.

Effluvia, to affect the organ of smell, must come into immediate contact with the organ; they act at no distance, however small.

We cannot know certainly that an odorous substance affects one man precisely as it does another, but we have reason to believe, that if there be any difference, that difference, when the organ, nerves, &c. are in a sound state, is but slight.

Many substances do not excite any sensation of smell in man, whatever they may in brute animals. The air, water, metals, most minerals, the earths, woody fibre, and wood mostly, bones, fibrin, &c., are destitute of the property of so doing.

Although numerous bodies operate powerfully upon the nasal organ, our knowledge that material existences are the causes of sensations of smell is not alone acquired by means of the sensations.

As from sensations of taste, so from sensations of smell, we can make divers inferences. We can infer that there is an external cause, or there are external causes thereof, also that there exists in effluvia a power or property to occasion sensations of smell.

Dr. Reid says, " This sensation, in my mind, is occasioned by a certain quality in the rose." — *Essays*, vol. i. p. 322. The power more properly inheres in the effluvia of the rose than in the rose itself; rose-water and attah of roses affect the organ equally with the flower itself.

Substances can as satisfactorily be distinguished by means of sensations of smell as they can by means of sensations of taste; both are of equal use as instruments of philosophical and commercial investigation; a difference of scent, however delicate, in two masses or quantities, indicates unequivocally some difference in their constitution or composition.

Little attempt has yet been made to characterise and classify the sensations of smell: the generic words in common use are few, but distinct.

Sensations of smell might be termed Mukterian sensations, from *μυκτηρ*, the nostril; and that, or some like philosophical term, is necessary for scientific classification.

The earlier of modern metaphysicians appear to have confounded sensations of smell and taste with their external causes, or at least used upon the subject language so ambiguous as to induce the supposition that they conceived no difference between them. Dr. Reid wrote largely upon this delusion, or misrepresentation, whichever it was. See his "Essays" and "Inquiry."

Sensations of smell are subjects of memory, and give exercise to other mental faculties.

Sensations of smell, like sensations of taste, are effects, of which certain properties in substances are the causes.

To sensations of smell an especial organ is appropriated; this organ is called the nose. It is in man divided by a cartilage, and the two passages which are termed the nostrils are lined with a membrane in which numerous nervous filaments take their origin.

These filaments together form the nerves which are called the olfactory nerves, or the first pair of nerves.

The olfactory nerves end in a portion of the cerebrum, or great brain; and here the mind is directly, but mysteriously, affected with sensations of smell.

Any injury to the olfactory nerves, or that part of the brain to which they appertain, prevents, or modifies, sensations of smell.

Our knowledge of an organ, of a peculiar pair of nerves, and of the brain, as essential to sensations of smell, comes not to us solely by these sensations.

Sensations of smell, every time they are experienced, indicate the existence, in the human mind, of the attribute of susceptibility or sensibility.

They evidence also, in common with sensations of taste, that there is *something* within us which feels:

this sensitive existence or principle we term the mind, or soul.

A comparative examination of sensations of taste and smell is desirable. Some substances affect both organs, —others do not. Many fruits have not only agreeable flavour but fragrance; and other vegetable substances, as assafœtida, are offensive alike to the nose and palate. Chlorine gas affects the organs of taste and smell, producing sensations, however, which are utterly dissimilar.

OF SENSATIONS OF SOUND.

SECTION THE FIRST.

Of Human Beings, Brute Animals, and Animal Matter, as Causes or Occasions of Sensations of Sound; or, concerning Sounds produced by Human Beings, Brute Animals, and Animal Matter.

Natural Sounds. — SOUNDS are produced by most animals, and by man, by means of a certain apparatus which comprises the lungs, the throat, and the mouth, but especially an instrument in the windpipe called the larynx.

Amongst the sounds produced by the human organ of voice which are analogous to brute animal sounds, are those which are known by the terms sighing, sobbing, crying, moaning, screaming, screeching, shrieking, sneezing, whistling, coughing, hooting, hissing, gurgling, hiccuping, hallooing, shouting, huzzaing, laughing, mimicking, or imitating the tones or sounds of others, the death-rattle in the throat, &c.

The simultaneous shout of a multitude of individuals under excitement is very affecting, and, under certain circumstances, very alarming, cowing, in some degree, the most resolute. Bodies of soldiery usually rush to the charge with loud shouting. The huzzaing of troops when they depart for foreign service must, I think, move violently the sternest hearts: the roar of a mob in a tumult is frightful. The shrieks of a mass of families under some dire and sudden calamity, as a large ship going down, an earthquake, and the like, are appalling and distressful to the last degree. "So the people shouted when the priests blew with the trumpets; the people shouted with a great shout."—*Joshua.*

The exclamations of calamity and wretchedness are frequently depicted in Holy Writ. "And Esau lifted up his voice and cried with an exceeding bitter cry." "A cry was heard in Ramah, Rachel weeping for her children." "And there was written thereon lamentation, and mourning, and woe."

There is an extensive variety of tones in use amongst all animals, as well as by man, which are expressive very largely of the feelings, and, to some extent also, of the wants and desires. These have been much studied by orators, and have been described with considerable minuteness and exactitude by poets and other describers, and by such writers as Alison in his "Essays on Taste." It is a complaint that, in civilised life, this natural language is very much smothered or deadened,—that savages far surpass polished communities in the vocal expression of passion, as they do in the action of passion. It is the business of the theatrical performer to give full and accurate expression to sentiment in his tones; and it ought to be the duty of the Christian minister in the public reading of the Word of God to give proper force to its numerous exquisite narratives, expostulations, invitations, &c., a duty, however, which is ill understood, and disgracefully and senselessly neglected.

Animals of the same kind have, for the most part, peculiarity of tone in the sounds they produce, although in character there is considerable agreement in the sounds. The cry of distress in all animals is recognised, and yet that cry varies in reference to nearly every individual.

The same is the case also with the tone of anger, and with other tones.

There are but limited means of discriminating by phraseology the sounds which brute animals produce. As illustrations, merely a few may be noticed: —

The agouti has a most plaintive cry when sensible of danger.

The ass makes a most outrageous sound at times, which is called braying. The herds of wild asses in Africa produce a concert which his horrific.

The baboon. — These animals are warned by their sentinel, who raises a loud cry.

The babyroussa, or *Indian hog*, growls dreadfully.

The bear has a fearful, interrupted growl.

The bee. — The buzzing of the bee — a sound made by their wings — is familiar.

The bittern. — The boom of this bird is dismally hollow.

The buffalo bellows more loudly than the bull.

The camel, when overloaded, sends forth lamentable cries.

The canary bird. — The melody and variety of its whistle or song are very grateful.

The cat purs, caterwalls, hisses, or spits, &c.

The cock crows.

The cricket chirrups.

The cuckoo has a well-known note, from which it derives its name.

The dog barks and growls.

The songsters amongst birds are most interesting little creatures, filling the fields and woods with their melodies, sounds which are most grateful to man, as doubtless to themselves. The melodies of birds are one great source of soothing and joyous pleasure, certainly to man, most probably to their own kind, and it may be to various other animals; they were, in great measure, undoubtedly so intended to be by a benevolent Creator.

The tones of animals are exceedingly numerous and various, and some attempt is made in zoological works, and in descriptive works on nature, to represent these. To such writings I refer for farther accounts of the sounds produced by brute animals.

There is a tolerable variety in the terms which are employed to express the tones of brute animals, and, to some extent, a beginning at least might be made to arrange animal sounds. A few of these terms are, crying, moaning, shrieking, growling, bellowing, roaring, hissing, chirruping, whistling or singing by birds, &c.

Combined brute animal sounds. — Animals which are gregarious, or which hunt in a pack, in many cases, if not generally, raise their voices in concert. At night also, in tropical and woody climes, the din of the forest, comprising every kind of roar, hiss, screech, &c., is said to be terrific and horrifying.

Articulate sounds.—Man and some few birds are able to produce a species of sound considerably different from what are termed natural sounds. This species of sound is called articulate sounds, and the production thereof is ordinarily termed speaking.

The articulate sounds of the human voice are perfectly familiar to us in our daily intercourse with one another; but the charm of one person's tones is too often forcibly contrastible with the unmeaning, dry, monotonous tones of another. One man or woman raises the feelings and rivets the attention by the simplest descriptions; whilst another sinks, or greatly weakens, the most important or interesting transactions by a totally unimpassioned or irrational mode of narration. It is said of Garrick, that when Goldsmith, if I mistake not, read to him a play of his own composing, the actor snatched the manuscript from the author's hand, and told him that he did not understand his own composition.

Articulate sounds are nearly peculiar to the human race, few animals only being able to make them, and those, very curiously, the least likely in our anticipation or preconception to possess the capability. The parrot talks with considerable imitative power, and that to the great surprise of those who are unaccustomed to it; whilst the ape and monkey species, the most like to man in anatomical structure, even in the organism of the throat, can get no nearer to articulation than a kind of chattering.

Articulate sounds, unlike inarticulate sounds, are readily arrangeable. In spoken language, each is represented, or may be represented, by a character, so that any one duly qualified, on seeing the character, may make with his voice the represented articulate sound. In alphabets we have an arrangement of this class of elementary sounds.

The arrangement of articulate sounds, their representation by written characters, and even their completeness and distinctness, are not, even in the present advanced stage of human knowledge, philosophically satisfactory. There are constantly occurring philological disputes amongst grammarians and scientific men, who give attention to the philosophy of sounds. Vowel or open sounds are not sufficiently discriminated from consonant sounds; combinations of open or vowel sounds are not fully marked; and still less does the pronunciation of syllabic sounds accord with the symbols of which those syllables are constituted. The English language is seriously imperfect and inaccurate in this particular, so that important disputes have arisen whether words ought to be pronounced as they are spelt, or written as they are pronounced; the former of these is, as far as practicable, the best, the truest rule.

The variety of simple articulate sounds, and the almost innumerable verbal combinations of which they are capable, is exceedingly wonderful. "There are," says St. Paul, "so many different kinds of voices in the world," &c. Every language is in great degree a peculiar combination of articulate elementary sounds.

Some persons have the power of mimickry in respect to sounds in great, and at times amusing, perfection. Whether the sound to be imitated be a human sound, a brute animal sound, and even, to a limited extent, a sound from inanimate nature, it can be produced with wonderful precision, so as to deceive the most practised ear. Herein consists mainly the art of the ventriloquist, and in part it constitutes the faculty of the satirist and the actor.

Musical sounds produced by the human voice.—There is a large and delightful class of sounds produced by the human voice which are termed *musical.* These sounds are generally connected with articulate sounds, constituting a song, a psalm, a hymn, a glee, an anthem, &c.

Singing is exceedingly common with a single voice; and favourite melodies are constantly being rendered by individuals, usually with words attached; then they become songs. There is no need of particular illustrations of, or references to these, they must be patent to every one who is partial to music. We may find illustrations in abundance, ranging from the song of the public singer to the simple, joyous, or plaintive melody of the villager. The singing of an individual of a family, whose voice and style are both good, is perhaps upon the whole of all musical enjoyments the sweetest, and leaves, if, unhappily, death or other circumstances snatch away the loved performer, the most interesting *souvenirs.*

Besides the melody of a single songster, we have the performances of a combination of voices in parts or in harmony. Part-singing has become a delightful art in modern times; a glee, a chant, an anthem, a catch, give perhaps the most exquisite sensual gratification, taking all things into consideration, that the mind is capable of experiencing; it is a gratification which, to a musically-toned soul, is never cloying; it need leave no moral stain; it may give ample scope for the most innocent reminiscences and anticipations; whilst we know that chorus-singing is one of the grand enjoyments of heaven. "And suddenly there was with the angels a multitude of the heavenly host, praising God, and saying," &c. &c. See, especially, the Revelations.

Part-singing, unaccompanied with instrumental music, has not been common except in respect to glees. Latterly it has been introduced with great effect by Mr. Hullah; and I am told the congregational singing amongst dissenters, who usually have no instrumental music, has been much improved by it: more taste is displayed, less shouting or vociferation is to be heard.

Although commonly melodies are performed with words, this is by no means necessary; they may be hummed or warbled; they may even be produced in full tone. It is common also to hear a popular or favourite strain half whistled as it were by an individual in a suppressed tone, or loudly whistled by lads and men in the streets or roads. In general whistling is the performance of some tune, except when employed as a call or as an imitation of birds' voices.

There is a description of imaginative or ideal sounds which is very singular. It is quite common with us to follow out mentally a tune without producing the slightest audible hum or murmur; — the tune seems to be in the throat; we are quite aware of going through it correctly, and we seem to hear it ourselves, although not an audible breath is produced. At times a particular strain recurs in this way so pertinaciously as at last to become a nuisance. This production of inward inaudible sounds is not confined to musical tones, it may be and is carried out constantly in language. A person when reading a book or manuscript does not usually merely observe the printed or written words, but speaks them mentally. Whilst writing this passage I am inwardly speaking it, and seem to have the sounds distinctly in the ears, although I move not a muscle of the vocal apparatus. This is a very curious phenomenon.

The tones of the human voice, as well as the tones of animals, may to a certain extent be classified according to the musical scale; each person and animal has a key-note. Nevertheless it is matter of notoriety, if a hundred voices sound the same tone, there is vast variety still in the character of the sounds evolved by these voices; this diversity is not to be registered by any means of classification in our power.

Besides vocal sounds, human beings, by their action, occasion at times other sounds. The tramp of a body of soldiery, their measured step along a road, over a bridge, &c., is a very peculiar sound. The rustling or scraping of the feet by dancers in a ball-room is a somewhat peculiar suppressed sound; the hands are employed in clapping, generally in token of approbation; the feet in stamping, shuffling, &c., not unfrequently as a signal of disapproval. Rubbing the hands when cold occasions a considerable amount of noise.

Animals make sundry noises otherwise than vocal, amongst them are the following: —

The noise made by the tramping of the enormous herds of horses in the wild state in the plains of South America is said to be truly astounding. This is in like manner, but in a lesser degree, the case with all gregarious animals. Whether they run or fly, the action of their limbs produces strong and peculiar noises. The rush of buffaloes, wild asses, &c. in the wilds of Africa, the prairies of America, &c., raises a loud combined sound. "I heard the noise also of the wings of the living creatures." — *Ezekiel.*

Combined human and brute animal sounds. — In the chase, the voices of the hunters and the barking of the dogs are usually mingled in chorus. The galloping of the horses, on which the sportsmen are mounted, adds to the noise.

Parts of animals and animal matter considered as occasioning sounds. — There are certain parts of animals which are used, after suitable preparation, in some musical instruments. The strings of violins, &c., and of their bows, are, I believe, animal fibre. The parchment of drums, tambourines, &c. is prepared skin, &c., which, being stretched and struck, vibrates musically.

SECTION THE SECOND.

Of the several Varieties of Vegetable Matter as Causes or Occasions of Sensations of Sound; or, of the Sounds produced by or from Vegetable Matter.

When the branches of trees are set in motion by the winds, certain sounds of a subdued character are produced. The rustling of leaves by a gentle wind is esteemed a very pleasing and soothing sound. When the wind is high, louder sounds are occasioned, especially in woods; sometimes the trees crack, and, as is said, groan, under the force of the tempest; and when the storm rages furiously, massy trees are prostrated with a mighty crash.

The sounds occasioned by living plants are very few and simple. The seeds of some plants burst with a slight explosion.

Under the action of fire all wood crackles. When piles of buildings take fire the crackling of the timber is strong. "The crackling of thorns under a pot," is a biblical expression, and any one who has witnessed the burning of stubble in fields has heard this sound. The drier the wood the louder the crackling. Some seeds and other parts of plants, when exposed to heat, decrepitate or fall to pieces, with a slight explosive sound. There are besides the clashing of wooden swords in savage combat; the noise produced in single-stick combat, &c.

The arrangement of the parts of some vegetables or their texture seems to be such that they admit of vibration, and thereby various peculiar sounds are originated. Certain timber is particularly so constructed; and of such wood musical instruments, in great variety, are formed. Organised vegetable matter, when made to vibrate, acts in some mysterious manner upon the air, and through that upon the ear, occasioning sensations of sound.

SECTION THE THIRD.

Concerning Sounds produced by or from Mineral Matter.

SOUND is adopted as a character of minerals.

Slaty aphrite, when put into water, falls to pieces with a crackling noise.

Native arsenic, when struck, gives forth a ringing sound.

Bole, when dry and put into water, breaks with a crackling noise.

Clinkstone. — Thin plates of it, when struck, emit a ringing sound, and so on.

Two *quartz* or other stones, struck against each other, produce sound.

Various minerals, when acted upon by the blow-pipe or thrown into the fire, decrepitate or crackle: thus does common salt.

Metals all, or nearly all, give forth, when struck, a ringing or other sound. Of certain metals musical instruments are formed.

SECTION THE FOURTH.

Of the Earth, the Waters, the Clouds, the Atmosphere, and simple Substances, as Causes or Occasions of Sensations of Sound; or, of the Sounds therein or therefrom.

Natural echoes. — There are various places which reflect, return, or reverberate sounds. The sounds originate elsewhere, and by other causes, but these prolong and multiply them as it were. Many natural echoes are very curious.

Besides these, some buildings become artificial echoes: such is the Whispering Gallery of St. Paul's. In the construction of large rooms, halls, &c., intended for public speaking or for concerts, the architect seems never sure that there may not occur an unseemly aptitude to echo the sound, to the detriment of the intended effect.

Volcanic eruptions. — The sounds produced during eruptions, especially from the more celebrated volcanic mountains, are very astounding, and increase to a dreadful roar or bellowing. Naturalists have given many interesting descriptions of eruptions from Mount Vesuvius, Mount Ætna, &c.

Earthquakes. — These awful phenomena, when very destructive, are usually attended with loud noises, chiefly from gaseous explosions within the bowels of the earth, and partly produced by their concomitants and effects. See descriptions of the great Earthquake at Lisbon in 1755, of the many dreadful ones which have occurred in South America, &c.

Falling mountains and *rocks, avalanches,* and the like, when they take place, produce sounds commonly as loud as, or louder than, thunder.

The gurgling of a *brook* or *river* is a very pleasing, gentle sound.

Ice is very sonorous; it vibrates readily when a stone is cast along it.

Cataracts, cascades, &c. — The fall of the water at the celebrated Cataract of Niagara, is said to be heard at several leagues' distance.

The tremendous roar of the *ocean,* when its waters are much agitated, has been witnessed by multitudes, and described frequently. When the waves beat against a rocky shore the sound is continuous and great; the rolling of the waves over the beach at the rising and fall of the tide produces a gentle sound, very pleasing to nearly all persons.

Whirlpools. — The Maelstroom is described as making a great noise.

" And his voice was like the sound of many waters." — *The Apocalypse.*

Steam. — There arises a kind of under-sound when water in vessels approaches the boiling point. Steam, as it escapes, is generally noiseless; but when it has to pass through a narrow tube, as in the escape-pipes of steam-boilers, it makes a rushing sound, and may be made to produce the now well-known loud whistle of the locomotive.

Winds. — The atmosphere whilst in motion produces, like moving water, sound more or less loud, according to the quantity in motion, its velocity, and the obstructions it meets. The wind is sometimes said to whistle; during a hurricane it roars; the noise is continuous, but swelling and moderating at intervals.

" And suddenly there came a sound from heaven as of a mighty rushing wind." — *Acts.* " I heard behind me a voice of a great rushing," — " A noise of a great rushing." — *Ezekiel.* " The wind bloweth where it listeth, and thou hearest the sound thereof." — *John.*

Meteors. — Large ones make, in general, a hissing noise, as they rush through the atmosphere, ending generally with a loud explosion.

Thunder. — When clouds in an opposite electric state, and coming up in different directions, strike and discharge their electric matter, a dreadful rolling, intermitting, crashing noise is occasioned, which is known to all by the name of thunder. In tropical regions thunder-storms are far more dreadful in sound, as well as in their effects, than ever is the case in our temperate and more serene climate.

Electrical discharges, if of any force; are accompanied with a hissing or cracking sound.

Simple metals. — Iron is amongst the most sonorous metals. Copper is said to be the most sonorous. Tin, when bent, gives forth a cracking noise. Silver and gold are both sonorous.

SECTION THE FIFTH.

Of Combinations of Two or more simple Substances as Causes or Occasions of Sensations of Sound.

Oxygen and chlorine. — The chlorides and chloric acid, when heated, explode with more or less violence.

Oxygen and hydrogen.—These gases, when set on fire together, explode.

Hydrogen gas, when mixed with atmospheric air and set fire to, detonates, the hydrogen and the oxygen of the air uniting.

Chlorine and azote. — The explosions are loud and dangerous.

Chlorine and sodium. — Common salt, when thrown into the fire, decrepitates.

Copper and zinc (brass).—Of this mixed metal musical instruments are made.

Copper and tin (gun-metal). — Guns made of this metal, usually termed brass guns, give a much louder report than those made of iron.

Bell-metal. — Less tin is used for church bells than for clock bells.

Triple and other mixtures. — Oxygen, hydrogen, and sulphur. — Sulphureted hydrogen gas and oxygen gas, when mixed and fired, explode.

Oxygen, carbon, and sulphur. — When an electric spark is passed through oxygen charged with vapour of percarburet of sulphur, the detonation is exceedingly powerful.

Oxygen, azote, hydrogen, and silver — Ammonia and silver — Fulminating silver. — This powder fulminates with the slightest touch. See chemical books for descriptions of fulminating gold and platinum, and the other fulminating mixtures, including gunpowder.

A catalogue is desirable of the numerous explosive mixtures. Gunpowder and the other fulminating powders, as they are the most readily explosive and dangerous, so do they make the loudest noise.

Decrepitation. — Many salts decrepitate. For a list of these see the usual chemical treatises.

SECTION THE SIXTH.

Musical and other Instruments considered as ratificial Productions with or by which Sounds are produced; also of Manufacturing Processes, in which Sound is generated.

Wind instruments. — Shells and horns are used by savages and others to produce sounds by blowing through them: "And the priests blew with the trumpets," *i. e.* with the rams' horns.

Bird-catchers make use of divers small instruments to imitate the voices of birds, and allure them to their nets, — *bird-calls*, *quail-pipes*, *whistles*, &c.

In hunting the *horn* is made use of to keep together and inspirit both hunters and dogs.

Pan's-pipes. — These, I believe, are the pipes which itinerant musicians sometimes carry about with them,— a row of reeds producing a loud, but rather harsh, sound.

Amongst the metal wind musical instruments are the *French horn*, the *trumpet*, the *serpent*, the *trombone*, &c. " He blew a blast so long, so loud."

Amongst the wooden wind musical instruments are the *flute*, the *soldiers' fife*, the *oboe* or *hautboy*, with the mouth-piece thereof, &c.

Some wind musical instruments are not sounded by human breathing, but mechanically. Of such are organs, some of which are played with the fingers, others by a handle, the wind to which is supplied by bellows. Of the finger organs some of the pipes are metal, others wooden, and, in the large organs, different pipes are in use which produce different tones; these pipes are called stops. The wind is supplied by bellows.

Some new wind instruments have of late been constructed, such as the accordion, a class which produce very sweet tones, and admit of much taste in execution. These are instruments into which the air is admitted as into a pair of bellows or the bag-pipes.

The *Æolian harp* is a small stringed instrument which, being suspended in the air, is acted upon by the breeze, the strings vibrate, and a low, murmuring, swelling sound is produced.

A large and valuable class of musical instruments is constructed with strings, some of catgut, others of metallic wire, which, by their vibration when acted upon by hand or otherwise, produce most pleasing sounds. Some of the principal of the class of stringed instruments are the *lute, guitar, harp, pianoforte, violin, violoncello, bass-viol.* The vibration of these instruments is vastly assisted by a thin board or plate, which, by its ready vibration, materially aids the vibratory action of the string or wire. The harp is a very ancient musical instrument. David's playing upon the harp is repeatedly noticed in the Psalms, and in some of the historical parts of the Holy Scriptures; it was a more simple instrument, in all probability, than that now in use, not having so many strings. "We hung our harps upon the willows."

Another class of musical instruments is that which comprises the *tambourine*, the common *drum*, the *kettle-drum*, &c. In these parchment is stretched upon a frame, and the instrument is struck by the knuckles, or by a stick. A single sound unvaried, except in degree according to the force applied, is alone produced; but in concerts the kettledrum player operates upon two drums, one of the key-note, the other of the fifth. In certain passages of choruses, marches, &c., the kettledrum is a most effective instrument. The frame of the drum being thin and vibratory, aids materially the sound. "Sound the loud timbrel."

Glass is a compound which is highly vibratory and sonorous. The musical glasses are well known. Various inventions have at times been offered to notice, wherein glass, being struck or pressed upon, musical tones are produced; these seem not to have succeeded as yet, owing, I believe, to the difficulty of keeping them in tune, or restoring them to tune. In my early days I repeatedly heard Mr. Evans, the alto singer, cause, in a public room, the drops in the chandeliers to vibrate, and give forth a strong musical tone in unison when he swelled powerfully upon a certain high note of his song.

Musical instruments were in use in the earliest ages. In the fourth chapter of Genesis is said, " And his brother's name was Jubal; he was the father of all such as handle the harp and organ." In the thirty-first chapter is said, " That I might have sent thee away with mirth and with songs, with tabret and with harp." " And Miriam the prophetess, the sister of Aaron, took a timbrel in her hand, and all the women went out after her with timbrels and with dances." The tabret, or timbrel, is said to be the tambourine still in use in the East.

Other instruments, or artificial bodies, occasioning sound. — *Clocks and watches* — their ticking. — The striking of a clock-bell. An alarum is sometimes attached to a house-clock.

Bells — tolling and pealing. — Bell-ringing is considered an art. There are some very celebrated peals of bells and single bells. Bells attached to the dress, to horse-furniture, &c., are mentioned in Holy Writ.

The explosion of artillery and fire-arms is very audible, and in the case of the former, tremendous. The sound is attributable chiefly to the gunpowder, but the peculiarity of the sound to the ordnance. Armaments in the present day (1854) are terrific. The fleet which has just sailed for the Baltic against the Russians is armed with guns far larger than any in use during the last war.

The steam-engine. — The rapid hissing, blowing, or puffing noise of the steam escaping from the engine. The scream of the whistle.—The noise occasioned by the friction of the wheels of a railway train against the rails.

Water-mills.—The clacking of the water-wheels, and of the machinery of the mill.

Wind-mills. — The whirring of the sails, — the heavy roll of the axis and wheels.

Spinning-wheels. — The whirring thereof.

The noise of a great city is chiefly occasioned by the rattling and rumbling of carriages over stone pavement.

Many manufacturing processes and operative trades are exceedingly noisy, and all produce sound more or less. In the process of converting skins into leather, and, indeed, in the preparation of skins for many purposes, they are beaten heavily with mallets, by which much noise is constantly produced. When iron is struck on an anvil, and copper is beaten into form, and generally in the Birmingham, Sheffield, and other districts where hardware is the staple manufacture, stunning noises are incessant. We may instance also the uproar in the iron and other steam-ship building yards, public and private.

Musical concerts generally combine vocal and instrumental music, and are private entertainments or public amusements. The latter may be attended almost daily in large cities, during what is termed the season. Some of them are, in modern times, monster concerts, comprising large masses of singers and instrumentalists; and in the choruses is produced an enormous volume of sound. The celebration of Handel in Westminster Abbey, described, I believe, by Dr. Burney, is a well-known instance; but the oratorial performances at Exeter Hall are very grand and astounding, the voices being numerous, and many of the instruments being much more powerful than formerly.

We have, in the Apocalypse, the height of sublimity in the descriptive choruses of the Heavenly Host, where voices are represented as being blended with harpings. No musical imagination can soar to this. Handel has gone far beyond any other in his conceptions of angelic minstrelsy and song.

SECTION THE SEVENTH.

The several Varieties of Matter considered generally as Causes or Occasions of Sound. The Media of Sound. Sensations of Sound generally. The Organs of Hearing, &c.

Substances in the massy state occasion sensations which cannot be occasioned by individual or separated particles. In sensations of taste and smell, matter operates atomically upon human organs; but to the production of sensations of sound, a union of particles, if not indeed a certain degree of organisation, is necessary.

Sensations of sound are produced by bodies striking against each other, or by bodies of such texture or construction that, when acted upon, vibration is occasioned. The air then usually becomes affected, and acts upon the auditory organ.

Sensations of sound seem greatly to result from peculiar organisation of the animal, vegetable, and mineral bodies which occasion them.

Bodies suitably organised are called sonorous bodies.

The texture of sonorous animal and vegetable bodies is, I apprehend, fibrous; and the particles of sonorous metallic bodies are arranged in a peculiar manner; —this is proved by the extreme care which is necessary in casting bells.

The texture or disposition of particles, must be such as to allow of elasticity.

Organisation is not essential to the production of some varieties of sound. The clashing of clouds, and gaseous explosions strongly affect the auditory organs.

Vibration. — There is one peculiar mode of motion which is known to take place in organised bodies; it is termed vibration. Vibration appears to depend upon the texture of a body, or the manner in which its particles are placed relative to one another; and sound, in some mysterious manner, results from vibration.

There are the vibration of buildings, occasioned by the passage of ponderous vehicles in the streets or roads; the vibration of steeples, by the ringing of bells or by gusts of wind; the vibration of suspension and other bridges. The Eddystone Lighthouse vibrates from the force of the waves beating against its foundation. Heavy discharges of artillery make buildings vibrate strongly.

Vibratory motion we can perceive oftentimes by touch, and sometimes by sight, but generally, I believe, we become aware of it by means of its visible effects upon minute bodies, which are put into a state of agitation or tremor, when on or very near to a vibrating body.

Much vibration of bodies takes place without sound being produced; something peculiar in vibration is necessary to the origination of sound.

Tone is dependent upon the quickness or slowness of vibration, loudness upon the force of vibration. See Dr. Roget's "Bridgewater Treatise," vol. ii. p. 419.

Media of sound. — The vibration of an elastic solid body is not sufficient of itself to produce in us the sensation of sound, unless, perhaps, it be in actual contact with the ear. A bell struck in the vacuum of an air-pump may be seen to vibrate, but no sound is heard.

As sonorous bodies do not usually, if ever, act directly upon the auditory organ, but through a medium which is in communication with the organ, that medium must also be elastic, or capable of vibratory motion.

The atmosphere is the ordinary channel of communication between a sonorous body and the auditory organ.

When sonorous bodies are made to vibrate the air seems to be affected in a peculiar manner. It is not sufficient that the air be driven into the ears. On a windy day the air enters with considerable force, and in all probability the momentum is much greater than when thunder is heard; but in the two cases there is no comparison in respect to sound.

The hypothesis respecting the undulations of the atmosphere in the propagation of sound I consider to be very unsatisfactory. In a very large missionary assembly, all singing to the full stretch of their voices, I once heard one voice bear down the whole, and predominate to that degree, that I could not avoid attending to it. Now, what became of the multitude of other atmospheric undulations, and what must have been the capability of one man's wind apparatus, to overpower the united strength of lungs of two thousand men and women? Because smooth water undulates when a pebble is thrown into it, that is no reason that air should undulate when a sonorous body vibrates: the commonly received hypothesis respecting sound, rests, however, upon this analogy. Analogy is the curse of philosophy.

Water is a medium of sound; ice, wood, and other solid substances, are likewise media of sound. If a watch be placed on a bath, the bather may hear the ticking whilst his head is beneath the surface of the water, although he may not hear it when his ear is above the surface. There is an experiment which is familiar to most schoolboys. A string is tied round the head of a poker; the ends of the string are wound round a finger of each hand; the holder presses hard his thumbs against his ears, so as to close the ears as completely as possible, and the poker, thus suspended, is struck against a stove or other metallic body; the consequence is a very deep, loud, melodious sound. This experiment proves that the intermediation of air is not indispensable to sensations of sound, seeing that the internal cavity of the ear is not in this instance acted upon by the air.

On the media of sound, see Roget's "Bridgewater Treatise," pp. 416. 513. 417, 418.

It has been seen that substances must in general be peculiarly organised to originate sensations of sound; but it must be borne in mind also, that sonorous bodies affect through a medium, and as that medium operates directly upon the organ of hearing, so the power or property of exciting this description of sensation appertains strictly to the medium which comes in contact with the organ; but even here some peculiar arrangement of the parts of the air, or water, or other medium, whatever it may be, seems essential; these media do not act by virtue of a property which appertains to each particle or atom separately.

The philosophy of the organisation of sonorous bodies, of vibration, of the action of vibrating bodies upon the atmosphere, and of atmospheric action upon the ears, is very incomplete, and perhaps will ever remain so.

Sensations of sound. — These vary materially in quality or kind; and those variations depend mostly, if not entirely, upon the bodies occasioning the sensations.

Sensations of sound of the same kind vary greatly in degree, *i. e.* loudness.

This class of sensations might more definitely be designated Ousian sensations, from *Ous*, the ear, or Aeoustie sensations, from *ακουω*, I hear.

Sensations of sound give not by themselves information coneerning their eauses, or the organs essential to hearing, or the nerves eonneeted with the organs. To other sources in connection with that of sensation must wc refer our knowledge of these important matters.—Sec Dugald Stewart's "Elements," p. 100.

We are able, though in a limited degree and subject to mueh mistake, to determine by mcans of sounds thc distanec and the position of objects.

We can partially discriminate objects organised and inorganie by means of the varied impressions which they produce upon our auditory organs.

Sensations of sound arc universally employed by mankind as rcprcscntativcs or signs. Articulate sounds are by eonvcntion eonnected with matters of all deseriptions, mcntal and material, with whieh the human mind is conversant; so that, when certain sensations of sound arc oecasioned, the matters with whieh they are arbitrarily associated are suggested to the mind of the individual acted upon. — See Lockc's "Essay," vol. i. p. 157.: "That voluntary conneetion, &e."

The act of associating sounds with things, which is in a certain sense an arbitrary or voluntary aet, presents to us an intellectual phenomenon of a nature quite different from either the operation of producing articulate sounds or the faeulty of hearing them.

The organs of hearing.—There is a pair of organs called the ears or the auditory organs, by means of which exclusively that large and important class of sensations ealled sensations of sound are experieneed. These organs have a peeuliar eonstruetion and a large and exquisitely sensitive nervous substanee.

The ear is widely different in eonstruction from the organs of taste and smell; these are little more than plain surfaces inwardly furnished with nerves; but the ear is of very complex and peculiar formation, and the auditory membrane and nerves seem to be affected in a manner entirely unlike the other organs of sensation, the impulse or impression being of a vibratory character.

The organisation of the ear has been described by various anatomists. The principal parts are the concha, or external ear, which terminates in the meatus auditorius externus, or external auditory canal; the membrana tympani; the tympanum or drum; the labyrinth, including the cochlea, &c.—See Dr. G. Gregory, "Economy of Nature, &c.," vol. iii. p. 416.; Dr. Roget's "Bridgewater Treatise," p. 420. &c.

The advantage of hearing, or of experiencing sensations of sound, is denied to some persons; they are said to be deaf. Deafness arises from a stoppage of the organ by an accumulation of wax, or by some malformation or disease, either of the ear or of the nerves connected therewith. The case of the young man of Chartres, who suddenly came to his hearing and thenceforward began to speak also, has been recorded in the "Mem. Acad. Scien." and referred to by several naturalists and metaphysicians.

An instrument has been contrived for the use of aged and other persons who hear with difficulty; it is shaped like a trumpet, and collects and condenses the pulsations or vibrations of the air, causing the membrana tympani to be struck or acted upon more forcibly. The metal also, to a certain extent, I apprehend, vibrates. If so, the ear-trumpet, to be most effective, ought to be very thin and of the most sonorous material. — Would glass very carefully blown be such a material?

By combining the use of a speaking-trumpet with that of the ear-trumpet, both formed scientifically of the most sonorous material, the deafest persons, with some hopeless exceptions, might perhaps be able to enjoy conversation without requiring that extreme exertion on the part of others which is so irksome.

Dr. T. Reid and others have discussed the subject of the smallest intervals of musical and other sounds which can be distinguished by means of the ear. Dr. Reid concludes that the sixtieth part of a second is discernible by the human mind. — See "Essays," p. 463.

There is evidence to induce us to believe that the auditory system of some persons is so constructed that they do not experience musical sensations. In others again those sensations are peculiarly exquisite.

In what consists a musical ear is not easily determined. Whether it depend altogether upon physical organisation, or whether it principally and essentially depend upon mental structure, cannot perhaps be satisfactorily decided. When we consider that men who seem utterly incapable of appreciating musical sounds, who seem indeed unable to distinguish one musical tone from another, show no want of appreciation of oratorical or conversational expression and quality of voice, we can scarcely avoid concluding that music appertains chiefly to the soul.

The nerves of hearing. — The vibratory action of the air or other medium having been communicated or transferred to the ear, and that organ, or some part of it, having been made to vibrate too, a special nerve subservient to the auditory organ is in some mysterious manner affected. This nerve is called the acoustic or auditory nerve, its commencing filaments are expanded over a fine membrane, and it terminates in a particular portion of the brain.

There is great doubt if hearing be more connected than sight with the emotions and intellect. — See, in Enfield's "History of Philosophy," a statement by Theophrastus. In these days of so much reading the connection of vision with the passions and reason is far greater that it could have been in the Grecian ages.

Sensations of sound supply us with a third class of important phenomena (if we may so use the term), from which we can infer the existence of the soul or spirit, its sensibility to the influence of matter, the power of matter to act upon it, and the radical distinction between matter and spirit. We have not a shadow of reason to suppose that when matter acts upon other matter, be it inorganic or be it organised, any such result ensues as sensation, or any result at all similar to or analogous to it; the results upon matter and mind are as opposite as the poles of the heavens, as light and darkness, as reality and nonentity. If it be not irreverent to say so, we need hardly the book of Revelation to establish this important truth; the scientific reading of the book of nature demonstrates it, supplies irreproachable, irrefragable, evidence of it.

OF SENSATIONS OF COLOUR.

SECTION THE FIRST.

Of Animal Matter in connection with Sensations of Colour; or, of Animal Colours.

THE propriety of ranging colours amongst sensations rather than amongst objects of perception may be questioned. In common language, we speak of *perceiving* colours, not of *feeling* or *experiencing* them. Still, as white light consists of coloured rays, and each ray is considered to *act* upon the eye, it appears advisable to class colours, *ad interim* at least, amongst sensations.

The skin of human beings varies according to climate. The inhabitants of the torrid zone in Africa and Asia are black; between the torrid and temperate zones the colour is what is termed copper, or it is dark, according to the degree of usual temperature. In temperate and frigid climes the human skin is white, though in the former it is common for the countenance to be tinged more or less with red, that is, the blood in the blood-vessels shows through the skin. Hectic persons have not unusually a brilliant rosy hue. In jaundice, the complexion becomes yellow from the bile, which in that disease mixes with the blood. The natives of temperate climes change colour at times, according to their physical state or their emotions; sometimes they become ghastly pale; in other conditions the face is suffused with blushes.

The outer coverings of animals are very often beautifully coloured. The skins of some beasts are highly valued on that account. But the plumage of birds, — oriental birds especially, — the wings and bodies of insects, with the scales of some fishes, are by the hand of the Creator painted with the most glorious and variegated hues.

Some animals have their coats or outer coverings of one colour throughout: thus there are black horses, black oxen, black dogs, black thrushes. Some classes are characterised by one colour: such is the case I believe with the lion and various other animals, at least in the same climate. Many tribes, those especially which inhabit intensely cold climates, are white — the polar bear, the ermine, &c. Some vary the colour of their coats according to the season, being white or very light-coloured in winter, and of darker hue in summer. The intensity or deficiency of the sun's rays has great influence on the external colour of animals.

Any enumeration of living animals according to their colours will ever be a hopeless attempt, so many colours being often exhibited in the same animal; the predominant colour even of many classes would be difficult to determine. A few animals yielding colouring matter are the following: —

The lac insect. — Its colouring matter lac-dye, shell-lac, seed-lac, &c.

The shell-fish yielding the colouring matter with which the ancients dyed their purple.

The ink-fish. — The black liquid emitted by it. Besides which are the *cantharis*, the *castor*, the *civet*, the *cochineal insect*, the *formica rufa* or *red ant*, the *kermes*, &c. &c. &c.

Of parts of animals which are peculiar for their colour we may notice: —

Bile. — Ox-bile is a liquid of a yellowish green colour. Water mixed with ox-bile acquires a yellow colour. Picromel is obtained from bile; it is a green-coloured matter. The bile of the thornback and salmon is yellowish white. The bile of the carp and the eel is very green. Human bile is green or yellowish brown, occasionally nearly colourless.

Blood. — Venous blood is dark reddish purple; arterial blood is a florid scarlet or red colour. Venous blood, by imbibing oxygen, becomes scarlet; this occurs in its passage through the lungs, also by exposure to the atmosphere. The cruor or clot retains the red colour of the blood. The serum is of a light greenish-yellow colour. The colouring matter of blood is obtainable from the cruor or coagulum. The fibrous part of cruor is white.

Bones are white, the exterior at least. The cartilage of bone is a white substance.

Brain. — The outermost part resembles in colour wood ashes; the innermost somewhat differs in colour.

Cerumen of the ear is yellow or orange-coloured.

Chyle is a white-coloured liquid.

The crusts of crabs, lobsters, prawns, and cray-fish, are, I believe, all black; when immersed in boiling water they turn red.

Eggs. — Numerous species of eggs are externally white, but many sorts are spotted or variegated with divers colours; some eggs are altogether of one colour, —yellow, &c. The albumen of eggs is white, the yolk is yellow.

Fat. — Purified fat is white.

Fæces. — Human fæces in a healthy subject is yellowish, being tinged, as is considered, by bile; oftentimes it is dark coloured.

Honey has a white or a yellowish colour.

Hair. — The hair of human beings, as of animals, is of various colours — black, brown, red, grey, white, &c. In old age human hair loses its colour, and becomes grey or white. In very cold climates the fur of animals is commonly white or grey. The colouring matter of hair appears to be an oil.

The kidneys are of a pale red colour.

Lymph is colourless.

The Liver is an organ of a deep red colour.

Marrow, when freed from blood and impurities, has a white colour, shaded with blue.

Milk is whitish; cream is yellow; butter is yellow; curd is white; whey is of a yellowish-green colour; sugar of milk is white.

Muscle or *flesh* is in general reddish, from the blood it contains; when well washed in water it becomes a white fibrous substance. Fibrin is grey or whitish.

Musk is brownish red.

The nerves are white.

Poison of the viper has a yellow colour.

Pus, when healthy, is yellowish white.

Saliva. — Human saliva is limpid, like water.

Silk is white or orange-coloured. The latter owes its colour to a resinous matter, which is separable, and is yellow; when exposed to the light it becomes white.

Spermaceti is beautifully white.

Teeth. — The enamel is white.

Urine. — Healthy urine is in general of a light amber colour; in inflammatory diseases the urine is of a red colour; uric acid is brick-coloured; urea, when perfectly pure, is white.

Albumen is white. Elain is colourless. Fibrin is white. Gelatin is, when pure, colourless. The best glue has a dark brown colour. Size is colourless. Isinglass, when good, is of a white colour. Margaric acid is pearl white. Oleic acid, when pure, is destitute of colour. Stearin is white.

The portion of animal matter which is strictly the colouring matter is in most instances, if not in all, separable from the mass, and may be obtained and exhibited apart. The separation is effected by various processes, and in some cases, because of the value of the colouring matter, to dye cloth, &c., the separation, the preparation, and the application of the colouring matter constitute regular and extensive departments of art, viz., the arts of preparing colour and of dyeing. Besides these, the preparation of pigments, for the use of artists, in oil and water, gives occupation to one class of extracters and preparers of colours.

The various kinds of animal substances might first be arranged according to the seven prismatic colours, in their order from red to violet; and then the several varieties of colouring matter, as found in and extracted from animal substance, might be so arranged.

SECTION THE SECOND.

Of Vegetable Matter in connection with Sensations of of Colour; or, of Vegetable Colours.

Arundo saccharifera.—Muscovado sugar is yellow, grey, or brown. Sugar, purified by sufficient claying or refining, is deprived of its colouring matter, and becomes white. Molasses is brown. Treacle is very dark brown, or even black.

Bixa orellana.—The pigment—anatto—is obtained from the seeds. Anatto is brown without and red within. The decoction is reddish yellow.

Cæsalpinia crista. — The wood — Brazil wood — is used by the dyer. It becomes red by exposure to the air. Water in which it is boiled, acquires a fine red colour. Alcohol takes up the colouring matter of Brazil wood.

Calamus draco. — Dragon's blood is of a dark red colour.

Carthamus tinctorius. — The flowers, properly prepared, are safflower. Safflower contains two colouring matters, yellow and red; the latter is rouge.

Cassia senna. — The leaves — senna — are of a yellowish-green colour. The infusion of senna in water has a brown colour, the leaves becoming green.

Crocus sativus. — The yellow pigment — saffron — consists of the petals.

Numerous other plants yield from some or other of their parts colouring matters, for which see botanical and chemical works.

Flowers have great variety and beauty of colour, few, however, are suitable for the dyer, being fugitive. Flowers are blue, red, yellow, &c.

In studying the philosophy of vegetable colours, the successive changes of colour, during vitality, of those parts of plants which yield the most abundantly colouring matter, ought to be well traced. A brown infusion, or extract by water, may be obtained from senna; the leaves, when deprived of this brown matter, are green; the green colouring matter, again, may be extracted by alcohol. Now, I suppose, that senna leaves are at first of a green colour, but that, in a more advanced stage of growth, they assume a yellowish or brownish tint. If so, how is the change of colour produced?

Leaves, which form so important a portion of all plants, are almost invariably green, but indefinite in their shades. The stems of plants are usually of a brown or darkish colour. The wood is of various colours, some light, some dark, some variegated or figured.

Plants and the parts of plants may in the first instance be arranged in the order of the prismatic colours, viz., red, orange, yellow, green, blue, indigo, violet, with, in addition, black, white.

If it be not practicable, or not useful, to arrange plants or parts of plants in the order of the prismatic colours, let such arrangement be made of the colouring matters which are obtainable from plants.

Many vegetable colours extremely beautiful cannot be rendered permanent, and therefore are unsuitable for the dyer of cloth; others, on the contrary, such as indigo, &c., are exceedingly valuable, and are extensively used for dyeing. Several colouring matters are used for pigments by artists: a few are prepared for personal adornment, such as rouge, hair-dyes, &c.

SECTION THE THIRD.

Of Mineral Matter in connection with Sensations of Colour; or, of Mineral Colours.

THE colours of minerals are very carefully described, according to their several varieties, in mineralogical works, such as Dr. Jameson's "Mineralogy."

Each mineral has a natural colour; but very commonly minerals have non-essential colours, also colours imparted by the accidental or local admixture of some colouring material. Mineralogists ought to examine minerals well, with a view to distinguish the natural or proper colour from the accidental. Were this done, colour would be as perfect a characteristic in mineralogy as primitive form is. Thus, a pure limestone, which is a carbonate of lime, is white; this colour is naturally and necessarily an attribute of the mineral: but particular limestones have different colours imparted to them by small admixtures of metal, &c.

I apprehend that a better principle in arranging minerals according to colour than Werner has suggested, would be that of the prismatic colours in their proper order, red to violet, with the addition of black, and ending with white. The classification ought to be according to the proper, not the casual colour.

The colouring matter may, in numerous instances, be separated from the mineral, leaving the substance of the mineral perfectly white.

The colouring matter of minerals seems very commonly to be metallic, and by the removal of the metal the colour is extracted. Nickel is the colouring matter of crysophax, chromium of the emerald, &c.

The colouring matter of minerals being mostly metallic, such colouring matter properly appertains to a succeeding section, and there ought to be classified.

Mineral colouring matter is much used by house-painters, ship-painters, &c., to preserve the wood, and for decoration; the preparation of such colours is a branch of art. Mineral colours are likewise employed to stain marble, &c.

SECTION THE FOURTH.

Of Water, Atmospheric Air, and simple Substances, in respect to Sensations of Colour.

Good water is entirely colourless. The sea is of a green colour.

Atmospheric air is colourless.

The sky. — The blue colour of the sky is occasioned by vapours in the air, which reflect the blue rays more copiously than any others.

The clouds are well known to be at times much diversified in colour.

The iris, or *rainbow,* is formed by the rays of the sun falling upon rain; the drops of rain decompose the white light and reflect the coloured rays, of which white light is composed, in prismatic order, or in the order in which the prism exhibits them.

Oxygen is colourless.

Chlorine is greenish-yellow.

Iodine. — Solid iodine is greyish-black; the vapour is violet-coloured.

Azote and *hydrogen* are colourless.

Carbon is black. *Boron* is olive-brown.

Phosphorus is of a light amber colour.

Sulphur is greenish-yellow.

Tables of metals arranged according to colour may be seen in Dr. Thomson's "Chemistry," and other like works.

SECTION THE FIFTH.

Of Combinations of Two or more simple Substances in respect to Sensations of Colour.

COPIOUS tables are given in some chemical treatises of oxides, chlorides, iodides, sulphurets, salts, &c., arranged according to colour; the colours of these compounds are exceedingly various in shade or degree.

SECTION THE SIXTH.

Of Colouring Matter generally. Of Light as the Cause or Occasion of Sensations of Colour. Of Ophthalmic Sensations generally. Of the Organs of Ophthalmic Sensation. Of the Optic Nerves. Of the Brain in connection with Sensations of Light. Of the Sensibility of the Soul in respect to these Sensations.

Colouring Matter. — Thus we have seen, though very cursorily, that from many natural bodies, animal, vegetable, and mineral, colouring matter can be separated. Colouring matters, though so important, are even now indifferently understood by chemists. These varieties of matter so act upon white light as to dissever its coloured elements, and then each acts separately upon the eye, and produces its proper colorific sensation.

The bases of many vegetable, mineral, and animal substances are found, when cleared of heterogeneous matters, to be perfectly white.

Some substances cannot have colouring matter discharged from them, — it is inherent in, or appertains to, their nature; such is the case with some simple substances. Gold cannot be deprived of its yellow colour, copper of its red, &c.

One important office of investigators in animal, vegetable, and mineral chemistry is, to determine and describe the flavour of each kind of matter, and to make an arrangement or classification of substances according to their flavours. A second is to discriminate and classify substances, compound and simple, according to their odours. The discrimination of sounds, and the classification thereof, and of sonorous bodies, is no duty of the chemist, but of the natural philosopher. The classification of colouring matters and of substances according to their colours is again within the province of the chemist.

As it is of great importance to separate the sapid matter of bodies and the odorous matter, so is it of equal moment to separate colouring matter, whenever practicable, from the substance with which it is commonly or naturally connected, and exhibit it apart. These three several processes being now carefully carried on, enormous progress is rapidly being made in chemistry, and one branch of the Science of Mind is greatly strengthened.

Light. — A ray of white light, when made to pass through a prism, is decomposed, or separated into seven rays of different colours, in the following order: red, orange, yellow, green, blue, indigo, violet. Sir Isaac Newton made the discovery of this truth by means of experiment and observation. Dr. Thomson says, "The phenomena of colours and the prismatic spectrum indicate the existence of seven different species of light, but to what the difference in these respects is owing has not been ascertained. We are altogether ignorant of the component parts of every one of these species." — *Chemistry*, vol. i. p. 23. There may not be, and most probably are not, component parts.

Sir David Brewster made a communication to the Royal Society of Edinburgh, March 21. 1831, in which he professed to have analysed white solar light into three primary colours, red, yellow, and blue, and contended that the other colours shown by the prism are composed of these. Mr. Hay also held the theory of three primitive colours only.

Each kind of light, when it strikes the eye, or impinges upon the retina, affects it in a peculiar manner, producing the sensation of its own colour.

Most bodies which allow light to pass through their interstices, and thereby are transparent, seem to have the property of decomposing light: but there is this important distinction between them and the prism; the prism, having separated white light into its component colorific elements, exhibits each and every element in its order to the beholder; but most other bodies, having effected the decomposition, allow of one colorific element only to proceed to the eye, or at most a combination of adjacent colorific elements. What becomes of the remaining rays is not clear; whether they are turned back, whether they pass out in some other direction, or whether they are absorbed, is undetermined. There is little probability of the latter, viz. absorption, as saturation must speedily take place. Drops of water falling in the atmosphere decompose light as perfectly as does glass of a prismatic form; precious stones do so also to a great extent.

Bodies having decomposed light, one prismatic colour only, in some cases, passes to the eye; but most commonly two adjacent varieties of coloured light proceed to the eye in conjunction, by which a medium or complex colour is produced, or a mixed sensation is occasioned. Thus, if a particular body allow of the green and the blue rays to proceed to the eye, and reject or disperse the remaining rays, an intermediate shade of colour results. By such admixture of adjoining colorific rays is occasioned the innumerable shades of colour which are found in nature, or which art produces.

When we contemplate colouring matter, and consider that commonly it is readily separated from the bulk of the organic body or inorganic mass with which it is naturally connected, and is as easily transfered to some other substance or material, we seem to be driven to the conclusion that there is a chemical attraction between certain kinds of matter and certain varieties of colorific light, each kind of matter being combined with a particular colorific light. And yet, perhaps, the true state of the case is, that there is some agreement in the texture or arrangement of the parts of the colouring matter and the substances to which they are applied; so that a certain coloured ray, or combination of coloured rays, is only refracted or reflected, as the case may be, to the eye. There may be some harmony in the arrangement of parts, which, so far from deranging the action of the colouring matter, rather facilitates it.

Two problems to be solved are — how bodies effect the decomposition of light? and how it is that, when the retina is directly exposed to a body, a particular colorific ray, or set of colorific rays, acts upon it, whilst others do not? The solution of the latter problem seems the easiest. When transmitted light is decomposed by bodies some of the rays are more refracted than others, and this circumstance renders it unlikely that all the distinct rays should proceed at the same moment to the eye. In the eye itself each separate colorific ray is again refracted differently by the humours of the eye; so that even if all or most of the separated rays reach the external surface of the pupil, they may not all become visible, or rather will not all affect the optic nerve, any more than the rays of white light proceeding from a distant object produce the vision of that object in a short-sighted person which they will in a long-sighted one. It may be said that the prism refracts differently the colorific rays, and yet they are visible at the same time; but be it remembered that in the prism the pores of the glass are so arranged that, after separation, they throw the colorific rays upon paper, &c., at slight distances from one another, in fact in contact; plane glass, however thick, does not so; that does not decompose white light at all. On the other hand, bodies which exhibit or transmit one colour only to the eye not only decompose, but refract, the colorific rays, perhaps to a greater excess than the prism does. Did not the prism exhibit the colorific rays in the close order it does, some of them, I apprehend, would not be visible, would pass outside the range of the eye, as certain more heated rays are said to pass.

What are called coloured bodies may generally be denser than glass, and, consequently, may refract more than the prism. The colorific rays having been separated by these bodies and thrown farther apart than they are by the prism, a less range will be compassed by the eye; and the remainder of the spectrum, if I may so term it, may be scattered without or beyond vision.

Coloured rays are said to differ in refrangibility. This mode of expression is somewhat objectionable; light surely is passive in the process; the body which refracts is the agent; or there is a mutual attraction, or something in the package of the particles of the refracting body, which obliges the passing light to take a particular direction through the pores or interstices of the body.

It seems that certain substances, which allow light to pass through their pores, exhibit to the eye different colours according to the thickness of the substances; thus, in respect to pitch, with very thin plates the transmitted light is a fine yellow, while with thicker plates the transmitted light is a bright homogeneous red. — See Brewster's "Life of Sir I. Newton," p. 93. May not, in such cases, the light be bent more or less out of its course according to the thickness of the medium, and so different-coloured rays fall upon the eye?

A great distinction ought to be made in respect to reflected and transmitted light, or rather in respect to the material which reflects or transmits. The separation of white light into the prismatic rays and the transmission of one or more to the eye seems to be tolerably evident and comprehensible; but, in the case of reflected colours (and colorific rays are mostly reflected, not refracted), there must be separation of rays analogous to the prismatic separation; and yet how is this done? What is there in a dense body, such as gold, or copper, or ebony, or indigo, or a variously-coloured feather, that severs impinged white light and reflects to the eye only one colorific ray and absorbs, or perhaps more properly turns off, all the others?

Leaf-gold reflects light yellow, but transmits it green; leaf-silver reflects light white, and transmits it blue; certain pieces of fir-wood reflect light whitish-yellow, the transmitted light is a brilliant homogeneous red. — See Brewster's "Life of Sir I. Newton,"

p. 93. Is not the light in these cases decomposed in such manner that one species of coloured light is seen only by the eye as refracted, and another species as reflected, the other portions, being differently refracted and differently reflected, not coming within the focus of the lenses which constitute the eye, part passing off beyond by transmission and part by reflection?

It is commonly represented by philosophers that bodies decompose common light, and reflect or refract one or more only of the coloured rays. In this manner are explained the various appearances in respect to colour which nature presents. But if the phenomena of colouring matters be closely considered, and especially their separability from the bodies with which they are found naturally connected, we shall perhaps find good reason to question the commonly received explanation. A red body, for instance, if transparent, will appear red, whether looked at or seen through. Now, it seems hardly reasonable that, if white light be decomposed by a substance, the red rays alone will be both reflected and transmitted. A red curtain throws a red colour upon surrounding objects, whether it transmit or reflect the light. If the red rays pass through the curtain to the eye, how can they be reflected also? if they be reflected to the eye, how can they likewise be transmitted?

"The disposition of bodies to reflect a particular kind of light occasions the sensation of colour." So says Dr. Reid ("Essays," vol. i. p. 338.). Is not this an inaccurate expression? Each kind of coloured ray is the proper cause or occasion of its own colorific sensation.

White light is the combination or intimate union of all coloured light. In that state it is sent forth by the sun and the fixed stars, reflected by the moon and planets, and diffused through the atmosphere. It passes through the pores of some bodies unaltered, and those bodies are termed transparent; it is reflected unaltered also by others, and these are said to be colourless and opaque. Why some masses in nature, simple and compound, reflect or transmit white light unaltered, whilst so many other masses of matter decompose it and transmit or reflect to the eye one variety only of coloured light, is yet one of nature's mysteries; the process has never been satisfactorily explained, and, perchance, never will be.

When the sun shines a denser mass of light is continually striking upon the retina and rebounding than when the day is gloomy. The sensitive effects here differ in degree.

The real colour of an object is nowise varied by distance, but its apparent colour alters when the object is at different distances. Rapidity of motion also blends and confuses colour. The shade of colour of an object is affected by the quantity of light thrown upon it at any moment, and by its position in relation to the observer.

When different colours are marked distinctly on a wheel, and the wheel is made to revolve quickly, the colours are blended and cannot be distinguished. In this case the sensation produced by one colour is not worn off before another is occasioned.

We speak of objects of dazzling brightness, too vivid for the eye to endure. Many descriptions of resplendent light are met with in our Sacred Books. At times glass, when the sun is shining upon it, reflects to the eye light of most exquisite purity and lustre; this may be most frequently experienced from skylights, and sometimes at sunset by looking at windows of houses opposite. A glorious specimen of the brilliancy of this reflected light from transparent glass (which is perhaps the purest light to be met with) may be patent to any one in the case of the Crystal Palace at Sydenham, now just on the point of being finished (A. D. 1854).

As each of the coloured varieties of light, as well as white light, affects the retina or nervous portion of the eye, which is especially adapted to light and is exclusively organised with reference to it, there must inhere in the matter of light a property or power of affecting that peculiar organisation of the nervous system. The existence of this peculiar material power we infer, and can know about it in no other way. A man without the organ, or one blind, knows nothing whatever of light or its power of affecting the intellectual or spiritual principle within, through the medium of a special organ.

In reading, if too strong a light from a lamp or candle be allowed to fall upon the paper, and be reflected to the eye, the eye-sight is likely to be damaged, not from excess of light, but from the heat which accompanies it.

The sensation.—That light, both white and coloured, acts upon the eye, and through that upon the optic nerve, is certain. That this impulse or impression is of the nature of sensation is most probable. That, if sensation, it differs materially in character from taste, smell, sound, and the other undoubted external and internal sensations, is unquestionable. We are in reality not aware of sensation when the eye is affected; we do not, unless the light be in overbearing quantity, feel it, and even then caloric, not light, is perhaps most commonly the exciting cause. The difference between the sensation occasioned by light and the sensations which are occasioned by the action of substances upon other sensitive organs and parts of the human frame, is evident from these circumstances, that colours are more commonly considered to be objects of perception than causes of sensation, and are ordinarily so described, and that metaphysicians have always been disputing on this point, and hitherto with an unsatisfactory result.

Let any one on a bright day look for a minute or two at whatever objects may be within the range of vision, whether coloured or not, and let him afterwards consider what sensation he has experienced — what sensual feeling he has had. He is unconscious of having experienced any. I cannot convince myself that I experience any sensation when I view colours. When I look at a marble chimney-piece, be it white or black, veined or spotted, I am not conscious of any diversity of sensation, or indeed of any sensation at all. Perhaps all effects produced upon the mind by substances affecting the nervous system may properly be considered sensations, and classed as such. If so, the action of light upon the eyes when they are uncovered is strictly productive of sensation. Yet, in that case, ophthalmic sensations constitute a species greatly different from any one of the species of sensation already or hereafter to be considered. Under any view of the subject there ought to be clear classification of the *effects* which are produced upon the mind by substances, whatever part of the physical system be the medium.

I propose, upon the principle already proceeded with, to denominate the class of sensations which light occasions Ophthalmic Sensations, from *οφθαλμος*, an eye. Those ophthalmic sensations which are produced by coloured light have already been usefully distinguished by the appellation " Colorific Sensations," but the sensation which is produced by white light has no especial designation.

Ophthalmic sensations are, like tastes and smells, employed as means of discriminating objects; they are so to an important extent in mineralogy and chemistry. In a great degree difference of colour indicates difference of nature. Each simple substance having an unalterable, a fixed, a determinate colour, any substance of a different colour, we may be sure, is in reality a different substance, or is at least disguised by a covering or admixture of colouring matter. There may be and are imitations of a substance, by artistic and deceptive processes, which the eye cannot detect; this is so with base coin, partially so with gilded silver ornaments, coloured sculptures, decorative painting, stained furniture, &c.; but in general colour is a great means of discriminating bodies.

The *sensation* which light occasions ought not to be confounded with the *perception* of objects by means of light.

When a tree is seen, light is reflected therefrom, and strikes the eye, and the effect of the stroke is perhaps properly sensation; but then light is exclusively the agent. The tree is perceived, but it operates in no respect upon the organ. It indirectly acts perhaps by reverberating, if I may so say, or reflecting the rays of light from all parts of its surface; but as an object of perception, it no way acts as the producer of ophthalmic sensation.

The organ. — The eye is, like the mouth, the nose, the ear, an organ of sensation most curiously constructed, and exquisitely adapted for its purpose. Like them, it has also an additional use: — the mouth is an organ of action in the processes of eating and speaking; the eye is an organ of perception. As the sensations of taste are of far less moment than the operations of eating and speaking, so ophthalmic sensation merely is of much inferior importance to visual perception. But there is an important distinction between this and the other organs to be noted. We may eat without tasting, we may breathe or inhale air without smelling odours of any kind, but we cannot visually perceive objects unless light acts sensitively upon the eye; a man who cannot experience ophthalmic sensations cannot perceive objects of sight.

Instances have occurred of the eye having been seriously injured and acute pain occasioned when persons have looked at the sun under eclipse with glasses not sufficiently darkened; but heat, not light, was the cause of that injury and painful feeling. Again, when the eye has been for some time accustomed to a very faint light, sudden exposure to vivid light causes a strong painful sensation. In this case the pupil of the eye and the attached muscles are suddenly contracted; and in consequence of the contraction the optic nerve is violently affected. I apprehend that the pain thus felt results from an affection of the nerve, and is to be resolved into ordinary nervous sensation produced by sudden and strong muscular action. In ophthalmia and other diseases of the eye, that organ becomes morbidly sensitive, and light even in ordinary quantity occasions acute pain. These sensations I conceive to be of a nature very different from what is to be understood by ophthalmic sensation.

The structure of the eye is exceedingly scientific and wonderful; its parts are the iris, the pupil, the vitreous humour, the crystalline humour, the retina. The iris admits of contraction and expansion, to become adapted to the quantity of light which enters or would enter the eye.

The optic nerves and brain. — The retina is that part of the optic nerve which is spread out at the back of the ball of the eye, and which is immediately affected by the light; this nervous network is collected into a cord behind each eye, and the cord or nerve proceeds directly to and ends in the brain, forming, like the extremities of all the other nerves of sensation, a portion of its substance.

The optic nerves are termed the second pair of nerves; they are of large size, and end in the thalami nervorum opticorum. Various branches of nerves are described as connected with the eye, but these nerves are, I apprehend, motor nerves, not nerves of sensation.

The thalami nervorum opticorum derive their name from being the termination of the optic nerves. The optic nerves have been described as so ending in the brain as to constitute a portion of the cerebrum. This account has not, I presume, been set aside by more recent and effective investigations into the structure of the brain.

I am not aware whether or not the nerves which are concerned in ophthalmic sensation and minister to vision have been accurately traced from the back of the eye to the brain, and been completely detached and distinguished from the motor nerves, which lead from the brain to various parts of the eye. Perhaps Dr. Mayo and others who have made the nerves and brain their study have cleared up this difficult but most important portion of organic science.

Sensibility.—The sensibility of the human soul cannot perhaps be so readily ascertained from ophthalmic sensations as it can be from other sensations, because of their delicacy, by reason of which they cannot be detected; the mind is hardly, if at all, conscious of them. Their character, as sensations, has perhaps been determined rather by anatomical and physiological investigation. To other sensations no knowledge of this kind is necessary; a child, or the most ignorant savage, has those sensations, without giving scarcely a consideration to the means by which they are originated or propagated; but even philosophers have scarcely spoken of sensation occasioned by light.

OF ORGANIC SENSATIONS GENERALLY.

Attached to the act of procreating the species is a description of sensation which is so far agreeable as to lead to the commission of the act. Unless pleasant sensation accompanied it, the inducement of prolonging the race might not be sufficient, just as without the agreeableness of feeding, or more often the pain of hunger, men might neglect to supply their bodies with needed nourishment. The sensation which accompanies copulation is *organic* sensation, there being organs in the sexes especially adapted to the service. "Therefore Sarah laughed within herself, saying, After I am waxed old shall I have pleasure, my lord being old also."—*Genesis*, xviii.

Sensations of taste, smell, sound, colour, and procreation, are organic sensations; they have each an especial apparatus suited to them, of so peculiar a construction that the sensations can have existence only through or by means of them, and each kind or class of sensations has its own organ.

The sensations which have thus far been treated of comprise the whole series of what may be more specifically termed organic sensations, as having special organs, wondrously constructed, each adapted for its peculiar class of sensations and without which none of those sensations can possibly be experienced. If a human being have not one of the sensitive or sensual organs, or if the organ be so imperfect or damaged as to be wholly inefficient, that person is entirely without the sensations appertaining to that organ. Whenever an organ has been utterly useless from birth, the individual so defective is entirely ignorant of the nature of the sensations, and can form no conception of them, beyond the deceptive one of analogy. A blind man may fancy that a scarlet colour is similar to the sound of a trumpet; but such conception is like very many philosophical analogies, worse than useless.

Organic sensations are chiefly exoteric or superficial; the surface of the organ — the outer skin or membrane — is immediately acted upon by the external matter which affects it; the extremities of the nerves, beneath the external covering, are then affected. With regard to ophthalmic sensation, there is some diversity. Light passes through the organ, and so acts upon the back membrane, by which the extremities of the optic nerves are slightly covered.

Organic sensations may usefully be compared with one another and contrasted; their points of agreement and dissimilarity may be noted: various writers have done so, and to advantage. All these sensations give evidence of the essential distinction between that in us which feels and the mass of organic matter of which our physical frame is constituted, and which is as insensible of itself as inorganic matter is.

Organic sensations indicate likewise to us the varied wisdom of the Divine Constructor of the human frame. How the organs can have been made to subserve the purposes they do, is to us, whilst possessing the use of them, most mysterious. We cannot comprehend how matter can affect these organs, and that so variously as it does. We cannot comprehend how it is that each organ ministers to its own class of sensations, why the construction of one rather than that of another assists in producing a peculiar class of sensations, and that class only. The nervous organisation appertaining to each organ is again a never failing subject of wonderment, and amazement is carried to its full extent when the brain, as the ultimate material organ of sensation, is found to be the indispensable means of that mysterious intercourse between matter and spirit which is continually being carried on.

OF INORGANIC SENSATIONS.

There are numerous sensations which require not, and have not, especial organs; these, to a certain extent, and in distinction to sensations hitherto described, are inorganic.

Proceeding from organic sensations, their causes, &c., to the consideration of inorganic sensations, their causes, &c., we will commence with sensations of heat and cold.

OF SENSATIONS OF HEAT, THEIR CAUSES, ETC.

When we place our hands, or any part of the body, on external objects, animal, vegetable, or mineral, in a certain state of temperature, that is, having a sufficient amount of caloric spread through and over them, we experience peculiar sensations, which are termed sensations of heat.

Sensations which are occasioned by the giving forth of caloric by animals and animal matter. — Human beings and living animals are so organised that they, in general, accumulate caloric and retain it above the ordinary condition, in respect to temperature, of the atmosphere, and of inanimate matter. This, however, is not the case with what are termed cold-blooded animals. Those animals which, by means of the lungs, separate caloric from the atmosphere as they breathe, and so heat the blood sufficiently, are termed, on that account, warm-blooded animals.

In general, when we handle or touch warm-blooded living animals, we experience the sensation of heat, or that moderate degree of it which is termed warmth. When an animal has undergone considerable exertion caloric is accumulated in excessive quantity, and by touching the animal in that state we feel the sensation strongly, or the animal is said to feel hot.

Some animals have naturally much more heat within them than others, and appear at times greatly to suffer from heat.

The nature of the outer covering of various animals, their thick skins, their hairy or woolly coats, &c., which are bad conductors of heat, and therefore impede and retard the exudation of superfluous caloric, causes the bodies of such animals to be ordinarily at a high state of temperature, and when we come into contact with them we feel more strongly the sensation of heat.

When life is extinguished in a human being, or in any warm-blooded animal, the excess of caloric above the temperature of the atmosphere quickly flies off, and the body becomes stiff, and no longer feels to our touch warm, but the contrary.

The skins of animals and their hairy or woolly coats being naturally bad conductors of heat, that is, not allowing caloric to pass quickly through them, are employed extensively by mankind as articles of clothing, or as means of retaining in the human frame the caloric which is collected by the lungs in breathing.

Hair and wool, when separated from the skin, together with that extraordinary and beautiful secretion silk, being fibrous, are, by the ingenuity of man, worked up into cloth, and so employed to cover the body, and obstruct the spontaneous dispersion of animal heat.

When a number of human beings or animals are congregated and closely packed together, the surrounding air becomes greatly heated, and the increased temperature is disagreeably felt. This is found to be the case in crowded assemblies, in well-filled stables and cattle-stalls. Sheep pack themselves closely under shelter to keep up their warmth during the coldness of night. Soldiers marching in close file, and in large masses, or formed into squares to repel attack, find the heat at times to be insufferable.

Sensations occasioned by the giving forth of caloric by vegetables and vegetable matter. — There is no evidence, I believe, that living vegetables have an apparatus for separating and accumulating caloric analogous to the lungs of animals: the warmth of a living plant is occasioned directly by the rays of the sun, or communicated by the surrounding atmosphere. I presume that living plants are not hotter, or possess more heat, than dead vegetable matter in like circumstances.

Leaves are considered to be the breathing apparatus of plants, inhaling, at one time, atmospheric air and carbonic acid gas, and at other times exhaling oxygen and carbureted gases, differently in the night from the day; but I am not aware that there has ever been evidence that calorie is, by the process, collected in plants, or that the ordinary temperature of trees is above the present temperature of the atmosphere, excepting that when the sun shines strongly upon them their texture seems to favour an accumulation of caloric, — in such state living trees and timber feel very hot to the touch.

The fibrous parts of vegetable matter — cotton, flax, hemp, &c. — are wrought into clothing and coverings, and are so employed, like animal fabrics, in retaining the natural warmth of the human body.

The human body requiring to be artificially heated during cold and wet weather, caloric is, for the purpose, accumulated temporarily, by means of the combustion of wood, which, being collected in heaps on the ground, on hearths or in stoves, and ignited, sends forth during the chemical changes it undergoes a large quantity of disengaged superfluous caloric, which heats the immediately surrounding atmosphere, and imparts to the human beings clustered around the burning fuel that sensation of warmth which is so genial.

Other dry vegetable matter — peat, &c. — is employed as fuel in some countries where it is abundant or wood is relatively scarce.

When buildings, stacks, &c., catch fire, great heat during the conflagration is liberated, and is sensibly felt by those who are near.

Minerals, metals, &c., considered as occasioning sensation by giving forth caloric. — Minerals, metals, &c., have, in their natural state, neither more nor less appreciable or sensible heat than the bodies by which they are surrounded; that is to say, their temperature varies with the temperature of those surrounding bodies. That all these bodies differ in respect to the absolute quantity of caloric with which they combine is undoubted, but this has nothing to do with the sensations of heat which we may experience from them.

Mineral bodies, like animal and vegetable bodies, differ materially in respect to the facility or difficulty with which they pass caloric, and so they affect us differently as regards calorific sensations.

Caloric passes into and comes from iron with greater facility than it will pass into and from wood. This is owing, in great degree, to difference of texture: the wood is fibrous; the fibres overlap or intertwine, confusing, as it were, the interstices, and thereby impeding the passage of the caloric; the pores of iron, on the contrary, are straight, and caloric, because of the inconceivable minuteness of its particles and their natural velocity, rushes readily along them.

In certain countries where coal is found in sufficient abundance, that most valuable mineral is used in preference to, or in combination with, wood, for purposes of warmth.

Burnt clay, or clay otherwise hardened, and stone, are employed in the erection of houses, to protect the human body from the inclemencies of the weather, amongst which inclemencies the want of warmth in winter is one of the least supportable. Stone and iron are also largely used in the construction of hearths and stoves, by means of which ignited fuel is kept together; and the caloric it gives forth during combustion is, to a great degree, concentrated, the stone and the metal themselves becoming greatly heated.

Compression of metals evolves caloric. When they are hammered, which process hardens them, or forces the particles more closely together, they become sensibly hot. Friction, or rubbing, has also the effect of evolving heat. This is found to be the case with wheels, pistons, &c., in rapid motion, so as to necessitate continual lubrication, or moistening with oil or fatty matter.

The heating effect of friction is not confined to metals; two stones rubbed rapidly and forcibly against each other become sensibly heated, so do two pieces of wood: this is a mode employed by some savages to obtain fire. Lucifers, &c., are ignited by being rubbed hardly against some rough or solid substance. Bones and even flesh become warmed by friction: rubbing hands is a custom with many in cold weather to increase warmth.

The earth, ocean, &c., considered as occasioning, by giving forth caloric, sensations of heat.—Different parts of the earth being differently exposed to the rays of the sun, affect differently the human body, by occasioning in more or less intensity the sensation of heat. In the torrid zone those sensations are commonly oppressive. The earth, in addition to the atmosphere, becomes greatly heated, and affects the human body by producing in high degree the sensations of heat.

Wide expanses of sand in Africa and the East Indies become intensely heated by the sun; travellers and animals crossing them feel the heat most oppressively and unbearably. "The burning desert."—*Goldsmith.*

It has been stated by Boyle and others, that the sensation of heat increases the lower persons descend in mines. There have of late been numerous geological investigations, which go to prove that the earth is hotter the deeper a descent is made into it.—See Lyell's "Geology," and the writings of other modern geologists.

In volcanic eruptions, the earth vomits forth vast quantities of burning stone, &c. in a liquid state, hot water, highly heated air, &c. Those who have had near views of volcanic eruptions have found the heat projected to be scarcely endurable.

The ocean and other masses of water are heated by the direct rays of the sun, and during the night generally, and in the colder seasons continually, give forth or part with caloric, and so to some extent keep up the warmth of the atmosphere. Water is said by divers to become colder the deeper the descent; perhaps the lower temperature or not of water at increased depths is not a determinable point by human sensation, moisture having great influence in rapidly depriving the human body of its caloric and reducing its temperature, which ordinarily is so much higher than that of water.

In some parts of the earth, and most extraordinarily in the coldest climates particularly, there issue from the ground streams of hot water, boiling springs as some are termed: such are the Geysers of Iceland. Many mineral springs in this and other countries send forth their waters in a tepid state.

Water artificially heated is, to some extent, employed in imparting warmth to rooms in the place of coal or wood fires.

The sun's rays pass through the atmosphere quickly on account of its rarity, and are to a large extent accumulated in the earth and ocean, and in the various objects on the surface of the earth. The atmosphere does not become heated by the direct passage of the sun's rays, as they are very partially intercepted by it, or by what floats in it. The reflected rays, and the caloric which is continually issuing from the heated ground and the heated substances upon it, warm the atmosphere.

We are especially affected with sensations of heat by the atmosphere, which is constantly fluctuating in respect to its temperature. The day is commonly hotter than the night, the summer is hotter than the other seasons of the year, and our bodies are so sensitive, that we feel keenly the changes in the calorific state of the atmosphere.

The atmosphere has always in it a portion of vapour, but much more at one time than at another. Vapour is water with a larger portion of caloric in connection with it than that substance in its fluid state possesses. Whenever atmospheric vapour becomes condensed, a portion of the caloric is liberated, and at the moment makes the air sensibly warmer.

When atmospheric air becomes partially deprived of its oxygen and moisture by the action of stoves, gas-burners, oil lamps, &c., or by respiration, we experience a sensation as of heat, indeed oppressively, and much greater than the thermometer would indicate. In some respects this may be termed deceptive, not being really sensation of heat, so much as unpleasant sensation occasioned by the more difficult working of the lungs, or the action of vitiated air upon that exquisitely organised and delicate organ.

There are certain winds which, in warm climates, are more highly heated than the atmosphere around. The sirocco and simoom in Africa and Southern Europe are such, and have been described by various travellers.

When the atmosphere and gases are condensed, caloric is set free, and is sensibly felt by bystanders.

Concerning caloric given forth by animal and vegetable matter, by minerals, metals, &c., by gases, &c., whilst undergoing chemical changes, and so producing sensation. — Man has invented or adopted various processes of heating the surrounding atmosphere. This is effected by the combustion chiefly of vegetable matter and coal, thereby imparting additional warmth to the human body in the cold season of the year, and at other times when the body is chilled by exposure to wet.

All fatty animal matters, tallow, oil, &c., are highly inflammable; and although they are chiefly employed in combustion to produce light, yet the heat liberated in the process is also considerable, and is frequently found to be disagreeably oppressive in crowded assemblies.

When the carbureted hydrogen gas obtained from coal is consumed for the purpose of obtaining intenser light than by almost any other means, the air is also sensibly heated; apartments in private dwellings, especially small ones, which are lighted by gas, are at times found to become oppressively, and it may be feared injuriously, warm.

Caloric exists in chemical combination with most substances, and when that combination is broken up, and the caloric becomes disengaged, we thereby experience the sensation of either warmth or heat, as the case may be.

By slaking pure lime considerable heat is occasioned, the water parting with its caloric as it mixes with the lime, and becomes solidified.

Generally in chemical combinations, when gases combine together or with other substances, and become fluid, caloric is freed; and when liquid substances, by combining together or with other substances, become solid, heat is also evolved.

Substances considered generally as giving forth caloric, and thereby occasioning sensation.—Caloric pervades all known bodies, and when accumulated in unusual quantity effects important alterations in their structure, consistency, and combination.

Bodies having an unnatural quantity of caloric thus forced into them, have a constant tendency to part with the superfluous portion, or rather that superfluous portion has a constant tendency or inclination to fly off, and when it does so, and we are in its neighbourhood, we feel the sensation of heat.

Perhaps every substance, simple and compound, is in chemical combination with caloric. This portion of caloric is termed latent, and is irrespective of the variable quantity of caloric connected with it according to the temperature of the surrounding atmosphere and adjacent bodies. So long as caloric, fixed or attached, continues in a body, we cannot be sensible of it; for us to feel it, or to experience its peculiar sensation, it must leave the body and act upon our physical system.

Sources of heat. — The chief, though not the only source of caloric, is the sun. The fixed stars are considered to be suns, and therefore primary sources of heat, not, however, to us, or very slightly so. Comets may also be sources of heat.

In temperate regions the sunshine of spring is peculiarly grateful after winter's severities.

By means of burning-glasses, caloric is concentrated to a focus, so much so as to set on fire inflammable substances, and to burn the hand or any part of the body to which the collected caloric is directed — instance Archimedes' burning mirrors.

In making observations on the sun by means of telescopes, inconvenience arises from the heat of the concentrated rays. In viewing an eclipse of the sun, it is necessary to use dark-coloured or blackened glasses, otherwise the concentrated caloric would injure the eye. These glasses turn back or reflect the calorific rays perhaps because the pores of the glass are partially filled with the particles of coloured matter.

Dr. Herschell examined the heating power of the prismatic rays, and found that it increases constantly from the violet end, and is greatest at the red end; he found also that the heating power is greatest of all beyond the boundary of the red ray. See Thomson's "Chemistry," vol. i. p. 28. &c.

Although the sun be the grand supplier of caloric to our earth, there, nevertheless, is an immense amount of caloric which appertains to the earth itself, being a component part of it, existing in chemical combination with nearly all terrene substances, and inseparable to any great extent from them. This caloric occasions sensation only when, by chemical decomposition, any portion of it is liberated.

In the working of all machinery and the moving of conveyances, viz., rail carriages, coaches, waggons, carts, &c., there is constant friction, and caloric is continually given forth in quantity sufficient to excite sensation, and mostly very strongly, when the hand or other part of the human body is placed in contact with the heated material. This caloric is perhaps supplied by the atmosphere, and not by the metal.

By means of the galvanic battery great heat is occasioned. This caloric is, perhaps, in no degree supplied by the electric light, but is furnished by the decomposition of the compound substances brought under its influence, — oxygen, when converted from the gaseous to the solid state, giving forth the largest portion.

Caloric a cause of sensation. — Most natural philosophers agree that there is in the material world a peculiar elementary substance, which they distinguish by the terms "Caloric," or the "Matter of Heat."

The bodily system of human beings is greatly subject to the influence of caloric. When concentrated in sufficient quantity, caloric entirely breaks up human physical organisation, reduces the system to its elements, or occasions destructive changes in their combinations.

"The God that speaketh by fire, let him be God."—*Elisha.*

Caloric must possess a peculiar property or power, by which it operates upon the human nervous system in a way in which no other substance can operate, unless the electric fluid be an analogous kind of matter. The existence of this inherent property or power is infered. The power which occasions the sensations of warmth and heat, resides or inheres in caloric alone. Whatever be the body applied to us, the sensation is produced, not by that body, but by the caloric which comes forth from it.

It is not certain whether or not light and caloric be distinct substances. Evidence as yet leads to the conviction that they are; for although light and the matter of heat are usually and perhaps always associated, and the sun is their principal source, yet intensity of the one is by no means identical with intensity of the other. A great degree of light is compatible with a small degree of heat, and extreme heat with scarcely any light.

In the action of light and caloric upon the human soul occasioning sensation through the medium of the physical system, there is this essential distinction. Caloric occasions sensation on whatever part of the human body it operates; to the action of light a pair of peculiar organs, exquisitely constructed for the purpose, is appropriated.

The sensation of heat, or calorific sensation, generally.—Besides the purely material effects of caloric upon the human body, it affects the soul through the medium of the physical system. The effect is undeniably sensation.

Caloric, in occasioning sensation, acts upon all the superficial parts of the human body, internal as well as external. There are no organs specially appropriated for sensations of heat.

Caloric applied to bared muscle, or even to the exposed fluids of the animal system, the blood for instance, does not, I apprehend, occasion sensations of heat, but painful sensations altogether different.

From the varying intensity of the sensations of heat which we experience is to be infered a difference in the quantity of caloric present at the moment, and affecting our bodies. See Thomson's "Chemistry," vol. i. p. 49.

"A child," Dr. Reid says, "who has once burnt his finger in a candle, from that single instance connects the pain of burning with putting his finger in the candle, and believes that these two things must go together." — *Essays*, vol. i. p. 399. If he found the flame to burn and pain his finger once, why should he not expect that it would do so again? He infers, from once experiencing the effect, that fire has a power of producing a particular kind of sensation.

Dr. Reid makes a similar representation in vol. iii. p. 138. of his "Essays," adding, that "Mr. Hume hath shown very clearly that this belief is not the effect either of reason or experience." This clear-showing seems to me to be perfectly ridiculous. Why does not the child exhibit strong apprehension the first time its finger is about to be burnt? See another passage from vol. ii. p. 323., where it is said the knowledge that flame will burn is one of the earliest notices of experience.

Calorific sensations vary exceedingly in degree from that of the most moderate warmth to that of burning. In the latter case pain accruing from the commencing destruction of fluid, muscle, and nerve, is an important ingredient, if it do not indeed constitute the whole of the sensation.

Dr. Thomson has well described the distinction between caloric, or the matter of fire, and the sensation it occasions. "Chemistry," vol. i. p. 27.

Sensations occasioned by caloric, besides being termed sensations of heat and calorific sensations, might be distinguished from other varieties of sensation by the appellation of Thermotean sensations, from θερμοτης, *heat*, or by that of Purian sensations, from πυρ, *fire*.

The lips are a part of the face by which temperature is very accurately determined. Mr. Gough, of Manchester, blind from an infant, by this means ascertained the connection between the temperature of caoutchouc and its elasticity. See Thomson's "Chemistry," vol. iv. p. 176.; also Gregory's "Economy of Nature," vol. iii. p. 409.

When caloric enters the human body, it expands the fluids, vessels, muscles, and nerves, as it expands nearly every kind of inorganic matter when it diffuses itself through it. Perhaps the nervous expansion is the immediate cause of calorific sensation.

Nerves, &c. — We have no nerves any more than organs peculiarly appropriated to caloric. The penetration of caloric may not be necessary to sensation, its superficial action upon the nerves may be sufficient; though that caloric, when applied to the nerves, does enter and expand them, is the fact; and it may be that to the dilatation or expansion of the nerves is to be attributed essentially the sensation.

The influence and action of caloric upon the nerves is conveyed or communicated to the brain, and thereby to the spiritual part of man, by all the nerves indiscriminately. Unlike organic sensations, a nerve proceeding from any part of the body is the medium of this kind of sensation and the other inorganic sensations which remain to be described. Here is another development of the mysterious phenomena of sensation, and the action of matter upon mind. Why a certain portion of nerve should be the instrument of one kind of sensation, and the entire nervous sensitive system an instrument of another kind of sensation, is by us incomprehensible, and ought to raise our conceptions of the wonderful power and wisdom of the Creator.

OF SENSATIONS OF COLD, THEIR CAUSES, &c.

Substances considered as occasioning Sensations of Cold.

THE chameleon is said to be very cold to the touch. All cold-blooded animals, when touched, especially during their period of torpor, occasion, I apprehend, to the person who touches or handles them, the sensation of cold. Animals in the torpid state, are sometimes frozen, and yet live.

Dead human beings and animals, or corpses and carcasses, are universally cold to the touch, being in temperature reduced much below the ordinary degree of heat which is kept up in the living human body. The cold sweat of death is spoken of by those who are accustomed to death scenes.

Living vegetables and wood do not ordinarily feel cold to the touch; in this respect they are considerably unlike to dead animal matter and to metals, into both of which caloric seems to pass from the living man more quickly than it does into vegetable matter.

Cold produces, or rather permits, the effect of a certain degree of contraction, thereby the descent of the sap is occasioned, and an end, for a time, is put to vegetation. This takes place at the close of the autumn, and continues during the winter, until warmer weather arrives in the spring.

During the night, both the earth, with all things upon it, and the atmosphere, are cooling; the caloric passes from them into the heavens, or into space. Whenever the earth ceases to be exposed, to any extent, to the rays of the sun, it cools; this is the case also with its waters and its atmosphere. In the depth of winter caloric has so left the earth, that the cold becomes intense; much of its waters, and at times other liquids, are frozen, and even mercury becomes solid. The sensation of cold is then experienced by man in its intensity.

In highly-heated countries no sensations are more delightful than those which are produced by the evening breeze, or which arise from bathing in shaded waters.

By means of evaporation caloric is carried rapidly away from the body, and, if long continued, the sensation becomes exceedingly painful. The continual application of water, spirits, ether, &c., to one part of the body, or to the entire body, will so reduce the temperature, that the sensation of cold is severely experienced. In local inflammations, wet cloths are constantly applied, to draw off the local caloric, which is there unduly accumulated. In fevers, cold drinks, &c. are administered.

The approach of floating mountains of ice is said by mariners greatly to increase the sensation of cold which they experience.

The sensation of cold in winter is not so intense, although the temperature indicated by the thermometer be lower, so long as the air is dry, and there is no wind. Moisture and wind deepen the sensation of cold, by more rapidly abstracting and carrying away the caloric of the human body.

In Goldsmith's "History of the Earth," ch. xii. p. 70., is an account of Elizabeth Woodcock, who, in February, 1799, remained buried for about eight days under snow. When the external air was admitted, she felt very cold.

The same atmosphere is felt by one person to be warm and by another cold, according to the temperature of the places whence they have proceeded. The individual who has come down from the cold summit of a mountain, will experience the sensation of warmth, while he who has ascended from the hot plains below, will have the sensation of cold.

Sensations of heat and cold depend, not only upon the temperature of the medium in which men may be, but upon the temperature of their bodies at the time.

Metals and some minerals, under ordinary circumstances, feel cold, and in sharp weather very cold. There have been instances, I believe, in northern regions, of the fingers becoming frozen to iron, which they have touched. Chlorate of lime and chlorate of strontian, when dissolved in the mouth, produce a sensation of cold. Saltpetre, so dissolved, produces a like sensation.

Bodies changing from the solid to the fluid state, rob the surrounding atmosphere of its caloric, and so occasion the sensation of sudden coolness, or even of cold. Bodies changing from the fluid to the gaseous state, produce the like results. There are certain mixtures, freezing mixtures, such as sulphuric acid and pounded ice, which suddenly occasion very great cold. Certain bodies, by their superior conducting power, rob the human body, when in contact with it, of its caloric more rapidly than other bodies do, and so occasion more freely the sensation of cold.

The sensation of cold considered generally.—By the abstraction of caloric from the human body, sensation is occasioned which, except in hot weather or when the body is in a heated state, is usually disagreeable, and when the cold is excessive is positively painful. Children and others not unfrequently cry because of the intense painfulness of the feeling. In northern climes, Russia for instance, it is common for the nose, toes, &c. to become frozen. At this extreme stage the cold is not felt, or at least the sufferer is not aware of the evil, which, if not remedied, results in mortification. The mode to prevent this is rubbing the organ or other frost-bitten part with snow, by which means circulation is restored. Intense cold occasions an irresistible disposition to sleep, which, if not counteracted, leads to inevitable destruction. When caloric is extensively withdrawn from the human physical system, the body becomes stiff, and is incapable of answering the influences of the mind.

Caloric cannot, as appears to me, be with any propriety considered as the cause of our sensations of cold. These sensations are consequent upon the withdrawment of caloric from our bodies. For the true cause we must, I imagine, look into the physical system itself; perhaps from the *contraction* of the nerves, which follows the abstraction of the matter of heat, results the sensation.

The painful sensation arising from great cold, is succeeded very commonly by numbness, in which state the sensation in great measure ceases. Numbness is the stoppage of circulation, or its partial suspension, in that portion of a limb where it occurs.

Dr. Roget says: "The sensation of cold is equally positive with that of warmth, and differs from it not in degree merely, but in species, although we know that it is only in its degree that the external cause of each of these sensations differs." — *Bridgewater Treatise*, vol. ii. p. 516. In the one case there is introduction of caloric, in the other abstraction; how then the two varieties of sensation can be truly said to result from the same cause I cannot conceive. One cause would not produce variety of effect, but difference of degree; the nervous effect I apprehend to be not merely very different, but antagonistic.

The degree of the sensation of cold depends upon the abstraction of caloric from the human body, or any part of it, and upon the rapidity of the abstraction; it varies from agreeable coolness to painful frigidity.

The sensations of heat and cold are most important to us, ministering greatly to our ease and pleasure, or to our discomfort. We are engaged at all seasons in modifying and regulating these sensations, so as to get rid of what is disagreeable, and avail ourselves of what is pleasant; — comfort in this world very materially depends upon them. Our corporeal enjoyment in a future state will also most probably result most essentially from being incapacitated from experiencing the unpleasant portion of these sensations, or even perhaps the sensations at all. "The sun shall not light upon them, nor any heat."

Extremes of heat and cold are alike productive of intense painful sensation, and prejudicial to animal life.

There is a state in which human beings frequently find themselves, of not experiencing sensation of heat or cold. When the temperature of the atmosphere is mild, and an individual is in a state of inaction, or of very moderate exertion, sensation of heat or cold is not felt, the soul is then, in respect to those kinds of sensation, in an insensate state.

Very many of our sensations are complex: of these, sensation of heat or of cold is mostly an element. Would we analyse our complex sensations as perfectly as we have the means of doing, we should be surprised to find how much they consist of sensation of heat or cold. Let any one place his hand upon a table, he will discover resistance to his hand, and he will also experience sensation. After considering carefully how much of the sensation is occasioned by the matter of heat entering his hand, or by the withdrawment of caloric from his hand, he will, if I mistake not, be greatly at a loss to satisfy himself that he experiences in addition sensation of any other kind. My conviction is, that there is no other, that the sensation is purely calorific or the contrary.

The following description by Dr. Reid is objectionable in certain respects: "*Heat* signifies a sensation, and *cold* a contrary one. But *heat* likewise signifies a quality or state of bodies which hath no contrary but different degrees. When a man feels the same water hot to one hand and cold to the other, this gives him occasion to distinguish between the feeling and the heat of the body, and although he knows that the sensations are contrary, he does not imagine that the body can have contrary qualities at the same time." — *Inquiry*, p. 75. Qualities of bodies and states of bodies are entirely different. The various temperatures of a body are various *states*, not various *qualities*. When a man feels the same water hot to one hand and cold to the other, the difference of *state* or *condition* is in the two hands, not in the water.

Dr. Reid further says: "The words *heat* and *cold* have each of them two significations; they sometimes signify certain sensations of the mind, which can have no existence when they are not felt, nor can exist any where but in a mind or sentient being; but more frequently they signify a quality in bodies which, by the laws of nature, occasions the sensations of heat and cold in us." — *Inquiry*, p. 96. A power resides in caloric, and caloric penetrates and pervades all bodies. By this power caloric produces sensation of heat; but it is not directly or positively the agent in occasioning the sensation of cold.

The nerves and brain considered in connection with sensations of heat and cold.—All the nerves of the body are, perhaps, propagators, if I may so say, of the sensations of heat and cold: no peculiar nervous organisation is appropriated to these sensations. It would be desirable, however, to ascertain with certainty, if practicable, whether or not the nerves of action, or the nerves connected with and appropriated to the involuntary functions of the human being, are insensible to heat and cold.

The nerves are no doubt oppositely affected by heat and cold; in the one case they are expanded or dilated, in the other contracted. The pleasure or pain of the sensation depends chiefly, if not entirely, upon the extent to which this expansion or contraction is carried; if in moderation only agreeable sensation follows, if to excess, exceeding pain results.

The nerves of taste, smell, sound, and vision are as readily affected by the action or withdrawal of caloric as the whole series of nerves which minister to inorganic sensation; but how so different sensations as those of taste and heat, or of smell and cold, can be occasioned through the ministry of the same nerves, is, like everything connected with sensations, wholly mysterious.

The sensibility or susceptibility of the soul. — Sensations of heat and cold, when experienced, convince us, or make us aware, of the capacity of the soul for, or its sensibility to, or susceptibility of, sensation. In this respect these sensations rank in the same category as most of the organic sensations.

Every sensation of heat or cold also indicates or evidences the existence of the sentient principle within us, or the existence of the soul or spirit, which is the passive recipient or subject of the sensation.

CONCERNING OTHER INORGANIC SENSATIONS, THEIR CAUSES, ETC.

Many inorganic sensations receive their characters and take their names from the part of the body which is affected. The human race has unhappily a long list of local ailments, varying specifically and in intensity of pain.

Pains peculiar to the head are, the head-ache, the ear-ache, the tooth-ache, ophthalmia or inflammation of the eye, tic-douloureux, plica polonica, &c.

The ear-ache is one of the most excruciating sensations which can be experienced, — the torment for the time is insupportable; it may be described as a maddening sensation.

In tooth-ache the nerve of the tooth is inflamed and swollen. When a tooth decays the end of the nerve becomes bared to atmospheric and other influences; it decays also with the substance of the tooth, all which process is extremely painful. When a tooth is drawn the nerve is stretched and sundered, and exceeding pain is felt.

Great torture is experienced when the eye is hurt.

The sensibility of the internal ear, as well as of the eye, is exquisite; the pain when either becomes diseased is almost past endurance.

In head-ache the pain is confined to the brain; the whole or a portion thereof is affected. The malady, when confirmed, was originated in part extraneously, that is, through over-exertion of the eye, &c., in part inwardly, that is, by undue strain upon the brain and connected muscles, through over-study, deep thinking, &c. The muscles and nerves also in immediate connection with the brain being, by the resolute will of the spirit, deprived of their necessary inaction and repose, become exhausted and finally damaged, leaving too frequently, as a result, a confirmed, constant, and incurable head-ache.

Tic-douloureux is a most painful affection of the face.

There is a very painful and dangerous disease of the hair, called plica polonica. The tubes of the hair become distended with blood and swollen.

Sensation of hunger. — When no food is in the stomach and it is needed, unpleasant sensation, or violent pain, is experienced. This is perhaps occasioned by the undue collapsing of the muscles of the stomach, and by the action on the coats of the stomach of the gastric juice. Sometimes, when the taking of food is too long defered, violent spasmodic pain is experienced. Dreadful accounts of the suffering of hunger may be read in the works of travellers and voyagers, and in historical descriptions of famines and sieges. In the Bible are some awful accounts of the excesses to which the pangs of hunger have driven individuals.

Sensation of thirst.—This sensation is always described by those who have suffered the pains of both hunger and thirst as by far the worst of the two; in its excess it leads to delirium. The crossing by caravans of the eastern and African deserts, shipwrecks, when the crew or a portion of them have had to resort to the boats, sieges, and confinement in dungeons have supplied the most appalling instances of this horrid variety of sensation. The sufferings of a body of Englishmen in the Black Hole of Calcutta is a notable instance of the torturing sensation of thirst and the physical consequences of a non-supply of water.

The sensations of hunger and thirst, and that which is incentive to procreation, are so distressing and craving, particularly the two former, that when they are felt a strong desire arises to allay them. Such desire, together with the sensation, is termed appetite; and those persons who evince the strongest inclination to gratify their appetites, because of the pleasing sensations they may experience and the painful sensations they may avoid, are termed sensualists.

Erskine, in his "Evidences," p. 31., has these remarks: "It cannot be denied that many vicious men enjoy much gratification through life; nor can it even be denied that this gratification is derived in a great measure from their very vices." A sensualist who has the means and opportunities of indulgence, derives, of course, gratification from it; he would not be a sensualist were it not that he likes strongly the pleasure which sense naturally affords.

The pain arising from vomiting, especially when it is forced on, is in some persons exceedingly great and dangerous. The intention in employing certain medicines is to occasion vomiting. In certain cases vomiting is violent and irrepressible, so much so as not to be counteracted by medicinal appliances. Spallanzani tried to obtain a quantity of gastric juice by vomiting, but he found the pain so acute that he was compelled to desist.

Mr. Locke says: " Sickness and pain are not in the manna, but are effects of its operation upon us, and are nowhere when we feel them not." Sickness is a word which here perhaps properly expresses the physical or material effect upon a person, viz. vomiting; the nausea and pain are the sensations.

The cholic is an excruciating pain. Much pain sometimes attends looseness of the bowels, as in the cholera, &c. Cramp and gout in the stomach are very painful.

Various of the internal vessels and organs of the human trunk, when inflamed or diseased, are accompanied frequently, and indeed commonly, by great pain. In inflammation of the liver a dull, heavy, distressing pain is experienced in the right shoulder.

Concretions, or calculi, are in some persons formed in the gall bladder, the urinary bladder, &c. Perhaps no malady in the sickening catalogue of human ills is more distressing than one of these complaints. Epicurus suffered intensely from the stone, and died of it. Sir Isaac Newton was a great sufferer by the same calamity, which ultimately killed him. A kindred disease, that of gravel, is nearly as painful.

Pain is attendant upon pulmonary complaints—pains in the lungs or chest.

When persons are unable to breathe by immersion in water the sense of suffocation must be great and painful. Pearl divers and other divers experience this. Culprits whilst being hung exhibit, by their violent efforts and struggles, the force of the sensation. Asthmatic persons and those who are in the last stage of consumption, seem at times to be nearly stifled.

The pains of parturition might, perhaps, be considered as organic; yet as they occur only at times and under special circumstances, and are never experienced by numbers of women, it would be hardly right to range them amongst organic sensations. For the time being the pain must be excruciating. Women are confessedly altogether superior to men in the endurance of bodily pain and generally of mental agony.

In cancer local organisation is destroyed, nervous and muscular substance separate and pass away, with intense suffering to the individual afflicted with this dismal disorder.

Gout is a disease chiefly affecting the limbs, but in violent paroxysms attacking the stomach, head, and any part of the trunk; the agony at times seems to be intense. The concretions — chalk stones as they are commonly called — which make their way through the flesh of gouty persons, occasion great pain whilst they are working through. Leibnitz was a martyr to the gout and stone, which disorders terminated his life.

Rheumatism. — Rheumatic pains are at times exquisitely distressing; they affect the head, the body, the limbs. How the nerves are affected in rheumatism has not, perhaps, been well ascertained. As in a sudden movement of the part affected the most pain is experienced, there exists, perhaps, an undue rigidity of nerve.

Sciatica is a nervous affection of the thighs.

Tumours, whilst forming in any part of the body, are accompanied by great pain, mostly perhaps because of their pressure upon and tension of adjacent nerves.

Sensation of tickling. — There are certain parts of the body where the sensation of tickling is most exquisitely experienced—under the arm-pits, &c. When the nose is gently touched backwards and forwards, either internally or externally, with a feather or a hair, the tickling sensation is insupportable. We often experience a strong sensation of tickling in the ear, arising apparently from the movement of the wax outwards or the motion of a loose hair.

If there be no blood-vessels and nerves in the outer skin, how is it that we experience the sensation of tickling by the slightest application of a feather, the crawling of a minute insect, &c.? The outer skin may be cut without pain being experienced, but in tickling the action of the applied substance is entirely superficial, and, being so, there must surely be some description of nerves at the very exterior.

The sensation of itching.—The itching of eruptions on the skin after inflammation has subsided; the itching which arises when a wound or sore is nearly healed; the loathsome disease of the itch. The motion of insects on the skin is sometimes referable rather to tickling than to itching; the bite of a flea or its movement from one spot of the body to another is properly, I apprehend, itching.

We are subject to involuntary shuddering under many circumstances; sensation arises from this source.

Another unpleasant kind of sensation results from the confinement of perspiration and its absorption by bed-clothes. See Dr. Franklin's little essay on the "Art of procuring Pleasant Dreams."

Uneasiness of body, or what is vulgarly, yet expressively, called fidgetiness, is another kind of sensation of the disagreeable kind.

Sensation occasioned by pinching, compression, &c.—Pinching is a very painful sensation. Great pressure of the hand by a strong man in shaking hands is exceedingly painful; some persons rather delight in this infliction. Pressure on the toes or feet by a person treading upon them, or planting his stick or umbrella upon them, is a most unwelcome pain. When the hand, foot, or any other other part, is caught by a closing door and pinched, the pain is very great. On many occasions by bruises, falls, blows, &c., parts of the nerves become bruised; this undue pressure upon the nerves affects them violently.

Sensation by pricking, &c. — When punctures are made in the flesh, whether by pricking, stabbing, or any other mode, the sensation experienced is very painful. On the field of battle this pain is felt by numbers. In bleeding, cupping, and such like surgical operations, this variety of pain is inflicted. Wounds are occasioned by musket-balls penetrating the flesh; dreadful ones are inflicted by cannon-balls, which smash the part of the body they strike. When shells burst, the splinters and fragments enter the body. In former times the arrow and spear were destructive and painful weapons of warfare.

Sensation by cutting. — Painful sensations to a great extent arise from cutting. Cuts are inflicted accidentally, as when a workman, using a knife, hatchet, scythe, reaping-hook, &c., cuts himself, a carver cuts his hand, a shaver his chin. Mostly they are inflicted intentionally; the operating surgeon cuts into the flesh for the removal of tumours, to extract balls, when he amputates a limb, and the like. Troopers in battle mutually inflict wounds by this mode upon their opponents, and too often very fearful ones.

It has been said that a man whose leg had been cut off has afterwards experienced just such a pain as he had been accustomed to feel in his foot before he lost the leg. The cause and exact situation of the feeling must have been mistaken, but the sensation was real. The origin of the pain cannot be in a part which has no existence, it must proceed from the extreme ends of the nerves which had entered the limb, and which were severed when the limb was amputated. This goes to prove that sensation alone does not indicate with accuracy the seat or place of its cause.

Sensation by tension. — Exquisite and sickening pain is occasioned by undue tension of the muscles of the arm, shoulder, &c., when attempting to reach something, or to touch another part of the body in an unusual manner. Dr. Roget remarks that "tendons and ligaments are insensible to many causes of mechanical irritation, such as cutting, pricking, and even burning; but the moment they are violently stretched (that being the mode in which they are most liable to be injured) they instantly communicate a feeling of acute pain." The nerves were unduly distended along with the muscles and sinews when an unfortunate wretch used to be stretched on the rack. This horrible torture, which, to the disgrace of human nature, was so freely used in political and religious cases before the Reformation, has happily become obsolete.

The cramp—contraction of the muscles.—Occasionally, and in bed particularly, the muscles of the leg become drawn up into knots, producing for a time excruciating agony. Some individuals are particularly liable to cramp in the limbs, others are subject to dangerous attacks of cramp in the stomach.

Sensations are occasioned when the organs of sensation are pricked, pinched, tickled, &c.; but these are not organic sensations, they are not peculiar to the organs.

Limbs are not unfrequently fractured by accident. The pain attending the fracture of a bone is intense.

The pain which arises when a dislocated limb is replaced in its socket, or a broken limb is set, is likewise intense, and commonly occasions the sufferer to faint.

Human beings, animals, vegetables, minerals, the elements, &c., considered as causes or occasions of these inorganic sensations.—Human beings occasionally inflict great painful inorganic sensation upon themselves, but this is unintentional. They also at times accidentally inflict pain upon one another. When quarrels lead to pugilistic or warlike attacks, human beings occasion to one another great pain by blows and wounds.

Brute animals, in their several grades, are, for defence and aggression, armed with various natural weapons. By these painful sensation, more or less severe, is oftentimes produced in individuals of the human race.

The greater part of animals are furnished with teeth, with which they cut, tear, or crush the flesh, and so occasion pain. The bites of the larger animals are agonising in the extreme, and end in destruction. Some of the serpent tribe have an apparatus by which, when they inflict a bite, poison is injected. The pain which arises therefrom is always considerable, and in the case of deadly bites is usually great before life becomes extinct. The rattlesnake, cobra di capella, and other serpents, destroy life. Centipedes inflict painful bites, which are at times dangerous.

The claws or talons of a beast or bird of prey, when thrust into the flesh, pierce and tear it, occasioning great agony. Crabs, lobsters, and other shell-fish, are armed with nippers, with which they pinch and cut; these are formidable weapons.

Oxen, elephants, and other animals, have horns, tusks, &c. The stronger beasts toss up individuals therewith, and by the direct blow and the fall occasion great suffering.

The large ferocious beasts beat down a man by a violent blow with the fore-paw, which is very muscular, adding much to the agony which the individual suffers from the animal's claws and teeth. Whales and other large and powerful fish strike violently with the tail. Horses and other animals kick with their hind feet. The elephant will beat a man dreadfully with its proboscis.

The largest species of snake destroy by entwining themselves about their victims, and crushing them to death with horrid agony.

The elephant, having knocked down the hunter, when he has opportunity, kneels on him, or treads him under foot.

Certain species of animals and insects inflict wounds, accompanied with pain, by the puncture of sharp, thin, pointed instruments, with which they are furnished, and which are called stings. Such animals are the bee, the wasp, the scorpion, &c.

The shock occasioned by the electrical eel or the torpedo to the person touching it is very violent and powerful.

The cantharis, or spanish fly, is used in plasters to raise blisters, a painful operation.

Many shrubs are armed with thorns and prickles, which, entering the flesh, occasion by the puncture acute pain, and frequently produce inflammatory sores. A splinter entering the flesh occasions considerable pain.

The vengeance and cruelty of the Roman soldiers, who crucified our Saviour, was shown in platting a crown of thorns, and forcing it on his brow. The pain of this must have been excruciating.

A strong itching sensation, which continues for some time, proceeds from the stings of nettles and other shrubs of the like character.

Snuff does not occasion sensation of smell, nor is it thrust up the nostrils for that purpose. The object in taking snuff is to irritate the nerves of the nostril, and excite a tickling, tingling sensation, wholly different from sensation of smell. This tingling sensation becomes, by constant indulgence, grateful, and almost a necessity.

Many vegetable substances are employed in medicine: some of these occasion nausea and other unpleasant sensations in the stomach. Squills, ipecacuanha, &c., occasion vomiting and its concomitant painful sensation.

Certain winds, the harmattan and others, originate unpleasant sensations, chiefly by affecting the skin.

Have persons struck by lightning ever described the sensations experienced at the moment? When the human body is placed under galvanic influence the muscles are convulsed, or perhaps contracted, the nerves are affected, and sensation is occasioned. The electric shock when strong is peculiarly painful. The fluid seems to rush along the muscles, and, perhaps, the nerves; but whether the passage is superficial, or the fluid penetrates, is, I apprehend, not ascertained.

Some substances are corrosive, acting painfully upon the substance of the human body. Such are concentrated nitric acid, sulphuric acid, fluoric acid, caustic potass, soda, lime, &c. Nitrate of silver is used as a caustic to destroy unsound flesh, eat away obstinate ulcers, &c. These corrosive substances will act upon the organs of sense if applied to them, and injure or destroy their organisation. In so doing they occasion distressingly painful sensation; but such sensation is altogether different from organic sensation: it is of an entirely different class of sensations, viz. the inorganic.

Strong spirits produce sensation altogether apart from the sensation of taste. The nerves of the throat, and those which are attached to the coats of the stomach, are strongly and oftentimes painfully affected by alcohol.

Oxides of lead and other metals, also some minerals and salts, taken into the stomach, produce poisonous effects, accompanied, in most instances, with strong pains. The painter's cholic is one painful disorder produced by inhaling metallic vapours. Arsenic is a poisonous metal occasioning severe pain.

Thus certain kinds of animal, vegetable, mineral, and other matter, when brought to act upon the extremities of the nerves which approach the external surface of the body, upon the coats of the stomach, or upon exposed parts of the flesh, occasion various sensations different from any described in previous sections, and oftentimes painfully distressing.

Artificial bodies, i. e. instruments, weapons, &c. employed to occasion inorganic sensation. — The *forms* of masses have so far to do with sensation that masses having certain forms are thereby adapted to produce certain sensations, which without such forms cannot be occasioned. A body, if pointed, will originate a description of pain which, if it be rounded, it will not occasion.

Substances, when in the solid state, that is, being hard, occasion sensations which cannot be produced by substances the cohesive power of whose particles is sufficient only to retain them in a state of softness. Hardness is an essential requisite to the production of certain kinds of pain.

Masses in motion produce physical effects upon us, accompanied with distressing sensation, from which we should be free were not the motion to take place. Many of the accidents of life, and the acuteness of pain which attends them, are attributable to bodies falling against or upon, and so striking us.

Instruments injuring and hurting by a blow.—A club, or bludgeon, a mace, the butt-end of a musket, &c. are employed in striking or giving blows. "The Jews therefore besought Pilate that their legs might be broken, &c."—*St. John,* xix. 31—33. The legs of criminals on the cross were broken at the instep with an iron mallet. See Lactantius, l. iv. c. 26.

A thong or lash applied to the body occasions severe pain. This and other modes of striking first depress or drive in the muscles and nerves; the muscles afterwards swell prodigiously, and distend the nerves. Sailors and soldiers are still flogged occasionally with the cat-o'-nine-tails; this is a disgusting mode of military punishment. Beating the soles of the feet with a thong of leather or other substance—the bastinado—is a punishment in vogue amongst Mahometans, and is, I apprehend, exceedingly painful.

Instruments occasioning pain by pricking or puncturing.—The stab of a sword, dagger, pike, or spear, the piercing of an arrow, a pointed stake thrust into the body, produce acute sensation. Balls propelled from muskets, rifles, pistols, &c. occasion pain by puncture.

Instruments giving pain by cutting.—A knife, razor, and sword are of this description. With various cutting instruments, suitable for each occasion, surgical operations are performed which produce terrible pain; such operations are, the amputation of a limb, the extraction of tumours, cutting for the stone, &c. In amputation the flesh has to be cut, and the arteries are to be taken up, the bone is sawn through, and the marrow or spinal cord is divided; the latter part of the operation is said to be exquisitely painful, the marrow being altogether nervous matter.

Some instruments produce pain by laceration or tearing. — Cannon balls, besides fracturing and shattering the bones, tear the muscles, vessels, and nerves.

Pressure by heavy bodies.—This, by partially or wholly crushing the human frame, or a portion of it, is a prolific cause of pain. By the falling of buildings and other heavy bodies limbs are broken, and persons are sometimes crushed to death. One mode of warfare in mountainous regions is to roll down upon an advancing enemy huge fragments of rock, whilst he is passing through defiles. "Those upon whom the tower of Siloam fell and slew them." Criminals used to be broken alive upon the wheel.

Some instruments occasion pain by tension.—The rack is an instrument of extreme torture; it unnaturally stretches, and, if carried far enough, rends or pulls asunder the limbs, and with them the nerves.

The *thumb-screw* and other machines of torture tear asunder the muscles and nerves, or distend, twist, and displace them.

"A man," says Mr. Locke, "on the rack is not at liberty to lay by the idea of pain, and divert himself with other contemplations." — *Hum. Und.* vol. i. bk. ii. ch. xxi. p. 227. He cannot lay by the pain itself, — idea has nothing to do with it. We are not free to experience sensation as we please, excepting so far as we have control over those things which produce sensation. If a man can get away or escape from the rack, he avoids the torture.

Of inorganic sensations generally. — Thus we see that there are many sensations distinct from one another, which have not organs appropriated to them. Much advantage in mental philosophy would undoubtedly arise from a more complete and scientific classification of inorganic, as well as of organic, sensations.

Inorganic, like organic, sensations are usually distributed into two classes — pleasant or agreeable, painful or unpleasant. This arrangement is, to a certain extent, useful; but it is a loose and, as to the line of demarcation, an indeterminate one.

Certain substances seem to have an influence on the nervous system otherwise than in producing sensation. Some substances stimulate the nerves, and through the nerves the muscles and secretory organs, occasioning in them more rapid action and operation. Other substances paralyse or deaden the nerves, so as to prevent sensation even of that painful kind which arises when surgical operations are performed. The vampire is said to prevent the pain of an inflicted wound by fanning the sufferer with its wings, and so deepening sleep. Chloroform has recently (A. D. 1847 and 1848) been applied to persons about to undergo painful surgical operations; by its inhalation the nerves seem to be so deadened that they are not for a time affected, and insensibility, and even unconsciousness, ensue.

In fainting fits and the like, there exists an insensibility to pain. Great torture seems to have the effect at last of producing a state of prostration in which the sufferer becomes insensible altogether to pain. In the hour of death insensibility is said to prevail, even in cases where, to bye-standers, there is apparent convulsive agony. See what Buffon says upon this matter.

There is great difference in human bodies as to sensibility to inorganic sensation, both pleasureable and painful. Some persons are morbidly sensitive to cold and other feelings, whilst others seem to be gifted with exceeding insensibility, so that they can not merely brave pain, which many a mind properly tutored will do, but seem not to feel it like other men. Flint, in his "Recollections of Ten Years in the Valley of the Mississippi," has some forcible remarks on the physical insensibility of the American Indians, — "Their impassible fortitude," &c., pp. 136—138.

Inorganic sensations, like organic sensations, are wholly distinct from and dissimilar to their material causes. Much mystification was formerly prevalent in Mental Philosophy in respect to sensations and their causes. Dr. Reid took great trouble to clear away the confusion and establish, what ought ever to have appeared unnecessary, the essential difference between a sensation and its cause. See, especially, the whole of his reasoning in pp. 354—356. of vol. i. of his "Essays."

Nerves of inorganic sensation and the brain. — The nerves which minister to inorganic sensation are spread over the whole body; they originate in minute and multitudinous fibres in the cutis or under-skin. It is held that they do not penetrate and arise in the outer-skin, or epidermis; and yet, when we consider tickling and other external sensations, it would seem that the epidermis cannot be altogether insensible. When the extremities of the nerves are bared and exposed to the immediate action of the atmosphere and other bodies, the contact is followed by much pain.

In the case of cutting not only are nerves separated, but the muscles contract or are drawn up, by which means other nerves attached to the latter which have not been divided are affected. Here is a case of complex sensation. We have abundance of like instances in the multitude of diseases to which the human system is liable. In some disorders the nervous organisation is partially injured; oftentimes the muscles, bones, cellular substance, organs, &c., are the seats of disease, and the nerves in connection with the parts adjacent are affected. Again, the fluids become corrupt, the vascular system is irritated, and the nerves proceeding therefrom are acted upon.

The decomposition of the nerves by powerful acids, alkalies, and other chemical or natural agents, occasions dreadful sensation.

In inward affections of the nerves there appears to be a swelling, an undue pressure and displacement, a tension, a fracture, or a destruction of the nervous cords. Some of these effects are occasioned by external violence, but a great portion by an undue collection of caloric in localities of the physical system, *i. e.* inflammation of parts where there is perhaps ever an undue distension of muscle and nerve immediate and adjacent.

Lord Kames says that "any intense exercise of the intellectual powers becomes painful by overstraining the mind."—*Elements of Criticism, Introd.* p. 3. Much of this pain is physical, or sensation arising from over exertion of that wonderful organ the brain, employed as an instrument in the working of intellect, but how much is not easily determinable.

There is a well-known sympathy between nerves of different parts, so that when the nerves of one locality are affected those of another are affected also; how this sympathy arises, or in what way the connection subsists, is not, I believe, to be explained.

Perhaps the chief intention of endowing nerve in general with the exquisite sensibility it possesses was to instruct the inhabitant spirit of the organised body that injury was being inflicted upon its comrade, so that precautions might be taken or remedies applied. We may infer this, inasmuch as pleasant inorganic sensation bears a very slight proportion indeed to painful inorganic sensation. The case is much reversed in respect to organic sensation; there pleasant feelings greatly predominate.

Dr. Watts says: "If any limb be cut or bruised while there is a ligament tied so hard round the limb that there can be no communication from the part by the nerves to the brain, the soul feels not the pain, the man hath no perception (×) or sensation of it."—*Philosophical Tracts.*

When serious injury is inflicted upon the brain, as when there is concussion or paralysis thereof, insensibility likewise ensues,—showing the necessity of that organ to sensation.

The organic nerves, in part at least, and that portion of the brain in which they centre or end, are said not to possess the sensibility which is common to the inorganic nerves. Majendie is reputed to have ascertained that the olfactory, acoustic, and optic nerves, and the portion of the brain which their extremities form, are insensible to pressure, pricking, and even laceration. See what Dr. W. C. Henry has said on this point in "Brit. Assoc. Report" for 1833, p. 87.

SENSATION, THE CAUSES OF SENSATION, ETC., CONSIDERED GENERALLY.

Substances, or the several varieties of matter, considered generally, as the causes or producers of sensation.— Substances affect the human soul only by exciting in it certain animal feelings. In what manner this affec-on of mind is produced by matter will most probably always lie concealed from the scrutinising eye of philosophy, but the fact ought to be indisputable.

Matter, in the atomic state, produces only some kinds of sensation; it must be in masses to produce other kinds; and to produce a farther kind it must be peculiarly organised. Did not matter exist in masses, many kinds of inorganic sensations could not be generated; were it not found in the atomic state, other varieties of inorganic sensation, as well as sensations of taste, smell, and colour, could have no existence; and were it not peculiarly organised, a great part of the sensations which organic matter produces could not be originated.

Dr. Reid, Essay II. ch. xvii. p. 342., says: "The atomists maintained that atoms had not smell, taste, and colour, that these qualities were something resulting from the operations of bodies upon our senses." The atomists, I take it, held that men experienced sensations, and that atoms or bodies, as the case might be, occasioned them.

We see that sensations are not indiscriminately produced by substances. Mostly a substance which affects one organ has no influence whatever upon another; and in no case can the special sensation which is produced by one substance be originated by another. In numerous cases, however, it is common for the same substance to affect two organs; in this respect those of taste and smell are the most intimately allied.

Many substances are tasteless and inodorous, and have little or no sensitive action upon the other parts of the human body; they seem to be devoid of all power, or nearly so, of affecting the spirit through the senses.

Mr. Locke represents that sensation depends upon the configuration of the particles of bodies; but for this opinion there is no evidence and, I think I may add, no probability. Epicurus had taught that "sensation is to be ascribed to the peculiar magnitude, figure, motion, and arrangement of the parts of bodies." See "Enfield," vol. i. p. 468. Dr. Reid says that "Des Cartes, Malebranche, and Locke acknowledged some particular texture or modification of the body to be the cause or occasion of the sensations of colour, sound, and heat." — *Inquiry*, ch. v. sect. 12. p. 132. But there is no evidence to substantiate these representations.

The query of Newton about a subtle medium occasioning sensations, and the hypothesis of Hartley about vibrations and vibratiuncles, received, I suppose, their quietus from Dr. Reid. See Essay II. ch. iii.

Dr. Reid speaks of effluvia being the medium of smell, the undulations of the air the medium of hearing, the rays of light the medium of sight. (Essay II. ch. ii. p. 117.) Now this mode of expression is objectionable. Effluvia are the causes of olfactory sensation, the atmosphere is more correctly the medium. The undulations of the air may be the medium of auricular sensations, because something precedent, vibration, for the most part, is necessary, by which the air is acted upon in some extraordinary manner: sound, nevertheless, can be propagated to the ear by other means than the air, viz. by water, by a string, &c. Light, again, is the actor, or agent, or producer, in ophthalmic sensation, not the medium.

Hobbes taught that "all knowledge originates in sensation, and (*sensation*) is produced by the pressure, either immediate or mediate, of external objects upon the senses. Sensible qualities are in their objects nothing more than the motion of matter operating variously upon the organs of sensation."—*Enfield*, vol. ii. p. 495. Part of our material knowledge originates in sensation, but very far from the whole. What is the meaning of the expression "sensible qualities are in their objects?" Mr. Hobbes uses the word *object* in the reprehensible manner which has been common amongst mental philosophers. There is no evidence whatever to support this dogma about motion.

I cannot help thinking that Dr. Reid has unintentionally done injustice to Mr. Locke, in one particular, by misapprehending his meaning. I cannot believe that Mr. Locke was ignorant of this truth, that "there can be nothing like sensation in an insentient being, or like thought in an unthinking being." Mr. Locke's unhappy phraseology is so strange that his views cannot always be satisfactorily gathered; but, I doubt greatly that he ever taught that there is anything like to sensation or thought in atoms or bodies. See Reid, Essay II. ch. xvii. p. 348.

The causes of sensations, and the nature of those causes, cannot be infered, or otherwise ascertained, by means of the sensations alone. Sensations of taste and all the other classes of decided sensation intimate nothing respecting the nature of their causes. Dr. Berkeley taught, and is considered to have demonstrated, that "a sensation tells us nothing respecting the nature of that which occasions it." In this doctrine he has been followed by Hume, Reid, and others, and now every metaphysician, I believe, admits the truth of it.

Dr. Reid unanswerably shows that philosophers never had any foundation for their doctrine, that "all our knowledge of the material world is obtained through the medium of sensation, and what is known thereof is *like* to our sensations;" and then goes immediately and declares that we obtain this knowledge through the medium of *sensations of touch!* instead of declaring that we obtain it otherwise than by sensation, obtain it in some other manner. See "Inquiry," pp. 124, 125.

Bishop Berkeley proved his position, that we cannot infer the existence of matter from our sensations, not, I apprehend, by reasoning, but by evidence. See "Inquiry," p. 127.

To the establishment of the general truth, that "the causes or occasions of all sensations are material," extensive investigation is necessary. The mind in all probability infers and generalises upon very limited evidence, as children may be observed invariably to do upon all subjects; but a well established conviction of the truth must be the result of considerable experience. It may, for instance, have been some time before mankind became convinced that all effluvia are material, the same being imperceptible, and their sources having been oftentimes unknown.

Although by our sensations alone we cannot determine that they are occasioned by matter and not by spirit, it cannot be otherwise than evident to any one who has read the collective evidence adduced in the preceding pages, that we do know, and well know, that substances, by virtue of certain powers possessed by them, do affect human spirits in the way of sensation. This knowledge must then be acquired, not by sensation alone, but by other means in connection with sensation, and those means have to be considered subsequently.

Material changes become known to us by means of sensation as well as in other ways. When a change has been wrought in a body, it differently affects the taste, smell, hearing, &c.; and by means of these changes in our sensations, we determine or ascertain, to a very considerable extent, the alterations that have taken place in the bodies which occasion them.

The sensations of smell and taste are made use of by the mind to distinguish substances from one another. The mind, in so doing, proceeds upon the principle that when two substances produce different effects upon the mind, in respect to smell or taste, &c., they must, if they be not wholly different, have some difference. Tasting and smelling are found to be as effectual agents in determining substances to be different, and in detecting impurity in a substance, as any chemical means of discrimination. See what Dr. Thomson says upon hydrogen. There must be mixture or impurity in one of the cases described by the Dr. The same substance, in a state of purity, is found by experience to produce always the same sensation. When one substance affects a particular sensual organ, and another will not, we know that those substances are distinct. One substance, in several instances, influences two sensual organs; organised bodies, animal and vegetable particularly, exercise this twofold influence. Chlorine also affects both the palate and the nose. By this combination of sensual effects all such substances are distinguished from every substance which does not act upon the same two organs.

Dr. Reid inaccurately affirms that the senses distinguish and detect, and the senses perceive changes in a body. — See "Inquiry," p. 82. The mind distinguishes by means of sensation and the mind perceives.

Mr. Locke sometimes speaks of external things being the *objects* of sensation. Now this word *object* is in such case erroneously employed. Material existences, or the several varieties of matter, are the causes or producers of sensation, not objects of sensation. Later metaphysicians are by no means free from this inaccuracy. Dr. Reid repeatedly falls into it, Hobbes and Dr. Paley also; and even Dr. Roget, in his "Bridgewater Treatise," uses the word thus erroneously, although in p. 373. he more correctly and satisfactorily describes them as *agents*. In "Insect Miscellanies," p. 2., the word *object* is similarly employed. It would be as pertinent to call actors subjects as it is to call causes of sensation objects. The mind in sensation is the object more properly, the substance is the subject of the property by which the mind is affected.

Dr. Reid inaccurately speaks of sensations being infered or deduced from bodies. "Inquiry," p. 388.

The material property or properties which occasion sensation considered generally. — We infer that a substance possesses a property or power of occasioning sensation as we infer the existence of all other material and external powers,—properties or powers not being in any sense objects of perception, as substances themselves mostly are.

The important truth that the several varieties of matter possess a property or properties of affecting the human mind, by occasioning a vast amount of sensations, hath been established by an extensive induction and a wide generalisation.

This property, or these analogous properties, matter might have been without, as nowise essential to its existence; and, in fact, every particular kind of matter is unable to occasion some one or other of the many varieties of sensation.

In cases where substances act atomically the power seems to inhere in every particle separately, although in each the power is so slight as to be insufficient of itself to produce appreciable sensation; a multitude have to unite their influences to make impression upon the human system.

To the production of other sensations organisation of substances seems to be necessary, and the power in some way appertains to the organisation and arises out of it.

When substances occasion sensation by reason of their solidity, the power of attraction must be considered as having much to do with the sensation: fractures, punctures, and cuttings, which are followed by so much agony, depend upon a strong aggregation of matter.

Epicurus taught that "different sensations are the casual effects of the different properties and qualities of external objects." — See "Enfield," vol. i. p. 468. Mr. Locke speaks decidedly of sensations being the effects of material powers. See "Essays," bk. ii. ch. xxxi. sects. 2. and 12. Dr. Reid sometimes speaks clearly, at other times somewhat equivocally. 'See "Essays," ch. xvii. pp. 335—348., and "Inquiry," p. 143.

Mr. Locke represents the material powers of producing sensation to depend upon what he terms the primary qualities of bodies, but he does not attempt to offer any evidence therefor.

Dr. Prout ("Bridgewater Treatise," p. 17.) says, that the chemical properties of bodies are not objects of sight, but objects of taste and smell. Now no chemical power, nor any other power, is perceptible; and chemical powers are causes, not objects, of sensation.

Dr. Reid is partial to representing sensations to be signs, the powers that produce them to be things signified. He carries this very far with other matters also, and I can scarcely avoid suspecting that it is done to avoid the recognition of powers and causes. The phraseology I dislike, and consider it unnecessary and misleading analogy. Sensations are effects or results of material powers; this is vastly more than signs and things signified,— things signified do not produce signs.

Dr. Reid says (Essay II. chap. xvii. p. 343.), "Mr. Locke distinguished the sensation from the quality in the body which is the cause or occasion of that sensation, and showed that there neither is nor can be any similitude between them." This is most happily expressed, excepting that I would call the cause or occasion *power* in preference to quality.

Different words should be used in speaking of a sensation and the power, property, or quality in a substance to produce sensation. In respect to the sense of smell we may say — the odorous property of the rose, the sensation of smell.

Dr. Reid (Essay II. ch. xvi. p. 330. &c.) has a number of remarks upon the distinction which Mr. Locke makes between the sensations which give us notice of the secondary qualities of bodies and those we have from primary qualities. Both philosophers appear to have floundered in this matter. I know not what sensations from primary qualities are.

Dr. Reid (Essay II. ch. xvii. p. 339.) says, "The thought of a secondary quality always carries us back to the sensation which it produces." Now the thought of a substance which has occasioned a peculiar sensation may carry us back to the sensation it has produced, so far as we can have a thought or a recollection of a past sensation; and so may the reminiscence of a past sensation lead to the thought of the material power which occasioned it. If we think of the power, or property, or quality in a substance which causes sensation, we may be led to revert to the sensation itself; but Dr. Reid, like Mr. Locke, seems to think that there is some quality in bodies analogous to what they term primary qualities, and which is not power.

The distinction between sensations and their causes. — The causes of sensations and the sensations occasioned are wholly dissimilar. Metaphysicians formerly did not clearly discriminate sensations from their causes; a vast deal of obscurity and false philosophy arose from this inaccuracy.

I do not believe that in a popular sense sensations and their producers are looked upon only in conjunction; the latter are decidedly considered to be the efficient causes of the former.

The organs of sensation considered generally.—There is a widely different constitution of the sensual organs, a different mode of action, and different influences on the part of the substances which affect them. With respect to the palate and the nasal organ, there is little more than an expansion of the nervous system; but the ear and the eye has each a peculiar construction, which is an essential characteristic of these organs.

It is the province of the physiologist or anatomist to develope the structure of the sensual organs, but the metaphysical student must follow his investigations, because of the intimate connection between organisation and sensation.

Any imperfection in the organs of sensation bears upon sensation itself, so also does any injury sustained by them; sensation is by these circumstances modified, impeded, or totally prevented.

It is well known that, although the same substance operate upon the same sensual organ, different sensations may be experienced according as the sentient being is in health or in sickness. By diseases some changes may be occasioned in the nervous system by which the sensations are altered, but most probably the organ is the part chiefly affected.

The delicacy of an organ may be materially affected by the manner in which we commonly employ it. The constant use of stimulants, narcotics, &c., will render an organ inattentive to influences which otherwise would occasion sensation.

It is of importance that the organs of sensation be kept in a sound and healthy state, otherwise sensation is not experienced with the advantage it might be.

The organs of sensation are likewise capable of improvement by the judicious use of them, or rather the spirit may learn to discriminate sensations more accurately by a careful employment of the organ; the wine-merchant and others do this.

The senses, by discipline, exercise, or mode of use, may be made more acute or obtuse. One man by his mode of life feels cold or heat less than another.

The nerves of sensation considered generally.—The covering or outer portion of the human body is the skin; this is composed of different layers, the outermost layer is called the cuticle. The cuticle is of considerable thickness and without blood-vessels and nerves, and serves as a protector to the second layer of the skin, which is called the corium. Here it is that the innumerable minute nerves, which are the media of sensation, take their rise. Thus, in each organ of sensation, and over the entire body, we have first a membrane, and next the outer extremities of the nerves of sensation. The membrane is acted upon immediately by the external causes of sensation, and the impression is, through the medium of the membrane, extended to and fixed upon the extreme points of the nerves.

The nerves of sensation, whose extreme points touch the protecting membrane or cuticle throughout the trunk and extremities, unite into larger cords; and such of these cords as appertain to the trunk and limbs enter the spine, where they form one continuous cord, constituting a portion of the spinal cord or spinal marrow. This nervous cord passes up a cavity in the spine, and becomes collected with other portions of the nervous system into that mass of nervous matter which occupies the skull, and is called the brain.

The organs of taste, smell, hearing, and vision, being situated in the head, their nerves do not enter the spine in connection with the sensual nerves of the trunk and limbs, but proceed directly to the brain; a limited portion of the nerves of inorganic sensation also appertains to the head.

Dr. Roget remarks: "It is usual to designate the end of the nerve which is next to the sensorium as the origin of that nerve, whereas it should more properly be regarded as its termination; for the series of changes which end in sensation commence at the organ of sense, and are thence propagated along the nerve to the sensorium."—*Bridgewater Treatise*, vol. ii. p. 508. The usual mode of speaking about the nerves is, however, correct with regard to voluntary and involuntary action, and perhaps perception.

Dr. Roget, in vol. ii. p. 369., has some excellent remarks on the sensibility and insensibility of different parts of the human body, and the intention of this difference. "It is a wise and bountiful provision of (*the God of*) nature," &c. &c.

That portion of the nervous system which is concerned in sensation deserves the most minute and accurate investigation; latterly, Sir Charles Bell, Majendie, Dr. Mayo, and others, have applied their talents, and with vast benefit, to this important subject. In the "Times" newspaper of Friday, October 18. 1839, is an account of the publications of Sir Charles Bell and his coadjutor Mr. Shaw, respecting the nerves of sensation, &c., and of the controversy as to priority of claim between Sir Charles Bell, Dr. Mayo, and M. Majendie.

Over that part of the nervous system by means of which the sensual feelings are occasioned, the mind has little or no control. Sensual feelings arise without its bidding, continue or depart against its inclination, and cannot be allayed by any simple intellectual endeavour.

If the nerves in subservience to an organ of sensation be seriously injured, the sensations of that class are as effectually prevented as they would be by the malformation or derangement of the organ. The sensations under such circumstances can no more have existence than they could have without the action of the bodies whose province it is to originate the sensation peculiar to that organ. "The destruction, or even compression of a nerve," says Dr. Roget, "in any part of its course between the external organ and the sensorium totally prevents sensation."

"At Worsley, near Stourbridge, there is now living a man of the extraordinary age of 112 years. In his youthful days he accidentally received a cut across the temple, which deprived him both of speech and hearing, and he now remains dumb, but his eyesight is remarkably good."—*Doncaster Chronicle*—*The Times*, Jan. 20. 1838.

It has been said, "A person who loses an organ of sensation does not lose the ideas previously acquired by it." There are no *ideas* of sensation; sensations are, however, in some manner *remembered*, and the loss of an organ or injury of its nerves does not obliterate the memory of sensations which have been experienced by means of that organ. The sufferer is not in the position of one who, for want of the organ or its attached nerves, has never known anything whatever of the sensations.

The brain considered generally as an organ or medium of sensation, or considered as the sensorium. — The nerves of sensation all centre in the brain. The brain is wholly or chiefly a conglomeration of nerves, part of which is appropriated to sensation.

Sensation is impeded, altered, or prevented, not only by the imperfection or derangement of an organ of sensation, or by any injury sustained by nerves of sensation, but also by pressure upon, or disease in, or laceration of the brain.

The human brain is the ultimate organ of sensation; it seems in some inexplicable manner to be in immediate connection with the soul, mind, or spirit. That portion of the brain which is appropriated to sensation *immediately* affects the soul, or, to speak figuratively, comes into contact with it. External bodies act upon the soul only *indirectly*, viz. through the medium of the nerves; and there is no ground to suppose that they possess any power of immediately affecting the soul or spirit.

If there be any particular portion of the brain which immediately affects the mind, that part may appropriately be termed the sensorium. To ascertain in what part of the brain the nerves of sensation concentrate is highly important, and much of progress has in late years been made in the investigation. See Sir Charles Bell's eight papers read to the Royal Society of London, and three papers read to the Royal Society of Edinburgh. The first paper was printed in the year 1811.

In the phenomena of sensation there is strictly a concatenation of influences. An external body influences the nerves; the interior extremity of the nerves, that is the sensorium, influences the mind.

These propositions (for which see Dr. Reid's "Inquiry," p. 102.), — "Sensation might have been experienced without the mediation of organs and a human body;" "sensations might have been experienced through the media of different organs from those that are now the channels of influence;" "sensations might have been experienced without the agency of external bodies," are three very different, very distinct propositions. You may as well set them to music as propose to prove them by *argument.* Is there any evidence, are there any phenomena, which impart probability in the slightest degree to any one of the three? We might have emotion without the agency of matter, as angelic beings have; but sensations, from their very nature, seem to require material agency and mediation.

Sensation considered generally.—Sensations of one class or order are entirely unlike those of another.

Sensations can only be known by experience. A person born blind is perfectly ignorant of colours, as is one born deaf of sounds. Some persons are exceedingly defective in the sense of smelling, others in the sense of taste. No description can make such individuals acquainted with colours or sounds, with delicate odours or flavours. The want altogether or in great part of the proper physical faculty is an impassable barrier to acquaintance with the sensations.

Sensations must, in their very nature, be differently experienced; the mind cannot, therefore, be properly said to discriminate sensations, as it discriminates substances by means of sensation :—the latter is, in part, an intellectual operation; the mind, in respect to the former, is perhaps wholly passive.

Most sensations admit of degree; they are forcible or weak according to the quantity or purity of the exciting cause, or the force of its application to the nervous system.

Some classes of sensations having their origin at the surface of the nerves, particularly the extremities, others taking their rise in the interior of the nervous system, two divisions might be made, if of any utility, viz., exoteric sensations and isoteric sensations. The sensations connected with sensual intercourse, those of hunger, thirst, and itching, that peculiar sensation which is produced by tickling, and the organic sensations of smell, taste, and hearing, are of the class of exoteric sensations. The sensations which are occasioned by the chemical action of bodies upon the substance of the nerves, those produced by laceration, puncture, unnatural tension, &c., constitute that other division of sensation which might be termed isoteric. In these cases the nerves are, I presume, always injured, and the sensations uniformly pernicious and painful.

Pain and pleasure are not names for particular sensations, they are two general words applicable to all sensation. Numerous sensations are highly agreeable; others, on the contrary, are as unpleasant; many, though in no respect disagreeable, cannot be said positively to gratify; they are of a medium character, standing as it were on the confines of both pain and pleasure. It is common for sensations to be pleasant or painful according to their intensity. It is not apparent that a useful classification of sensations can be founded upon these three characters. On the purposes for which some sensations are painful, others pleasing, see Dr. Reid, Essay II. ch. xvi. p. 328.

Dr. Berkeley, in his first "Dialogue," p. 247., says: "Surely an indifferent sensation is as truly a sensation as one more pleasing or painful." This statement, as the Doctor seems to understand and make use of the term "an indifferent sensation," is surely exceedingly erroneous. It will account for a large portion of the fallacy which clouds Dr. Berkeley's metaphysical views, because, if there ever is perception without sensation, then most of the principles and deductions of the Doctor are untenable, being based upon an erroneous representation of facts and inductions therefrom.

Every human being is aware of his own sensations, and of his own susceptibility of being acted upon sensitively by certain descriptions of matter and in various ways; but all his knowledge respecting the sensations of other human beings is obtained by an inductive process from their actions, appearances, and descriptions. It is of some interest and importance to determine how nearly the sensations of men in the earliest ages were identical with the sensations of men in the present day; and, farther, to determine the identity, as nearly as possible, of the sensations of human beings in all parts of the world at the same period and in all stages of civilisation. Whatever number of particular inductions may be made in respect to these two points, a general induction will be arrived at, viz., that little or no difference has in any period or in any place existed in human sensations or human sensitivity.

The knowledge in us of another human being's sensations being inductive, we never can be certain that the like sensations in various individuals are precisely identical, although there are abundant indications that the differences, if any, are very slight. This was a tenet of Aristippus: "No man can be assured that the perception (*sensation*) excited in his mind by any external object (*agent*) is similar to that which is excited by the same object (*agent*) in the mind of another person." — *Enfield*, bk. ii. ch. v. p. 194.

Sensations are subjects of mental occupation. We discriminate perhaps sensations. We infer the sensations of human beings and of animals from outward signs, &c. We classify sensations. Sensations may be recognised, and perhaps fancied; they may be compared and reasoned about.

Perhaps all the organs and means of sensation may be employed by the mind as instruments of investigation.

Dr. Reid is of opinion that there is a peculiar kind of sensation which he describes to be the sensation of touch, although he admits that both philosophers and the vulgar had before his time neglected to discriminate that variety of sensation, and seemed to be ignorant of its existence. See "Inquiry," ch. v. sect. 5.; also various other parts of that work, and of the "Essays." If the sensation of touch never had a name nor ever had been thought of ("Inquiry," pp. 100, 101.), its existence and its necessity to perception are very dubious indeed. As respects Dr. Berkeley's theory, sensations of touch would have to go in the same boat with all other sensations; no reservation could be made in their favour.

Dr. Reid holds that hardness and other primary qualities are ascertained by sensations of touch; that hardness, figure, extension, &c., in fact, produce sensations. See "Inquiry," ch. v. sects. 2—6. Now all this I consider to be erroneous; the reason why all such sensations have been overlooked by both the vulgar and philosophers (p. 112.) is because they have no existence — they are fabulous, a myth, a conceit. What sensation *figure* occasions would puzzle even Milton's infernal metaphysicians. These alleged sensations will not withstand Berkeley and Hume's crucible a whit better than real sensations have done. To introduce sensation as a means of obtaining knowledge of the causes of sensation where nobody ever before dreamt of finding it, is to strengthen the Bishop's sceptical doctrine, not to weaken it. The Doctor's representations on this subject are very unfortunate; he verily plays into the hands of the sceptics.

It is inaccurate and pernicious to say that sensations are perceived; this is confounding sensation and perception, which are widely different. The senses do not supply us with perceptions. Perceptions do not follow or result from sensation; we need not perceive a rose when we experience the smell. Locke, Reid, and others, have confounded Sensation and Perception. This I hold to be a grievous error, which has been followed by a numerous progeny of mistakes in the science of mind. I hope that in no one instance in the previous investigations concerning sensation have I employed the word *perception;* — I have studiously refrained from using it.

Sensations are not properly objects of memory or matters for remembrance. Dr. Reid, in his "Inquiry," p. 49., discourses about the remembrance of a sensation: such remembrance is something very indistinct indeed; there is nothing in the mind in this alleged remembrance at all like sensation itself; – recognition of sensation seems to me the only form of memory which there is in regard to sensation.

Sensations are not operations. It is a sad mistake to call sensation an operation. Dr. Reid, like all other metaphysicians, has committed this mistake repeatedly. See his "Inquiry," ch. ii. sects. 5—7. pp. 51, 52. 57, 58. 67., and other places. I demur to the assertion that the vulgar consider sensation to be an *act* of the mind (p. 80.); the mind, in regard to sensation, is passive, not active — matter is the actor. Dr. Reid says: "We call sensation, perception, memory, and imagination, various modes of thinking or various operations of the mind." — *Essay II.* ch. 13. p. 272. Now I beg leave to protest against representing either sensation or emotion to be operation or thinking. We do not think when we feel: we may think afterwards about our feelings, their causes, concomitants, and the consequences which follow them; but thought and feeling, action or operation and passion, are in themselves entirely distinct. In Essay II. ch. 17. p. 336., Dr. Reid says: "Sensation is the act or the feeling (I dispute not which) of a sentient being." Here he abandons a distinction to which he ought firmly to have adhered. It is no light matter to consider an act and a feeling as identical, or to make the two words sensation and action convertible. Mental philosophy must remain unsound so long as this indifference and indiscriminateness are persisted in.

Dr. Reid, in common with other metaphysicians, has failed to make a proper distinction between experiencing sensations, in which the soul cannot be otherwise than entirely passive, and the physical action which brings the soul within the influence of those substances which occasion sensation. A glutton is very active in supplying the material which gratifies the palate, but neither the motion of the hands to the mouth nor the act of eating is the feeling or sensation. A lady may place incessantly a scent-box or smelling-bottle to her nose, and draw in the perfume, but the action is wholly distinct from the sensation. In truth, action and sensation are ordinarily combined in tasting, smelling, &c.; yet it is improper to style the phenomenon an *act*.

Sensation is an item or ingredient sometimes in mental phenomena. An intellectual phenomenon is often complex, and one of the ingredients may at times be sensation. Operations of mind and emotions are, however, far more commonly amalgamated into one phenomenon.

There are no ideas of sensations, no imagination of sensations. Dr. Reid speaks frequently of the imagination of a sensation. See "Inquiry," sect. 3. This is erroneous. We can experience a sensation; we can remember that we experienced a sensation; and we can recognise a sensation as having been before experienced; but an idea or imagination of a sensation is nothing. Imagining a tuberose to yield a perfume in a place where it is not (see page 50.) is nothing but remembrance that the rose yields a certain perfume which has already been experienced. The sad disfigurement of Locke's "Essay concerning Human Understanding" by the incessant phraseology of "ideas of sensations" is well known. Bishop Berkeley ought to have taught the existence only of minds and sensations. Whence are ideas to be got according to his philosophy? He has only made evident that we have sensations, he has not made evident that we have ideas through them. — See Reid's "Inquiry," p. 135. Dr. Roget, in his "Bridgewater Treatise," like metaphysicians in general, perpetuates the delusion of there being ideas of sensations.—See vol. ii. p. 512., also in various places of part iii. of the same volume. In thinking about a sensation, the spirit is not necessarily in a state of sensibility, otherwise it would possess the power of originating feeling in itself; it would be a cause of its own sensations. Sensation is not the origin of ideas. Sensation of itself imparts some knowledge of the external world, knowledge which, without sensation, could have no existence. In conjunction with perception and other operations of mind, sensation supplies our knowledge of the material universe, and furnishes some portion of food for intellectual digestion. See what is said in Dugald Stewart's "Elements," vol. ii. p. 86.

Sensation is not a power.—Dr. Reid says, Essay II. ch. xiv. p. 305., "there must, therefore, be in the percipient a power to feel or to perceive," &c. It is, of course, correct to speak of a power of perception, but quite inaccurate to talk of a power of feeling; we have a capacity or susceptibility of sensation. "The production of a power" I do not understand. Either a being or thing has had a power or a capacity bestowed upon it by the Creator, or it has not.

"Belief of the experience of a sensation," a phrase employed by Dr. Reid, is surely waste of words. "I experience that peculiar sensation which a rose is capable of exciting," is an intelligible sentence. "I believe that I experience such a sensation" certainly expresses nothing more, unless it be that I am doubtful whether the odorous sensation is produced by a rose, or by some other flower. "I believe that I am walking," would be a useless, if not an unmeaning expression. Belief is not applicable to such matters.

Sensations do not accompany emotions. — See Reid's Essay II. ch. iii. p. 134. Passions and affections may accompany, or rather follow, sensations; but sensations do not accompany passions and affections.

Mr. Hume says: "Though the instinct be different, yet still it is an instinct, which teaches man to avoid the fire, as much as that which teaches a bird with such exactness the art of incubation, and the whole economy and order of its nursery." — *Essay on Hum. Und.*, sect. "On the Reason of Animals," p. 108. This I consider to be altogether a false view of the subject. Instincts are supposed to be something pertaining to the Intellectual Principle, prior to all experience. Now, the injurious action of fire upon the physical system becomes known to men and animals only and entirely by experience. A savage who had never known of the existence of fire, would be as likely to burn himself as an infant or an animal; or if more cautious, his caution would not be instinctive, but a result, a dictate, of experience. He may have learnt to fear a trial of any effects of which he knows nothing.

The human soul is passive in sensation. From the preceding investigation it clearly appears, I trust, that, in regard to sensation, the human soul is passive. Sensations, organic or inorganic, depend not upon human will. By a simple act of volition, we can neither have sensation nor escape it. Nor is sensation an operation of mind of any kind; there is no mental activity whatever when sensation is experienced.

The susceptibility of the human soul for experiencing sensation.—The human soul has clearly an aptitude, or capacity, or susceptibility, for experiencing sensation.

We may easily conceive of beings not possessed of such an aptitude upon whom no material impulse would take effect—beings of action and emotion, but devoid of sensual feeling.

The susceptibility of the human mind is made known to us the moment sensation is experienced. A particular sensation, when it is felt, not only apprises us of its existence as a peculiar and definite impression upon the spirit, but it makes us acquainted with a faculty in the mind, of the possession of which, without the experience of sensation, we should be wholly ignorant.

On various grounds, there is strong reason to infer that human souls differ greatly in respect to sensual aptitude. The incalculable differences observable in mankind in regard to sensations are not, in all probability, attributable entirely to diversity of physical organisation. In no respect is the difference more widely evident than in the exquisite sense of melody and harmony possessed by some individuals, and the freezing and repulsive indifference thereto exhibited by others. The excessive and offensive sensuality in respect to lust and the gratifications of the palate exhibited by some human beings,—a sensuality which throws into the shade all other enjoyments, and doings, and pursuits,—contrasted with the disposition to extreme moderation in these indulgences, and even indifference thereto, which are evident in others, betoken as much a difference of spiritual as of physical organisation.

The capacity for sensual feeling appears to be intended partly to minister to human happiness, and partly to detract from it. The happiness which man is capable of enjoying is the gift of a beneficent Deity and the evidence of his goodness; the sensual misery which we here experience, is a punishment attached to the commission of moral evil; and as moral ill-doing is, in many cases, inevitably followed by sensual suffering, sensual feeling, in this respect, evidences the constant displeasure of God against moral evil.

We know nothing respecting the world of angelic beings but from the Bible. Nothing in that blessed book leads us to suppose or infer that the angels experience any kind of sensation; they are *insentient* beings. To this general statement there may perhaps be some restriction. Angels, we are told in many passages of the Bible, have, at various periods, been sent upon earth, and usually in human form, though most likely of a far higher order than human physical nature as it now exists. They ate and drank, &c. These individuals may, for aught we know, have experienced sensations of some kind, although fire, we learn, had no effect upon their material, or apparently material, forms.

The existence of the human soul is made known by sensation.—By means of our sensations, not only become we aware that there is within us a *susceptibility*, of which property or faculty we can easily conceive we might not have been possessed, but the very experience of sensation proves also the existence of something within us which feels, that something which is the *subject* ultimately acted upon by the external causes of sensations, — in fact, sensation is continually apprising us and reminding us of our existence, our reality of being.

The evidence of sense, or of sensation, ought to sufficiently prove or indicate the existence, as sentient beings, of those who are experiencing sensation. Any imperfection of the senses might make doubtful their evidence as to the externality of the causes of sensation, but can throw no doubt upon the existence, the reality, of that which, at the moment, is experiencing sensation. There appears a great mistake in Des Cartes' views upon the subject. See Reid, Essay II. ch. viii. p. 187.

By means of the operations of the human mind — any one of them — we become aware of our individual existence. "Cogito, ergo sum," was Des Cartes' proposition. But our sensations equally well indicate to us, or give us notice of, our existence; we become aware of it — are conscious of it — when our spirit is operated upon, as thoroughly as we do when it acts. Our emotions also give intimation of our existence. We can hardly be said to be aware of our existence during heavy sleep, or whilst in a swoon. Action or passion seem to be necessary to our knowledge of our own being.

The expressions, "sentient principle," "soul," are perhaps better employed in respect to sensation than the term "mind." The latter word seems, by general consent, to be appropriated more exclusively to mental acts, operations, or processes; the word "soul," to sensations and emotions.

I object to Dr. Reid's admission ("Inquiry," p. 127.) that Hume proved clearly that we cannot infer from our sensations or those of others our or their existence. Hume proved no such thing; but, as was his fashion, very coolly assumed it. Nevertheless, we rather acquire a conviction or knowledge of our own existence at the instant of experiencing sensation than by an inductive process subsequent to that experience.

Dr. Reid remarks: "Perhaps a child in the womb, or for some short period of its existence, is merely a sentient being." — *Essay II.* p. 130. Embryos have also, as is well known by women, a power of motion and action in some slight degree. Elizabeth even said, "The babe leaped in my womb for *joy*."

A sensation suggests, or makes known, that there is a soul to feel; but the relation between the sensation and the soul is not so suggested; and may not even be thought of. See what is said on this point in Reid's "Inquiry," p. 67.

Matter and mind considered in connection, so far as regards sensation. — Sensations, being spiritual effects produced by material causes, show the departments of matter and spirit in the relation of cause and effect: matter operates as a cause upon mind; mind is operated upon by matter, by which an effect is produced upon it. How matter operates upon mind is incomprehensible to us, but the fact is undeniable.

When a limb or any other part of a body not essential to life is removed, sensation ceases in respect thereto with vitality, and it is no longer connected with the spiritual principle.

"It is of no moment to us," says Dr. Reid (Essay II. ch. 10. p. 240.), "whether they (our sensations, agreeable or disagreeable, our sensual pleasures or pains) are produced immediately by the operation of some powerful intelligent being upon our minds, or by the mediation of some inanimate being (*reality*) which we call matter." This I understand to be a representation of Dr. Berkeley's views.

We have many intimations that there are influences at times at work upon our minds which we cannot trace to material causes. Irrespective of religious considerations, there is considerable probability that supernatural influence is exerted to some extent upon the human mind. Impressions, however, which we are unable to attribute to sensible causes, may really arise from them, and the obscurity which hangs over the origin of these impressions may be attributable wholly to our ignorance.

THE INFLUENCE OF MIND UPON MATTER, PRODUCING HUMAN ACTION.

CONCERNING THE POWER OR PROPERTY IN THE HUMAN MIND OF OPERATING UPON AND WITH THE PHYSICAL SYSTEM.

The human mind influences, in some mysterious manner, a portion of that nervous organ placed in the head which is termed the brain.

The influence of the human spirit upon its own physical system, by the medium of a portion of the brain, and through its physical system upon external matter, is, in the clearest sense of the term, a power, and it supplies, perhaps, the most vivid notion of power that the mind is capable of entertaining.

Enfield gives somewhat of Aristotle's and Plato's views as to the influence of the human mind upon the human body and matter in general.

Aristotle says: " The soul is the first principle of action in an organised body." —*Enfield*, vol. i. p. 287. See also p. 288, " The nature of the first, &c.; " p. 239., " Upon the great question, &c.; " pp. 284, 285., " In a manner similar, &c."

In vol. ii. p. 90. of Enfield's work is this passage, which gives the view that Plotinus took of the subject, a view which is particularly clear and interesting: " Souls are in the body simply as the animating principle, for it is in this respect only (×) that we know the soul to be present with the body. The power of the soul is diffused through every part of the body; and though it be said to reside in its chief instrument, the brain, it is incorporeal, and exists entirely everywhere within the sphere of its energy. It is the principle of motion moving itself, and communicating motion to bodies." Sensation also gives us knowledge of the presence of the soul.

Enfield says himself, on this subject, p. 285.: "It still remains an inexplicable mystery in what manner pure spirit, either human or divine, is the efficient cause of motion in material bodies."

Mr. Locke has a number of passages in which he discourses of mental influence upon matter, especially in the production of human actions. See "Essay on Hum. Und." vol. ii. p. 122.: "So on the other side, &c." In this passage, for "thought" read "intellectual influence," for "ideas" read "thoughts," for "thought" read "sensation." P. 198., "We cannot conceive, &c." I do not hold with Mr. Locke in his notion that the conception of mental influence upon matter is more difficult than the conception of the influence of matter upon matter. The difficulty is to conceive how matter can of itself, or by any inherent power, act either upon other matter or upon mind. The influence of mind upon matter is as evident to us as is the influence of matter upon matter. See farther, p. 105., "The infinitely wise Author, &c.;" p. 108., "Observing in ourselves, &c.;" p. 157., "With such a power, &c.;" p. 223., "Barely by willing, &c.;" p. 223, "We find in ourselves, &c.;" p. 224., "Every one, I think, &c.;" p. 232., "If I can, by, &c.;" p. 301., "A power of putting, &c.," "So the mind, &c.;" p. 302., "Every one finds, &c.;" p. 307., "Of our souls, the power, &c.;" p. 309., "A power of action, &c."

Dr. Reid makes various remarks upon mental influence upon matter. See "Essays," p. 62.: "How, or in what manner, it (*matter*) is moved by mind, we know as little as how it was created;" p. 60., "We can produce no motion in any body in the universe but by moving first our own body as an instrument;" p. 329., "The language of all mankind, &c.;" p. 330., "It is very probable that, &c.;" p. 48., "Whether the conception, &c.;" p. 73., "How our minds act upon our bodies, &c."

Dr. Porterfield says, "How body acts upon body, or mind upon body, I know not." — *Reid, Essay II.* ch. xiv. p. 289.

Dr. Roget expresses himself thus: "Though he (*man*) soon learns that he is dependent for most of his sensations on the changes which take place in the external world, he is also conscious of an internal power which gives him some kind of control over many of those changes, and that he moves his limbs by his own voluntary act, — movements which originally of themselves appear in most animals to be productive of great enjoyment." — *Bridgewater Treat.*, vol. ii. p. 371. In page 365., when speaking of the sentient and intelligent principle, he says, also: "A principle, which we cannot otherwise conceive of as being distinct from matter, although we know that it is capable of being affected by matter operating through the medium of this nervous substance, and that it is capable of reacting upon matter through the same medium. Of the truth of these propositions there exist abundant proofs."

Goldsmith remarks: "Man would have been one of the most miserable beings upon earth, if, with a sentient (*active*) mind, he was so formed (*physically*) as to be incapable of obeying its influence; but nature (*God*) has otherwise provided, as with the most extensive intellect to command, she (*he*) has furnished him with a body the best fitted for obedience." — *Animated Nature*, vol. i. p. 195.

The existence of the intellectual power of influencing matter is not, I apprehend, with regard to ourselves personally, *infered* from our actions; rather is it the object of consciousness: or if power be in no case an object of consciousness, which, perhaps, is the truth, action evidences instantly the possession of power; the performance of the action and the possession of the power become known to us simultaneously, — there is no intermediate time for induction.

On the other hand, the existence of like power in other human beings we clearly *infer* from their actions, and we estimate the extent of their physical power, that is, properly, the capabilities of their physical system as an instrument of the mind, by the character of their actions.

We also infer from the actions of brute animals, the existence in them of a power or property of influencing matter no-wise dissimilar, so far as we can judge, to the like power in ourselves or in other human beings.

"Active nature" (*activity of nature*), says Mr. Edwards, "is a general thing; it is an ability or tendency of nature to action generally taken, which may be a cause why the soul acts as occasion or reason is given; but this alone cannot be a sufficient cause why the soul exerts such a *particular* act at such a time, rather than others. In order to this, there must be something besides a general tendency to action; there must, also, be a particular tendency to that individual action." — *On the Will*, p. 63. part ii. sect. 4. Here Mr. Edwards distinguishes between the power or attribute which the mind possesses of influencing matter, and the particular exertion of that power in every individual action, — the mind being impelled or induced to each action by a previous volition or determination of mind, immediate or more remote.

The mental power of influencing matter is, I presume, *simple* in its nature; it is not compounded of any other intellectual attributes, and is markedly distinct from every one of them.

Human actions are complex as to their causes; they result from the combination of human intellectual power with the material powers of the physical system; the former compels the action of the latter within limits, or works with them as agents. The incomprehensible association of matter and mind in human beings renders it, perhaps, impossible to discriminate, with any exactitude, what of human action belongs to material, and what to intellectual influence. Perhaps metaphysicians will always be necessitated to examine the sources of human action in this their compound character, and never be able to determine or approximate to the force of each influence.

Human beings have command over their own movements,—they have certainly the power of self-motion. They have likewise power over the movements of inanimate bodies. This power over matter they habitually exercise to a certain extent; but, like all other human powers, it is limited or restricted both by occasional and permanent circumstances.

The motions of the human body are subject to the ever-acting influence of gravitation, consequently the power of the human soul, in influencing the body, must be confined to a particular mode and direction of motion. Besides, the body will not at all times conform to the directions and the impulses of the inward principle:—a physical injury prevents the accustomed motions.

The mental power or property of influencing matter is altogether different from the mental power which is termed the will, and usually, if not always, succeeds in the order of being brought into exercise; we exert muscular force in consequence of a determination of the mind so to do.

From the power of willing results volition, determination, resolution; from the power of influencing matter results human action, and motions and changes in the states of substances. Volition is not necessarily followed by action; it perhaps always precedes, and, may be, necessarily so, the act of influencing the physical system. I resolve or determine to perform a physical action on a future occasion: this is willing or volition; at the appointed time I perform the purposed physical action. These two operations are surely as distinct in their nature as the act of memory; the link which binds them together is distinct from either. The powers which engender the acts are also as distinct as are the operations. These two powers, the power of willing and the power of influencing matter, have been discriminated, I believe, by scarcely any metaphysical writer.

Socrates, according to Enfield, bk. ii. ch. iv. p. 183., expressed himself thus, "Your own mind directs your body by its volitions." He ought to have said, "according to or in conformity with its volitions." Volition and action upon the body are two distinct mental operations springing from two distinct sources in the mind, the one from the will, the other from the power of influencing matter.

Mr. Locke very clearly describes the phenomena of intellectual influence upon the human body, and, through that, upon external matter (see the several references which have been just given); but he fails to discriminate between volition and the act of influencing matter, and, consequently, between the power of willing and the power of influencing matter.

Sir I. Newton employed this expression, ". . . . than we are by our will to move the parts of our bodies." To will, and to influence the physical system at the determination of the will, are, as I have said, two essentially distinct operations of mind, and proceed from two distinct powers; angels and demons will or determine, although they have ordinarily no bodies to move or act upon. Sir I. Newton has fallen into the mistake of all philosophers on this point.

Dr. Reid, in page 361. of his "Essays," discriminates the two; he there says, "understanding and will, without some degree of active power, can produce no effect." Understanding, or comprehension, of course produces not effects; will does, and those effects are volitions or determinations, not physical actions. In vol. iii. p. 48. he clearly distinguishes the two: "The effect produced, and the will to produce it, are things different from active power." But whilst Dr. Reid in these passages makes a clear distinction between the two powers, in other places he propagates the error of Mr. Locke, and is followed therein by Dugald Stewart and others.

Sumner perhaps discriminates the two powers in the following passage: "The communication to the limbs (*by mental impulse upon the nerves and muscles*) of the determination of the will."—Vol. ii. p. 265.

Dr. Prout, in his "Bridgewater Treatise," p. 360., keeps up the mistake when he speaks of a portion of the nervous system being under the influence of volition.

The electric power has great influence upon the nerves and muscles of the human body. Some frightful experiments have been made upon corpses by directing the galvanic power upon them; but the movements of those carcases have been evanescent, and the material power brought into play in producing the convulsive actions is, through these experiments, seen to be very different from, yea essentially different from, mental influence upon matter. How far the electric fluid is in human actions and motions an agent or assistant, during life, of mental influence, is a subject for farther investigation by physiologists. The electric state of the body, and the changes in its electrical condition, are now thought to be more important than had been previously supposed; in fact, it is considered that electricity is an important adjunct to, if not an absolute agent of, mental power over matter. The following description is given by Mr. Kirby, "Bridg. Treat.," vol. i. p. 42. Introd.: "Experiments have been made upon human bodies and those of other animals which, by the application of galvanism, after death have exhibited various muscular movements, such as lifting the eye-lids, moving the arms and legs, &c.; but though motions usually produced by the will (*mind*), acting by the nerves upon the muscles, have thus been generated by a species of the electric fluid, proving its affinity with the nervous power or fluid, yet the subjects of the experiment, when the action was intermitted, continued still without life, no return of that power or essence which was fled for ever being effected by it; which seems to render it clear, that neither caloric nor electricity, though essential concomitants of life, form its essence."

There is at times apparently suspension or loss of the power of influencing the muscular system; this may be because the brain is injured, or its action is prevented, or because the nervous system is injured or paralysed, or because the muscular system, or some part of it, cannot respond to nervous impulse. Congestion of the brain, paralysis of the nerves, laceration of muscle, fracture of bone, and the like, all incapacitate the organic structure from obeying mental influence; there is physical inaction, partial or complete. The suspension is oftentimes temporary only, as during a fainting fit or swoon. Epileptic persons fall instantaneously as if knocked down. I once witnessed the painful sight of a large man thus fall backward on London pavement with arms extended and an excruciating shriek. As age advances upon man, his physical strength gradually decays; and when death arrives the influence of mind upon body ceases. It is evident from the phenomena that the fault is in the material system, not in the spiritual principle; the instrument cannot obey the impulsive or impelling power.

There is great inaccuracy in the use of this phraseology,—"an idea of active power." We may speak of a *notion* of mental power over matter, or of material power over mind, or of any other power; we cannot have *ideas* of powers any more than *ideas* of spirits. Dr. Reid has made this mistake. See "Essays," p. 330., "It is very probable," &c.

THE BRAIN CONSIDERED AS AN INSTRUMENT OF THE MIND IN HUMAN ACTION.

The brain is the physical organ which the human mind directly influences; and through or by means of it the mind farther influences certain portions of the nervous system.

Whenever any portion of the brain which is connected with the motor nerves is injured, muscular action is prevented or impaired. A paralysis or congestion of the brain sometimes takes place, and this is then followed by a paralysis of the nerves and muscles.

That the motor portion of the brain is distinct from the sensorium, or the nervous termini in the brain by which sensation is occasioned, seems now by anatomical researches to be fully established. Sir Charles Bell, Majendie, and others, enjoy the honour of having prosecuted this intricate branch of anatomy to highly interesting and convincing results. See their papers on the subject. The excellent medical writers of the "Bridgewater Treatises" have treated fully and carefully of this important subject. Dr. W. C. Henry made an interesting Report to the British Association. See "Br. Ass. Report" for 1833.

Dr. Kidd, when speaking of the brain as an organ of the mind in providing for the supply of man's wants, and for other purposes, says: "Although with respect to the *brain*, we not only have no satisfactory evidence, but cannot even form a well-grounded conjecture of the mode of action of any particular part, yet we cannot doubt that it is the instrument by which our intellectual powers hold communion with external nature."—*Brid. Treat.*, p. 28.

Dr. W. C. Henry, in the "Br. As. Rep." for 1833, says that "the medulla oblongata is continuous in structure with the spinal marrow, and enjoys, by this relation, the function of propagating motion." He also, in the same place, affirms that the regulation of the bodily motions ceases when the medulla oblongata is destroyed. See p. 72.

The cerebellum is considered to be the part of the brain which is most concerned in physical motion and action—the seat of mental influence over the body in the production of action. Thus, Dr. Henry: "It may be regarded as nearly established by modern researches that the cerebellum is more or less directly connected with the function of locomotion. Roland found that injuries of the cerebellum were always followed by diminished motive power."—*Br. As. Rep.* for 1833, p. 150. Dr. Roget says: "Experiments and pathological observations seem to show that the cerebellum is the chief sensorial agent in voluntary motion."—*Brid.*

Treat. vol. ii. p. 565. The word "sensorial," applies to sensation, not to mental influence upon matter.

Large portions of the brain, the cerebellum especially, it seems, may be cut away so as to destroy the capability of physical motion and action, and yet not to destroy life. See Dr. W. C. Henry's account of M. Flouren's operations, "Br. As. Rep." for 1833, p. 65.

THE MOTOR NERVES, OR THE NERVES OF ACTION, CONSIDERED GENERALLY.

The motor nerves, or nerves of action, take their origin mostly, but not exclusively, in that portion of the brain which is called the cerebellum. These nerves are distributed in all directions, and with minutest subdivisions, amongst the muscles; they are acted upon by the mind through their original extremities in the brain, and they in their turn, by consequence of mental influence, act upon the muscles.

One portion of the nerves of action is spread over the face, proceeding directly from the brain; another portion enters into the composition of the spinal cord, and proceeds down the back-bone; these nerves leave the same through openings provided therefor, and branch off to the muscles, amongst which their innumerable extremities become distributed. Dr. Paley says: "The medullary canal giving out in its course, and in a convenient order, a supply of nerves to different parts of the body, notches are made in the upper and lower edge of every vertebra, two on each edge, equidistant on each side from the middle line of the back. When the vertebræ are put together, these notches, exactly fitting, form small holes through which the nerves at each articulation issue out in pairs in order to send their branches to every part of the body, and with an equal bounty to both sides of the body."—*Nat. Theo.* p. 20. Dr. George Gregory remarks: "Nerves are white cords distributed from the brain over the whole body; they rise either immediately from the brain or mediately from it, by means of the spinal marrow, which is itself a continuation of the fibres of the brain, and without impropriety might be considered as the largest nerve in the body. The nerves, as they pass off from the brain and spinal marrow, are invested and collected into firm cords by the dura and pia mater. The former, however, is soon reflected back, but the latter accompanies them through all their ramifications, and is supposed to be only thrown aside when they terminate in their sentient (*muscular*) extremities." — *Econ. of Nat.* vol. iii. p. 311.

In the "Times" newspaper for October 18. 1839, is a good article on the discoveries of Sir Charles Bell, Mr. Shaw, M. Majendie, and Dr. Mayo, respecting the motor nerves. Dr. Reid, in his "Essays," p. 118., has a passage commencing thus: "The nerves are fine cords, &c." Dr. Thomson says: "The brain and the nerves are the instruments of motion."— *Chem.* vol. iv. p. 482. Dr. Kirby: "Though the intellectual, &c." — *Brid. Treat.* p. 31. Dr. W. C. Henry, in "Br. As. Rep." p. 80., describes the motor nerves thus: "The class of nerves, &c."

The necessity of the nerves to physical action is proved by the circumstance that when any of the motor nerves are injured, the appropriate muscular action is prevented; and when the spinal marrow is seriously damaged, a general paralysis of the body ensues. On this point, see the following statements. Dr. Reid: "When the nerves, &c." — *Essays*, p. 118. Dr. George Gregory: "What is the nature, &c." — *Ec. of Hum. Nat.* p. 384.; "Nervous energy is effectually,

&c.," p. 399.; "The uses of the nerves, &c.," p. 324. Dr. Thomson: "An animal loses, &c."—*Chem.* p. 482. Dr. Paley: "To put the (*animal*) system, &c."—*Nat. Theol.* p. 36. In a note to the same work, p. 16., it is said, "That muscular contraction, &c." Dr. Watts: "If the nerves which go from the brain to any limb be cut, the will (*soul*) cannot make the limb move."—*Phil. Tracts.*

The motor nerves, and the nerves of sensation, although intimately blended throughout the physical system, have of late been traced and separated with very considerable success. The investigations of Sir C. Bell and others have already been referred to. See, also, on this subject, the following passages. Dr. Roget, "Bridg. Treat." p. 553., "The characteristic type, &c.;" p. 365., "The functions of sensation, &c." Dr. W. C. Henry, "Br. As. Rep." pp. 74, 75, 76. 91., "The vital offices of the, &c.;" p. 62., "In the higher manifestations, &c." Sharon Turner, "Sacred Hist." vol. ii. p. 151.: "The sensations from external things, &c." Dr. Henry, p. 83.: "There are thirty-two pairs of nerves, &c." Sharon Turner, "Sac. Hist." vol. ii. p. 152.: "I quote Dr. Henry's report, &c." Dr. George Gregory, "Econ. of Nat." vol. iii. p. 308.: "The medulla spinalis or spinal marrow is, &c." In "Convers. on Chem." vol. ii. p. 309., occurs this passage: "It is most probable, &c.;" for the last use of the word "body," read "mind." Dr. Paley, "Nat. Theol." p. 16.: "The nervous influence, &c."

Besides the nerves of sensation and the motor nerves, there are nerves which appertain to the vital functions: these are independent of the influence of the mind; they act of themselves so long as vitality exists; they have their origin in the head. The nerves which minister to involuntary motion have been disjoined from the nerves of sensation and action, and separately traced, at least to some extent.

The medulla oblongata is considered to be the part of the brain which is concerned in the respiratory functions. See Dr. W. C. Henry, "Br. As. Rep." p. 91. Perhaps it is chiefly concerned, also, in the other involuntary movements of the body.

The nervous influence is necessary to the vital functions; respiration, digestion, secretion, &c., cannot go on, if the influence of the brain and spinal marrow be intercepted. See Dr. Roget, "Bridg. Treat." vol. ii. p. 354. and ensuing pages. In p. 358. he says: "Although we are entirely ignorant, &c.;" in p. 360., "This distinction, &c." Dr. Prout, "Brid. Treat." p. 473.: "This resemblance is inferred, &c.;" p. 360., "This nervous power, &c." On the nerves of involuntary motion, see passages in the following writers: Dr. Geo. Gregory, "Econ. of Nat." p. 312.: "Some physiologists, &c." Dugald Stewart, p. 333.: "The vital and involuntary, &c."

A peculiar mystery seems to attach to the working of the brain in the involuntary and vital movements of the bodily frame. To a certain extent, we apprehend how the brain operates upon the mind in sensation, and the mind operates upon the brain in voluntary human action; or at least we know so much about these phenomena as to become thoroughly convinced that these influences operate. But with regard to brain-action in producing the mechanical movements of the vital organs, there seems to be an absence of moving power, — at least we cannot divine where it resides; — the machinery appears to be self-acting.

When the mind is overworked in purely mental occupation, or is seriously harassed by anxiety, the functions of the involuntary organs of the physical system are well known to be greatly interfered with; digestion, secretion, &c., are deranged. The laborious student, the man of business suffering under losses, and apprehensive of being unable to provide for his family or maintain his position in society, the minister of state in critical emergencies, all suffer in health by derangement of nervous and muscular action.

On the vital organs, Dr. Roget says: "The organs which are, &c."—*Bridg. Treat.* p. 354.

On vital existence, or vitality, see the same work, vol. ii. p. 362., "The whole of the phenomena, &c.;" and Dr. Prout's "Bridg. Treat." p. 417., "A living being considered, &c."

On the threefold distinction of the nerves, Dr. Kidd has a passage in his "Bridgewater Treat." p. 53., "The nervous system of man, &c."

On the nervous system of man, see farther, Kidd's "Bridg. Treat." ch. v. sect. ii., and Roget's "Bridg. Treat." vol. ii. part iii.

The exact composition of the nerves has not, I believe, been ascertained by any who have prosecuted researches in animal chemistry; there is yet to be determined whether the several sets or series of nerves do or do not differ, in some degree, from one another in respect to the substances which enter into their composition, or to the proportion in which the nervous elements are combined, or to their mechanical construction. "The brain and nerves," says Dr. Thomson, "have a strong resemblance to one another."

OF THE MUSCULAR SYSTEM GENERALLY.

Through the agency of the brain and motor nerves, the mind, in as mysterious a manner as in the case of direct influence on the brain, operates upon that portion of the muscular system which is under the control of the motor nerves.

The muscles are masses of fibrous matter attached in general to the bony structure of the body, and are capable of being contracted in length, and swelled out into unusual thickness. A contraction of the muscles is effected by the mind through the agency of the motor nerves. By the forcible contraction and thickening of muscle, the bones of the limbs and some other parts of the body are put into action. Locke says: "The instruments of motion are the muscles, — the fibres thereof contracting, move the several parts of the body."—*Nat. Phil.* p. 433.

The muscles are arranged in pairs, — one, being an antagonist to its fellow-one, draws the part of the body to which it is attached out of its ordinary or common state, — the other brings it back and keeps it in that state. Dr. Reid says, "Essays," p. 61.: "Anatomists inform us, &c.;" p. 130., "I will to stretch, &c." Dr. Gregory, "Econ. of Nature," has several good passages on this subject: p. 383., "Muscles never act, &c.;" p. 382., "The power of contraction, &c.;" p. 385., "The power which, &c." See also pp. 104. 156, 157, 158. 224, 225.

The muscles are naturally, in some degree, in a state of tension. When parted by accident or intention they contract or shorten; and there exists in the living subject a constant tendency of the muscles to contract, or rather a constant tendency of one muscle to pull against or draw out its antagonist muscle. Dr. Reid, "Inquiry," p. 205., says: "We know not how, &c." Dr. Gregory, "Ec. of Nat.," says, p. 158.: "Most muscles have others, &c.;" p. 167., "When there are two, &c.;" p. 108., "The muscles are more, &c.;"

p. 159., "When we speak of, &c." See also, pp. 164. 272. 383, 384. 385, 386.

During sleep, the mind seems to be deprived of its power of influencing the muscular system. In dreams, we are under a delusion that we are employing our muscular power in the ordinary way. In incubus, we are conscious of making, or suppose that we are making, great effort, but ineffectually, to relieve ourselves by muscular exertion from some severe pressure or restraint; but, as to this effort, are we also under a delusion; or do we really make it, though the nerves and muscles will not obey the impulse? We are not to forget that we are asleep — not partially awake — when agonised by incubus. The phenomena of somnambulism demand investigation. See what Dugald Stewart, in his "Elements," says: p. 330., "The will (*mind*) loses, &c.;" p. 331., "The fact seems to be, &c.;" p. 333., "In sleep the body, &c.;" p. 332., "During the disturbed, &c.," "In that particular, &c.;" p. 346., "There are many cases, &c."

Muscle, like the brain and nervous system, is susceptible of injury, so that it may become in an unfit state to perform the offices which naturally appertain to it. Muscle likewise becomes diseased, and wastes away; — in that case, muscular power goes. Man in sickness and in old age is prostrated more or less, becomes physically imbecile.

In muscular action the properties or powers of matter, both organic and inorganic, are necessary; mental influence, without the conjunctive influence of these, is wholly unavailable.

In paralysis, palsy, &c., the nervous and muscular systems seem to be so incapacitated that the impulse of the mind can no longer be obeyed. The physical system ceases, in part or wholly, to be an instrument of the mind. Locke says ("Hum. Und." vol. i. bk. ii. ch. xxi. p. 226.): "A palsy or the stocks hinder, &c."

Paley, in his "Nat. Theol.," has a number of lucid remarks upon the muscles and muscular action. Attention is especially directed to the following: p. 16., "The number and variety of, &c.;" p. 24., "Muscles with their, &c.;" p. 28. note, "Soft and yielding at one, &c.;" p. 24., "A muscle acts only, &c.;" p. 27., "The action of all," &c.;" p. 54., "Muscular action is, &c.;" p. 16., "In consequence of the, &c.;" p. 25., "It appears to be a fixed, &c.;" p. 16., "The principle of muscular, &c.," "We see nothing, &c.;" p. 24., "The animal functions, &c.;" p. 16., "Obscurity as to, &c."

In "Chambers's Journal," No. 251., occurs a passage: "Among the many wonders, &c." This number is on the Muscular Powers.

Muscular action can, after death, be affected to a limited extent by the impulse of the electric fluid. Dr. Kirby says, p. 32.: "When death separates, &c." Dr. Gregory, p. 384.: "Besides being influenced, &c."

OF INVOLUNTARY MUSCULAR ACTION.

Extensive and important departments of the nervous and muscular systems are not, in general, within range of the mind's influence. The movements of the lungs and other parts concerned in respiration, of the heart in propelling the blood, of the stomach in digestion, of the liver and other organs in secretion, of the intestines in passing rejected matter, of the vessels in depositing and carrying away matter,—all go on without human interference or control. We know not how these processes are effected within us, and if we had any power of direction we undoubtedly should do mischief.

Hobbes says: "There are in animals two kinds of motion, one vital and involuntary, the other animal (×) and voluntary."—*Enfield*, vol. ii. p. 496. See, in addition, passages in the following writers:—Locke, "Nat. Phil.," p. 433., "The contraction of the muscles, &c.;" vol. i. p. 226., "A man's heart beats, &c." Dr. Gregory, "Ec. of Nat." vol. iii. p. 283., "Uninterrupted respiration, &c.," "Over some of the muscles, &c.;" p. 268., "The heart is a hollow, &c.," "The ventricle receives, &c.," "The arteries pulsate, &c.;" p. 269., "The third tunic, &c.," "The muscular coat, &c.," "The second coat of, &c.," "The muscular coat of, &c.;" p. 384., "In the jejunum, &c.;" p. 250., "The bladder has a muscular, &c." Also other places in vol. iii.

Dr. Paley, in his "Natural Theology," treats of the vital and involuntary motions of the system:—p. 8. note, "The rapid shutting and opening of the eyelids goes on, &c.;" p. 34., "The salivary glands, &c.;" p. 16. note, "The gastric nerves, &c.;" p. 31., "It is by the contraction of, &c.;" p. 29., "By the contraction of, &c.;" p. 28., "Whatever be the cause of, &c.;" p. 36., "Observe the heart, &c.," "The lungs performing, &c.," "The liver, the kidneys, &c.;" p. 32., "We must remark the, &c.;" p. 36., "The bowels silently, &c.," "These several operations, &c.;" p. 31., "We cannot consider but, &c." Dr. Kidd, "Brid. Treat." p. 71., says: "The visceral nerves are appropriated to the mere vital functions of nutrition." Dr. W. C. Henry, "Brit. Ass. Rep." for 1833, p. 91., says: "There is no necessary dependence of the motions of the heart and the other involuntary muscles on the spinal marrow."

Weeping is involuntary; grief is expressed by weeping. Sobbing is involuntary. Laughter is in general irrepressible, hysterical laughter and sobbing always.

There are certain motions occasionally of the muscles which go directly contrary to the influence of the mind, and are usually accompanied by or produce intense agony: such is the cramp. In St. Vitus's dance, delirium tremens, and other like cases, the head, the hand, &c., move backwards and forwards, or shake, against the endeavours of the afflicted person to prevent these movements. Mr. Locke, "Hum. Und." vol. i. bk. ii. ch. xxi. p. 226., says: "Convulsive movements agitate a man's legs, &c."

Dr. Southwood Smith has drawn a beautiful contrast between the incessant untiring action of the involuntary muscles and the necessity of rest to the motor muscles. "The functions of the organic life are performed, &c." The terms "organic life" and "animal life," are not to my mind sufficiently distinct, nor are they, I think, quite accurately used.

Upon extraordinary occasions, mental influence has been known to extend to the independent or self-acting portion of the muscular system. Occasionally individuals are met with who seem to have considerable control over the vital functions of the physical system which ordinarily are in action wholly irrespective of mental influence. Dr. Cheyne gave an extraordinary account of a man who could to all appearance expire when he pleased and recover himself, exhibiting an instance of the power of the spirit over what are considered to be the independent organic operations of the body. See "Quarterly Review," No. 53.; Dr. Reid's Essay on "Hypochrondriasm and other Nervous Affections." See also the account of the Diver in the "Ency. Brit.," and that of the Posture Master in Burke's "Essay on Taste." In medical books also are recorded various extraordinary cases of the influence of the soul over the vital functions.

OF THE BONY STRUCTURE OR SKELETON

AS AN INSTRUMENT, OR APPARATUS, OR SYSTEM OF MECHANISM UNDER MENTAL INFLUENCE IN PHYSICAL ACTION.

The bones of the body are all hung together so as to form the framework of a wondrously constructed machine. Upon certain portions or parts of them the muscles and nerves, under the influence of the mind, operate, and by their means are the bones brought into action. The bones are levers by which motion and action are performed, and the muscles are firmly attached to them. When the arms and legs are moved, the head turned, and the trunk of the body contorted, the bones appropriated to these several movements are, by muscular contraction, &c., brought into play, and the several varieties of bodily action spring into existence.

Some parts of the bony structure are moved to a limited extent by the muscles of vital action. Thus the ribs rise and fall continually under the respiratory action of the lungs. But in general the bones are but walls, columns, or supports to the soft and fluid parts of the system, which could not sustain or keep themselves together, without these solid aids and protectors.

OF HUMAN ACTION GENERALLY.

Human actions present themselves almost invariably to our observation in a complex state. We have not frequently opportunities of observing detached simple acts; it is not therefore easy, with a view to illustrate each variety of simple human actions, to select instances wherein other parts of the physical system are not also engaged.

There is, however, no necessity to search for such instances, if only, in noticing human actions, we confine our observation exclusively to those parts of the body that exemplify the variety of mental influence which at the time we have under especial consideration.

The working of the muscles by the mind, through the medium of a portion of the brain and nervous system, originates a great variety of complex and simple human actions or physical operations.

No metaphysical work that I ever heard of enters into anything like a systematic examination of human action: notwithstanding the importance of, and indeed palpable necessity for the proceeding, scarcely has this part of the science been noticed by writers on the philosophy of the human mind. Under these circumstances we must proceed in the best manner we are able.

Physical actions give to the mind as eminently vivid and decisive an idea of *operation*, as mental influence upon and through the human body gives a clear notion of *power*.

It seems almost impertinent to again remark that human muscular action is altogether distinct from and unlike to volition, but metaphysicians having made the will the immediate author both of volition and human action, the intimation is not unnecessarily repeated.

Muscular action is of various kinds, according to the parts of the body which are brought into play by mental influence.

We may employ our limbs and put into action other parts of the body without necessarily having subjects to act upon.

The human body is always necessarily in contact with some of the masses which surround it; the material property of gravitation enforces this. There is perhaps no human action to which external bodies are not parties or auxiliaries, though not subjects; in all cases the earth or the water, or some other body supported by them, forms a *fulcrum*, without which human action could not have existence.

Masses exterior to the human body are operated upon by the mind through the agency of the physical system. The mind has the power of specially placing any of the superficial parts of the physical system in contact with, and in action upon, particular substances or masses organised or inorganic.

I at one time thought it desirable to confine as much as possible the attention in the first instance to those actions which are unconnected with external bodies as subjects, and then to consider human actions as they spread themselves out upon exterior masses; but I was obliged to abandon this distinction, finding it extremely inconvenient, if not impossible, to sustain it; such an arrangement, however, if practicable, might in a metaphysical respect be useful.

"The physical differences," says Dr. Kidd, "observable in comparing the structure of the infant with that of the adult, which enable the one to execute many operations of which the other is incapable, exist to a certain extent in every part of the body, but are perhaps more remarkable in the spine than in any other part."—*Bridg. Treat.* p. 12.

Human beings very frequently combine their physical powers, and act in concert in the performance of actions to which numbers are essential.

Besides the employment by mankind of their muscular powers in combination, they use them in opposition, giving rise thereby to an extensive class of social actions.

OF THE MOTOR NERVES, MUSCLES, AND ACTIONS OF THE HEAD AND ITS PARTS.

Action of the organs of sensation. — The organs of sensation have attached to them particular motor nerves and muscles, by means of which these organs are, in some degree, moveable at the pleasure of the individual; the utility of these organs as sources of gratification is thereby added to considerably.

Mental influence over the organs of sensation gives birth to a class of human actions which is of considerable importance to us in regard to sensual gratification. The organs of sensation being, in some degree, under the management of the mind, stand in the relation of *instruments*, of which the mind makes use at its pleasure for specific purposes, viz., to increase, diminish, or avoid sensation.

By every individual exercise of the sensual organs is evidenced the existence and energy of a ruling inward influence, not organic, but operating by means of nervous and muscular organisation. Each such exercise brings with it to the individual operating a knowledge of this power of influencing the sensual organs.

We experience numerous and important sensations through the medium of various parts of our body, which are not, with reference to sensation, organic. Over some of these parts we have no immediate or proper influence; over others we have influence, partially in some cases, in others to some extent.

Human action, either in bringing the organ of taste or of smell into contact with a sapid or odoriferous substance, or in bringing the substance into contact with the organ, may, perhaps, with propriety, be considered as one means in the process of discovering the causes of sensation.

The action of the eyes, eyebrows, and eyelids. — The eyes are the organs of sensation which, perhaps, are most under mental influence. Ophthalmic sensation we can altogether prevent by bringing together the eyelids, and can partially prevent by covering part of the eyeballs with the eyelids. The latter act we are in the habit of performing when the light or heat is too strong for the eyes, and would, if not in some degree excluded, occasion pain.

The eyes are organs of perception, as well as of sensation, — the other organs of sensation are not. The mind controls the eyes, not only so as to modify the action of light thereon, but also so as to regulate vision.

The field of vision we may vary by moving the eyeballs, but it cannot be completely altered without the movement of the head.

Short-sighted persons, when endeavouring to see as clearly as they can an object which is rather beyond their range of distinct vision, contract the eyelids, perhaps slightly compress the eyeballs, and, I think, a little propel them.

The eyelids, as the protectors of the eye, are readily and freely moveable up and down.

Infants immediately after birth partially employ the visual organs of perception, and move their limbs; but in their earliest growth they make more rapid progress in the use of the eyes than of the limbs.

For a description of the muscles by which we move the eyes, and the adjacent parts connected therewith, see Roget's "Bridg. Treat." p. 464.

Dr. G. Gregory, in "Econ. of Nat.," enumerates the muscles of the eye, eyelids, &c., and points out the purposes they serve. See especially, p. 161., "The ball of the eye has, &c.," "The effect of this curious, &c.," "The use of the oblique, &c.," "By acting successively, &c.," "The muscles of the eyelids, &c.;" p. 160., "The skin which covers, &c."

Dr. Reid has many remarks on the movements of the eye and its adjuncts. "Inquiry," p. 282., "We need only, &c.;" p. 327., "It is well known that, &c.;" p. 265., "We have naturally, &c.;" p. 203., "Nature (*God*) hath wisely, &c.;" "When both eyes are open, &c.;" p. 276., "The parallelism of the, &c.;" p. 329., "In order to direct, &c.;" p. 207., "The power of varying, &c.;" p. 265., "In the ordinary and natural, &c.;" p. 204., "Of this motion, &c.;" p. 325., "There are several motions, &c.;" p. 326., "Although we are not, &c.;" p. 216., "When we see in so many, &c."

On the rapid movements of the organs of vision, see Stewart, "Elements," ch. ii. p. 117.

It is remarked in Paley, that "muscles are attached to the ball of the eye, which enable it to move easily, &c."—Note, p. 4. to *Nat. Theol.*

Men roll the eye under excitement.—"The poet's eye in a fine frenzy rolling, glances from heaven to earth, &c."

Other actions are: that of frowning; knitting the eyebrows in anger; staring to alarm, to threaten, in wonder, to annoy; winking, when not involuntary, but the effect of a bad habit; working the eyebrows and the skin of the forehead up and down, a habit with some persons when the mind is more than usually on the fret.

The action of the ears. — The organs of hearing are scarcely at all under the direct influence of the human mind; we can neither close nor open our ears; we, in fact, possess very little immediate authority over the muscles which are in connection with these organs, or form part of their organisation; and therefore by such means can neither prevent, nor increase, nor diminish, the sensations of sound. Many classes of brute animals, on the contrary, can move their ears with great readiness, the dog, the horse, the ass, &c. "The muscles," says Dr. Gregory, "with which the ear is furnished, and which are much employed by quadrupeds, are of little or no use to man."

The action of the nose. — Over the organ of smell the mind has some control, although the organ itself is only slightly moveable. We can avoid sensation of smell by refraining to breathe through the nostrils, but the restraint is short-lived. On the other hand, we can increase sensation by snuffing effluvia.

Snuffing is an act or operation performed on some occasions for the purpose of increasing sensation. It is, however, frequently performed with ulterior objects, viz., to ascertain in part from what body or substance an odour proceeds; also to distinguish bodies.

In smelling, there is usually both sensation and action, and, in common language, when we are said to smell, combined action and sensation are generally intended.

Dr. Gregory describes the muscles of the nose over which the mind has some little power, "Econ. of Nat.," vol. iii. p. 162.: "The nose is affected, &c.," "The levator labii, &c.;" p. 415., "The nostrils are furnished, &c.;" p. 254., "We have the power, &c."

Some persons, when anger is brewing within them, work the muscles of the nose violently, and the state of their feelings is, by that action, made evident to beholders.

Blowing the nose is an action of the lungs at the instigation or under the impulse of the mind, by which the breath is forcibly driven through the nostrils.

Turning up the nose in disgust or contempt.

It is the practice of some savage people to play their wind instruments by blowing into them through the nostrils instead of the mouth.

The action of the mouth and its parts. — The mouth is a most important instrument of the mind, being employed in eating, speaking, singing, &c. It is therefore readily under mental command; and the muscles are numerous and very curiously arranged and inserted.

Dr. Gregory describes with particularity the muscles employed in the movements of the mouth and its parts, with their special uses. See "Econ. of Nat." vol. iii. pp. 164, 165, 166, 167. 412.

Captain Cook, in his "Voyages," describes the several modes in which various actions with the lips, tongue, &c., were performed by the uncivilised nations of the countries he visited.

Some of the actions of the mouth and its parts are these: — Sucking. Dr. Reid says ("Essays," p. 80.): "We come into the world, &c." Paley says ("Nat. Theol." p. 26.): "There is one case, &c." Smacking the lips. Opening and shutting the mouth, opening the lips without separating the teeth, showing the teeth in rage. Kissing. "And he gave them a sign, saying, Whomsoever I shall kiss that same is he, hold him fast; and he came to Jesus and said, Hail master, and kissed him." "Betrayest thou the son of man with a kiss!" "Suffer me to kiss my father and my mother;" kissing the hand in compliment; kissing the hand of a monarch.

The tongue is readily movable by direct mental influence, and in tasting it is brought constantly into action; seldom, however, solitarily, because there is commonly a necessity to place the substance to be tasted within the mouth, to do which another kind of action is required, which will be considered hereafter; ordinarily also mastication and deglutition accompany tasting. Tasting usually comprises both sensation and action. It is beneficially employed in discriminating bodies, as has been already remarked.

Licking the lips; licking any other things.

"Rolling sin as a sweet morsel under the tongue."

Masticating or chewing food, opium, tobacco, &c. Biting in rage. "He bit off his opponent's nose." Biting the arms, fingers, &c. Grinding the teeth in rage. "And they gnashed upon him with their teeth." "There shall be weeping, and wailing, and gnashing of teeth." Spitting or expectorating. Spitting at or upon a person as an insult. "And they spat upon Jesus." Expectoration in pulmonary consumption. Constant expectoration is frequently an accompaniment of old age. Swallowing solids and liquids. Expelling the breath forcibly against anything, as in blowing out a candle. Blowing through wind instruments. The action of the various parts of the mouth in modulating articulate sounds in speaking, and musical sounds in singing. Paley has many excellent remarks on the exquisite facility of action there is in the tongue, &c., in articulation and singing. "Nat. Theol." p. 25.: "It is worth any one's while, &c.;" "Each syllable of articulate sound, &c.;" "The inextricable multiplicity of fibres, &c.;" "The muscles of the tongue, &c." Sumner remarks ("Records of Creation," vol. i. p. 46.), "Whoever has watched the progress of speech in children, &c."

The mouth and its parts as an entire organ is thus extensively and freely under the influence of the mind. The mouth and its parts considered as an organ of sensation is more under the mind's control than either the ear or the nose; nevertheless, the mind has no power of producing sensations of taste otherwise than by bringing into contact with the organ those substances which will excite the organ, nor of preventing sensations of taste whenever suitable substances are applied to it. It is not, in fact, as the organ of taste that the mouth and its parts are movable or under mental influence, but as the organ of mastication, articulation, &c.

Other actions of the head.—Amongst the physical operations of which man is capable, the movements of the head are most important, some of them little on their own account, but greatly because they corroborate other important actions, particularly those of the organs of sensation and perception.

The head also performs an effective part in that most valuable class of actions which are termed Gestures, and which will be particularly considered hereafter.

Dr. G. Gregory describes with minuteness the muscles of the head, and the action each is intended to perform. See "Ec. of Nat."

Dr. Paley remarks, "The head was to have the power, &c."—*Nat. Theol.* p. 18.

Among the actions of the head are bowing—in the worship of God, as an act of respect to man. "And he bowed the head, and gave up the ghost." In this act the body or trunk is usually bent along with the head. Nodding to a friend or acquaintance in recognition, to a child or other person as a token of approbation; inclining the head aside, &c., for the purpose of hearing better, listening. Tossing the head in disdain.

Shaking the head, or turning it from side to side in disapprobation of conduct, or dissatisfaction with argument, &c. Smiling to an individual whom we are pleased to see or of whose conduct we approve. "A few days after infants are born," says Dr. Reid, "sometimes a few hours, we see them smile in their sleep, &c."—*Essays*, p. 79. Grinning: "Ran about the street grinning like a dog." Making faces: distortions of the eyes, face, &c., in the war song of the New Zealanders. See Cook's "Voyages," vol. v. p. 236., vol. ii. p. 254.

Besides these varieties of mental influence, there is the command of the countenance. The muscles of the face constitute an engine of immense force, under the control of the mind, on account of the association of the movements of the face with the intentions, feelings, desires, &c., of the soul.

The expression of the countenance is a species of human action when it is voluntary or intentional, as in the performances of the stage, in mimickry, in diplomacy, and not unfrequently in oratorical exhibitions. In unsophisticated life the expression of the countenance is almost always spontaneous, there being some inexplicable connection between the muscles of the face and the emotions and workings of the mind; and most commonly we are unaware of the changes in our countenance. "The muscles of the face," says Gregory, "are the organs which, being affected by the passions, render the human countenance an index of what is passing in the mind." Control over the physical expressions of feeling, so as to deceive lookers on, is exhibited by culprits under trial for heinous offences — it is a finished acquirement of the hypocrite. The movements of the features of the face, and consequent alteration of the countenance, by tragedians, by comedians, by mimics (such as Mathews was), who are clever in putting on droll looks, distorting their features, &c.; by culprits under trial, and others who wish to cover or conceal their feelings and consciousness of guilt, and to impose upon those who they know are keenly watching the changes which the countenance usually and almost unavoidably undergoes in trying circumstances. An individual who can stifle the natural changes of the face is said to be imperturbable.

OF THE MOTOR NERVES, MUSCLES, AND ACTIONS OF THE TRUNK.

The action of the throat. — Dr. Gregory describes the muscles employed in swallowing, &c. "Ec. of Nat." p. 347, &c. Paley says: "There is a muscular constriction," &c.; "The small muscle of the glottis," &c. —*Nat. Theol.* pp. 24, 25. Some persons experience great difficulty in swallowing through defect of muscular energy in the throat, &c.; and occasionally by disease or injury of the parts no solids can be passed, and scarcely liquids. The act of eating is a complex act, comprising the muscular co-operation of the mouth, throat, &c., in chewing and swallowing. Drinking is also somewhat of a complex act, requiring the assistance of some of the muscles and parts of the mouth to corroborate the action of the muscles of the throat.

Resisting strangulation. Attempting to eject any substance which has become fixed in the gullet, and occasions irritation or threatens suffocation: the muscular effort is often very violent. The action of the throat in endeavouring to vomit is a reverse action to swallowing, and to few persons is it facile.

The action of the throat in producing and modulating sounds. Holding in the breath or suppression of breathing: this is a violent, painful, and injurious effort on the part of divers, the pearl-divers especially.

The action of the lungs.—Respiration is essentially a spontaneous physical operation; it goes on without mental interference, and must not be prevented, or vitality ceases: still the soul has control over the machinery of the lungs, so as to regulate in some degree the admission, retention, and emission of air. We are sometimes in situations where the regulation of breathing is of moment; such is the case when we bathe, when we pass through a tainted and offensive current of air, or have such current pass over us; and when we wish to conceal our approach from others. For descriptions of the muscles of the lungs see Dr. G. Gregory, "Econ. of Nat."

When the sirocco approaches, travellers exposed to it must fall on their faces and avoid inhaling it, or death is the consequence. Shrieks, &c., under flogging or other tortures, are suppressed by North American Indians, by soldiers and sailors, and were in former times by state prisoners. A full inspiration takes place in the act of singing; public singers are seen to heave or expand the chest, to take in the fullest quantity of air.

Forcible expiration takes place in blowing out a candle, in puffing away dust, in blowing up feathers, bubbles, &c., in attempting to kindle red-hot wood or live coal into flame. "And God breathed into his nostrils the breath of life." "And he breathed upon them and said, Receive ye the Holy Ghost." Breathing into the nostrils or mouth is, I believe, part of the process in recovering persons who have been drowned.

In producing vocal sounds, an act which is so important to man in a variety of respects, the quantity of air emitted from the lungs is regulated in part by the muscles of the lungs. In singing and talking the loudness or softness of the tone, and the swell, are generally the result of the influenced action of the lungs. The swell is preceded by a very full intentional inspiration, as is remarkably observable in first rate female singers.

In blowing into pipes, trumpets, and such like musical instruments, the lungs are made forcibly to emit an unusual quantity of air, and, of course, an equivalent quantity must be intentionally inhaled.

The conjoint action of the lungs, throat, and mouth.— The production of musical vocal sounds requires the united action of the lungs and throat, and articulate sounds demand in addition the action of the mouth. Shouting, singing, speaking, are therefore complex acts, in the performance of which parts of the trunk and of the head are combined, constituting an apparatus as surprising as is the construction of some other parts of our wonderful frame.

The sounds which are the product of this exquisite apparatus, are divisible naturally into, first, inarticulate sounds, or such as man makes in common with the brute; secondly, articulate sounds, or speech, which a few animals only can produce; and, thirdly, musical sounds.

The management of the vocal organs is a most important species of mental influence upon the physical system.

The atmospheric air passes into and from the lungs, and in its passage out, or rather expulsion from them, it can be regulated and made to act upon certain parts of the throat and mouth which are peculiarly organised with a view to the production of sound.

The inarticulate or animal sounds which are produced by man are very distinctly various, and are of great value as expressive of the intentions and desires, as well as of the emotions, of the mind. They are universally understood, but least of all in highly polished communities, because the perfection of articulate expression there attained leads to the neglect in some degree of that natural and forcible expression of which animal sounds are notoriously capable. These sounds constitute one part of what is termed natural language.

The muscles employed in producing natural sounds are described by Dr. G. Gregory, "Econ. of Nat." vol. iii. pp. 379, 380.

Amongst inarticulate sounds are hallooing, shouting, yelling, hurrahing by a mob, by soldiery when attacking, &c.; cheering at a public dinner; cheering, hissing, &c. in legislatures and at political assemblages; cheering on dogs in the chase; the huntsman's tallyho; whistling, which is a mode of producing a kind of musical sound; murmuring; imitating, or mimicking the natural voices of animals.

Laughter is a description of sound which an individual oftentimes appears quite incapable of restraining; circumstances of a peculiar character affect the mind in such a manner that this variety of sound is unavoidably occasioned. Laughter, however, may be assumed, or, as it were, imitated; this is done by comedians, and by other individuals when desirous of misleading or amusing those who are in their company. Laughter, being properly neither the result of mental effort nor a mere mechanical operation, appears to be a particularly mysterious phenomenon.

Vocal sounds are expressive of grief or pain, when the emotions or sensations are violent and uncontrollable. These stand in much the same relation to the mind as laughter; they are in a certain sense independent of the mind, but result only from action upon the mind. Weeping, sighing, moaning, groaning, hysterical sounds, and sometimes shrieking, are of this class. All these sounds, however, are also producible voluntarily, and it is not always easy to determine when they are natural and when put on.

Howling at deaths and funerals was not unusual amongst the ancients. According to the descriptions of Parke and other travellers, the Africans make dismal howlings on these occasions. The Irish howl at wakes.

Coughing is a sound occasioned by material action upon the lungs and throat, increasing irritation of those parts, usually against mental effort, and sometimes producing so much pain and inconvenience that the individual affected strives hard to repress it. Its inconvenience at times to others also induces an endeavour to stifle it.

Articulate sounds are simple single sounds, or combinations of simple sounds. Spoken words or vocal symbols are mostly syllabic combinations of simple sounds.

The class of articulate sounds is most valuable, because of its associations with beings and substances, with ideas and notions, with physical and intellectual operations, with sensations, feelings, &c.

Articulate sounds are and have been universally used by mankind for symbols of material and intellectual matters; and if the almost innumerable diversities of language current amongst the several races and nations into which mankind is divided be an astonishing phenomenon, the universality of speech, and its invariable application to all and each of the above purposes of expression, is still more wonderful. Rude tribes have been discovered ignorant of the employment of fire, but no tribe has been found without spoken language, nor has any one failed to apply it to those several uses which have been above enumerated.

On muscular action in speaking, see Gregory, "Econ. of Nat." vol. iii.

On the act of speaking, see Reid's "Essays," vol. iii. p. 141.: "Articulate language is spoken, &c." Locke, "Hum. Und." vol. i. p. 138., "When children have got, &c.;" p. 427., "Man had therefore, &c.;" p. 430., "As those articulate, &c.;" vol. ii. p. 28., "This mark A is, &c.;" p. 138., "When children have, &c." Stewart's "Elements," p. 15.: "It has been found by actual trial, that it is possible to pronounce about two thousand letters in a minute."

Articulation includes reading or reciting well, elocution, declaiming.

Speaking is the chief element in oratory, though eloquence produces an imperfect effect without gesture and facial expression.

The voice is modulated, or the various tones of which it is capable are so used as to give proper expression in speaking, reading, &c. "Plutarch tells us that the sophists, in order to allure and interest their hearers, took great pains to soften and modulate their voices by the sweetest musical accents, and soothing tones, and harmonised modifications, which they could practise." — *Turner's Sacred Hist.* vol. ii. p. 141.

We have, as combinations of voice, the responses of religious assemblies,—in a Jewish synagogue, in Roman Catholic churches, in the English Church, &c.

Whispering is one mode of vocal utterance. "The larynx is very little used, if at all, in whispering, and seems to transmit the air in this case as a simple tube, like the windpipe."—*Gregory, Econ. of Nat.* vol. iii. p. 381.

There are in the case of some persons difficulties of a muscular or nervous nature in the way of a clear articulation; such are stammering, &c.

The voice is occasionally lost by catarrh, &c. Dr. Reid says ("Essays," p. 77. vol. iii.), "A man in his sleep may be struck, &c."

There are certain instrumental aids to speaking. Tubes are spoken through for the purpose of increasing the loudness of the voice . — the speaking-trumpet used at sea.

Singing is the act of producing both articulate and musical sounds. There are solo or air singing, glee singing, chorus singing, cathedral chanting and intoning, anthem singing.

Captain Cook, in his voyages, gives many descriptions of the singing, chanting, &c., of the South Sea Islanders and others. Accounts are given by various writers of the celebrated *Miserere* in St. Peter's at Rome, and other musical voice-performances; also of the modes of teaching practised in Italy and elsewhere.

Other actions of the trunk.—We have power over the muscles of the throat in swallowing, &c., and over the lungs; but over the internal operations of the trunk, the action of the stomach, heart, &c., we have little, if any power.

Dr. G. Gregory describes the muscles of the various parts of the trunk and their several uses.

In the emission of fæces and urine we can exert muscular force and control involuntary muscular action, until, by a weakening of the muscles, the consequence of disease, accident, or age, this influence is much straitened or is lost.

In forcing or preventing excretions, the effort is oftentimes violent and exceedingly distressing. Forcible expulsion is chiefly effected by the agency of the lungs, &c., pressure being produced upon the stomach. The action of the muscles at the back of the head is also very evident.

The mind has much power in producing the attitudes, postures, &c., of the body. By special muscles the trunk is erected, bent forwards, backwards, or sideways.

In addition to various particular actions, there is the general action of the trunk in its many changes of posture and attitude, and in that constant balancing which requires the unceasing attention and influence of the mind. The continuous act of balancing the body is shown when standing, when in motion or action, riding on horseback, dancing on the tight or slack rope, standing on one foot, hopping, sliding, skating, standing or walking on stilts, standing on a horse whilst the horse is going in a circle at full speed, as at Astley's theatre, &c.

In balancing the body, such actions as sliding, skating, walking on stilts, not being common, require much care and practice, particularly skating, which is learnt with difficulty, and, when acquired, is, in England, performed ungracefully by most skaters. In countries (Russia, Holland, &c.) where the winter is colder and much longer, skating is more common and more pleasingly executed. Dr. Reid has some remarks on balancing the body. See "Essays," vol. iii. p. 207. : "It may be compared, &c." "One of these is the instinct, (×), &c."

Amongst the actions of the trunk are shrugging the shoulders; rolling the body over and over, as children do on the turf, persons in bed when sleepless and restless, individuals in great bodily pain; placing the body very upright, as required by the drill sergeant; lifting up or raising the body by muscular effort, to overcome the gravitating influence of the earth, which is done when we rise from the ground, or from a seat, jump up, or take a standing leap; turning the trunk partly round on either side and back again; bending the body sideways, and pulling it up again; bending the body downwards in front, and raising it again by the action of the muscles about the lower part of the spine: this act is termed bowing, and is done, in reverence, to God,—as an act of respect, to equals or superiors. Throwing the body on the earth, or prostration;—in adoration, to God: "And he fell on his face and worshipped;"—as a servile act to an absolute monarch—Chinese prostration to the Emperor; — in terror: "And Paul fell on his face to the earth." Captain Cook and African and Asiatic travellers describe many ceremonies of prostration, &c., practised among among uncivilised and semi-barbarous tribes and nations. Tumbling, or throwing the body over and over, by means chiefly of the hands, as done by gipsies; in this complex act, great power in bending the spine and working the muscles of the trunk is exhibited, facility in which is acquired only by constant practice in childhood and youth. Writhing under the lash or other infliction of injury, partly involuntary; bending and twisting the body to weaken the effect of lashing or flogging; the movements of the trunk, or parts of it, in gestures, oratory, natural language, &c.; the general action of the muscles of the trunk in supporting or assisting the action of the limbs. When we apply violent exertion to the arms or the legs, we corroborate the effort with the muscular force of the trunk, that of the back and loins particularly. Holding in a spirited horse by main force: this act causes a violent strain upon the muscles of the trunk in resisting the great force exerted by the animal. Thrusting the body against anything to displace or move it, or pressing with the weight of the whole body against it for the same purpose, besides some other actions.

OF THE MOTOR NERVES, MUSCLES, AND ACTIONS OF THE INFERIOR OR LOWER LIMBS.

The limbs are the parts of the physical system which are the most effectively under mental control. Let us first consider the action of the lower or inferior limbs.

To distinguish the action of the inferior from those of the superior limbs, the former might be called skelion actions from σκελος, leg; or pedal actions, from *pes*, a foot.

The various muscles of the leg, foot, and toes, are described minutely by Dr. G. Gregory, with the movement each muscle or combination of muscles effects. Dr. Roget says, "Bridg. Treat.," vol. ii. p. 355.: "Of the function of voluntary motion, so far as concerns the moving powers and mechanism of the instruments employed, I have already treated at sufficient length in the first part of this work."

The principal use that man makes of the lower limbs is to move the body from place to place; they are the instruments of locomotion.

The modes of moving the body from place to place by the instrumentality of the lower limbs are various in character. The common but essential varieties of human locomotion have obtained suitable terms in all languages. Locke says: "To slide, roll, tumble, &c." —*Hum. Und.* vol. i. p. 210.

Human movements vary also in degree. We walk slowly or run rapidly, &c. Degrees of human motion are indicated in most languages with tolerable precision.

Amongst the modes of movement we have

Walking.—"Infants, before they can walk without stumbling," says Dr. Reid, "must be exposed to many a fall and bruise." —*Essays*, vol. iii. p. 221. Travellers and voyagers represent uncivilised and imperfectly civilised people to be far more firm and graceful in their walking than Europeans. The Hindoos and other Asiatics, the North American Indians, the South Sea Islanders, are described as having these characteristics. Reid says, "Essays," vol. iii. p. 101.: "When the opportunity, &c."; vol. ii. p. 268., "The power of walking is, &c."; vol. iii. p. 452., "It is natural to, &c." Capt. Cook remarks, "Voyages," vol. v. p. 436.: "The graceful air and firm step, &c.;" vol. i. p. 188., "In their motions, &c."

A considerable portion of many men's daily occupation consists in walking to and from their places of residence and business. The multitude of young men engaged in commercial pursuits who press into and depart from London every morning and evening except Sunday, from the hours of eight to ten A. M., and five to seven P. M., affords a lively, and, to a countryman, a marvellous illustration of this variety of human action. "Walking is the best possible exercise; habituate yourself to walking very far. The Europeans value themselves, &c." —*Jefferson's Memoirs.*

Many have been the feats in pedestrianism. Capt. Barclay's performance of 1000 miles in 1000 hours is one of the most noted. Matches or contests in rapid or lengthy walking frequently take place. Amongst the varieties of this mode of motion, we have striding, or taking the widest possible steps:—"a giant's stride." Marching: this is measured walking; it is the practised step of soldiery. Moving the legs as if walking or marching, but without change of place: this is required in the drill of soldiers and in gymnastic exercises; it is a droll sight. Walking on stilts. In several of the arts polite and common, the inferior limbs are employed in the subordinate occupation of changing the position of the artist as occasion requires.

Running.—"Then Ahimaaz ran by the way of the plain and overran Cushi." "So they ran both together, and the other disciple did outrun Peter, and came first to the sepulchre." Foot-racing, in the Olympic games, amongst savages; modern matches in England and elsewhere; the surprising expedition and length of travel of couriers or runners amongst some Asiatic nations. Coursing or hunting hares, &c. on foot. Running in the game of prisoners' bars, and in other children's games. In running measured strides are sometimes taken, as in the boys' game of hop, skip, and jump. Trotting or skipping along, the same leg sometimes being kept foremost: female children in their gaiety may frequently be seen to skip along, but generally putting each leg foremost alternately.

Leaping or jumping over a thing or over a space—a standing or running leap.—The leap is taken chiefly by the muscular energy of the trunk, and its height or length depends mainly upon the muscular vigour of the trunk compared with its weight; whilst an individual is cleaving the air, both the legs and trunk are passive. Leaping over fences, streams, &c., without the aid of the hands. Many instances of extraordinary leaping are recorded. Ireland was a celebrated vaulter: see "New Monthly Magazine." Professional vaulting is, however, usually performed with the assistance of a pole, spring-board, &c.

Dancing.—The lower limbs are chiefly, but not exclusively, used in this complex amusement. An amusing anecdote of Lord Sandwich is given in Cradock's "Memoirs."

Other motions or actions of the legs are these:—Hopping or moving along upon one leg; the performance of this act requires much muscular energy in raising the body and balancing it. Swinging round on one foot, a wondrous feat amongst female opera dancers; the uplifted leg assists in balancing the body during the whirl; the muscular action is chiefly referable to the trunk. Rubbing the feet on mats, &c. Skating by the northern nations,—the evolutions of graceful and skilful skaters. Kneeling or bending the knees; in prayer, to God; supplicatory to a monarch or magistrate. In this act frequently one knee only is brought to the ground, the other being bent. The use of the legs in creeping on all fours. The co-operation of the knee or of the foot in breaking a bar when placed against it, the ends being forcibly pulled by the hands.

Trampling or treading upon. "And he put his foot upon the necks of these kings." Crushing insects, &c. Stamping the feet in approbation at a public assembly, political, social, or charitable—in anger. Standing on tiptoe; this position requires strong muscular action of the forward parts of the foot. Spreading the legs or straddling. By this act the body is placed on a firmer basis, and offers more effectual resistance to a driving or dragging force. The action of the legs in swimming, by which the body is chiefly propelled. In swimming the body is thrust on partly by the legs, and partly by the arms, but the most so by the former; the feet are drawn in and then struck out with violence directly against the water.

The foot is employed in striking or kicking a person, and to drive a thing from its place: in the game of football; in wrestling, as it was practised by the professed wrestlers of antiquity, and is now pursued in the West of England and elsewhere; in tripping up a person.

The lower limbs are habitually employed in common with other parts of the muscular system in supporting and conveying masses animate and inanimate from place to place. The action of one foot upon instruments: turning a wheel by the knife-grinder, by females at the spinning-wheel; working the bellows of a chamber organ. The action of both feet upon an instrument: working the pedals of an organ, a very laborious part of the performance.

In certain subordinate respects, the lower limbs are instruments of grasp or prehension; with these men keep themselves firmly on horseback, take hold in climbing, and cling to a person or thing.

When let down from precipices, as in the Orkneys, a man swings himself from spot to spot by pushing with his feet against the rock.

There is a variety of minor movements with the legs and feet: altering, for comfort's sake, the position of the legs whilst sitting; crossing, uncrossing, and stretching them out; shaking the foot quickly; widening or bringing together the legs for the purpose of catching anything thrown into the lap; dancing a child on the knee, &c.

In most of the varieties of action enumerated in this section, the lower limbs are the agents principally concerned; yet the superior limbs and the muscles of the trunk, are all necessarily employed in connection with them. Racing, dancing, swimming, climbing, &c., are in truth complex actions.

Some individuals, having been without hands, or having lost the use of them, have employed their feet in writing and painting. Hindoos use their toes very much when Europeans would use their fingers. See Ward's "View of the Hindoos," vol. i. p. 187.

Invasions, migrations of families, tribes, &c., are carried on to a great extent on foot.

The *act* of moving and the *state* of being in motion, ought ever to be clearly distinguished from the *power* of self-motion, and of occasioning motion in others.

ON THE MOTOR NERVES, MUSCLES, AND ACTIONS OF THE SUPERIOR OR UPPER LIMBS.

To discriminate human actions performed by means of the arms and hands from the preceding class, they might, in philosophical works, be called Agkalian actions, from *αγκαλη*, a bent arm; or Cheirian actions, from *χειρ*, a hand. They are called Manual actions, from *manus*, a hand.

Dr. G. Gregory describes the several muscles of the arm and hand in the "Econ. of Nat."

The hand is an exceedingly flexible organ, admirably adapted in its construction for the purposes for which it was intended; and it is, perhaps, more perfectly under the control of the mind than any other part of the human body. The hand is the corporeal organ which pre-eminently distinguishes man from the brute.

Galen, "On the Use of the various Parts of the Body" (lib. i., also lib. iii. cap. 10.), describes with great minuteness and beauty, the adaptation of the hand in all its parts to effect what it was constructed to perform. Dr. Kidd, in his "Bridgewater Treatise," pp. 31. 33. 39., gives some most interesting extracts from Galen. Dr. Kidd himself makes a number of excellent remarks on this subject; his third chapter is on the powers of the human hand, considered as a corporeal organ. He describes the hand as "that wonderful auxiliary of the human powers," p. 11.; and says, "Of what use, under these circumstances, would be that *instrument of instruments* the human hand, where there was (*would be*) no presiding mind to direct its movements," p. 11. See also p. 19.: "Were man's form deficient, &c." Dr. Roget ("Bridg. Treat." vol. ii. p. 392.) says, "The sense (×) of touch attains, &c." Paley remarks ("Nat. Theol.," p. 19.): "The fore arm, that is, &c." In a note to that work, p. 26.: "Were man's hand as strong, &c." Turner ("Sacred Hist.," vol. i. p. 510.) says, "The chief distinguishing superiority (*over brutes*) which, &c."

Amongst the various uses of the parts of the hand are the following: —

Employment of the nails in scraping, peeling, scratching, &c.: scratching a person's face with the nails is a mode of conflict to which women and children occasionally resort. Snapping the fingers: when negroes snap their fingers it is a sure sign of desperation. It is common to snap the fingers after taking a pinch of snuff to clear them of the loose adhering particles. The fingers are sometimes snapt at a person in derision. Snapping the fingers is a common action with boys. Shooting marbles with the knuckles. Pointing with the fingers to a place or object to direct or to guide observation; pointing in scorn. Conversing with the fingers — a method of interchanging thoughts between deaf and dumb persons and others. Clinching the hands or intertwining the fingers forcibly when in agony. Twisting together the fingers, and placing the hands in particular relative positions for the purpose of throwing shadows on the wall, like to the head, &c., of certain animals,—an action performed to amuse children. Using the finger to trace on a table, &c.: "And he stooped and wrote with his finger on the ground." Clapping the hands, in token of approbation, in political and other public assemblies; by children as a joyous act; by a schoolmaster to obtain attention. Beckoning with the hand to approach, to go back, to keep silence, &c.: "Paul stood on the stairs and beckoned with the hand unto the people." Rubbing together the hands, as a token of satisfaction, or for the purpose of warming them. Rubbing any part of the body with the hand, to promote circulation, to increase warmth, to allay pain ; shampooing. We particularly rub a bruised or swollen part. Stroking an animal, a boy's head. Wringing the hands in affliction. Shaking the fist in threat at a person or a domestic animal. Women polish tea-trays with their hands.

Touching an object, or passing the hand over or handling it with a view to perceptive examination. The hand must be esteemed the most important organ or instrument of perception; by its agency the most essential part, the groundwork, of our knowledge of the material world is obtained. The exercise of the mind's influence over the hands, as organs of perception, is most important. By means of contact and touching, the mind obtains, as will be fully shown hereafter under the head of "Perception," much elementary and indispensable information concerning the material world; it obtains knowledge of the *condition* or *state* in which masses at any moment are in respect to consistency, figure, and magnitude; it acquires, indeed, knowledge of the very existence of substances. We touch and handle objects; we examine them by touching.

The employment of the hands and arms in making the signs of natural language: natural language is commonly a complex act, but the hands and arms are perhaps the chief agents employed. The employment of the hands and arms in oratorical action, or moving the arms and hands oratorically: oratorical action is complex action. Moving the arms and hands upwards and downwards by the conductor of a concert to mark the time, he holding usually in his hand a roll or baton. Raising the arms and hands in prayer to God; in supplication of help from, or in deprecation of punishment or injury by man; as an act of swearing or solemn appeal to God.

The action of the arms and hands in crawling or dragging along the body whilst lying stretched on the ground: here the hands and arms are the instruments of locomotion.

Thrusting, or the act of using the arms and hands in pushing anything. By a mental effort we thrust the hands against that which we propose to move, and by the force of the impulse it is driven from its place. The weight of the body or trunk is brought in aid of this action of the arms and hands. Pushing a boy before one. A butcher thrusting a sheep into the slaughter-house. Thrusting food into the mouth with the fingers, the usual mode of eating amongst uncivilised nations, who know not the use of forks. Pushing open a door; shutting it by a thrust. Pushing down fragments of rock upon an enemy in a narrow pass. Rolling stones, casks, &c. Pushing an invalid's wheeled chair. "And rolled a great stone to the door of the sepulchre."

Patting a child's head, or cheek, or shoulders, in approbation of its conduct, or as a token of affection; patting a horse, dog, &c. Striking with the hand, open or closed. Persons striking themselves under the influence of grief, remorse, &c.: "And he smote upon his breast, saying, God be merciful to me a sinner." "And all the people that came together to that sight, beholding the things that were done, smote their breasts and returned." Fighting with fists; pugilistic encounters; prize fights; sparring with gloves. Slapping a person's face; the rude boisterous salutation of slapping a person on the shoulder. "The man who calls you Tom or Jack, &c." Striking a ball to the ground with the hand, to cause it to rebound; or against a wall (the game of fives), or into the air.

The impulse of a body is mostly by the hand or foot; in the game of fives a direction to the ball is given with the hand; in the game of football, with the foot. Bodies, when moving, may have their motions accelerated by the impulse of the hand; they may be pushed along or struck. They may also be set in motion by the like impulse, or their courses may be changed.

Taking hold with the hands, or drawing together the muscles so as to grasp. This important act is termed prehension, and is necessary to all actions in which instruments are employed, as well as in many actions performed without instrumental aid. The hand and fingers are pre-eminently the organs of prehension; nevertheless in clinging about a person or thing the arms and sometimes the legs are employed, so as to be more properly the means of prehension. In grasping, the muscles and bony parts of the hand are brought into the closest contact which the enclosed substance or substances will allow. Embracing an individual; hugging; clinging to a person or thing. Fondling a dog or other animal. Gently pressing a person's hand in token of affection. Forcibly squeezing the hand. Shampooing. Pinching the arm, ear, or other part of the body. Pressing matter from a tumour or boil. Seizing a culprit, a deserter, &c. by the arm, throat, &c.; by the hair. The forcible grasp of the wrestler. Throttling a person: "And he took him by the throat, saying, Pay me that thou owest." Milking cows, asses, mares, &c., or squeezing the teats to force out the milk. Crushing an insect between the fingers or nails. Pressing an orange, lemon, &c., to expel the juice. Kneading dough. Holding on to a rope, a rafter, &c., by which an individual is hanging. Amongst the chief subjects of grasp are instruments, tools, &c., for the purpose of effecting operations upon substances which could not be performed by the unaided capabilities of the physical system of man.

Throwing. The thing thrown is first grasped, and then other muscles of the arm are employed in casting it forth. Throwing stones by boys, by mobs, in savage warfare, &c. Throwing darts, javelins, &c.: "And a javelin was in Saul's hand, and Saul cast the javelin, for he said, I will smite David even to the wall." Throwing a ball upwards in the game of cricket after it has been caught—the ball to the bowler; bowling in the games of cricket, nine-pins, &c. Throwing a thing on the ground; throwing down the gauntlet; throwing down anything in a rage. Dashing a person or thing to the ground, against a tree, wall, &c. Pitching the quoit; pitching into a hat or a hole, into the lap, &c. Throwing a person over a precipice, a ship's side, the ballustrades of a staircase, into a pond or pit, down stairs: "And he commanded the most mighty men that were in his army to bind Shadrach, Meshach, and Abednego, and to cast them into the burning fiery furnace." Throwing the line, with the bait attached, in fishing. Throwing the lasso in South America. Sowing by hand, or scattering about corn-seed, the seeds of artificial grasses, and of other vegetables usually grown in fields: "A sower went out to sow his seed, and as he sowed, &c." Throwing by hand the shuttle in weaving silk, &c. This manual operation, once so common, is now almost entirely superseded in manufacturing countries, the shuttle being cast backwards and forwards by the action of the steam engine

Dealing cards and playing them. Throwing dice from a dice-box.

Picking, or taking up, or lifting things. Lifting or raising a child, animal, or inanimate object from the ground. Tossing an infant as nursery-maids are seen to do. Picking up fish on the sea-coast for food, a common mode amongst savages of collecting subsistence. Pulling up fish with the line in the complex occupation of fishing. Picking up shells for conchological purposes. Lifting or conveying food to the mouth without the aid of fork or spoon, a practice still prevalent amongst eastern nations. Lifting the rammer by paviers: the fall again is the effect of gravitation; raising the ponderous instrument in counteraction of gravity is human action.

Pulling. A thing pulled must be grasped and held firmly, and then the muscles of the arms, trunk, &c. are brought into action. Pulling the nose, ears, hair, beard; pulling a dislocated leg, arm, shoulder, hand, &c., into its socket or place,—a surgical operation. Dragging a net to shore. Pulling along a sheep, &c., by a butcher. The Athletæ, their exertions in pulling. Pulling up weeds; weeding by hand in gardens and fields; pulling vegetables and roots out of the earth for the market or table. Plucking fruit from trees and bushes. Gathering the leaves of the tea plant, grapes, coffee berries, cocoa nuts. These and such like are constant occupations, and sources of subsistence to numerous gangs of labourers in various countries. Pulling or plucking hops in the hop gardens of Kent, &c., a valuable mode of employment in the picking season to numbers of women, girls, and children. Gathering various other kinds of fruit for market in orchards, &c. In the most barbarous state of existence in which man is found he is almost wholly occupied in plucking fruits and seeds and pulling up roots, the spontaneous productions of the earth for his precarious subsistence. Pulling ropes by sailors, &c. The great muscular effort of Samson, when he pulled down the pillars on which the temple of the Philistines rested.

Dragging or pulling anything along is an operation which requires the general energy of the physical system. The thing drawn, or a rope, chain, &c., attached to it, must be held firmly, and motion of the thing by human strength is usually accompanied by the locomotion of the man himself. Dragging a cart by paupers, a garden roller, a boat to shore. Artillery pulled up precipices, &c., by sailors or soldiers.

Shaking, pulling and pushing alternately. Wringing the nose. Shaking hands as an act of friendship or recognition. Shaking a boy by the shoulders; a phial with medicine in it: "When taken to be well shaken." Brandishing a weapon. Shaking a stick at a person or animal in threat. Waving. The wave-offering in the Jewish religious ceremonies. Ladies waving handkerchiefs in honour of a monarch, a warrior, &c. Whirling the arm over and around the head, in huzzaing, in slinging. Fanning. Rubbing gently or forcibly one thing against another. Rubbing together sticks to produce fire. Rubbing one stone against another, or rubbing stones with a particular kind of stone to smooth and polish them, as stone-masons do. Sharpening a knife or razor by rubbing it on a hone. Rubbing is an operation frequent in the arts to polish and smooth; by abrasion or friction particles are removed.

Striking things against one another. Producing fire by striking a flint and iron against each other,—the old process before the days of lucifers, &c. Soldiers striking swords, &c. against shields, to produce terror in the foe: "Arms on armour clashing." Negroes making a great clatter to scare away ravenous beasts, Musical sounds are produced in considerable variety by striking one sonorous body against another, striking cymbals, gongs, bells, &c.; beating drums.

Breaking by hand. Snapping a stick. Breaking a pole by placing it against the knee and pulling forcibly at both ends; this is united action of the superior and inferior limbs. Breaking bread: "And he took bread and blessed, and brake, and gave to his disciples."

Tearing asunder food. Savages and half civilised nations tear with their hands animal and vegetable food into fragments. Tearing or rending cloth, a constant operation with dressmakers. "Let us not rend it, but cast lots whose it shall be." "Rend your hearts and not your garments." Rending the dress was a common mode of expressing grief amongst the Israelites of old.

Turning a rope, in the game of long rope. Turning a rope by children in the healthy and exhilarating amusement of skipping. Turning a pestle in a mortar, a key in a lock, a wheel. Twisting or twining by hand. Animal and vegetable, and some kinds of mineral matter have, by virtue of some powers or qualities, with the nature of which we are little if at all acquainted, a disposition to intertwine. The original fibres are extremely minute, but they are found naturally twisted together in various lengths and thicknesses. By employing the hands, and various ingenious appliances, man farther twines the fibrous matter which nature presents to him so as to obtain increased length, thickness, and strength, and to impart form, which makes them incomparably more useful to him. The fibres of certain parts of animals and vegetables are separated and collected by human labour and employed for purposes of immense importance,—flax in the manufacture of linen, wool of woollen goods, hemp of rope and coarse cloths, cotton in numerous articles of clothing and for domestic use. Twisting the sinews of animals into cordage. Twisting thongs of leather into ropes or cords. Twisting grass so as to make matting; the fibres of cocoa-nuts into matting, baskets, &c.; osiers and other flexible stems of plants so as to form baskets, &c.; the fibres of flax into thread, &c., of the hemp plant into string.

Folding or wrapping up dead bodies in cloths as done by the ancient Egyptians with their mummies. Rolling silks, ribbons, &c., on rollers. Placing ropes in coils on board ship. Unrolling mummies (Mr. Pettigrew's performances in this way); silks in mercers' shops for inspection, manuscripts, &c.

Using the hands in arranging things or placing them in order; preserved specimens of animals and fossil animal remains, in a zoological museum; plants in a greenhouse or conservatory, on a parterre or lawn, along walks, upon steps, &c.; prepared plants, parts of plants, fossil remains in a botanical museum. Sorting fruits according to quality for the market. Arranging minerals in a mineralogical collection. Placing musketry, swords, &c., in order in an armoury: the small armoury lately in the Tower of London. Stacking wood; piling cannon-balls. Arranging the books of a library, the furniture of rooms, goods in a warehouse or store, chessmen on a chessboard, draughts on a draught-board, skittles, goods in a shop window to show them off to the best advantage and attract customers.

Physical arrangements cannot take place without the accompaniment of mental arrangement. A person who is occupied in arranging a library must do so according to some plan generated in his own mind or laid down for him by some other mind. The dressing of a shop window requires much judgment and taste. Mental and physical arranging are operations, analogous certainly, yet as essentially diverse as possible.

The advantage to the memory of methodical physical arrangement is very great. See Dugald Stewart, vol. i. p. 433.: "The advantages which the memory, &c."

Slight-of-hand performances, or jugglery. Stewart, says, vol. i. p. 119.: "The dexterity of jugglers, &c."

A common use of the hands is in altering the forms of bodies whose consistency will admit of it; the alteration of the form of a body may be made without taking from, or adding to, its volume.

Travellers and voyagers give innumerable descriptions of manual processes by the natives of the countries they visit: these processes, in communities where machinery is unknown, or the simplest descriptions only are used, are interesting, and display vast ingenuity and skill. Travellers record also a number of ceremonies, modes of salutation, &c., in which the hands are principal agents.

THE CONJOINT ACTION OF THE HEAD, TRUNK, AND LIMBS,

UNASSISTED BY INSTRUMENTS, PRODUCING COMPLEX ACTIONS.

The human body, as a whole, is a complex machine in a great measure under the direction of the mind, and at times all its parts are in vigorous and violent action.

Climbing is a complex operation; — trees, masts, and rigging, by sailors; precipices, chimneys, a greased pole at a fair; the dangerous feat of climbing the steeple of a church to oil the vane.

Swimming is a complex operation; for, besides the muscles of the limbs and trunk being strained to their full exertion, the head is upheld in an unusual position, and breathing is peculiarly regulated. The swimming and diving of the South Sea Islanders are commended most highly by Captain Cook and others. Diving for pearls off Ceylon and elsewhere; diving in marine operations to discover the state of a wreck, &c.: it formed part of Colonel Pashley's operations in blowing up the "Royal George," A.D. 1840-43; see "The Times" newspaper. There have been many extraordinary instances of swimming, diving, &c. In the "Encyclop. Brit." are alleged cases of persons being web-handed.

Wrestling is a complex action. Africans are much given to wrestling-matches. See Park and others. The wrestling contentions of the Greeks and Romans at the Olympic games, in the Circus, &c. Modern wrestling-matches in England, particularly the west of England, "And Jacob was left alone, and there wrestled a man with him until the breaking of the day." "Wrestlers acquire their strength and agility by many a combat and violent exertion." — *Dr. Reid.*

Sparring and *pugilism* are complex actions, although the fists and the arms are the instruments mainly employed. The scientific pugilism of England; see accounts of celebrated prize-fights in the early part of the present century.

Dancing. — Though dancing consists chiefly of the action of the legs, it is commonly a complex performance in which the muscles of the head, arms, and trunk combine. This is particularly the case in uncivilised communities, dancing with them consisting more of an indefinite variety of attitudes than in peculiar and measured motions of the legs and feet as among Europeans. The sacred dances of the Hebrews; the dances of Miriam and the Hebrew women. Asiatic, Grecian, and other ancient dances. The dances of barbarous nations; the dancing-girls of India. Modern European dances;

the waltz, the boldero, and other measured dances of the Spaniards. Spanish dancing consists more in elegance of attitude and action than in the mere measured movement of the legs. The English country-dance; village evening-dances on the green in France, and elsewhere. A man or woman oftentimes, at the theatres, dances alone. The great attraction of the ballet at the opera, is the pirouetting, &c., of some celebrated performer. Dancing, however, usually comprises the combined action of many. The war-song or war-dance of the New Zealanders; it consists more of action to excite terror, than of singing. Tight-rope dancing, or balancing the body on a tight-rope, and performing thereon various evolutions. Performing on the slack-rope at fairs, &c.

Horsemanship. — Instructions in horsemanship at riding-schools. Extraordinary performances in horsemanship at steeple-chases, in hunting, &c. Equestrian feats at Astley's theatre, &c.

The sports of youth. — Childhood and youth are the periods for acquiring flexibility of muscle and skill in physical amusements and accomplishments; to deprive a child or youth of that time which ought to be employed in muscular exercise, and devote it to book-lessons, is unwise in respect to the mind, as it is injurious to the body.

The athletic sports of youth and manhood. — See "Rollin's Ancient History" for examples of the athletic sports of antiquity.

Gymnastic exercises — among the ancients — as now taught to lads in public schools — to a portion of the British soldiery. In gymnastic exercises, nearly every part of the human body is put into action.

Moving along on the hands and knees, or going on all-fours, as it is termed. Crawling or creeping by an infant; by sharpshooters and other soldiery when making cautious approaches, or in an ambuscade. Leaping by means of the joint action of the hands and feet, over gates, &c.; over boys' backs: the games of leap-frog, &c.

Dragging or pulling along anything somewhat bulky is a complex act, requiring great muscular exertion. Dragging a person by the arm, hair, collar, legs, &c., when he or she is unwilling to accompany the dragger. A boy pulling along, or attempting to pull along, a goat, &c., by the horns. Dragging guns by sailors, artillery by soldiers; paupers dragging a cart. By dragging bodies in motion their swiftness is accelerated.

Carrying is a complex act: the thing carried is taken hold of by the hands, and kept in the hands or arms; the conveyance is by means of the legs. Women and girls carrying infants in their arms, holding children on the back or shoulders, and so carrying them. Carrying living animals: "He shall carry the lambs in his bosom." The carcases of animals are carried about by the sportsman, the poulterer, the butcher, the fisherman and fishmonger, the skin-dealer and tanner. Negroes in the West Indies and elsewhere, used to be much in the habit of carrying canes, trash, &c., on their heads and shoulders, in preference to using barrows. Market-women carry on their heads ponderous baskets of vegetables.

Amongst complex actions *gestures* are calculated to attract particular notice. All important gestures have a moral or mental character; some are serious and religious, some merry and gay, some intended to occasion terror, others to express it; some are lascivious, some supplicatory and deprecatory, some droll, some insulting, whilst others express strong feelings and desires. On this subject, see Alison "On Taste." The Roman actors in pantomimes. Dramatic actions or performances at theatres, such as are unconnected with the employment of weapons, &c. Oratorical action: in exhibitions of oratory, the organs of speech, the countenance, the eyes, and the limbs, are all in constant requisition. Descriptions of the oratory of Demosthenes, Cicero, and celebrated modern speakers.

Skill in the performance of dancing, swimming, &c., is acquired only by repeated attempts; and of some of these accomplishments there are professed teachers.

Those actions which are performed for the sake of pleasure, though relatively few, and in great degree confined to the leisurable part of society, yet, considered by themselves, are positively numerous: such are hunting, athletic field-sports and games, the in-door amusements, of billiards, chess, cards, &c.

ON THE EMPLOYMENT OF INSTRUMENTS, TOOLS, IMPLEMENTS, WEAPONS, MACHINES, ETC.,

AS AIDS OR ASSISTANTS TO THE ACTION OF THE SUPERIOR LIMBS.

COULD man exercise no more influence over inanimate matter than his unassisted physical capabilities would allow, he would ever, perhaps, be little more than able to emerge from a state of barbarism, and would always be at the mercy of ravenous beasts, more muscular and naturally better armed than himself; but, happily, he is capable not only of acting *upon* external bodies, but *with* them: he adapts and employs some masses as tools, implements, instruments, and machines, to affect the combinations, forms, &c. of other masses, and to make them otherwise subservient to his purposes.

By these aids his dominion over the material or inanimate world and over animals is vastly, yea, almost indefinitely, increased.

Some natural substances in the exact state in which they are found have been employed as instruments; thus were the shark's tooth, a piece of sharp flint or shell, seen to be in use amongst the islanders of the Southern Pacific Ocean, when their islands were discovered by Europeans.

In a rather more forward state of civilisation natural materials undergo various rude processes of rubbing, grinding, chipping, fixing into handles, or upon poles, &c., by which they become somewhat better adapted to effect the operations which the individuals so adapting them desire to perform.

By a farther stretch of art one tool is employed to fashion and improve another.

But it is when art has made such progress that iron, or any other of the hard yet tractable metals, can be wrought into tools, that improvement in the construction of instruments takes an astonishing stride; metal, by its superiority in respect to almost all purposes for which tools are required, supersedes instantly teeth, shells, bones, and stones, and, to a certain extent, wood also.

The construction of complicated machines by the agency of other machinery is the summit level of this variety of human occupation.

The hand is the physical cause, or material agent, in the construction of instruments: had man hoofs he could not fashion those simple tools which are the precursors of the most elaborate and powerful machinery with which the wondrous triumphs of modern art are achieved, and to which those simple tools stand in the same relation as the elementary principles in geometry do to the sublimest theorems of La Place and other most advanced mathematicians. Although possessing intellect vastly superior to the most intelligent of brutes, yet without the hand man might never have possibly risen above them; he would be physically incapable of developing his conceptions.

Instruments are intended to effect different operations, and each kind of instrument is constructed with a view to the special operation which it has to perform. Some instruments and machines are intended to *cut*, others to *pierce*, some to *batter*, some to *take off asperities*, or to *smooth* and *level*, and so on.

Instruments have to be constructed not only with reference to the special operation which they are to perform, but they must be adapted to the material on which they are intended to operate: what will cut or pierce flesh or wood, will make no impression upon bone, or stone, or metal.

Amongst rude nations each individual usually makes his own tools, weapons, &c. The construction and ornamentation of these afford regular occupation to the males.

Amongst civilised communities, where implements and weapons are more elaborately constructed, and in far greater variety, and where they are formed of metal and wood, to the exclusion of stone, bone, and other like rude materials necessarily made use of by savages, the making tools, arms, and machinery constitutes several distinct employments, in which the individuals engaged are rendered expert by a long course of training and practice, and the operations in forming them are carried on in large establishments. In these founderies, factories, &c. are collected bodies of workmen all occupied in conformity with the most approved systems of division of labour.

Very many of the instruments of art are intended for aggression and defence, supplying substitutes for the natural weapons, which render ravenous beasts so formidable. The sword, the spear, the shield, the arrow, and, beyond all, the gun, place man above the powerful animals by whom he would, unarmed, be inevitably destroyed.

Perhaps the best course of proceeding in this multifarious and involved subject is, first, to consider the simple operations of cutting, scraping, piercing, battering, &c., and then contemplate the complex operations of each variety of art or occupation, as in advanced society it presents itself to observation.

" Human labour," Mills remarks (" Political Econ." p. 6.), " produces its effects chiefly in two modes, either with or without the aid of implements." See also the same work, p. 6., " This chapter naturally divides, &c.;" p. 16., "We have already observed, &c.;" p. 8., " To conceive the separate, &c.;" snares and clubs are instruments, not naked physical appliances. Stewart, " Elements," vol. i. p. 51., says: " In the mechanical arts we know how, &c." Dr. Reid, " Essays," vol. iii. p. 70.: " In order to produce, &c."

By the use of implements man is distinguished from nearly all kinds of brute-animals, who are unfitted by physical organisation for the employment of so important an acquisition. Dr. Kidd, " Brid. Treat." p. 18., says: " The comb of the bee, &c."

Many actions with implements require the full or general strength of the body to be put forth; others demand the particular exercise of the various parts of that most exquisitely formed physical instrument the hand. Most of the mechanical arts at times, if not commonly, require the former. In the liberal arts the instruments mostly employed are comparatively delicate, and are under the especial guidance of the fingers; such is the case in writing, drawing, and painting, engraving, modelling, &c.

Various instruments, simple and compound, are used by man to *separate* or *divide* masses,—the knife, the saw, the hammer, the mill, &c. With other instruments as important, he *combines* masses,—the press, the hammer, &c. And whilst effecting either of these processes he commonly imparts or varies *shape.* The *motions* of bodies he influences by means of the cord, pulley, wheel, hydraulic press, the drag-chain, traces, &c.; the waggon, barge, railway-truck, &c. Mills, "Pol. Econ." p. 16., says: "As examples of the earliest, &c." Dr. Reid, "Essays," p. 75.: "The finest productions, &c." Stewart, "Elements," vol. i. p. 209.: "What I have now said, &c.;" vol. i. p. 243., "In those complicated machines, &c." Dr. Prout, "Brid. Treat." p. 20.: "When a series of wheels, &c."

The act or operation of cutting.—The operation of cutting can be performed only by means of some sharp material or instrument; it is an act which brute-animals, with the exception of the monkey tribe, are incapable of effecting otherwise than with their teeth, as the beaver does, unless tearing flesh with the claws be considered a variety of cutting.

Instruments for cutting take generally different names, according to the material upon which they are intended to operate.

The custom of cutting the body, face, &c., as an indication of distress. "And it came to pass at noon that Elijah mocked them; and they cried aloud, and cut themselves after their manner with knives and lancets till the blood gushed out upon them." The Otaheitans and New Zealanders formerly cut their faces and bodies in token of grief. See Cook's "Voyages."

Scalping.—By the North American Indians. See

Dr. Robertson's "America," and other works. By a certain negro tribe. See Murray's "Africa," vol. i. p. 425.

Circumcision. — Among the Jews, see the "Bible;" the Egyptians and other ancient nations, see the "Bible" and "Herodotus;" the Mahomedan nations; the Abyssinians, see Bruce's "Travels;" the Otaheitans, see Cook's "Voyages." The circumcision of Abraham, Ishmael, and the males of Abraham's household; of Hamor, Shechem, and the males of Shalem; of the children of Israel at Gilgal. "Enfield," vol. i. p. 368., says: "The Theban priests prescribed Pythagoras many severe and troublesome preliminary ceremonies, among which was that of circumcision." Cook's "Voyages," vol. v. p. 440.: "The men were all, &c." vol. vi. p. 150.: "Cutting or inciding, &c." Murray's "Africa," vol. i. p. 177.: "In passing a place, &c."

Shaving the beard and cutting the hair of the head—shaving the head with a shark's tooth — scraping off the beard with shells—cutting the hair with scissors—shaving the beard with a razor. — "Wherefore Hanun took David's servants and shaved off the one half of their beards." Cook's "Voyages," vol. v. p. 324. "I was fortunate enough, &c." "Encouraged by what I now saw, &c."; vol. v. p. 299., "Capt. Clarke at last hit, &c.' The head is shaven when there is inflammation on the brain. Shaving and hair-cutting constitute a distinct occupation in dense communities.

Surgical operations. — Amputating a limb; cutting for the stone; the cutting portion of the Cæsarean operation; cutting out cancers and other tumours; incisions in ulcers, tumours, &c.; trepanning. Emasculating male children (making them eunuchs), practised in ancient times by eastern nations, Ethiopians, &c.; more recently among Mahomedans, for guards of the harem;

by the Italians, to preserve fine treble voiees; gelding horses, bulls, boars, &e.

Cutting as a mode of punishment and torture.—Cutting off the eyelids, and exposing the eyes, unproteeted, to the full rays of the sun, a barbarous Roman punishment; the modern practiee of beheading noblemen and gentlemen, sueh as the beheadings with the axe on Tower Hill; the Freneh mode of beheading with the guillotine.

Cutting with the sword, &e.—The attaek of eavalry; eleaving with the battle-axe in elose eombat; attack with cutlasses by sailors when boarding a vessel. "David ran and stood upon the Philistine, and took his sword and drew it out of the sheath thereof, and slew him, and cut off his head therewith."

Other cutting operations upon living subjeets. — The custom of the Abyssinians in eutting steaks from the flanks of live oxen; see Bruce's, Salt's, and Lord Valentia's "Travels." Slaying sheep and oxen for saerifiees by the Jewish priests, by the Greeian, Roman, and other heathen priests; slaughtering sheep and swine for human food, the buteher eutting their throats; slaughtering horses, the knaeker cutting the throat. (See aecounts of the slaughterhouse at Paris.) Sheep shearing.

Disseeting. — The disseetion of the human body, the oeeupation of the anatomist, is an employment whieh requires great skill in the use of instruments, and eompels a long apprentieeship. The medieal student is by the praetice of the hospitals fitted for the performance of whatever surgieal operation the aeeidents of soeiety may require. Anatomy, being of primary importanee to to the surgieal and medieal arts, has called forth very considerable ingenuity in the eonstruction of instruments, and many of great delicacy and very eurious have been invented and made. The disseetion of animals for the purposes of seience is termed Comparative

Anatomy. The bodies of animals, as organised structures, are the subjects of experiments; we are not content with observing the outside, we want to be acquainted with the internal parts and structure. This knowledge is attained by means of *dissection* in the first instance, and then by *observation* of the parts laid bare by dissection. Enfield says, vol. i. p. 401.: "Alcmæon is said to have been the first person who attempted the dissection of a dead body;" vol. i. p. 425., "Democritus employed his leisure in dissecting the bodies of animals;" vol. ii. p. 501., "Descartes employed a whole winter in dissecting and examining animal bodies, and in chemical operations." Dr. Reid, "Essays," vol. i. p. 151., says: "We are so far from perceiving, &c." Stewart, "Elements," vol. ii. p. 490.: "The study of comparative anatomy, &c." The difference between the anatomical structure of the human body and of brute bodies was ascertained only by dissection of both, and by observation. Analogical reasoning was found to have led into gross errors. Thus anatomy is established upon experiment and observation; in other words, upon human action and perception. On dissecting animals and human beings, see in Stewart's "Elements," vol. ii., p. 412. an historical sketch from Dr. William Hunter's "Lectures on Anatomy."

Cutting open dead bodies to embalm them; flaying horses, oxen, and sheep, or taking off the skin by the knacker and butcher, for the use of the tanner; taking off the skins or furs of the tiger, the sable, the fox, and various other animals, for ornamental dress; stripping off the skins of serpents and other animals, that they may be stuffed and preserved in zoological museums; the separation of the horns of oxen, deer, &c., from the carcase by the butcher, &c., these parts being of great utility in the useful arts; cutting up oxen, sheep, calves, pigs, &c., into joints, by the butcher, for human food; carving joints of meat, poultry, game, and fish; cutting up carcases of horses for dogs' and cats' meat, sausages, and so on.

Cutting bone into handles of knives and other instruments; sawing or otherwise cutting elephants' teeth or ivory into various figures and other ornamental or useful forms. The cutting by Chinese of concentric spheres. The artists of that ingenious people are famed for their skill in cutting ivory. Cutting horns into various articles of utility. Horn is softened by heat previous to being cut or moulded into shape. Horn, bone, teeth, &c., are cut by the carver with his carving instruments, by the turner with his lathe; they are also sawn.

Pruning with shears, the vine, wall-fruit trees, espaliers, shrubs, coffee trees, &c. Clipping hedges with the shears. The operations of the woodman in cutting underwood, lopping and sawing off branches with bill-hooks, saws, &c. Barking oak trees for the tanner: this is only partly performed with cutting instruments. Felling trees with axes and saws for timber, or to clear wooded land for cultivation, as in North America. Mowing natural and artificial grasses, oats, &c., with the scythe. Cutting turf; cutting peat for fuel. Reaping wheat, &c., with the sickle. Cutting the sugar-cane with the bill.

Plants are the subjects of experiment in various respects; but experimenting in regard to them with instrumental aid is more particularly carried on by *dissection.* By this process, followed up by microscopical observation, are discovered their texture and organisation, the nature of their vessels, and the course which the fluids therein take.

Cutting with a knife apples, pears, or other fruit, for eating.

Fashioning the trunks of trees, after they have been cut down, into timber by the axe, hatchet, &c.; sawing timber into planks, boarding, &c.; shaving boards, &c., with a plane; cutting planks, poles, &c., with the saw, chisel, &c., by the house-carpenter, boatbuilder, shipwright, carriage-builder, &c., in their several operations; cutting mahogany and other hard woods in the process of turnery for furniture, &c.

Carving in bone, ivory, &c., the human figure, various animals, various ornaments. Carving in wood, the bust, head, the entire figure, animals, fruits, scrolls, domestic utensils, canoes. Captain Cook gives ample descriptions of the ingenious carving of the South Sea natives.

Quarrying. — The operation of cutting out blocks, slabs, &c. of stone from rocky masses. The gigantic quarrying of the Egyptians, Etruscans, &c.

The scientific operation of cleaving crystals; this is done with the knife and hammer. Many, and important in their results, have been the experiments and investigations of the crystallographer. One of the principal of his operations is the *cleavage* of crystals; another being the measurement of their angles.

Sawing blocks of stone into smaller blocks, slabs, &c., a part of the work of the stonemason. Cutting stone into shape with the chisel and mallet by stonemasons in architecture. Cutting inscriptions upon tombstones, buildings, &c. with the chisel and mallet.

Glyphography, seal-engraving.

The art of statuary, or of cutting stone into the figure of an object by the chisel, &c., and mallet. Egyptian sculpture of colossal idols, kings, &c. Grecian sculpture of idols in the temples, of illustrious men, &c.; the celebrated works of Phidias and others.

Cutting the earth in the operation of digging in private gardens, in market gardeners' grounds, in clearing out ditches, and other water-courses. Cutting the earth by means of the plough. Ploughing is a complex operation; the skill of the ploughman in guiding the machine is combined with the strength of the horses or oxen by which the plough is drawn through the soil. None of the cutting part of the operation can perhaps, with propriety, be attributed to the ploughman.

Cutting woollen cloth with shears by the draper and tailor for male dresses; linen and cotton cloth, silks and woollen stuffs, by the dressmaker and the female part of families, with scissors for under garments, gowns, &c.; thread with scissors; cord and rope with sheers and knife; sail-cloth in making sails; woollen stuffs, &c., for curtains in sitting-rooms, bed-rooms, &c.; carpeting to fit rooms, &c.

Instruments for cutting. — These may be made of various materials — animal, vegetable, metallic. In the rudest stages of society teeth, shells, bone, wood, stone, &c. are used in almost their natural state, being no more than brought to an edge and fixed into some kind of rude handle. As civilisation advances, cutting tools improve in their construction, and steel, finely tempered and sharpened, is the cutting part. At last complex machinery is constructed for cutting, shaving, &c., acting with great force, velocity, and precision.

Whenever men have attained knowledge and skill in extracting metals from their ores, and working these metals into shape, instruments made of other materials are, as regards their cutting part, thrown out of use; they are superseded by metallic tools, especially by such as are of iron and steel.

Amongst metallic cutting instruments are: — common knives; the surgical knife, in its various forms, for special purposes; the battle-axe, a weapon of former times, broad, heavy, and sharp, to cleave the skull. The sword; the factories at Damascus were celebrated for the temper and elasticity of the blades. Adzes, hatches, axes. The saw, the hand-saw, the large saw of the saw-pits, the stone-worker's saw. The plane. Chisels. The spade. The sickle; it is spoken of in the Bible as having been in very early use. The scythe.

Very complex machines have been invented and constructed in modern times, by which the operations of cutting, sawing, planing, &c. are performed with extreme rapidity and accuracy. By some of these machines metal is cut and shaven with as much ease as wood. Such machines are to be seen in government and private dock-yards, where screw and other steamers are built, in the workshops of the locomotive-engine makers, &c. The cylinders, pistons, &c. of steam-engines require to be planed with the extremest nicety. See, in "The Times" for June 11. 1855, a notice of Mr. Whitworth's machine for measuring the minutest variations in length, used by him to obtain the greatest accuracy in pistons, &c.

The act of scratching or scraping with instruments. — Scratching or scraping, although confined to the surface, is really, in most cases, an act of cutting. The only natural means man possesses of scratching or scraping is the nails. Scratching the head with a comb; brushing or gently scratching the eye by oculists in certain ophthalmic complaints; scraping off the bristles from hogs; shaving or polishing wood-surfaces; smoothing or polishing hard woods, by scraping off the asperities or roughness of the surface with shave-grass. Raking garden-grounds, flower-beds, &c. Graving upon copper, steel, stone, &c., or scratching with the graver. Scratching or cutting the surface of glass with a diamond by glaziers, that they may break it accurately.

Instruments used for scraping, &c.—The comb for the human head; the curry-comb for horses. Rasps; files. The hoe and rake.

The act of piercing. — Piercing by man requires an instrument. Amongst the varieties of piercing are: — tattooing; see Cook's "Voyages." Bleeding human beings, the practice of phlebotomy; it is done with the lancet by European surgeons, — with a kind of poniard by the Moorish surgeons. Cupping is, in part, puncturing with fine needles. Puncturing tumours; tapping for the dropsy; puncturing the eye in couching, &c.

Stabbing with a dagger, knife, poniard, stiletto; with a sword in war, in duels, in fencing, &c. Piercing with spears or lances in warfare. Military charge with the pike by the Macedonian phalanx; the same by the Roman legions. Charge with the bayonet by the English infantry, and the infantry of other nations. Assassination by the stiletto is a national crime amongst the Italians. Spaniards and some other continental nations are in the habit of using their knives, daggers, &c. in cases of personal dispute, — a crime abhorrent to Englishmen. Bleeding horses by veterinary surgeons, farriers, &c. Stabbing bulls by the matador in the Spanish bull-fights. Slaughtering animals by sticking; sheep are usually slaughtered by being stuck in the throat. The Jews, I believe, kill all their cattle either by stabbing or cutting their throats, that the blood may be discharged entirely from the carcase.

Puncturing or tapping the maple to obtain its juice for making sugar; some other trees are also tapped that their juices may flow out. Piercing timber, boards, &c. with the auger, gimblet, &c., for the reception of nails and screws. Digging with a fork having two or three prongs; with the pickaxe. In digging into the bowels of the earth to obtain stone, metal ores, coal, water, &c., that is, in sinking shafts and wells, also in excavating, tunnelling, &c., the pickaxe is largely used.

Sewing together skins for dress, coverings of canoes, &c. Working with the needle by tailors in making men's and boys' dresses; by dressmakers and females generally in making under garments, gowns, frocks, and other articles of dress. Working tapestry; embroidering; figuring lace; sewing carpeting; making and repairing sails with the needle; using the awl, &c. by boot and shoe makers and repairers.

Engraving by puncturing or dotting with the graver. —*Hand instruments used for piercing*: these are the dagger, poniard, stiletto, the pike or spear; augers, gimblets, gouges, &c.; spikes, nails, screws, the pickaxe, needles, pins, &c.; surgical instruments for puncturing, probing, &c.

The act of beating or battering with instruments.—Beating boys with a cane, flogging them with a birch; flogging or lashing soldiers and sailors with a cat-o'-nine tails; the Russian punishment of the knout; whipping culprits at the cart's tail; the Turkish punishment of the bastinado. Scourging was a common mode of punishment among the Romans. The Jewish law forbad more than forty stripes. Flogging women in Africa for certain offences; see Park's account of Mumbo Jumbo. Flogging slaves. Horsewhipping a mode of aggression in quarrels, formerly somewhat in vogue in England. The game of single-stick; cudgel-playing; assaulting with clubs and sticks; slaying by blows of clubs; murdering, by fracturing the skull with hammers, bludgeons, &c. Using the club, mace, butt-end of a musket, &c., in battle. The mace was a knight's weapon in the days of chivalry. Sir W. Walworth killed Wat Tyler by a blow with his mace.

Striking horses with a whip or switch.—This is the usual mode of managing these animals when ridden or driven. Slaughtering bullocks, &c., by knocking them on the head and fracturing their skulls with a kind of axe or hammer. Beating skins with mallets, in the process of tanning, to make the leather supple.

Thrashing wheat with a flail. Ramming down earth with a wooden hammer, to harden it. Driving down paving-stones and blocks of wood by the pavier with the rammer. Using the mallet by shipbuilders to foree pieees of timber into their exaet plaee or position; by stone-masons, in fixing a block of stone in a mass of masonry. Wrought-iron instruments are shaped by being first softened in the fire, and then battered with iron hammers. Beating heated iron bars into shape with hammers, on an anvil, by blaeksmiths. Construeting iron steam-boats,—the ineessant beating of a number of men eonstitutes this operation a very noisy one. The faetory in the Isle of Dogs, Blaekwall. Beating plates of copper into boilers, teaehes, &e., by eoppersmiths; here is, also, the simultaneous hammering of a number of men earried on with great regularity and rapidity in the strokes. Working in gold and silver;—ornaments are extensively formed by being beaten into shape.

Propelling or driving a battering-ram against the wall of a fortress, a mode of assaulting strong plaees in aneient times. Beating the drum by regimental drummers; the kettle-drum in a military band and an instrumental eoncert. Coopers driving hoops on easks. Striking a ball with a bat in the games of erieket, trap-ball, &e.; with the raeket, in a raeket-court; striking a shuttlecock with a battledore.

Battering and cutting. — Using the chisel and mallet by earpenters, by stone-masons, by the seulptor.

Battering and piercing.—"Then Jael, Heber's wife, took a nail of the tent, and took a hammer in her hand,

and went softly unto him, and smote the nail into his temples, and fastened it into the ground." "She put her hand to the nail, and her right hand to the workmen's hammer, and with the hammer she smote Sisera." Driving wedges into the earth with mallets to break it away in cuttings for railroads; driving stakes, poles, &c., into the earth with mallets; driving nails, hooks, &c., with hammers in house-building, and other carpentery work; in shipbuilding. Driving nails into coffins—a very quick operation.

Instruments used in battering or beating.—The club, stick, cane, or switch; the whip, cat-o'-nine tails; mallets, hammers, the pavier's hammers; the monkey used for driving in piles; the battering-ram; the pestle; crushing-machines, &c.

The act of throwing instruments or weapons for the purpose of piercing, battering, cutting, &c.—Throwing the lance, dart, javelin, &c., in human contests: "And a javelin was in Saul's hand. And Saul cast the javelin; for he said, I will smite David, even to the wall." Striking land-animals with lances, &c.; spearing fish, or striking them with a dart, is a mode of obtaining fish prevalent amongst savages on the sea-coast or the banks of rivers. Striking the whale with the harpoon in the whale fishery,—seals and porpoises, also. Throwing the lance, &c., at distant objects, is done for the sake of practice; it is an important part of education in savage life, and used to be amongst all people in former ages.

Using instruments to assist in projecting missiles, &c.—Stones are thrown with the hand, and by some uncivilised communities with great effect, but a simple instrument, a leathern thong, was generally introduced in very early times, by means of which the force of the propulsion became greatly increased, and the range of the missile widely extended. "Among all this people were seven hundred chosen men, left-handed; every one could sling stones at an hair and not miss." "And David chose him five smooth stones out of the brook, and put them in a shepherd's bag which he had, even in a scrip; and his sling was in his hand: and he drew near to the Philistine. And David put his hand in his bag, and took thence a stone, and slang, and smote the Philistine in his forehead, that the stone sank into his forehead, and he fell upon his face to the earth." See in Bagster's Comprehensive Bible the note to Judges, xx. 16. Throwing darts with a stick or a becket, see Cook's "Voyages," vol. iv. p. 75., vol. ii. p. 220. Discharging arrows by means of the bow: the cord is pulled to the utmost of the physical strength of the archer or bowman, by which the arch of the bow is still farther bent; the cord being then suddenly let go, the arrow is propelled with great force and velocity. "And a man drew a bow at a venture, and smote the king of Israel between the joints of the harness." The cross-bow of the feudal times, the days of chivalry, the middle ages. Archery is now revived as an amusement, a trial of skill, especially for ladies.

Using the pistol, musket, rifle, fowling-piece, &c., to propel shot and bullets. "The total change," says Malthus, "in the art of war by the introduction of gunpowder gave to improved skill and knowledge the decided advantage over physical force."— *On Population*, vol. i. p. 163.

When a man is about to perform the act of striking with an instrument, or other missile, an object in motion,—for instance, a flying bird with an arrow, or with a shot from a gun,—he has to take into consideration the velocity of the object, and its different distances at different moments. When the bird is struck, it is in a different place from that in which it was at the moment the shot was fired; and the place and distance of the latter of these depend upon the direction in which the bird flew, and the respective velocities of the bird and the shot.

When a marksman is accustomed to take aim from a fixed spot, the mind becomes familiarised with the surrounding objects, and derives some advantage from the acquaintance; but when he varies his position, no such assistance can be obtained—on the contrary, surrounding objects ofttimes mislead him.

The most difficult operation must be to bring down or strike a moving object when the marksman himself is in rapid motion. Bruce declares that, when in Abyssinia, he frequently shot birds whilst in full gallop. A running fight between two ships of war, or two squadrons, especially if there be much tacking, must present far more difficulty to the gunners than a stationary combat.

The operations of artillery in battle. The practice of gunnery to qualify for war operations. Human action is in these operations employed only in loading, moving at times, pointing the guns, and firing them with the match; the force of the gunpowder and the cohesion of the metal do all the rest.

Using instruments for throwing up, turning over, &c.—Throwing up or over the earth with the spade, shovel, &c., in spade husbandry.

When the ground is being cut by the plough, the ploughman turns the plough a little on one side, and so turns over the soil that has been cut.

Turning over grass and tossing it with a fork to make it into hay; throwing up hay and corn into the waggon, and from the waggon on to the stack in stacking it. Throwing up dung with the pitchfork. Throwing about corn, &c. with the shovel; this is a constant operation in granaries, to keep it dry and sweet, and prevent it from heating. Throwing fuel on a fire with shovels, &c. in manufactories; in the engine-room of a steam vessel; on locomotives; in domestic apartments, &c.

Using nets, snares, traps, &c. to catch land and marine animals. — Nets, as well as other modes of snaring, are employed in catching birds and other small animals. In fishing with hook and line, pulling and piercing are combined. Angling is a complex operation, the fish actually hooks itself, or chiefly performs that operation; the angler, after the bite, jerks it out of the water by means of the rod and line.

Using instruments in the operation of rubbing — applying by their means friction for the purpose of separating particles. — Rubbing the body with a towel, flesh-brush, &c.; the hair with a hair-brush. Cleansing wool by scouring. Rubbing woollen cloth with a brush to free it from dust and dirt; furniture with a brush; boots and shoes with a blacking brush, to clean and polish them.

Using instruments for the purpose of grinding, &c. — Grinding wheat into flour by the hand-mill, an ancient process: "Two women grinding at the mill."

THE USUAL OCCUPATIONS OF MANKIND,

AS EXHIBITING THE SEVERAL VARIETIES OF COMPLEX HUMAN ACTION.

Men are constantly employed in obtaining and preparing food, in providing themselves habitations with their furniture, and in procuring materials for clothing and working them up. These pursuits constitute the daily avocations of the mass of mankind, and are forced upon them by the imperious laws of necessity, or, more properly speaking, by the ordinances of God: "By the sweat of thy brow shalt thou eat bread." Besides these ordinary occupations, men have carved out for themselves various additional labours: the mechanical processes of the fine arts, ceremonial state observances, the physical pursuits of pleasure; whilst in many religions numerous ceremonies are enjoined and practised.

The occupations of life are so numerous and various, that a mere enumeration of them only can be attempted. The art of fishing generally. Hunting and snaring. Pastoral occupations, the employments of the shepherd, swineherd, herdsman, grazier, &c. Operations in agriculture, horticulture, landscape gardening, &c. Digging wells. Forming horse and carriage roads, canals, railroads, &c. Mining and quarrying. The operations of the dairy; the art of curing meats; the arts of preparing vegetables and vegetable products for food and drink. The occupations of mankind in erecting, ornamenting, and furnishing dwellings, &c., including architecture, civil engineering, military engineering and fortification, naval architecture or shipbuilding. General employments in fabricating clothing, &c., or the manufactures generally. Navigating vessels. Mercantile occupations. Trading, wholesale and retail. Civil employments, or the physical occupations of those who are employed in the various public establishments indispensable to carrying on the business of a great country.

The art of war, or naval and military operations in general. The arts of writing, printing, drawing and painting, engraving, lithography, photography, modelling and sculpture. The surgical and medical arts. The arts of astronomy, geography, mensuration or land surveying, &c. The chemical art and experimenting generally. The art of the musician. The dramatic art. Public or general amusements; the general performances of religious rites and ceremonies; court and public ceremonies; marriage and funeral ceremonies. Domestic operations and the offices of menial servitude.

One of the most important applications of human physical power, aided by manifold instruments, is in experimenting for the purpose of physical investigation. Much of natural science may be ascertained by minute and accurate observation, combined with correct comparison and induction; but experiment widens immensely the range of research, and leads to discoveries to which observation is unequal. Experiment is a grand engine of discovery in natural philosophy; observation alone cannot lead far into a knowledge of the secrets of nature. By experiment we become acquainted directly with numerous unexpected material effects, and indirectly with the operations and properties by and from which the effects result. Experimenting requires in general the aid of utensils and other instruments; many experiments, however, and those not the least valuable in demonstrating the principles of nature, may be effected with slight extraneous aid, or, in other words, with a very simple and inexpensive apparatus. Enfield, vol. i. p. 426., says: "Democritus spent his life in making experiments upon natural bodies;" vol. ii. p. 484., "Physical experiment, the organ or instrument which Lord Bacon proposed, &c." See also the "Edinburgh Review," vol. iii.: "The great problem which Lord Bacon, &c." Kirby, "Bridg. Treat." vol. i. p. 43.: "The great and wonderful genius, &c." Dr. Hooke: "There ought to be some end, &c." Newton: "You know the proper method, &c." Enfield, vol. ii. p. 497.: "It is much to be regretted that Hobbes, &c." Stewart, "Phil. Essays," ch. ii. p. 32.: "That it is by means of experiment, &c.;" vol. ii. p. 354., "The physical discoveries, &c.;" see also vol. i. p. 356., vol. ii. p. 345. "Edinburgh Review," ch. iii. p. 31.: "By experiments too, &c." Bentham, "Logic," ch. x. p. 213.: "By experiment is, &c."

To resolve compound bodies into their elements, or amidst the complexity of matter to detect and lay bare simple substances, is the work of the chemist, and it has of late years been admirably performed; this species of chemical operation is called *analysis*. See Reid's "Essays," vol. ii. p. 129.: "Chemical analysis is an operation, &c."

Substances are frequently employed as agents rather than as instruments in compounding and dividing bodies. These are commonly called chemical agents, and great use is made of them in the arts. The ordinary operations of the laboratory are called chemical manipulations.

Animal chemistry.—The animal body is resolvable into several kinds of animal matter, and ultimately into inorganic principles. Peculiar animal matter is detected in certain animals. These investigations are carried on by chemical experimenting.

Vegetable chemistry.—We are not satisfied with a knowledge of the structure and organic functions of vegetables, which is to be obtained by means of dissection, observation, and induction; philosophical curiosity carries us farther, we want to get at the proximate and elementary principles of vegetables, as well as at their combinations. Vegetable chemistry has brought to light many peculiar vegetable matters, and has detected some vegetable principles.

Animal and vegetable chemistry are connected under the general term organic chemistry. Inorganic chemistry applies to inorganic substances. The vast strides of late in civilisation, and the enormous command which man has recently acquired over the powers of nature, have in a great degree sprung out of chemical and mechanical experimenting upon inorganic substances.

Experimenting in other branches of physics, or material philosophy.

CONCERNING THE PHYSICAL SYSTEM GENERALLY IN RESPECT TO ACTION.

VARIATIONS in respect to strength in the physical structure of man. — These variations are very considerable amongst individuals, and in the same individual at the several stages of life and in various states of bodily health.

There have been many remarkable instances of great strength of body: the fabled strength of Hercules, the strength of Samson, Milo, Maximinus, and others.

The physical weakness of certain races of men: the Hindoos, &c.

Whateley, in his "Logic," App. p. 284., says: "Not that but one person, &c." On the physical strength of the human body, see Malthus, vol. i. p. 17.

The education of the physical powers, or physical education, and the increase of muscular strength by exercise. — Human beings, at the very earliest period of infancy, enter upon a course of physical action which is to be continued through the various phases of life.

It is a most useful exercise in the study of the Science of Mind to watch the development of physical action in children; to observe how they acquire, by tentative means, skill in the performance of the ordinary actions of life, and occasionally, of actions which deviate from what is usual.

An advanced step in physical education is when a lad is introduced into the agile and boisterous games of boyhood. It is interesting to notice the aptitude, the natural ease and rapidity, with which some youths master these games, and acquire distinction amongst their comrades; whilst the awkwardness, and positive inability, of others, which is evinced in repeated, but failing, endeavours, is surprising and unaccountable.

See Alison "On Taste," p. 78.: "The common or general motions, &c." Stewart's "Elements," vol. i. p. 469.: "That best of all educations, &c.;" vol. iii. p. 30.: "The effects of early, &c." Reid, "Inquiry," p. 367.: "Another part of, &c."

The next stage in the progress of physical education is when a youth comes to be initiated into the mechanical or liberal art, profession, or occupation by which he is to gain his living. Usually he is apprenticed or articled to some one, who, by himself or his assistants, undertakes to teach the performance of the requisite actions in a manner creditable alike to instructor and pupil. Dr. Reid, "Essays," vol. iii. p. 203.: "What should we think of a man, &c." Kames, "Elem. of Crit." Introd. p. 8.: "We need but reflect, &c." Jardine, "Outlines," p. 37.: "The institutes of Persian education, &c." Robertson, "Amer." bk. iv. p. 323.: "If another direction were, &c." Stewart, "Phil. of Mind," vol. i. p. 21.: "It is not in the awkward, &c." See also Xenophon on the emulation of young men in feats of agility and strength.

The diminution or decrease of physical strength by disease, illness, old age, &c.—The muscular powers relax by the indulgence of inaction; physical strength is for a time prostrated by severe illness, and locally destroyed by disease; it is gradually undermined by intemperance or excess, and in the unalterable course of nature gives way gradually, and decays in old age, however favourable an individual's mode of life may have been for husbanding and preserving his strength. The physical system is oftentimes also prematurely worn out by excessive labour in early life. Malthus, in vol. i. p. 17. of his work on Population, makes various remarks on weakening the human frame. See also Cook's "Voyages," vol. v. p. 436.: "Their strength and activity, &c.;" vol. vi. p. 136., "The muscular appearance, &c."

Accuracy and rapidity, or expertness, in performing actions acquired by practice.—Processes in the arts mostly require great accuracy in manipulation. Correctness in the direction and use of the bodily organs is not easily attained; it can be acquired only by constant and careful repetition.

By repetition, actions are performed with precision in respect to place and direction,—as in shooting with marbles, with arrows at a target, with a rifle at game or in war, and with artillery.

Actions may be performed with sufficient accuracy, yet that is not all which is desirable. To become a superior workman or artist, what is to be done must not only be done well, but quickly; and to attain a high degree of excellence in this respect, repetition is indispensable. There is no possibility of acquiring a habit of performing actions both accurately and expeditiously, —no possibility of becoming an expert workman or performer, especially if the operation be complex and difficult,—but by a long educational course of practice. Sleight-of-hand performances probably supply us with the best illustration of rapid execution.

Actions are performed with very different degrees of facility and expertness,—the practice which will be sufficient to qualify highly one man will do little for another; excellence in workmanship depends much upon natural aptitude, both physical and mental.

Acquiring expertness in the performance of actions constitutes a most important department of education, throughout infancy and youth; and if this education be neglected and sacrificed to the comparatively inactive acquirement of knowledge, a great injury is inflicted;—the organs on which the attainment of knowledge itself depends are kept weak, and the information mastered is, in general, indifferently available, that is, cannot be brought to its full use. See Mills, "Polit. Econ." p. 10.: "The foundation of this class, &c." Cook's "Voyages," vol. ii. p. 34.: "The inhabitants of New Zealand, &c.;" vol. i. p. 138., "Human nature is endued, &c."

A result oftentimes will admit of a variety of ways in its attainment. Opportunity is thus given for knowledge and judgment. There may be in a performance of required operations a waste of labour, or the exact quantity only may be applied: useless actions may be introduced, or those only which are needful; and the operations which are indispensable may be performed in the best order, or in an objectionable method. Stewart, "Philosophy of Mind," vol. i. p. 49.: "In the mechanical arts, &c.;" vol. i. p. 60., "In all the arts of life, &c." Reid's "Analysis," p. 108.: "Practice, joined with rules, &c." Locke, "Hum. Und." p. 125. ch. ix. bk. ii.: "If we consider how, &c." "Conduct of Understanding." p. 331.: "A middle-aged ploughman, &c.;" p. 337., "Would you have a man write, &c." Stewart, "Elements," vol. i. p. 284.: "The word habit, &c." Reid, "Essays," vol. iii. p. 139.: "Habit is commonly defined 'A facility of doing a thing, acquired by having done it frequently.'" This is expertness, dexterity, but I think not habit. Habit is a disposition or determination to perform actions which have been frequently before performed; a man can scarcely refrain from performing them, and the repression of the inclination is unpleasant. Reid, "Essays," vol. iii. p. 141.: "Every art furnishes, &c." Stewart, "Elements," vol. i. p. 285.: "In the Essay on Attention, &c.;" p. 109., "The wonderful effect of practice, &c.;" p. 109., "I do not mean, &c." Reid, "Essays," vol. ii. p. 515.: "There are likewise talents, &c."

Of labour or toil.—After having become an expert operator or workman, or an indifferent one, according to his natural ability, means of instruction, and assiduity, a man has to occupy himself daily in his vocation; and this unintermitted action is imperative, as upon it depends the supply of his own wants and the wants of his family, which the laws of nature never permit to be set aside: man is necessitated to labour,—by the sweat of his brow must he eat bread. A routine of physical action, usually characterised by an ever-returning sameness, is the common lot of the vast majority of the human race.

Sumner ("Records of Creation," vol. ii. p. 194.) says: "Without labour nature gives nothing anywhere." This is inaccurate; nature gives spontaneously much that is valuable, but man must labour in collecting or gathering what nature offers: commonly he has also to adapt and work up natural materials in accordance with his wants. See the same work, vol. ii. p. 60.: "The ordinary exertion, &c.;" p. 280., "The food by which, &c." And on severity of labour, see Malthus, "On Pop.," vol. i. pp. 6. 19. 21.; also, vol. i. p. 129 "The incessant toil, &c.;" "In that part of, &c.;" p. 56., "Amongst most of the tribes, &c.;" p. 58., "They are condemned to excessive labour."

Division, combination, arrangement of labour.—These important matters are treated of in works on political economy and kindred publications. Mills, "Politic. Econ." p. 11., says: "There is a certain immense aggregate, &c." Sumner, vol. ii. p. 171.: "The abundance of labourers, &c.;" vol. ii. p. 180., "According to the existing, &c." Mills, p. 13.: "If the immense aggregate, &c." See also Smith's "Wealth of Nations."

Natural tendency or disposition to physical action.—One man is distinguished from another by the greater disposition to action, and the consequent superior energy in most cases of his actions.

Both men and animals—the latter by species as much as by individuals—evince that much enjoyment results from action: the gambols of the chamois, &c., the violent sports of manhood and youth, and the unwearied playfulness of children, all demonstrate this.

In some men the propensity to action arises to a high degree of irritability,—they are morbidly active; to be kept in a state of quietude is to them worse than death,—they must be doing. Such a man was Napoleon Bonaparte; such has been Brougham. Dr. Reid, "Essays," vol. iii. p. 151., has this passage: "Nature intended that we should, &c." Cook's "Voyages," vol. i. p. 203.: "The boys and girls are kept awake by the natural activity and sprightliness of their age;" vol. v. p. 443., "Their domestic life is, &c." Reid, "Essays," vol. ii. p. 481.: "We can perhaps conceive, &c." Sumner, vol. ii. p. 317.: "The poorer ranks of, &c." Kidd, "Br. Treat." p. 23.: "It seems as if there were implanted, &c." Sumner, vol. ii. p. 215.: "The moderate exercise of, &c."

No one may hope to obtain the reward of fame in active life, whether he be engaged in civil or military pursuits, in the liberal professions, or in scientific observation and experimenting, who is not habitually energetic and laborious; and those who distinguish themselves are usually, perhaps, constitutionally active.

Natural tendency or disposition to inaction — sloth, idleness, &c.—To some men inaction is highly agreeable, and action positively tormenting. Indolence and sloth often, though far from invariably, accompany strong sensual propensities. To Sardanapalus and other like votaries of animal pleasure, who, by their excessive indulgences, have obtained an unworthy notoriety in history, inaction was almost as pleasurable as the more active enjoyments of lust. Malthus, p. 132., says: " A state of sloth, &c." The representation, in this passage, of human nature I hold to be exceedingly doubtful with regard to a large portion of mankind; it is probably erroneous: men would like to choose their own employments and make action subservient to gratification, but idleness is mostly misery. See the immediately preceding section. Fergusson: " The desire of property, &c." Sumner, vol. ii. p. 165.: " Whatever may be thought, &c.;" vol. ii. p. 394., " That activity which, &c.;" vol. ii. p. 48., " Man is easily brought, &c." Cook's " Voyages," vol. iv. p. 73.: " These people are like all, &c." Goldsmith, p. 138. vol. i.: " The actions of the natives, &c."

The necessity of rest or relaxation to the muscular system after action or exertion. — Rest is necessary after long continued or violent action. Sleep or periodical rest is incident to human nature, a condition of its existence. Whewell, " Brid. Treat." p. 40.: " The physiological analysis, &c." Reid, " Essays," vol. iii. p. 73.: " Great efforts, whether of body or mind, &c."

THE INFLUENCE OF THE HUMAN MIND OVER THE PROPERTIES OF SUBSTANCES

AND

THE EMPLOYMENT BY THE MIND OF THE POWERS OF MATTER.

The direct Influence of the Mind over the Powers of the Body. — The human skeleton, or system of bones, is thrown into action during life by means of the muscles, tendons, sinews, &c.; the cohesive or attractive force of these must therefore be great, and the mind in this case makes use of, and controls, the material power of cohesion.

Men vary in physical strength; the cohesiveness of one human frame is much less, or much greater, than that of another. If there be not in the body of the stronger man a greater quantity of matter (and the biggest and heaviest men are usually not the strongest), the matter which is there is more closely packed together, both in the bones and the muscles; and possibly, in peculiar cases, the matter so compressed, or a portion of it, is of such a nature as to possess cohesive power in a higher degree than ordinary, giving peculiar tenacity and solidity to the frame.

The human body, being the agent of the mind in its operations upon external matter, becomes suitable for the purpose, chiefly by virtue of its cohesive force; and therefore the authority which the mind exercises over the body, and to which the body implicitly bends, is an authority exercised over the material property of cohesion.

The influence which the mind of an individual exercises over its own physical system is dependent, in a certain sense, upon the power of cohesion. Were not the particles of which the human body is composed held steadily together by cohesive force, and, in respect to its bony portion or framework, very firmly, the mind would have no hold upon matter, — it would so far be powerless.

One man is far more active and agile than another; his bones seem to move much more freely in their sockets, and his muscles swell with greater ease. This aptitude for action, which makes the body a fitter instrument than usual for the mind's influence, is probably the result of greater elasticity in the muscles, tendons, &c.; and they are indebted for this to a somewhat different arrangement of particles, or to a more than ordinary admixture of particles which possess a higher degree of elastic power, than the matter which enters into the composition of the human frame usually possesses. Here the mind has command over, and makes use of, the power of elasticity.

The muscular structure of the human frame is fibrous; its sinews, tendons, &c. are fibres knitted together or interwoven, and to the fibrous condition of each man's system his strength and elasticity are perhaps mainly attributable. Whatever may be the material power concerned in holding together the particles of animal fibre, — and there seems to be a necessity of polarity of attraction, — the mind employs it as an instrument or agent.

The human body being held together by the powers of cohesive and polar attraction, &c., the influence then which the mind exercises over the body, as an instrument or servant, is intellectual control over the material powers of attraction, as well as over, it may be, other powers which the body, as an organised structure, may possess.

Under the action of disease, *i. e.* the action of unusual influences, the prostration of strength in the human body is oftentimes wonderful, both as to rapidity and extent; the cohesive force seems to be almost suspended; the body appears ready to fall to pieces; the mind, by the greatest effort, is unable to give action to the limbs, or cause them to support the trunk; at times the man lies powerless, altogether abandoned to the resistless influence of gravitation.

Too long a continuance of bodily action not only brings weariness, but occasions stiffness; the limbs and joints for a time lose their elasticity, and frequently it is only recovered gradually. Why is this? What is the nature of the change which takes place?

The cohesive or other forces of the human body are in all human actions which affect external bodies directed against and made to bear upon the accumulations or aggregates of power in those external bodies.

Employment of the muscular power of the human body to overcome the influence of gravitation upon the body itself. — In the act of rising from the ground or from a seat, mental energy overcomes, in the most direct and evident manner, the power of gravitation. Every time that we lift an arm or a leg, we overcome gravitation.

Locomotion is the communication of motion to the human body by innate mental influence overcoming the influence which gravitation constantly exercises upon the human body. In moving the body from place to place by means of the legs and feet, the mind overcomes the power of gravitation. Gravitation, unresisted, would bind the living body to the spot where it might be as effectually as it does the carcase. The energy of the vital principle within conquers at intervals the never-ceasing influence of gravitation.

The power which the mind possesses over its own physical system consists very much in superior influence, but to a limited extent, over the power of gravitation. A block of stone remains motionless wherever it may lie, but the body of a man, greater it may be in weight than the stony mass, is raised at the pleasure of the man and removed to another spot; and in so moving its own body, the mind of man triumphs over the influence of gravity.

The constant influence of gravity over the human body is counteracted by the continued influence of the mind upon the body in balancing it. In this constant impulse of the mind during our waking hours, whether we be standing or moving, whenever an error is committed, and cannot be retrieved, gravitation asserts its sway and triumphs, the individual falls, and all that he can do whilst in the course of falling is to moderate, by judicious management, the evil results of the fall.

Our most direct influence over the power of gravitation is exercised through the agency of the power of cohesion, and resolves itself into the employment by each man's mind of the cohesive force of its own body to control gravitation.

In walking, running, leaping, &c., gravity is overcome by muscular force. Constantly are strong men performing or attempting extraordinary feats of strength or agility. An instance is just recorded in the public papers (July, 1848) of a man leaping 1000 hurdles in less than four hours; the exertion in overcoming gravity was here astounding.

Employment of the muscular power of the human body to overcome the cohesive force of external bodies. — In breaking a stick or plank, by means of the hands, or of the hands and knees, or of the hands and feet, we overcome the resistance of cohesion. We pit the cohesive strength of our muscular system, combined with the force of mental impulse thereon, against the cohesive force of the stick or plank.

In tearing asunder anything by muscular force, we overcome the cohesiveness of the body by means of the superior cohesive force of our arms, influenced by the energy of the spiritual principle within us.

As bodies differ in cohesive force, the physical strength which is equal to the counteraction of the cohesive force of one mass is not equal to the overcoming of that of another.

Men also greatly varying in physical strength, an amount of external cohesive force which one man can overcome another man is unable to subdue.

Every man finds his influence over external cohesive power limited; he meets with numerous masses which he can, by his own strength, neither break nor rend asunder. In unaided attempts to overcome the cohesive power of masses, we thus find that the influence of an individual is barred both by the amount of his own physical strength and the amount of cohesive force of each mass.

Employment of the muscular power of the human body to overcome the influence of gravitation upon other bodies. — The human body being ever under the influence of the material property of gravitation, mental influence over the physical system in moving or raising masses is an influence counteracting to a limited extent the gravitating power. The cohesiveness of the human body, which constitutes it in part a forcible agent or instrument of the mind, is made an antagonist to the power of gravity.

In lifting or raising persons or things, we use our muscular power to overcome the force with which gravity is unceasingly acting upon them. The blacksmith, coppersmith, and others, employ their physical power with wonderful energy and endurance, in lifting the ponderous hammers which they wield in their truly muscular employments.

Lifting any weighty thing supplies us with an illustration of the superior force, within definite limits, of the influence of the human mind upon matter in comparison with the power of gravitation.

Dr. Reid says ("Essays," vol. iii. p. 78.): "If a man wills to raise, &c."

When we hold out anything with extended arm, — a child for instance, or a weight at the end of a pole,—we counteract the influence of gravitation both upon the object held and our own arm; and the effort is too great to be long sustained.

When we support heavy bodies, we counteract the influence of gravitation. When we remove bodies from place to place by carrying them, we do the same. When we apply our physical force to a mass, and by impulse thrust it from its position, we overcome the power of gravity. Thus Sisyphus is fabled to have been always employed in rolling a great stone up a hill. Stewart says ("Phil. of Mind," vol. i. p. 78.): "It is by impulse alone, &c.;" vol. ii. p. 330., "The communication of motion, &c." See also vol. i. p. 117. for some excellent remarks on the feat of equilibration: "When an equilibrist balances, &c."

In kicking anything before us, or removing it by the foot, we overcome the mutual gravitating influence of the earth and the body we are acting upon.

In throwing anything from the hand,—a cricket-ball, a quoit, a stone, &c.,—we overcome for a time the influence of gravitation, and the longer in proportion to the force of the effort or impulse.

When bodies are pulled along from their positions by unaided human strength, gravity is overcome.

There are various tests of the muscular power of an individual, and of the relative physical strength of different individuals, in endeavours to overcome gravitation. Lifting heavy weights, holding out a loaded pole at arm's length, supporting the pressure of large masses, as Atlas is fabled to have sustained the earth on his shoulders, drawing or thrusting a weighted carriage, &c., are such tests.

The influence possessed by man over the power of gravitation is in some sense analogous to the attractive influence which the earth exercises over detached masses on its surface and over its atmosphere in opposition to the attractive influence of the sun; which latter influence, although as a whole it is far more powerful, yet beyond a certain distance is more than counterbalanced by the former.

Employment of muscular force to overcome elastic and other forces.—The elastic force of certain substances, to be made available by man, must usually be first overcome by human strength. When an archer wants to propel his arrow by means of the elastic force of his bow, he must first by main force bend the bow into a position not natural to it, so that when muscular force is removed, the elastic power of the bow may act as a propelling force to drive off the arrow, and the greater the muscular force applied, the greater will be the action of the elastic force upon the arrow.

So also, for the watchmaker to avail himself of the elasticity of steel as a moving power to his exquisite machinery, he must first by physical strength, or by united mechanical and physical strength, coil up the steel, and so overcome its resisting elastic force, that it may afterwards spontaneously act as a spring or moving power in its endeavours to uncoil or straighten itself. An officer in doubling a Damascus sword-blade, or one equal to it, overcomes for the moment its elasticity.

Employment of the muscular power and gravity of the human body to overcome the cohesive force of other bodies. — In treading upon anything and crushing it, we employ the power of gravity, accompanied generally by muscular pressure, to destroy the cohesion of the animal or inanimate object crushed.

When we so place a piece of wood that by jumping upon it we may break it, we make use of the power of gravitation and the momentum which our bodies acquire by falling through a space to overcome cohesion.

When we avail ourselves of the gravity of our bodies, the employment of the cohesive power of the same is necessarily superadded. The cohesive force of the human body is as essential as its gravitating force, otherwise instead of the substance being crushed, the human body itself would be wounded and disparted; this indeed is ever the case when the substance trodden or jumped upon is hard and sharp.

Employment of the muscular power and gravity of the human body to overcome the gravity of other bodies. — We avail ourselves usefully of the properties of cohesion and gravitation in our own bodies to overcome the gravitation of other bodies, when we lean or press against anything, or thrust ourselves against it with the intention of displacing or overturning it: we in all such cases bring the whole weight of the body to bear upon the object against which we are acting; or, in other words, we suspend our customary resistance to gravitation, and allow to it its full power over our bodies.

When we pull a heavy inanimate thing, holding it with our hands, we make use of the cohesive force of our bodies and the force of gravitation ; we throw ourselves entirely under the influence of gravity, by letting our body hang off from the body which we want to move, or the gravity of which we desire to overcome, and thus make gravity to bear against gravity.

Both in thrusting and pulling, gravity is made to overcome gravity; we incline our body towards the thing acted upon, or in an opposite direction, so as to avail ourselves of the weight or gravity of our body.

When it happens that we lose our grasp of the thing we are pulling, or the thing we are pushing against unexpectedly gives way, a fall is the consequence, and amusement to bystanders usually ensues ; the gravity of the earth asserts its triumph over our mental influence, and the figurative gravity of lookers on is overcome with it.

Employment of muscular force and the gravity of the human body to resist or overcome other forces.—We avail ourselves of the power of gravitation, when we offer resistance to any person or thing which is driving against us and endangers our displacement from our position. We then incline the body towards the aggressor with so much deviation from the perpendicular that, were it not supported by the opposing body, it would be drawn down by gravitation. If, when a man is about to receive a thrust, he inclines not to the operating individual or thing, but remains upright, he is easily upset, or his power of balancing the body is overcome, and then gravitation aids irresistibly the attack, and he is at once prostrated.

In pressing down the pedals of an organ with the feet, or in working with the feet a wheel as street knife grinders do, gravitating power is employed to overcome the resistance of some other powers, which, without our interference, are more than a counterbalance to the influence of gravity upon the matter which possesses those powers, or upon which they are exercised.

By presenting physical resistance to the movements of persons or things, we retard their motions and sometimes stop them, and this is done by physical force and the weight of the body.

The retardation of motion is always, I think, effected by presenting physical resistance; we bring the hand or foot, or some other part of the human body into contact with the moving mass, but not so effectually as to altogether stay its motion.

When I speak of stopping or originating the motion of a mass, I mean local or secondary motion, for all masses over which we exercise influence are, with ourselves, constantly moving about the centre of attraction. We have no power to stay the *absolute* motion of bodies.

General observations on the employment of the physical powers unaided by any powers of external masses. — Thus each human mind, by using its own physical system as an instrument or agent, exercises a control over the powers which are inherent in, or in operation upon, external bodies; it employs the cohesive and gravitating forces of the physical frame to affect and control material powers external to it.

Notwithstanding that human bodies are subject to the power of external attraction, yet men we see have power to a limited extent over the cohesive, gravitating, elastic, and other influences of external bodies, so as to occasion in them changes of consistency, form, and magnitude, and to alter their motions and positions.

The physical system of man is always and necessarily the medium of this intellectual influence, and the substances which enter into the composition of the human body take part in these changes, &c., by means of their natural properties.

Whatever effects in the material world are attributable to human power, can be produced only to a limited extent: the powers of external nature are, in numberless instances, beyond the control of human influence without assistance. The tenacity of many masses cannot be overcome by human strength alone, nor by it can the heaviness or gravity of others be surmounted.

The influence which men individually possess over the material powers of their own bodies they often employ against one another; the muscular power of one man is pitted against that of another. These efforts may be witnessed in all athletic contests; formerly they were common in warlike encounters.

When two human beings are pulling or thrusting each other the muscular force and gravity of the one are together employed both to overcome the gravity of the opponent, by driving or drawing him from his place, and to resist being overcome. Boys have a game in which a number hold one end of a rope, and an equal number the other end; the entire muscular force and gravity of one party is then energetically put into competition with the combined strength and weight of the other.

The physical powers of men are constantly exerted in opposition to the physical powers of brute animals: a horse, a calf, a powerful dog, a sheep, &c. Unaided human strength, however, is a sorry antagonist to the strength of many species of the brute creation.

Employment of the cohesive power of substances to overcome cohesion.—We break a stick oftentimes by striking it against a wall, or other hard body. In this case the cohesive force of the stick and that of the wall are brought into violent collision, and the weakest of course gives way. Thus we make the cohesive power of an external mass, aided and directed by our own muscular force, to conquer the cohesive power of another mass.

Persons have been known to dash the heads of others against rocks, walls, or pavement, and so fracture their skulls and occasion death. "Happy shall he be who taketh thy children and dasheth them against the stones."

The cohesive force of the principal branches of a tree and the cohesion of the trunk cannot be overcome by human strength alone; but the cohesive power of metal or stone being greater, these substances can be employed instrumentally, and by their assistance the tree, however bulky and spreading, may be separated into parts, and adapted to human requirements.

Whenever we employ cutting instruments to divide flesh, wood, minerals, &c. we bring to bear the higher degree of cohesive force possessed by one substance against the lesser degree of cohesive force which appertains to another, and so, by the use of cohesive power, we overcome cohesive power.

In most instances that we employ an instrument to sever bodies we take advantage of the various kinds and degrees of attraction which determine the consistency of bodies: hardness and texture are important conditions of masses, in respect to their suitability for instruments. To constitute a good cutting instrument it is not sufficient that the material be *hard*,—its particles must be peculiarly placed also.

By means of pestles and mortars, and of mills, substances are pounded or ground into fine or coarser powder, as may be desired. The cohesion or hardness of the instruments breaks up the cohesion of the substances operated upon, and reduces them from the massive state to independent particles, or, at least, to a minute state of division of parts.*

Masses are not only reduced to parts by cutting, grinding, and pounding instruments worked by hand, — large masses of minerals, mineral ores especially, are beaten to pieces by huge hammers worked by machinery.

A mass of matter is often so great that its aggregate of gravitating force is too much for the human mind, by its own efforts upon and with the physical system, to overcome. In such cases oftentimes the first process is to conquer the force of cohesion by reducing, with the aid of instruments, the mass into pieces, and then each fragment presents an amount only of gravitating resistance which man's strength may master.

The cohesive power inherent in matter is, in all these and such like cases, turned by human intellect against that material power itself; greater intensity of the power (and substances differ greatly in the attraction of aggregation) is employed to overcome an inferior degree of it.

Employment of the cohesive force of substances to overcome or counteract gravitation. — In pulling up persons or things by means of a cord we make use of the cohesiveness or tenacity of the cord in conjunction with our own physical strength, and so overcome gravity: instance Cleopatra drawing up Marc Antony.

When we suspend ourselves, or any other mass, by means of a rope or chain, we trust to the cohesive strength of that by which we hang, or by which the other masses are upheld, to resist the influence of gravitation. If the latter prevail, the rope or chain is disparted, and the power of gravity triumphs: instance the suspended sword of Damocles; the nest-hunters at St. Kilda; miners let down and drawn up in a bucket, to whom accidents are not unfrequent by the breaking of ropes.

When bodies are suspended to hooks by means of ropes, the cohesive power of that to which the rope is fastened, as well as of the rope itself, is employed to counteract gravity.

In constructing bridges over which heavy loads are to pass, the cohesive strength of the materials employed, as well as their mode of arrangement, is to be well considered; otherwise the weight, *i. e.* the gravity of the materials and of the loads to be supported, will bend in the bridge, and occasion its fall. There have been several instances of the fall of iron railway bridges.

Suspension bridges are interesting instances of the command which human genius has assumed over the cohesive force or tenacity of matter, iron particularly, to countervail the force of gravity.

The tubular iron bridges over the Conway and the Menai Straits, which Mr. Stephenson has just erected, are triumphs of art; they are unequalled specimens of tenacity or cohesive force directed by human power against the force of gravity.

The pulley, crane, &c. are most useful instruments in elevating bodies, and in them we avail ourselves of the power of cohesion to overcome the power of gravitation. In the crane the axle of the wheel on which the rope or chain is wound must, as well as the rope or chain itself, possess ample tenacity to bear the strain which gravity brings to bear upon it, otherwise gravity conquers. Anchors are weighed or drawn up by hempen or chain cables, and worked by the windlass.

When cords, &c. are employed to drag along bodies, the cohesive strength of the cords is enlisted to overcome the property of gravitation. We have an instance in the iron cords by which the carriages on the Blackwall Railway were at first dragged along.

When a ball is struck with a bat or racket, a shuttlecock by a battledore, &c., gravitation is overcome, partly, by the cohesion of the bat, &c.

The employment of the cohesive power of substances to resist and control expansive force, and other forces.—Metallic and earthen vessels are employed to contain and keep together ignited fuel, and to prevent to a considerable extent the dispersion of the caloric which is generated or developed, and which seems to be naturally incoherent and dispersive. Here the tenacity or cohesive force of the vessel, coupled with the texture of the material, presents an obstruction to what would otherwise be a rapid dispersion of the particles of caloric.

When water is exposed to the action of caloric, the caloric combines with it, and both pass off together into the atmosphere in the state of vapour usually invisible; but to raise water to a heated state, and retain it so, covered vessels of earthenware and metal are employed, the cohesion of whose parts accumulates and condenses the caloric, so that the water becomes elevated to a high temperature.

On the cohesive power of the retaining vessels rests, in great part, the utility of the furnace and the boiler: were it not for the great tenacity of metal which accumulated steam cannot, up to a certain point, overcome, the steam-engine could not be constructed. This tenacity cannot, beyond a certain point, resist the immense expansive force of the compressed steam, and destructive explosions of boilers ensue. To all steam-boilers and condensers, safety-valves weighted up to a certain point are attached, and numerous explosions having occurred through the recklessness of engineers, safety-valves are now usually placed beyond reach.

Muskets, cannon, mortars, &c., all require to be tested before use; for if not sufficiently strong to bear the expansive force of the charge of gunpowder when it is ignited, or there be any flaw or imperfection in the metal, they burst and injure those who work them. They are tested by increased charges of gunpowder, and so their power of resisting a certain amount of expansive force is ascertained.

Employment of the power of gravity in bodies to overcome cohesion.—The gravitating tendency of bodies is employed as a means of destroying cohesion.

When a tree is to be felled, a part near the ground is chopped away on one side until the hold of the trunk upon the root becomes so weakened, or the tenacity of the uncut portion becomes so insufficient to support the trunk, that it cannot resist longer the force of gravity: the tree snaps and falls.

In making cuttings for railways, &c., the excavators undermine the earth; and then having loosened by wedges, &c., considerable masses, gravity completes the severance, and tumbles them down.

It is required to test the cohesive strength of cables, iron rods, &c.; this is commonly done, I believe, by suspending from them heavier and heavier weights until they break.

Employment of the gravity of bodies to overcome gravity.—Water, being a fluid, has a constant tendency, under the influence of gravity, to seek and maintain a level; and wherever the earth slopes, and the rain falls heavily, the power of gravity draws off the accumulated waters from the higher to the lower lands, the motion being more or less rapid, according to the declination. This natural, and in many places constant flow of water, man has contrived to employ as a moving power to important machinery. In water-mills, ponderous wheels are turned by the running stream dammed for the purpose, and in turning these wheels the gravity of the water overcomes the gravity of the wheels and of the moveable portion of the machinery.

When a man makes use of a lever to raise weights greater than human strength alone can lift, he presses down the longer end of the lever by resting upon its extremity the whole of the weight of his body, and in this case employs the gravity of his body and the gravity of the long leg of the lever to overcome the gravity of the shorter leg and of the mass attached to it.

In the steel-yard, and in scales employed to ascertain the comparative weights of masses, the weight suspended at one end of the lever of the steel-yard, and the weights placed in the scales, become counterpoises to the bodies weighed; the gravity of one mass, or of several masses, is employed to balance the gravity of that which is weighed.

In a clock the pendulum, when swinging, has a constant tendency to cessation of motion by the influence of gravity; but by means of a weight which is also acted upon by gravity, the pendulum is kept for a length of time in a state of regular oscillation.

Employment of the gravity of bodies to overcome other forces.—When the safety-valve of a steam-engine is properly loaded and placed beyond the reach of the engineer, that the engine may be self-acting and keep the pressure at a safe height, gravity is the power employed to resist the expansive force of the steam.

Employment of the united forces of cohesion and gravity to overcome cohesion.—When in a narrow pass, the natives of mountainous countries roll down huge fragments of rock and crush their foes, they avail themselves of both the cohesive and gravitating forces of the massy fragments. They apply, however, first their combined muscular energies to start the masses into motion.

In lifting a hammer, a elub, a mace, or a battle-axe, a man overcomes gravitation ; but in giving the blow, he avails himself of the force of gravity and muscular force together, raising himself often as mueh as possible that the instrument or weapon may acquire greater impetus by falling through a greater spaee, inflicting thereby a more deadly or effective .blow ; he throws the entire weight of his body and his full muscular strength into the crushing blow. The hardness of the weapon is likewise as necessary to the effect as the muscular force and the force of gravity. "The momentum," says Dugald Stewart ("Phil. Essays," p. 411.), "of falling bodies is, &c."

The cohesion of a mass is overcome by pounding, by smashing, by grinding. In all these cases men do not avail themselves alone of the cohesiveness of the pestle, the mallet, the hammer, and the grindstone, but of their gravity and momentum, backed by the muscular force of the operators themselves.

When ore, previous to being washed and smelted, is pounded by means of ponderous hammers raised by mechanieal means and allowed to fall, the crushing is effected by the cohesive power and the gravity unitedly of the metal hammers.

When plates of gold are beaten out into gold-leaf, the cohesion of the partieles of the metal is, by the united agency of physical force and the cohesive force and gravity of the hammer, partially overcome, so far as the relative position of the particles is altered and they are forced to assume a new position.

When a tree, after having been deprived of its limbs, is to be rooted up, a rope is placed over its head, the ground is dug away from the roots, and the hatchet is applied to them on one side; the head of the tree is then bent down as much as possible by human force in a direction opposite to the cutting; after a time the force of cohesion in the parts of the roots is reduced below that of gravitation, and the tree falls with a tremendous crash. The wood-cutter employs the cohesive forces of the axe and rope, and the gravitating forces of the earth and tree, with the physical and gravitating forces of any persons who will assist in pulling the rope.

Employment of the cohesive and gravitating forces of bodies to overcome gravitation.—When piles are driven into the earth by the falling upon their heads of monkeys (large solid iron blocks) from a considerable height, the monkeys must first be raised. This is done by human strength acting upon wheels, and thereby winding upon cylinders the chains which pass over pulleys, and suspend the monkeys. In this operation we have the force of gravity overcome by the united agency of physical force, the cohesive force of the chain and machinery, and that increase of gravitating power which, I imagine, is acquired by using the wheel and cylinder.

Human sagacity and ingenuity have contrived a powerful apparatus (the wheel and cylinder), by means of which one man can elevate a greater weight than several can without. In this apparatus, the additional power obtained is, I believe, the power of the lever, so that muscular force, cohesion, and gravity, are the powers brought by the human mind to overcome gravity.

On railways proceeding from the mouths of pits which are in the sides of hills, the gravity and tenacity of the loaded waggons and the cohesion of ropes are employed to draw up the empty waggons; I recollect seeing this mode in operation near Cheltenham.

The barometer is a valuable scientific instrument, in which the gravity, or weight, or pressure of the atmosphere, and the cohesion of the upright glass tube, are made to act in concert, so that the gravity of the mercury is alternately being overcome or is overcoming, thus showing the variations in the density of the atmosphere.

The atmosphere, in consequence of gravitation, presses with great force upon the surface of the earth. By the employment of a suitable apparatus, the air may be drawn out of tubes placed in water; the water then, by the pressure upon its surface of the external air, is forced up the tubes a definite height, and may be discharged. This mode of elevating water, viz. by pumps, is of great utility, and in it various natural powers are employed,—physical force or mechanical force in working the pump; the gravity or pressure of the atmosphere; the cohesive power of the apparatus, &c. By these the gravity of the air pumped out and of the water admitted is overpowered.

The amount of the gravitating force of bodies varies according to the quantity of matter in them. Human strength in a multitude of instances is no match for accumulations of gravitating power. A heavy fallen tree cannot by human power alone be moved from the spot where it has fallen, but the tenacity, or firmness, and the gravity of other bodies, supply him with opportunities of constructing machinery whereby the trunk, however large and ponderous, may be raised and carried away entire.

In all cases where the gravity of some bodies is employed to counteract the gravity of others, instruments or machinery must be also employed, and the utility of the latter is very much derivable from the cohesion or tenacity of their parts; so that in truth cohesion and gravity are together made use of—invariably, I believe, to counteract gravity.

Employment of the cohesive and gravitating powers in union, to overcome elastic, expansive, and other forces.—In certain industrial pursuits, atmospheric air is collected in large vessels, and then driven out forcibly through a narrow passage. By this means a larger quantity of oxygen gas is supplied to burning fuel than the natural expansion or motion of the air would furnish; the action upon the fuel is strongly stimulated, and caloric is given forth far more copiously for the purpose for which it is wanted, viz. to melt metal, glass, &c., than by the ordinary process of combustion. Here man acts upon the air, first by the cohesive power of the containing vessel, which prevents the dispersion of the air, and next by physical or mechanical power, pushing or pressing one portion of the bellows against the other, which compresses the contained air, and thrusts it through a narrow tube or passage provided, and with such swiftness and in such direction as it may most beneficially be applied to the burning fuel.

Employment of the elastic power of animal and vegetable fibre and of steel, to overcome other natural forces.—In the case of cord and cloth, flexibility is of that description that the cord or cloth remains as it is bent; but the particles of muscular fibre, woody fibre, and steel, have a strong tendency to resume or recover their former relative positions respectively. This property or power is termed elasticity, and under human management becomes eminently useful.

Whalebone, when cut into slips of sufficient thinness, is highly elastic, and is employed, as steel now commonly is, in women's stays and some other parts of their dress, also in umbrellas, &c.

Caoutchouc is so elastic and yet strong, that, since the mode of properly treating it has been discovered, it is employed in a variety of useful ways; it is used in articles of dress, such as braces, the wrists of gloves, &c.; it is also employed advantageously in some of the finer mechanical arts.

The elasticity of the bow, as a power employed in the chase, in war, &c., has already been remarked upon. In the balistæ of the ancients, human and mechanical power first overbore elastic force, and then elastic power overbore gravity.

The particles of good steel arrange themselves, when the steel is cooling, in such manner (by virtue, I apprehend, of polarity of attraction) that the metal becomes strongly elastic, and is applicable in a variety of ways where that property is required; thus, in watch-springs the elastic power is made a moving power to overcome inertness or gravity; in carriages the force of springs is employed to modify the jolting, or upward and downward motion, when they pass over uneven roads; in railway carriages they are employed to soften the shock of the carriages when they strike against one another: the buffers are powerful springs which yield to a certain extent to strong pressure, and break the shock of contact.

Employment of other attractive forces to counteract or control material forces. — The particles of animal and vegetable substance, and of some kinds of mineral matter, arrange themselves fibrously. To what property or properties this arrangement is attributable we know not; most probably it is to polarity of attraction. Instead of the particles, under the influence of the attraction of aggregation, attaching themselves indiscriminately in respect to their points of contact, they seem to attach themselves lengthways.

By twisting together natural fibres, we obtain thread, cord, and cable; and their properties, among which flexibility and cohesion are most valuable, we turn to our own purposes, employing them in a variety of ways as agents to overcome other material properties.

The matter of heat has a tendency to diffuse itself equally throughout the atmosphere, the waters, and other fluids, and likewise the solids of the earth; but an equal diffusion of temperature is very far from ever taking place, by reason of the countervailing action of other influences. Changes of temperature being in many parts of the earth very great, the sensitive nature of man in regard to calorific influences or abstractions is severely affected. Now there are various natural productions — wool, silk, cotton, flax, &c., — which, by reason perhaps in great part of their fibrous texture, suffer caloric to pass through them with less facility and greater slowness than substances commonly do. This difference in the transmission of caloric has been advantageously seized hold of and applied by man: he has woven these fibrous materials into clothing, and in cold and variable climates adapts his clothing to the changes of temperature and weather. Thus we employ these states of substances, and the power or powers which occasion them, to regulate and partly control the natural action of caloric. The power which gives to certain substances their fibrous texture is perhaps a species of polar attraction; and this power we employ as an antagonist to caloric.

Plants differ greatly in their calorific character, some requiring a higher temperature than others to keep them alive. Numerous tropical plants perish when exposed in a cold climate, or in one subject to sudden and quick changes of temperature. But as the preservation of these delicate plants is, in such a climate as ours, desired by many who delight in natural productions, an artificially heated atmosphere is constantly kept up, or at least the plants are protected from frosts and chills. With these views they are kept in greenhouses and hot-houses. In the latter caloric is artificially generated and kept in, and in both the cold external air is not permitted to enter and injuriously act upon the plants. We avail ourselves of the obstruction which glass, from its texture, offers to the rapid dispersion of caloric, and so pit one natural power against another.

In tropical climates, and in the hot season in temperate climates, it is desirable to have liquids, jellies, &c., kept as cool as possible. From cellars, wells, &c., wherein wines, iced creams, and ice itself are preserved, the approach of caloric is kept off by means of those substances which difficultly and slowly pass caloric. The tendency also which caloric has to unite with a portion of fluid, and still more so with ice, and carry itself off with either in the form of a vapour, or, in other words, by evaporation, is also made use of to cool down and keep cool wines, &c., at the moment of use.

The retention and accumulation of caloric in earthen and metallic vessels seems to depend in a very material degree upon the texture of the vessel; caloric, from some cause which is not well understood, cannot pass through the pores of some vessels so readily and expeditiously as through those of others. The peculiar placing or package of the particles in these vessels, &c., seems, as already said, to depend upon *polarity* of attraction.

By means of a concave glass, the rays of the sun can be collected into a focus; and the accumulation of caloric thus effected being directed upon one spot, conflagration in certain cases can be usefully occasioned. Here the position of the particles of the glass causes the direction of the caloric; yet the particles become so placed by polar attraction, or some variety of attraction analogous to it. The direction of the rays of caloric is thus regulated by the agency of polar attraction.

Polarity of attraction is shown by magnetised iron when freely suspended; — the tendency of the needle to point always to the north has, in the mariners' compass, become an invaluable instrument to man.

Employment of the moving force of the air to produce motion in machinery, and so overcome gravitation, cohesion, and other forces. — Atmospheric air is under various influences. Homogeneous attraction has a tendency to bring all its particles together, and condense them into a solid mass. Gravitation tends to keep them in a stagnant or quiescent state, and to drag them to the earth. Caloric has a contrary tendency; it struggles to elevate and expand the atmosphere. The action of the sun is unequal upon the earth's surface; that luminary is habitually operating more forcibly upon one portion of it and its superincumbent atmosphere than upon another, and differently operating upon the same part of the earth and its atmosphere in the course of every diurnal revolution, and at different seasons of the year. The atmosphere in every place is thus in a continually altering state of dilatation or condensation. Still the tendency of the atmosphere is to an equilibrium of density; and, therefore, it not only rises and falls, but moves horizontally, currents of colder air passing along the earth's surface to fill up the comparative void or diminished density in those places where great heat has much rarefied the atmosphere: sometimes it rushes forward with great rapidity, at others it advances with more moderation, yet with considerable strength. Sudden electrical changes are considered to occasion some of the violent commotions in the atmosphere.

This frequent motion of the air, under the opposing influences of caloric, electricity, and gravity, man in civilised communities applies, as he applies the force of a regular flow of water, to suitable apparatus or machinery; and in so doing he first overcomes gravity by moving the wheels, &c. of the machinery, and then effects the ulterior objects which he has in view, viz., to overcome the cohesion of masses, &c. In this oftentimes complicated process he compels the powers of cohesion, gravitation, and the expansive power of caloric, to overcome cohesion, gravitation, &c.

The moving force of the air is applied to windmills, the sails of which are turned by it with rapidity; and these being connected with and revolving upon an axle, move it round, and so turn grindstones, or set in motion other machinery.

One mode of employing the force of moving air is to produce motion in sailing vessels, and so overcome the gravitating force of the vessels and their contents, and of the water in which the vessels are immersed, and which is to be displaced. The mariner spreads a large surface of canvass to the breeze, and by this contrivance accumulates an amount of power sufficient to overcome the aggregate gravitating power of the vessel, its cargo, and the water, which is usually very great.

The moving force of the air is applied to other useful purposes; it is employed to turn vanes or weathercocks, showing to us thereby its changing directions, or the alterations in its current. Its course is directed through hospital chambers, sewers, &c. to ventilate or cleanse away foul vapours, &c.

Employment of the repulsive or expansive force of ca-

loric to overcome or modify the attractive and other forces of substances.—When fire is nakedly applied to animal and vegetable substances, it operates to expand or dilate them, and so overcomes, in part, their attraction of aggregation; it proceeds next to separate the more volatile portions,—the gaseous and aqueous parts,—and ultimately it severs entirely the connection of their elements, or, as is commonly said, it consumes the bodies.

Animal matter is rarely exposed by man to the destructive process by the application of heat, except when it is unfit for food. It is thus ordered occasionally by the municipal authorities in London, and other large cities, to be destroyed for the sake of the health of the inhabitants.

Mankind seldom employ fire to destroy vegetable matter for the sake of destruction, beyond the burning of weeds, refuse vegetables, &c. When fuel is burnt, it is for the sake of the great heat which is liberated in the process of combustion, which heat is turned to the valuable uses of warming, cooking, generating steam, softening, melting, &c.

One great purpose to which calorific power is applied by man is to subdue, for a time, the great cohesive power of the most important metals; and whilst they are in a state of comparative softness, he beats, or bends, or rolls, and so works them into new and useful forms.

Sometimes caloric is applied to a metal in no greater force than is requisite to partially subdue the cohesion of the parts; the caloric mixes with the metal and makes it red hot, the metal is softened, and becomes fit for the anvil.

The power of caloric over metals is continually urged beyond the softening process, so that they are reduced to a state of fluidity. In this state the distance of the particles of the metals is very slightly increased, yet sufficiently so to allow of an easy change in the relative position of the particles, and permit them to run into a new form, provided it be done expeditiously, so that no considerable portion of the unnatural and excessive accumulation of caloric have time to disperse.

Melting gold and silver, casting iron, and dissolving other metals by the agency of intense heat, constitute some of the most valuable of the mechanical arts.

There are other solid bodies, besides the metals, which may be reduced to fluidity by the action of caloric. Sometimes, by being melted together, these substances mingle, or in part mingle, and form new compounds. One of the most valuable of these compounds to man is glass.

Caloric, or the matter of fire, is one of the prime agents of man in his operations upon substances. He manages this mighty and dangerous element by amassing fuel upon which he intends the fire to act, igniting it, confining the caloric when necessary in earthen or metallic furnaces, and supplying constantly additional fuel so long as the service of the fire is wanted. Thus a continuance and intensity of calorific power is obtained, which is made to bear against other properties of matter.

In hot climates bathing is much practised, that the unpleasant and injurious accumulation of animal heat may be got rid of; the superabundant caloric of the body passes off into the liquid, and a portion of vapour is generated, which flies away into the atmosphere. Here, for our convenience and pleasure, we avail ourselves of the greater attractive influence which, at the moment, exists between caloric and water than between caloric and the solids and fluids of our bodies.

Fire is employed to act upon animal and vegetable matter, and produce some changes in them of a chemical nature, by which they are made suitable for human food. When caloric is employed by itself in cooking, the food is roasted or baked; when employed in conjunction with water, the food is boiled, stewed, &c.

Water raised to the boiling point or a less degree of temperature, when brought to act upon a vast variety of substances, so affects their properties as to make them more serviceable to man; besides thus preparing much of his food, man adapts other natural substances for being used in the arts.

Employment of the expansive power of caloric and other material power in conjunction, to overcome cohesion and other forces. — Caloric alone will not, in numerous cases, overcome the elective attraction which exists among the elements of compound bodies. Other substances, with which new combinations are to be formed, must be present, and not only present, but must be actively exerting their attractive energies in forming the new connection. Atmospheric air, or one of its elements, oxygen gas, is, in almost every case of conflagration, indispensable: a fire breaking out in a confined place cannot continue its ravages if fresh supplies of air from without can be excluded. This shows that, in combustion, the attractive powers of some other substance or substances is indispensable, and that, in fact, caloric, so far from acting alone, operates in conjunction with some other material power or powers. In using fuel to effect the many purposes for which he requires it, man does not employ the power of caloric alone, as, at first sight, might appear; he employs it in conjunction with the elective attraction of other elements of bodies: the new combinations formed liberate the caloric in the large quantities which he wants.

The employment of the action of fire in reducing and purifying gold and silver is aided by other matters, termed fluxes, the properties of which act attractively upon the metal, or upon the heterogeneous matters mingled with the metal.

Clay cannot be reduced to fluidity or softness by means of heat; but, on the contrary, when it is properly worked up and shaped, it is hardened by being subject to intense heat. This hardening or baking process is constantly going on in the potteries; and in brick-making caloric seems to be utterly powerless when directed against the cohesive force of argillaceous particles, and when applied thereto seems to assist, rather than counteract, the action of cohesive attraction, by driving off all moisture which kept the clay soft.

As caloric, when it combines with mercury, spirits of wine, oil, &c., expands them, scientific men have availed themselves of this effect, and constructed an instrument of great utility, the thermometer, by means of which they ascertain and measure the variations of temperature in the air, in water, other fluids, &c. In the open air the expansion of mercury, &c., takes place, but then the effect is scientifically unavailing; the confinement of the expansive matter in vertical tubes is essential, and so the power of cohesion is employed.

Employment of the expansive force of steam and the cohesive force of vessels to overcome cohesion, gravitation, and other forces. — Water, in the ordinary arrangement of natural things, is in a state of fluidity; a sufficient quantity of caloric is habitually in connection with the particles of water to keep them in that state; but man, having the power of accumulating caloric in great quantity, applies concentrated heat to water, aud raises it either to a state of vapour, or steam, or to any intermediate degree of temperature he may require.

When great heat is applied to water in boilers, and the steam generated is in a great degree confined in the boilers, the expansive force of the steam is a power mighty in the extreme and almost resistless; and when the escape of a portion is permitted, and regulated, and properly applied, a moving power of indefinite energy is at the command of human intellect.

This mighty force has, in recent times, been brought by the civil engineer under most manageable and wonderful control, and is daily and nightly doing his bidding with a docility and untiring energy which enables him, in some cases, to dispense advantageously with animal, wind, and water power, and in other cases to perform operations and produce results which no combination of brute, human, or other natural power is able to effect.

This power is managed by first collecting, and in some degree condensing, the steam in metallic vessels of great capability of resistance, by reason of the powerful cohesiveness of their particles, to the vast interior pressure or expansive force of the confined vapour, and then regulating its escape in such manner that there shall be a rush of the impetuous fluid against a yielding surface, —a piston in a cylinder—which, by its displacement, allows a portion of the steam to escape, and by its moving communicates motion to axles, wheels, and any kind of machinery attached thereto.

Such is the immeasurable force of confined and compressed steam, that great care is necessary to allow the escape of a portion occasionally, and so to keep the entire amount of expansive force below that of the cohesive power of the containing vessels; when this is neglected, the most dreadful and disastrous explosions of the boiler are occasioned.

The force of gravity may be overcome to a small extent by unaided physical, human, and brutal force; or, in other words, small masses and limited machinery may, by such means, be moved and worked. But, to set and keep in motion a huge ship, or a train of strong and heavily-laden carriages, or to lift and discharge torrents of water from deep mines, and other such like operations, a mighty apparatus or machinery, and a moving force vastly superior, are required. Such a force the intellect of man has discovered and applied — the force of steam.

Under one system of applying steam, provision is made to reduce quickly the expansive force by presenting to it a quantity of cold water; the caloric of the steam immediately diffuses itself through the water, and the expansive force is suddenly and greatly diminished.

Attempts have been made to apply the expansive force of heated air, the vapour of mercury, &c., as a moving power, instead of steam, but hitherto without success. Mr. Howard tried the latter, Capt. Ericsson the former (A. D. 1855).

Employment of the expansive force of gases and explosive mixtures without and with the cohesive force of vessels, to overcome cohesion, gravitation, and other forces. — The atmosphere, though it has its particles naturally distant from one another, may, by a suitable apparatus, and suitable containing vessels, be compressed into a much smaller space, — the particles retaining, notwithstanding, unimpaired their disposition to revert to their accustomed relative distance, and, in their endeavour so to do, pressing with force proportional to the condensation against the sides of the vessel. The air, by means of the forcing air-pump, is thus condensed in the chamber of the air-gun, and then being allowed to escape, the expansive force of its particles propels or gives violent motion to the bullet.

There are some gases which, when made to combine with other substances, sink into a solid form, but which are held in that state so loosely that the combination is easily severed, and the gas re-assumes its natural dimensions with vast rapidity and force. Such are the fulminating powders. These explosive mixtures have not, on account of their extremely dangerous nature, been in use for explosive purposes.

Gunpowder is a granular compound which, when the slightest spark of fire is applied, instantly decomposes, and becomes, for the most part, resolved into gaseous matter. The gases, in resuming their natural bulk, spread themselves out with inconceivable rapidity and almost irresistible force. Man has availed himself of this expansive power in various ways.

Gunpowder is placed by civil engineers in a hole of a rock, or under an old foundation of a bridge or building. When ignited, it breaks by its expansive power the cohesiveness of the mass of rock or masonry, which, by ordinary means, could not be done but by immense and tedious labour and displaces and scatters abroad, the fragments by overpowering their gravity. Rocks under water, which prevent or render dangerous the entrance of vessels into harbours are blown away by vessels of gunpowder being placed in them and ignited by the electric wire.

The explosive force of gunpowder is employed in war to burst open the gates and blow up the walls of fortifications. Bags of gunpowder are carried to the gates, piled against them, and then set fire to by a fusee. Walls are undermined, and masses of gunpowder placed in the galleries of the mines are exploded by a train of the powder. In these operations, the cohesiveness and gravity of the strong structures against which the explosive force is brought to act are overcome by the superior power of the destructive material.

Large cylinders of gunpowder were employed to blow up the "Royal George;" they are employed, also, by the officer under the Conservators of the Thames, when occasion requires, to remove sunken vessels which might become obstructive and dangerous to the navigation of the river.

Bombs, shells, &c., are hollow iron balls filled with gunpowder; they are projected from mortars, &c., into fortified places, or amongst bodies of soldiery, and, having a lighted fusee attached, they burst upon reaching their destination and deal around mutilation and death.

Most extensive use is made by mankind of the explosive force of gunpowder in their bloody and deplorable contests with one another. The gunpowder is placed in tubes of various kinds, sizes, and strength, and when exploded, it drives forth with great force solid masses of metal, greater or smaller, or metal vessels containing explosive mixtures, &c. The fire-vessel gives to man the cohesive power without which the expansive power could not effect the distant and destructive results contemplated, but would be wasted in the immediate vicinity of the explosion.

The tubes from which shot, shells, &c., are propelled, must be of ample strength to resist the expansive force of the gunpowder, otherwise, instead of propelling the missiles, the insidious agent will burst the musket, cannon, &c., as is sometimes unexpectedly done. The power of cohesion is here a necessary auxiliary to expansive power.

Employment of the power of the electric fluid to overcome other forces. — Scientific men having discovered the means of accumulating the electric or galvanic fluid in large quantities, and of discharging it at once, or rather discovered the means of obtaining a continual supply, and discharging it in a desired direction, have obtained the command of a most powerful and useful agent.

The galvanic fluid is employed to explode gunpowder: portions of the Shakspeare Cliff were thus blasted on the formation of the railway from Folkestone to Dover.

The galvanic fluid has been very successfully employed in breaking up chemical combinations which resisted all or nearly all other means. By its powerful agency, Sir Humphry Davy severed potassium, sodium, &c., from oxygen, the mutual attraction of which elementary substances being conquerable by scarcely any other forces.

This fluid has been made a most valuable servant in the electric telegraph. By its motion along a great length of wire, and action upon the hands of a dial-plate at the extremity, intercourse is carried on with distant regions in almost an instant of time. The communication between Balaklava and London is as yet the greatest instance (A. D. 1855) of the distance the fluid will travel in man's service.

Employment of other natural powers. — Light acts upon the visual organs, and by means of it we perceive objects. It is chiefly, but not exclusively, furnished to us by the sun, and therefore during about one half of our existence upon earth we are naturally without it. To remain so long in darkness as, without some contrivances, we should be obliged to do in the winter season, would be a serious inconvenience. To avoid this, the ingenuity of man has contrived various means of supplying civilised communities with a sufficiency of light for all needful uses. By promoting the action of caloric upon certain inflammable bodies, various decompositions and combinations are brought about, during which light is evolved in more or less quantity. To effect this artificial evolution of light, man avails himself of the powers of substances, managing them so as to consummate his desires. The preparation of inflammable matters, viz., inflammable gas, candles, lamp-oil, &c., for affording light most conveniently, is the daily occupation of numbers, and gives vast employment to capital.

When a number of rays of light pass through glass, they are bent out of their direct course, or are refracted; they diverge or are brought to a focus according to the form of the glass. This influence upon the movements of light, or, perhaps more properly, effect upon them, has been directed to the construction of extremely useful instruments, viz., refracting telescopes, microscopes, eye-glasses, &c. By these means man has greatly enlarged the sphere of vision, and counteracted the disadvantages arising from imperfect and decaying vision.

The rays of light are reflected or turned back from many bodies; the particles of light seem to strike upon these bodies, and, being unable to penetrate them, rebound. The direction of the rebound depends upon the form of the surface of the reflector and the incidence of the rays. Man has availed himself of this action (influence it cannot be called) upon the motion of light to construct the mirror and the reflecting telescope and microscope.

The various modes of employing natural or material powers considered generally.—We cannot combine, separate, or arrange bodies, neither can we alter their forms or bulk, without producing motion. In all these operations there is motion of the masses or of the parts of the masses which are operated upon. Some philosophers attempt to resolve these phenomena into the production of motion alone (see Mill's "Political Economy"): but motion is not all; otherwise, what distinguishes the division of a mass from the recombination of its parts? In the first case, there is the counteraction or overcoming of a material property, viz., cohesion; in the second case there is not. Besides, in all removal of masses, great or small,—in other words, in all cases where motion is produced,—the power of gravity is overcome.

Numerous instruments and machines are so constructed by man as to make available the natural properties of substances. Certain powers of nature are seized upon by human skill and converted into moving powers and agents, and machinery is so framed as to be acted upon fully and freely by those powers. There must be in all cases an adaptation of instruments and machines to the powers employed; otherwise there is a waste or misdirection of power, and results not intended, or not such as are exactly desired, ensue. In new inventions or adaptations constant mistakes are made by projectors in this respect.

Instruments and machines, besides being adapted to the powers which are to act upon or with them, have to be constructed also with a view to the materials upon which they are to act; — an instrument suitable to one material would be powerless as to another.

Effects brought about by physical strength and skill alone are as nothing compared to the results of human power operating in conjunction with the properties of inanimate substances employed as instruments. These results are to be attributed in less degree to human influence than to the properties of inanimate nature.

Machinery, being the production of art, derives in a limited sense its origin from man, and the more simple kinds are worked by his muscular power; but the working of the higher and more potent varieties of machinery is mostly carried on by natural agents, requiring little more than human supervision and occasional applications of human power.

In the improvement of instruments and in the invention of more effective machinery, we have palpable evidence that man's dominion over the natural world is a control which admits of expansion, and to what extent we are ignorant; nevertheless, it is but pitting one material property, against another,—our primary influence can never go beyond individual physical capacity.

When men have to employ material powers in new adaptations they must know beforehand somewhat of the relative strength of each power about to be employed; and in their machinery they have to adjust the several powers to one another, so that they may work harmoniously, and produce the due degree or quantum of result desiderated: a mal-adjustment of influences either deranges the machinery employed or produces a disproportionate result different from that required and intended.

The productions of art, in respect to their form and connection, but not in respect to their material or to their natural properties, are of the nature of effects of which the human spirit—acting in conjunction with and controlling the physical system and external masses and their properties—is the efficient cause. We see these productions, and trace them—save in regard to their material and to their natural properties—to human agency.

Did not the atoms of bodies naturally cohere, the ability of combining and fashioning masses could not, in its present mode, be exercised by man. The corpuscles of bodies are individually beyond the observation, and for the most part the control, of man. Were it otherwise with respect to any kind of substance, he might perhaps influence the movements of the corpuscles, and in so doing might alter their relative positions; he might place them in contact, yet could not connect them. As affairs really are, the authority which man exercises over matter enables him to alter the combinations of bodies and to bring them into connection in such ways as the undirected properties of matter would never effect.

For various important general remarks on human influence over the properties of matter, see the following passages: — Enfield, "Hist. of Phil.," Prel. Obs. p. 26.: "The business of philosophy is (*in part*) to, &c." Bacon: "Every (×) accession which man gains to his knowledge extends the limits of his empire over the world which he inhabits." The knowledge which increases human influence over matter must be of a *particular* kind; there is much knowledge which has no connection with human action and control over the powers of nature.

Dugald Stewart, "Elements," vol. i. p. 48.: "Lord Bacon was the first person who pointed out to all classes of literary (*scientific*) men, &c." This end had occupied the attention and exercised the mechanical wit of men long before Bacon lived. What was Archimedes about during the most important part of his life?

Locke, "Hum. Und.," bk. ii. ch. ii. p. 94.: "The dominion of man over, &c;" ch. xii. p. 143., "This shows man's power, &c.;" bk. iv. ch. iii., "Power of moving matter." See also the passage commencing thus: "No human art can create, &c."

Dr. Reid, "Essays," vol. iii. pp. 517, 518.: "It has been further observed, &c.;" p. 368., "Within the sphere of his power, &c.;" p. 65., "However small, &c." Dr. Priestley: "Every advance in (*scientific?*) knowledge is, &c." D. Stewart, "Elements," vol. i. p. 206.: "We are enabled in many, &c.;" vol. i. p. 208., "That particular species of, &c.;" ch. ii. p. 55. et seq., "The savage who never heard, &c.;" vol. ii.

p. 342., "The more we are enabled, &c.;" "Phil. Essays," ch. ii. p. 35., "With respect to, &c."

Whewell, "Bridg. Treat.," p. 359.: "Man can construct, &c." Laws are not *results* of laws. Man cannot invest matter with any one new property.

Mill's "Political Econ." p. 5.: "It is found that the agency, &c." Man can produce material *motions* only by controlling and using certain material *powers*, so that motion is not all: when a nail and a plank are brought together, the nail does not, undriven, enter the wood; nor when a needle and a piece of cloth are placed in juxtaposition, will the needle, unforced, pierce the cloth, and perform the part of the tailor or sempstress. Man has to exert his power over material powers, and then the latter produce the desired and contemplated results. P. 5.: "Labour produces its, &c." Labour or human action must spring from *power*, or there can be no co-operation or conspiring. P. 65.: "Superintendents in all, &c." Kidd, "Bridg. Treat.," p. 28.: "Having passed the preparatory, &c."

The changes which man, by the power he possesses over the properties of material existences, and with the assistance of those powers, effects, are to be witnessed in the industrious efforts of civilisation. Wherever enlightened man settles, the face of nature becomes speedily and essentially altered. Man's influence upon the soil, in increasing its productive powers, is being developed in the present day by the vast agricultural improvements which have been introduced: among these, in this country, draining, deep ploughing, cleansing, manuring, removal of useless hedges, and the introduction of improved implements and machinery are the most conspicuous. In India, Africa, &c., improved and more extended modes of irrigation, — in America, clearances of land from wood, &c., are the most valuable. In all cases the benefit is exceedingly great, and all evidence the control and application by man of the powers of matter.

Dr. Reid, "Essays," vol. iii. p. 67.: "By his power, &c.;" p. 66., "By human power, &c.;" p. 363., "The motions of, &c." Dr. Robertson, "America," bk. iv. p. 280.: "The effects of human, &c." "Monthly Review," vol. xviii.: "The aggregate labours, &c." Dr. Prout, "Bridg. Treat." p. 412.: "Such is man and, &c." Turner, "Sacred Hist." vol. ii. p. 26.: "Mankind are connected, &c."

THE SUBORDINATION OF THE SPIRITUAL PART OF MAN TO THE POWERS OF MATTER.

The human body, like other kinds and combinations of matter, is subject to the influence of the power of cohesion. Hard substances break, or cut, or pierce the body with facility, according to their form, and, so doing, they overbear, at times, the influence of the human mind over the powers of matter.

The influence of gravitation over the human body is evidenced in the difficulty of ascending a steep hill, accompanied as it is by the unpleasant and sometimes painful sense of weariness. Again, gravitation is found to accelerate human motion when the hill is descended. Man, by the force of gravitation, is prevented darting off into the expanse, and cleaving the air like a bird. By the same force he is oftentimes dragged down from fearful heights and dashed to destruction. Fat, heavy persons, those who are enfeebled by sickness, and all of human kind when they become aged, feel likewise disagreeably, in the action of walking, the drag or drawback of gravitation.

Thus the human mind, connected so intimately as it is with its own physical system, and that again connected with extraneous masses, is ever checked and restrained in its operations by the properties of matter. The spiritual part of man is controlled by all those material properties or powers which exercise an influence over the human physical system.

Reid, "Essays," vol. iii. p. 66.: "Human power is, &c.;" p. 60., "Our power to move, &c.;" p. 118., "Man's body by which, &c." Stewart, "Elements," vol. i. p. 436.: "A knowledge of nature, &c." Sumner, "Records," vol. i. p. 15.: "Man is subject to the laws (*powers*), &c.;" p. 101., "In taking a general view, &c." Whateley, "Logic," Appendix, p. 284.: "What may be called, &c."

SENSATION AND HUMAN ACTION

ALSO

THE SUSCEPTIBILITY OF THE HUMAN MIND IN RESPECT TO SENSATION AND ITS POWER OF INFLUENCING MATTER CONSIDERED IN CONNECTION.

HAVING investigated sensation and human action separately, we will now very shortly consider them as associated in the same individual.

It is rarely that any one experiences sensation without setting in action the organ by means of which the sensation has existence. That the feeling may be mitigated or extended, sensation and the action of the organ of sensation are commonly mingled; when he snuffs the effluvia from newly made hay, there is the agreeable sensation accompanied by an action. Taste is commonly combined with eating.

We frequently connect the action of the legs with sensations of hearing, taste, smell, and sight, or with some of the inorganic sensations. By so doing we extend our range of sensation: we also, by the same means, frequently escape from sensation which is disagreeable.

We still more commonly associate the action of the hands with some one species of sensation. How usual is it to pluck a flower, or seize upon some other odorous substance and hold it to the nostrils, or to throw from us what is disagreeable to the taste or smell.

There are other actions connected with sensation besides these. When we endeavour to hear distinctly what is said at a distance, or is addressed to us in a low tone, we point our ear towards the speaker, and place one hand against the ear, that the sounds may be reflected or turned into it, and no portion be lost. To avoid flagellation, or a blow, the body is twisted or bent.

We ought to accustom ourselves to analyse associated sensation and action; that if a simple sensation or action, or a modification of any kind of sensation or action, should be concerned in the phenomenon, we may detect it and attain to more accurate knowledge of these two important departments of the Science of Mind.

The employment of the organs of sensation as instruments has occasioned tasting, smelling, seeing, and even hearing, to be commonly described as operations, and has originated the serious metaphysical error of confounding sensation and human action. In the phenomena of tasting, smelling, &c., sensation and human action being in general combined, it is alike incorrect to speak of such phenomena as sensation only or as action only. Peculiar phraseology ought to be employed if we desire to possess exact notions upon the subject, and to express ourselves clearly. Nothing is more needed in the Philosophy of Mind than a set of terms to indicate combined sensation and action. Had we such terms, sensations would no longer be called intellectual operations, as Dr. Reid and Dugald Stewart frequently describe them to be. In respect to language, combined emotion and intellectual operation has greatly the advantage,—the word *sentiment* expressing, if I mistake not, the association.

THE RECIPROCAL INFLUENCES AND THE CONNECTION OF MATTER AND MIND.

To sensation the union of body and soul, of matter and mind, is essential. A disembodied spirit may be affected by matter in a manner of which we can form no conception; but if so, the effect is feeling or emotion, not sensation.

To human action the union of mind and matter is equally essential. A spirit may, and doubtless does, possess the power of influencing bodies; but its *modus operandi* is direct, not intermediate — intellectual, not physical.

The brain is the part by which matter and mind in the human system mutually communicate and influence. The mind operates in a mysterious manner upon the brain in action, and the brain as mysteriously operates upon the mind in sensation.

Plato (Enfield's "Philos.") said: "Life being the conjunction of the soul with the body, death is nothing more than separation." Dr. Reid, "Inquiry," p. 164.: "There is no phenomenon, &c." Stewart, "Elements," vol. i. pp. 63. and 64.: "Among the various phenomena, &c." Burke, "On the Sublime," part iv. sect. i. p. 243.: "When I speak of cause and efficient cause, I only mean certain affections (*a certain power or property*) of the mind that cause (*causes*), &c.;" p. 241., "I do not pretend, &c." In the latter passage is much confused blending of sensation, emotion, and the powers of matter.

On the innate force of human beings, and the innate forces of inanimate external nature as acting and reacting upon one another, see Gregory's "Econ. of Nat." vol. iii. p. 101.

Dr. Roget. "Bridge. Treat." vol. ii. p. 534.: "If the sensorial (*nervous?*), &c." The term "sensorium" is, I think, properly to be restricted to that part of the brain, if such there be, where the nerves of sensation all centre. Dr. Roget seems to extend its meaning to the entire body of nerves. The "separate set of nervous filaments" proceed, or issue, directly from the brain, and they are under the direct control of the mind, not of the will. Instead, also, of the "mental act of volition," read "the mental influencing of matter." There is a corresponding physical movement of the brain, not a physical change.

Dr. Roget, vol. ii. p. 535.: "A voluntary action occurring, &c." This representation, excellent as it is, appears to me to comprise too much, and too confused blending of distinct phenomena. Turner, "Sacr. Hist." vol. i. p. 501.: "It is not easy, from, &c.;" p. 510., "These three (×) advantages give, &c."

END OF THE FIRST VOLUME.

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