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THEORY
OF
HEAT AND THE VITAL
PRINCIPLE.

BY
ARTHUR TREVELYAN.

"All motion is caused by the contraction and expansion of matter—whether the matter be solid, liquid, or gaseous."—MACKINTOSH'S ELECTRICAL THEORY OF THE UNIVERSE.

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1850.

THEORY

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THEORY OF HEAT.

ALL HEAT, whether named SOLAR—that is, heat from the direct rays of the sun; or when the rays are expanded, as electric, galvanic, magnetic, or mesmeric,—heat from the spark, whether magnetic or electric,—heat from condensed air, or from flame, heat evolved by chemical combination or disintegration,—heat produced by friction or percussion,—also heat in the animal and vegetable kingdoms,—is one and the same, but in modified intensities, and is secondarily excited by different causes, but springs all from one source, and that source is the SUN. The vivifying and exhilarating influence of the rays of that luminary pervade all nature, both organic and inorganic; and when light is chemically acted on, by coming within a certain distance of substances on the earth, then the sun's rays are expanded, and electricity pervades all space, producing the life-creating phenomenon in addition.

Light at a high altitude, the electric or magnetic spark, and highly and suddenly condensed air—like high-pressure steam when the hand is held near the orifice from which it issues—has no sensible heat to the animal feelings; but reduce the intensity of the light, the air, or the spark, by expansion,—thus in the latter igniting any substance,—or, as in the steam, by expanding in the atmosphere, the hand will then be injured if held in the flame or the steam; and, in the former case, the heat also becomes perceptible, beyond the direct rays of the sun.

Light and heat are so intimately connected, that a distinction cannot philosophically be drawn between them, but may for convenience be allowed.

Light is generated in the sun, and, expanding and pervading all space, is chemically attracted by everything gaseous, animal, vegetable, and mineral on the earth, and thus, by chemical combination, becomes heat. Being imponderable, it can neither have substance or form. Heat is evolved in a greater degree by the action given to the molecules of any substance, by increased chemical attraction, or by a force crushing them together, *i.e.* percussion.

Fire expands a substance placed in it, and the greater the intensity of the heat, and the longer the substance is kept in contact with it, the greater is the increase of the outward attraction, until such substance falls into a fluid state, or disappears in gaseous product, the minute molecules forming the substance being torn asunder by all the surrounding visible and invisible attracting agencies.

Lightning (electricity), which is concentrated light in its descent from the sun (the generator), is collected by certain clouds (acting as a battery), and when such charged clouds come within attracting distance of each other, if overcharged, an explosion ensues; the lightning invariably taking the form of fork; and being nearer our globe than any other object, is naturally attracted there, the light is then diffused by all chemical agencies. Sheet lightning, as seen to the observer, is merely the reflection of the fork on intervening clouds, which it lights up, like an artificial light behind a transparent screen.

There is one *invariable* natural law, in the conduction of heat, which has continued, and will continue through all eternity; that is, a difference in the attracting or conducting power of the attracting substances, from that of the substances attracted—causing, by a difference in the temperature, arising from a difference in the power of absorbing heat, expansion and attraction; and thus constant action or vibration; this difference in the two substances arises from a variety of different phenomena (perhaps the principal one is density), which makes a good or bad conductor or attractor.

My proposition that light and heat are one, is supported by passages which occur in RUMFORD's Essays on Heat, in LESLIE on Heat, and in HUNT's Researches on Light; and the following remarks by those philosophers, and by DELAROCHE, BECQUEREL, FRESNEL, and MELLONI, are some which support that theory:—

“If liquids are non-conductors of heat, they ought certainly, *on that account*, to be peculiarly well calculated for confining, and consequently furthering the operations of that heat which is *generated by light*, or by any other means, in their integrant particles, or in infinitely small insulated particles of other bodies that are dispersed about, or held in solution in them; as I have already more than once had occasion to observe.”
—RUMFORD's Essays, vol. ii., p. 353.

Many liquids are conductors; mercury and all the metals when fused.

“RUMFORD found that when pieces of ribbon were coated with a solution of gold, that those which were exposed to the strong light of the sun gradually changed colour, and in a few hours acquired a fine purple hue, whilst those preserved in darkness remained unchanged.”
“He also found that by putting small pieces of charcoal into a glass tube filled with solution of gold or of silver, and exposing it to a temperature

of C 99° (F 210°) for two hours in the dark, that veined gold or silver adhered to the surface of the charcoal. Similar tubes, filled as before, were exposed to the direct rays of a very bright sun, in less than half an hour veined specks of veined gold, or silver, in all its metallic splendour, appeared on the surface of the charcoal."—HUNT on Light.—(1844.) Sec. 16 and 17, p. 13.

"A remarkable analogy between the effects of heat and light deserves notice; and it is also of some practical importance in the preparation of the papers." (Photographic.) "If a piece of nitrated paper is placed on hot iron, or held near a good fire, it will be found that at a heat just below that, at which paper chars, the salt is decomposed. Where the heat is greatest, the silver is veined, and immediately around it the paper becomes a deep blue; beyond this a pretty decided green colour results; and beyond the green, a yellow or a yellow-brown stain is made." ("We have already seen that Count RUMFORD found the nitrate of silver in contact with charcoal, or an earthy carbonate was soon reduced to the metallic state under the action of strong sunshine.")—*Ibid.*, sec. 51 and 52, p. 44.

"It does appear to me that a broad distinction is established between the solar influence, light, and the solar influence, heat. That in many phenomena their operations so run together, that it is impossible to separate the one from the other, I am ready to admit; and also that it would appear from the experiments of DELAROCHE that light and heat are convertible into one another. The curious fact, discovered by this philosopher, that radiating heat becomes more and more capable of penetrating glass as the temperature increases, till at a certain temperature the rays become luminous,—almost seems to confirm this, did they stand alone. The results obtained by MELLONI with the solar rays, do, as it appears to me, compel us to consider light and heat as two distinct powers, *intimately* connected with each other in their operations."—*Ibid.*, sec. 415, p. 250.

"It has generally been admitted that these radiations which accompany Light are different from each other, and that according to such and such a sensible substance, the active rays were also different; but I do not suppose that the question is so complex. In fact the luminous phenomena, according to the theory of undulations, depend on the vibrations of the molecules of the illuminating body, which are transmitted to the retina by the intermediation of the ether, the molecules of which are themselves in *vibration*.—(E. BECQUEREL.)" FRESNEL, whose beautiful investigations have contributed to the triumph of this theory, has stated that the chemical effects produced by the influence of Light, are owing to a mechanical action exerted by the molecules of ether on the atoms of bodies, so as to cause them to assume new states of equilibrium, depend-

ant on the nature and the velocity of the vibrations to which they are subjected. This idea had been suggested to him by a remarkable experiment by M. ARAGO, the result of which was to show, that the chemical rays which influence the chloride of silver, interfere in the same manner as the luminous rays."—*Ibid.*, sec. 420, p. 254-5.

M. ARAGO remarks,—“The velocity with which a luminous ray *passes through* a given body, depends exclusively on the refringency of this body, and on *the velocity of the emission of the ray*, on the velocity it had *in vacuo*.”—*Ibid.*, sec. 422, p. 257.

“I have now given the hypotheses of M. E. BECQUEREL and M. ARAGO, which both lead to the conclusion, that the chemical influences of the solar rays are one of the phenomena of Light.”—*Ibid.*, sec. 423, p. 258.

“MELLONI and M. E. BECQUEREL have both suggested the probability that the solar rays are but one principle—Light; and that, as they are received upon bodies differently constituted, they produce the phenomena of colour, and vision, of heat, or chemical action.—We already know that the physical properties of heat and light are similar, that they can be similarly reflected, refracted, and polarized; and the same applies to the chemical principle.”—*Ibid.*, sec. 441, p. 270.

We have now seen that LIGHT, *heat, machine electricity*, and a *voltaic current*, all produce that disturbance on the surfaces, at least of solid bodies, which disposes them to receive vapours upon definite spaces. It will also be found, that any mechanical disturbance to which the plates may be subjected, will act in precisely the same manner as the above elements.”—*Ibid.*, sec. 404, p. 239.

It appears to me to be probable, that one of the above elements exists along with the mechanical disturbance.

“If a body be exposed to the sun’s rays, it will in every possible case be found to indicate a measure of heat, exactly proportioned to the quantity of light it has absorbed.”—“Enough has, I presume, been stated to establish the conclusion, that heat is only light in a state of combination.—LESLIE on Heat, p. 160-2. 1804.

Having attended the excellent lectures on light and heat delivered by Professor FORBES, in Edinburgh University, during the session 1849-50; his observations and experiments illustrating the laws of heat and light, have induced me to add the following eight conclusions to the essay in support of my theory:—

1. The transmission of heat and light are analogous.
2. Rays of heat, like rays of light, are both refracted and reflected.
3. As light can be transmitted at right angles, so can heat.
4. There are some bodies as transparent to heat as glass is to light; and others are as impervious to heat, as an opaque substance is to light.
5. Flame exerts in heat a quality, exactly similar to light for colour.
6. The law of the reflection of light and heat are analogous.

7. Heat, like light, can be polarised; which experiment, and several others of a most interesting character, the Professor took great pains (many of the experiments requiring much patience, and great nicety of manipulation) to show to those of his class, either amateurs or professional pupils, who were interested in the subject.

8. The laws of light and heat are nearly identical.

THEORY OF THE VITAL PRINCIPLE OF ANIMAL AND VEGETABLE LIFE.

The primary principle of life is Heat. Physiologists who seek the principle elsewhere, commit a great error, it being heat that causes excitability and its results in all their different forms, as irritability, sensibility, &c.

Heat is the vital, thus the creating principle of animal and vegetable life. When heat ceases to be conducted by the nerves and various tissues of the body, life, either animal or vegetable, becomes extinct.

In animals, that great nervous ganglion, the brain, acts as a reservoir or multiplier of electricity, from whence, and from the earth, there is a constant circulation of heat, by means of the nerves and tissues, which act as conductors, and thus form a galvanic circle, the heat passing up one set of nerves and tissues, and down the others.

I have been told that I might as well call breathing, or the circulation of the blood, the vital principle; as when they cease, animal life is extinct. My answer is in the negative, for this reason,—in the case of temporary insensibility, caused by intoxication from the use of alcoholic or other narcotic poisons, from suffocation (asphyxia), by gases, or from drowning, insensibility from a blow on the head, or from fits, both breathing and the circulation of the blood are suspended; and, in all such cases, there is an extraordinary diminution of the temperature of the surface of the body. And what is the principal remedy employed to restore the action of the lungs and heart? Why, every method is resorted to, that is likely to restore heat to the surface of the body, either by employing the magnetic, electric, or galvanic apparatus; by friction, or by applying heated substances either in a solid or fluid form. When by any of these methods sufficient heat is restored to the body, again are the lungs brought into play; at the same moment the heart starts into action, the blood circulates, and the animal exhibits signs of revivification, where a moment before, to all appearance, life was extinct.

When sufficient heat cannot be absorbed to restore vitality, we may conclude that the nerves and various tissues of the body no longer possess the power of distributing heat through the animal frame, &c., owing to

some important organ or organs having been injured by the accident, or from disease, or poison causing the insensibility; or that from the length of time which elapsed before the remedies were applied, disorganization has taken place, particularly if there was any organ in an abnormal state of weakness.

Heat brings animals and vegetables into existence, after which it is the power of conduction (by means of the nerves and tissues), of electricity (heat), generated by chemical and mechanical action on light, that keeps them alive; and when the power of conduction ceases, life becomes extinct.

That the nerves are, at any rate, partly the conductors and distributors of heat to the animal body, is strikingly exhibited in the dead body, when its nervous system is excited by the heat given out by a galvanic apparatus; and, provided all the organs are sound, revivification may ensue.

Paralysis of any portion of the human frame is caused by a total or partial cessation in the nerves and tissues of the power of conducting and distributing heat to that part of the body affected. Restore the nervous energy, by animal magnetism (mesmerism), or other vital or heat-producing remedy, and the affected part again becomes healthy.

Inflammation is the effect of too great a flow of heat to the part of the body affected, by the too active or diseased energy of the conducting power of the nerves and various tissues, excited by some injury to that portion of the body attacked by inflammation, which injury might be caused by cold, a blow, the effects of poison, of fright, or of disease, &c.

Electricity (heat) lights up the different organs of the brain, and brings them into action, either violently or mildly, according to the size of those organs, and to the circumstances in which the individual is placed at the time the organs of the brain are affected, which circumstances regulate the amount of the heat conducted by the nerves and tissues to the various organs. The increased flow of blood to the excited organ is a secondary result. The greater the outward exciting cause, the greater is the flow of heat to the organ (as can be proved by means of the flat-bulb thermometer, when placed in contact with the cranium over the excited organ or organs), and consequently the actions of the individual will be regulated by the degree of heat, (excitement) which affects the organ or organs irritated by certain circumstances. Thus heat also brings all the other organs of the body into action as needed.

All substances, organic or inorganic, either in a quiescent or an active state, possess attraction and conduction, varying in power from many external and internal causes, acting on all sides, at different intervals, always causing vibration by expansion and contraction, thus keeping the molecules of such substances in constant vibratory action; in the organic, by the conduction of heat through the nerves and tissues, the conductors; in the inorganic, by the conduction of heat through the particles it is formed of.

Indeed, it must be admitted, that a very remarkable analogy exists between the operations of light, heat, vitality, and electricity, so much so, that the weight of evidence favours the position I wish to maintain, and, until these elements and light are more clearly shown to be separate, they must be regarded as identical.

“LIGHT, HEAT, and ENERGIA, for it is necessary to recapitulate, are the three principles (or the modifications of an elementary first principle) detected in the solar rays. The first, acting upon the organs of vision, and enabling us to distinguish external objects, and giving colour to all. The second is that principle which regulates the solid, liquid, or gaseous states of matter, and which maintains this planet in the condition which is essential to the well-being of its inhabitants. And the third, ENERGIA, that power which effects all the changes, whether chemical or molecular, which are constantly in progress; it is that agent which is for ever quickening all the elements of growth, and maintaining the conditions of a healthful vitality; and it is no less energetically employed in the processes of corruption, which, indeed, are no other than the necessary changes of matter in its progress from one organization to another.”—HUNT, sec. 440, p. 270.

“The influence of this power (the solar rays) on the vegetable kingdom is strikingly evident, and we are now enabled to trace nearly all the functions of the plant up to the operations of a principle which appears to have its origin in the sun.”—*Ibid.*, sec. 452, p. 279.

Is it not also evident, that the condition of the animal kingdom is not merely influenced, but dependant for health and vigour on this solar power?

“It will not be denied by any one, that the sun’s rays have a quickening, an almost life-kindling power.”—*Ibid.*, sec. 455, p. 280.

“Organization and life exist only at the surface of our planet and under the influence of light.”—*Ibid.*, p. 286.

Liebig states animal-heat to proceed from chemical combustion of the food &c. taken into the body. Thus, according to his theory, animal heat cannot be generated except food is present; but he is wrong, as we can revivify the inanimate carcass, empty of all nourishment, by the external generation of heat, and without such heat, life cannot be restored.

It is satisfactory to find in the following paragraph, that so successful an experimenter as ALFRED SMEE, is practically approaching my theoretical view of the electrical uses of the brain and nerves.

“By a test which ALFRED SMEE terms *electro-voltaic*, he has discovered that the termination of the sensor nerves is the positive pole of a voltaic circuit, whilst the muscular substance is the negative pole. The sensor nerves are the telegraphs which convey the sensation to the brain, and the motor nerves carry back the volition to the muscles. The brain he infers to consist of five distinct voltaic circles, which, upon theoretical

grounds, he believes to be sufficient to account for all mental phenomena, SMEE has succeeded in making artificial electric-fish, and artificial muscular substance."

From the Editor of the Chemical Gazette, March 15, 1843.

"A. T. (Edin.) The author's views are so entirely opposed to those generally entertained on the subject, that we must beg to decline the insertion of his communication."

From the Editor of the Phrenological Journal, May 24, 1843.

"I have read the letter on vital principles which you were kind enough to send me yesterday, and regret to say it does not seem adapted for the Phrenological Journal, even if the theory be true. I confess that your opinions seem to be unsupported by facts, and at variance with some that are established."

From the Editor of the Electrical Magazine, Sept. 28, 1843.

"I have read the two papers which you were kind enough to draw out; but the opinions they advocate involve a complete revolution in our established views, and would require such an extensive investigation to confirm them, that it would not be wise to insert them in the Elec. Mag. I return them as you desire."





