IX. *Experiments and Observations on the Light which is spontaneously emitted, with some Degree of Permanency, from various Bodies.* *By* Nathaniel Hulme, *M. D. F. R. S. and A. S.*

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INTRODUCTION.

THE discoveries which have been made with respect to light, as it proceeds immediately from the sun, are many and important; but the observations on that species of light which is spontaneously emitted from various bodies, are not only few in number, but in general very imperfect. The author is therefore desirous of drawing the future attention of the philosopher more particularly to this subject, and of communicating his own experiments and observations upon it, to this learned Society.

By the spontaneous emission of this light, the author wishes to distinguish it from all kinds of artificial phosphorus; which, as he apprehends, differ essentially, in some of their properties, from that light of which he means to treat. And, by its adhesion to bodies with some degree of permanency, he distinguishes it from that transient sort of light which is observable in electricity, in meteors, and in other lucid emanations. The light which is the subject of this paper, he shall therefore beg leave to discriminate by the name of *spontaneous light*.

The substances from which such light is emitted, are principally the following.

Marine animals, both in a living state, and when deprived of life.

As instances of the first may be mentioned, the shell-fish called *Pholas*, the *Medusa phosphorea*, and various other *Mollusca*.

When deprived of life, marine fishes in general seem to abound with this kind of light. The honourable Mr. BOYLE commonly obtained light, for his use, from the whiting, as appears from many parts of his works: the author of these experiments and observations procured his fish light chiefly from the herring and the mackerel.

The flesh of quadrupeds has also been observed to emit light. Instances of this are mentioned by FABRICIUS *ab Aquapendente*; by T. BARTHOLIN; by Mr. BOYLE; and by Dr. BEALE; for which, see T. BARTHOLIN, *de Luce Animalium*, p. 183; BOYLE'S Works, Vol. III. p. 304; Phil. Trans. Vol. XI. p. 599.

In the class of insects are many which emit light very copiously, particularly several species of *Fulgora* or Lantern-fly, and of *Lampyris* or Glow-worm; also the *Scolopendra electrica*; and a species of crab, called *Cancer fulgens*.

Rotten wood is well known to emit light spontaneously. Peat earth also has the same property. Of the effects of the latter, a remarkable instance is related in PLOT'S Natural History of Staffordshire, p. 115.

The place where the following experiments were made, was a dark wine-vault, which, for distinction's sake, the author calls the *laboratory*. The heat of this laboratory varied, throughout the year, from about 40 degrees of temperature to 64°. The thermometer made use of was that of FAHRENHEIT.

The weight is always to be supposed that called Troy weight. The liquid measure employed, was that used for wine in this country: the ounce containing 8 drams Avoirdupois; and the pint, 16 ounces.

The water used in general for the experiments, was pure spring water, drawn up from under ground by means of a pump; and it was always employed cold, unless otherwise expressed.

SECTION I.

The Quantity of Light emitted by putrescent Animal Substances, is not in Proportion to the Degree of Putrefaction in such Substances, as is commonly supposed; but, on the contrary, the greater the Putrescence, the less is the Quantity of Light emitted.

EXPERIMENTS.

Exper. 1. Two very fresh herrings were bought in the morning, and hung up in the laboratory; on examining them in the evening, they were beginning to be luminous.

Exper. 2. Three herrings, which were quite fresh, after being scaled and gutted, were hung up by a string in the laboratory. The next evening they were become exceedingly luminous in every part, and much lucid matter had exuded, as it were, upon their surface, which was easily scraped off by the blunt edge of a knife; it also adhered to the fingers, or other parts of the body, when touched; but, as they grew more putrescent, the quantity of light diminished, and at last was extinguished.

Exper. 3. A single herring, that was perfectly sweet, was hung up in the laboratory. On the second night, it was covered with light; on the third, not so lucid; on the fourth, less so; and so on, in proportion to the degree of putrescence.

Exper. 4. Two herrings, somewhat stale, were hung up in the morning, and at 8 P. M. one of them was pretty luminous, but the other less so. On the next evening, the former

was but slightly luminous, and the latter was dark; on the succeeding evening, they were both dark.

Exper. 5. Two mackerels were brought from the market at 1 P. M. which, to the sight and smell, were perfectly sweet and good. Being then carried into the dark laboratory, and examined, the one was found to be a little luminous, and the other pretty much so, especially about its belly.

Exper. 6. A fine fresh mackerel, with a bright eye, was purchased about noon, and placed as usual in the laboratory, the temperature of which, at that time, was about 54°. At 11 P. M. this beautiful fish was luminous about the head and upper parts; and the inside of the mouth, which was wide open, shone with most brilliant light. The next evening, the whole body of the fish was very luminous: on the third night, it was less so; and on the fourth the light was nearly extinguished.

Exper. 7. In the forenoon, about ten o'clock, a couple of fine-looking mackerels were hung up in the laboratory, at the temperature of 56°, and at 10 P. M. they began to shine in various parts, the light seeming to proceed from within outwards. On the second night, they put on a luminous appearance all over their surface: on the third, the light was not so vivid; and on the fifth it was almost extinct.

N. B. In experiments of this kind, for the production of light, the fishes should always be gutted, the roes taken out, and the scales, if any, carefully removed. As the roes are likewise very productive of light, they should be preserved.

OBSERVATIONS.

Obs. 1. These experiments clearly prove, that light begins to be emitted by marine fishes, before any signs of putrefaction

appear: they likewise demonstrate, that as soon as a great degree of putrescence has taken place, the luminous property of the fishes is destroyed, and the light extinguished.

Obs. 2. In the instance of light proceeding spontaneously from animal flesh, recorded by AQUAPENDENTE, the flesh emitted light before any sensible putrescence had taken place, the meat being hung up in the larder for use. In that also mentioned by BARTHOLIN, in 1641, the flesh must have been fresh and sweet, for it was not intended to be dressed until the next day. Mr. BOYLE, in his report of light issuing from flesh, expressly says, that neither he, nor any of those who were about him, could perceive in it any offensive smell, whence to infer any putrefaction; the meat being judged very fresh, and well conditioned, and fit to be dressed. And, lastly, Dr. BEALE, in his account of a luminous neck of veal, says, that when it was dressed, on February the 27th, some of the neighbours, who saw it shining, were invited to eat of it, and all esteemed it as good as they had ever tasted; that a part of it was kept for February 28th and 29th, in which time it lost nothing of its sweetness.

Obs. 3. Whenever I wish to obtain a plentiful supply of light from fishes, for the purpose of experiments, I always endeavour to procure the freshest that can be had: long experience and frequent disappointments have taught me to adopt such a precaution.

SECTION II.

The Light here treated of is a constituent Principle of some Bodies, particularly of Marine Fishes, and may be separated from them, by a peculiar Process; may be retained, and rendered

permanent for some Time. It seems to be incorporated with their whole Substance, and to make a Part thereof, in the same Manner as any other constituent Principle.

EXPERIMENTS.

*The Flesh of Herring.**

Exper. 1. A fresh herring was split, or divided longitudinally, by a knife, into two parts. Then, about four drams of it, being cut across, were put into a solution, composed of two drams of Epsom salt or vitriolated magnesia, and two ounces of cold spring water drawn up by the pump. The liquid was contained in a wide-mouthed three-ounce phial, which was placed in the laboratory. Upon carefully examining the liquid, on the second evening after the process was begun, I could plainly perceive a lucid ring (for the phial was round) floating at the top of the liquid, the part below it being dark; but, on shaking the phial, the whole at once became beautifully luminous, and continued in that state. On the third evening, the light had again risen to the top; but the lucid ring appeared less vivid, and, on shaking the phial as before, the liquid was not so luminous as on the preceding night.

Exper. 2. The same experiment was repeated. On the second night, the liquid, being agitated, was very luminous; on the third, not so lucid; and on the fourth the light was extinguished.

Exper. 3. With sea salt or muriated natron half a dram, and two ounces of water. On the second night, the liquid, when agitated, was dark; on the third, lucid; on the fourth, very luminous; on the fifth, it began to lose light; on the sixth, it con-

* The quantity used in each experiment was about four drams.

tinued to decrease; and on the seventh it was quite gone. Neither the liquid, nor the herring, had contracted any putrid smell.

Exper. 4. With sea water two ounces. On the second night, dark; on the third, fourth, and fifth, luminous; on the sixth, nearly extinct; and on the seventh, totally. The piece of herring, when taken out and examined, was remarkably sweet.

*Roe of Herring.**

Exper. 5. With Epsom salt two drams, and water two ounces. On the second night, the liquid was pretty luminous; on the third and fourth, still luminous; and on the fifth its light was extinct.

Exper. 6. With GLAUBER'S salt or vitriolated natron two drams, to two ounces of water. On the second night, when the phial was shaken, as usual in all these experiments, the liquid was pretty luminous; on the third, less so; and on the fourth the light was scarcely visible.

Exper. 7. With sea water two ounces. On the second night, dark; on the third, the liquid was moderately luminous; on the fourth and fifth, it had extracted much light; and on the seventh it was still shining. After this process, both the roe and the sea water remained perfectly sweet.

The Flesh of Mackerel.

Exper. 8. With Epsom salt two drams, and water two ounces. On the second night, the liquid was finely illuminated; on the third, a similar appearance; on the fourth, a diminution of light; on the fifth, it continued lucid in a small degree; and on the sixth the light was extinguished.

* The quantity used in each experiment was about four drams.

Roe of Mackerel.

Exper. 9. With Epsom salt two drams, and water two ounces. On the second night, the liquid, when agitated, was exceedingly bright; on the third, the same; and on the fourth and fifth, still lucid.

The Tadpole.

Exper. 10. It occurred to my mind, in the year 1797, to try what effect a saline menstruum would have upon the tadpole. Accordingly, I procured some tadpoles on the 10th of June, and put six of them into a solution of two drams of GLAUBER'S salt in two ounces of water. On the 11th, in the evening, the menstruum was dark; on the 12th, after shaking the phial, I was agreeably surprised to find it impregnated with light; on the 13th, the light was so abundant as to float on the top of the menstruum; on the 14th, the same phænomenon appeared; on the 15th and 16th, it was still present; on the 17th, the lucidness began to diminish; on the 18th, it was faint; and on the 19th it had vanished.

Exper. 11. On the 11th of June, six other tadpoles were dropped into a solution of one dram of common salt in three ounces of water. On the 12th and 13th, the menstruum was dark; on the 14th, it had extracted from the tadpoles a very beautiful bright light; on the 15th, the menstruum was exceedingly luminous; on the 16th and 17th, nearly the same: the light then gradually faded, so that on the 21st it was merely visible; and on the 22d it disappeared.

Exper. 12. On the 21st of June, the above two experiments were repeated; when the tadpoles remained in the menstruums

till the 27th, but no light was emitted. What was the cause of this failure in these two last experiments? Was it the ten days' increased growth of the animal, which was taken from the same pond, that made the difference?

Exper. 13. The above experiments were repeated, when the tadpole had just put on the state of a frog, but without producing any lucid appearance.

The Light is incorporated with the whole Substance of Marine Fishes.

Exper. 14. A fine fresh herring, being gutted, was divided longitudinally into two parts, both of which were hung up, by pieces of string, in the laboratory. On the 2d night, they were very lucid on the skinny side, but not on the fleshy or inward part; on the 3d, the fleshy or central parts of the fish, were thickly covered with a rich azure light; on the 4th, they continued exceedingly luminous; and on the 5th and 6th they were still lucid. It is surprising to think what a profusion of light was emitted from the interior substance of this single fish.

Exper. 15. A similar experiment was made with a mackerel, and with similar effects. These two experiments were frequently repeated.

Exper. 16. But the soft-roe, of both the herring and the mackerel, abounds more with light than even the flesh. When it is in its most luminous state, which generally happens about the 3d or 4th night, it will sometimes shine so very splendidly, as to appear like a complete body of light. It is remarkable that the hard-roe, in general, does not emit so much light as the soft-roe. When the roes were used, they were laid upon plates, and deposited in the laboratory.

OBSERVATIONS.

Obs. 1. The above experiments clearly prove, as I apprehend, that this light is a constituent principle of marine fishes: and that it is separated, by the menstruum employed on this occasion, in the same way that the principles of any other body are separated, by the menstruum fitted to decompose it. They likewise show, that it is not partially but wholly incorporated with every part of their substance, and makes a part thereof, in the same manner as any other constituent principle.

Obs. 2. Light is probably the first constituent principle that escapes, after the death of marine fishes. The experiments of the first Section teach us that it appears soon after death, even in fishes which, to the eye, seem quite fresh and sweet; or, at least, long before any sensible putrescence takes place. And we have seen that the flesh and roes, infused in the saline menstruums, continued to emit light for several days, without undergoing any apparent putrefactive change.

Obs. 3. The experiments likewise render it probable, that no offensive putrefaction takes place in the sea, after the death of such myriads of animals as must needs daily perish in the vast ocean, (quite contrary to what happens on land;) and that the flesh of marine fishes remains pretty sweet for some time, and may become wholesome food for many kinds of those which still remain alive. An eminent instance this, of the wisdom of the Creator, in the construction of the aqueous part of the world, which comprehends, by far, the greatest portion of the terraqueous globe, and is the most replete with animal life!

SECTION III.

Some Bodies or Substances have a Power of extinguishing spontaneous Light, when it is applied to them.

EXPERIMENTS.

The luminous matter proceeding from the herring and the mackerel, was quickly extinguished when mixed with the following substances: 1. Water alone. 2. Water impregnated with quicklime. 3. Water impregnated with carbonic acid gas. 4. Water impregnated with hepatic gas. 5. Fermented liquors. 6. Ardent spirits. 7. Mineral acids, both in a concentrated and diluted state. 8. Vegetable acids. 9. Fixed and volatile alkalis, when dissolved in water. 10. Neutral salts: *viz. saturated* solutions of Epsom salt, of common salt, and of sal ammoniac. 11. Infusions of chamomile flowers, of long pepper, and of camphor, made with boiling-hot water, but not used till quite cool. 12. Pure honey, if used alone.

SECTION IV.

Other Bodies or Substances have a Power of preserving spontaneous Light for some Time, when it is applied to them.

EXPERIMENTS.

Exper. 1. Some luminous matter scraped from the herring, was mixed with a solution of two drams of Epsom salt in two ounces of cold pump water: after shaking very well for some time the phial which contained them, the whole liquid became richly impregnated with light, and continued shining above twenty-four hours. This experiment was frequently repeated, and with the same effect.

Exper. 2. Two drams of GLAUBER'S salt and two ounces of water being mixed with herring light, the solution was thereby quickly made very lucent, and remained so till the succeeding evening.

Exper. 3. Mackerel-light, being mixed with two drams of Rochelle salt or tartarized natron and two ounces of water, caused the fluid to be very luminous.

Exper. 4. Two drams of soda phosphorata and two ounces of water, mixed with herring-light, formed a very lucent fluid, which retained the light for a long time.

Exper. 5. Herring-light, with one dram of saltpetre or nitrated kali and two ounces of water, made the solution pretty luminous.

Exper. 6. Half a dram of common salt dissolved in two ounces of water, with the addition of mackerel-light, composed a very shining mixture, which retained its splendour for the space of a day or two. The same effect was produced by herring-light.

Exper. 7. Two ounces of sea water, being agitated with the light of a mackerel, soon obtained a brilliant illumination. The sea water preserved its luminousness for several days. The experiment was successfully repeated.

Exper. 8. Two drams of pure honey, that had not been clarified, or exposed to heat, were dissolved in two ounces of water; and, after the admission of some mackerel-light, and shaking the phial, the solution was fully impregnated with light, which was visible the next evening.

Exper. 9. Two drams of purified or refined sugar being dissolved in two ounces of water, and mixed with the shining matter of a herring, the fluid acquired a great degree of lucid-

ness. The same effect took place when the experiment was made with soft brown sugar.

N. B. It is almost needless to mention, that the degree of illumination in these liquids must depend upon the quantity of lucific matter applied; but, in general, as much as can be scraped off by the blunt point of a moderately-sized knife, at a few times, will be sufficient, being assisted by a strong agitation of the containing phial.

OBSERVATION.

These experiments enable us to take light and diffuse it through water, so as to render the whole liquid most brilliantly luminous, or, in other words, to impregnate water with light. By these means, the light is so extended in its surface, and combined in such a manner, as to become exceedingly convenient and useful for various other experiments.

SECTION V.

When spontaneous Light is extinguished by some Bodies or Substances, it is not lost, but may be again revived in its former Splendour, and that by the most simple Means.

EXPERIMENTS.

Exper. 1. On the 1st of June, 1795, the following experiments were made, to know what was the best proportion of Epsom salt to water, in order to produce the most luminous liquid. Some shining matter was taken from a mackerel, and mixed with a solution of seven drams of the salt in one ounce of water; and its light was immediately extinguished. The same effect ensued, but in a less degree, with a solution of six, and

one of five drams. In a solution of two drams, in the same quantity of water, the liquid was luminous; but much more so when only one dram of salt was used. Observing the extinction of light to take place, as above, in the more saturated solutions, while the diluted solutions were luminous, it occurred to me to endeavour to discover what became of the extinguished light, in the former case, and whether it might not be revived by dilution. For this purpose, I took the solution of seven drams of salt in one ounce of water, in which the lucid matter from a mackerel had been extinguished, and diluted it with six ounces of cold pump water; when, to my great astonishment, light in a moment burst out of darkness, and the whole liquid became beautifully luminous! This revived light remained above 48 hours, that is, as long as other light in general does, which has never been extinguished. Hence, it had lost nothing of its vivid luminous powers by its extinction.

Exper. 2. The last experiment was then reversed. A solution of one dram of Epsom salt in one ounce of water, was brilliantly illuminated with mackerel light. Then, six drams of the salt were put into this luminous liquid; and, after shaking the phial very well for a little time, to promote the solution of the salt, the light was totally extinguished. But the same light was again recovered, by the addition of six ounces of water.

In this manner, the light may be frequently extinguished, and as often revived. In one instance, the same light, by a repetition of this method, was made to undergo ten extinctions.

Exper. 3. A good quantity of herring-light, being mixed with a solution of four drams of common salt in two ounces of water, was immediately extinguished. Then, fourteen ounces of cold pump water were added thereto, and the whole liquid

was at once finely illuminated. On the next evening it appeared still very lucid; and likewise on the succeeding night.

Exper. 4. The experiment was reversed. Half a dram of the salt, being dissolved in two ounces of water, had herring-light mixed therewith, so as to be made very luminous. On the addition of two drams more of the salt, the lucidness was instantly destroyed: but the light was again recovered, by pouring eight ounces of cold water upon the extinguished luminous fluid. The revived light was very vivid the next evening.

Exper. 5. Two ounces of sea water were illuminated with mackerel-light, and then extinguished by adding two drams of common salt. The light was again restored, by diluting the solution with eight ounces of cold spring water.

N. B. If the illuminated liquid be uncommonly brilliant, it may sometimes require more salt to extinguish the light completely, than is here specified; in that case, the measure of water for dilution, must be always calculated in exact proportion to the weight of salt employed.

SECTION VI.

Spontaneous Light is rendered more vivid by Motion.

EXPERIMENTS.

Exper. 1. A quantity of illuminated liquid was poured into a broad vessel, which was placed in the laboratory. The next evening, on examination, it appeared to be quite dark. But a finger, or rod, being drawn through it, was followed by a luminous line.

Exper. 2. A phial, containing a pretty large portion of liquid impregnated with light, having been at rest a number of hours,

the liquid seemed to have lost its luminous quality, except a little glimmer floating at the top. It was then gently moved, and the light diffused itself gradually through the whole liquid: on agitation, the lucidness was much increased; and, the brisker the motion, the more vivid was the illumination.

SECTION VII.

Spontaneous Light is not accompanied with any Degree of sensible Heat, to be discovered by a Thermometer.

EXPERIMENTS.

Exper. 1. A luminous herring, and another that was quite fresh and not luminous, were placed for a considerable time in the same degree of temperature. A thermometer was then applied to each of them, but no difference of heat could be discovered.

Exper. 2. The soft roe of a herring, in an exceedingly lucid state, and a thermometer, were kept together for some time in the laboratory. The roe was then put upon the bulb of the thermometer, without affecting it.

Exper. 3. A mackerel, which shone with very brilliant light, was also put to the test of a thermometer, but the instrument remained stationary.

Exper. 4. The bulb of a thermometer was surrounded by many small pieces of shining wood, uncommonly luminous, which were kept in that situation for some time; but the light made no alteration upon the thermometer.

Exper. 5. Illuminated liquids, and spring water, being kept together in the laboratory, always preserved the same degree of temperature.

SECTION VIII.

The Effects of Cold on spontaneous Light.

EXPERIMENTS.

The Light of Fishes.

Exper. 1. Five small gallipots, containing three pieces of soft-roe of herring, and two of the herring itself, all very luminous, were placed in a frigorific mixture, composed of snow and sea-salt; and, in about an hour and a half, the light was quite extinct, and the bodies totally frozen. The gallipots were then removed into a vessel of cold water, that their contents might be gradually thawed; which being done, they all recovered their pristine luminous state. The pieces were afterwards observed to shine during three succeeding nights.

Exper. 2. A small phial, containing three or four drams of liquid impregnated with light, was placed in a frigorific mixture. As the liquid froze, its lucidness gradually diminished; and, when it was quite congealed, the light perfectly disappeared. The phial was then taken out, and put into cold water, at about 49° temperature, that the ice might be gradually liquefied; and, when that was accomplished, the whole fluid became as luminous as before.

The Light of shining Wood.

Exper. 3. A fragment of shining wood was put into a small wide-mouthed phial, which was plunged into a frigorific mixture. As the cold affected the wood, the light gradually faded,

and at last was totally imperceptible. The phial was then taken out, and placed in water at about 62°; by this change of temperature, the frozen wood gradually thawed, and then regained its former lustre.

The Light of Glow-worms.

Exper. 4. A small phial, containing a luminous dead glow-worm, was exposed to the cold of the frigorific mixture; as the coldness penetrated the phial, the light diminished, and at length was totally extinct. But, by placing the phial in water at about 62°, the glowing property of the insect soon returned. In this experiment, the glow-worm was evidently congealed; for it adhered to the side of the glass, and was covered with a hoar-frost. This experiment was frequently repeated, and with the same result.

OBSERVATION.

By these experiments we learn, that cold extinguishes spontaneous light in a temporary manner, but not durably, as the substances of the third Section do; because the light revived again in its full splendour, as soon as it was exposed to a moderate degree of temperature.

SECTION IX.

The Effects of Heat on spontaneous Light.

EXPERIMENTS.

The Light of Fishes.

Exper. 1. One side of a luminous herring was held before the fire, for a short space of time, but so as to receive its heat very strongly. It was then conveyed into the laboratory; when that side which had been exposed to the fire was found quite dark, but the other continued still luminous. The fish was preserved till the next evening, but the extinguished light did not re-appear.

Exper. 2. A whole herring, finely shining, was thrown into a quantity of boiling-hot water, and the light was immediately extinguished: after keeping it there for some time, it was taken out, but the light did not revive.

The Light of shining Wood.

Exper. 3. A piece of shining wood, its light being very faint, was put into tepid water at about 90 degrees of temperature, and it became in a short time much more lucid. Another piece, at 96°, was rendered beautifully luminous.

Exper. 4. A pretty thick piece of shining wood was put into a gallipot, and sunk under water by means of a weight, together with a thermometer, at the temperature of 64°. Boiling-hot water was then added by spoonfuls; and the light, at first, was rendered much more vivid, but soon after began to decrease, and was apparently extinct at about 110°. I say apparently, be-

cause on the next evening the light had somewhat revived; which shows, that the heat of 110° was not sufficient to extinguish totally all the light inherent in this piece of wood.

Exper. 5. Finding that 110 degrees of heat did not wholly extinguish the light of shining wood, a good many fragments, of different sizes, were then submitted to the power of boiling water, and detained therein for some time, in order that the heat might penetrate them thoroughly. The effect was, that the light became quickly extinct, and did not, as before, reappear on the following evening.

The Light of Glow-worms.

Exper. 6. A dead shining glow-worm was put upon two ounces of water, contained in a wide-mouthed phial, at the temperature of 58°. The phial was then sunk, about two or three inches deep, in boiling-hot water; and, as the heat communicated itself to the contents of the phial, the light of the glow-worm became much more vivid.

Exper. 7. Another lucid dead glow-worm was put into warm water, at 114°, to see if that degree of heat would extinguish the light; but, on the contrary, its glowing property was augmented. All the water was then poured off, yet the insect continued to shine for some length of time.

Exper. 8. The effect of that heat which is obtained from dry solid bodies by friction, was next tried upon the light of the glow-worm. Two living glow-worms were put into a one-ounce phial, with a glass stopple; and, though they were perfectly dark at the time, yet, if the phial was briskly rubbed with a silken or linen handkerchief, till it became pretty warm, it seldom failed to make them display their light very finely.

This experiment was very frequently repeated. It had the same illuminating effect upon the light of a dead glow-worm.

Exper. 9. The complete influence of 212 degrees of heat was now applied to the light of a glow-worm, by pouring upon one when dead, but in a luminous state, some boiling water. Its light was instantly extinguished thereby, and did not revive. The experiment was repeated, and with the same result.

Any of the saline Solutions mentioned in the fourth Section, being impregnated with luminous Matter, and left some Time at rest, are rendered more lucid by a moderate *Degree of Heat.*

Exper. 10. A quantity of illuminated solution was deposited in the laboratory. The next evening, when it was examined, it appeared in a manner quite dark; but, by putting the phial which contained it into hot water, the light revived, and was soon rendered exceedingly vivid.

Exper. 11. About a pint of solution impregnated with light, had become obscure, by time and rest, as is the nature of this mixture. Such a quantity of boiling-hot water was then added to it, as only to give it a small degree of warmth, and it quickly caused it to appear luminous.

Exper. 12. Illuminated liquid, to the quantity of four ounces, was placed in the laboratory until the next evening, when it had become almost dark. One spoonful of boiling-hot water being put into it, the light re-appeared; and, by means of two more, it was rendered considerably lucid.

Their Light is extinguished by a great *Degree of Heat.*

Exper. 13. Some boiling water being poured upon three or four ounces of illuminated liquid, in an earthen vessel, the light was immediately extinguished; and, though afterwards kept a

considerable time for inspection, and often agitated, to stir up the hidden light, yet no remains of any shining property could be perceived. This experiment was frequently repeated, and always with the same result.

Exper. 14. Four ounces of very luminous liquid, together with a thermometer, were put into a small earthen vessel, glazed white, the better to reflect light. Boiling-hot water was then added, by spoonfuls at a time, and by slow degrees. The first few spoonfuls made it considerably more lucid; and then, by adding more, the light began to fade, and at length was gradually extinguished. This effect took place, in one instance, when the liquid was heated to 96°; in another, to 98°; and in a third, to 100°. Hence, this species of light, when thus united with water, seems to begin to be extinguished at from 96 to 100 degrees of heat. This is a very elegant and pleasing method, of knowing how much heat is required to extinguish the light; because it measures it exactly, provided the hot water be added in small quantities, and by slow degrees, as above directed. To prevent the possibility of any light reviving after an experiment of this kind, would require a much greater heat than that of 100°. The intention of the present experiments was only to show, that all light may be apparently extinguished, at so low a degree of temperature as from 96° to 100°.

Exper. 15. A phial of an ounce and a half was filled with some very luminous liquid, but not corked. It was then suspended by a string, in a quart of boiling-hot water contained in a white earthen mug, and the light was wholly extinguished in about three or four minutes. After this, the phial was kept in the water some time longer, was then taken out to cool, and well shaken, but the light did not revive. It was examined the next day, and agitated again, but no luminous appearance could be

discovered; a proof that all the light had been totally extinguished by the power of heat.

If much Heat be applied to the Bottom of a Tube filled with illuminated Liquid, which has been some Time at rest, the Light will descend in luminous Streams, from the Top of the Tube to the Bottom, and be gradually extinguished.

Exper. 16. A glass cylindrical tube, closed at one end, being 9 inches long, with a bore of $1\frac{1}{10}$ inch, when used, was put into a gallipot $3\frac{1}{2}$ inches deep, and $3\frac{1}{2}$ wide, which held about 12 ounces of boiling water, and was placed in another larger vessel, to receive the overflowing water upon the immersion of the tube. The tube being filled over night with some very luminous liquid, was placed in the laboratory until the next evening. The light had then ascended plentifully to the top of the fluid, (the rest being dark,) and, taking the circular shape of the tube, formed a very lucid ring. The vessels with the boiling-hot water were then carried into the dark laboratory; and the tube being gently and carefully placed (without shaking) in the gallipot, the light was, generally in about half a minute, seen plainly to descend in streams from the top to the bottom, illuminating the whole fluid in its descent in a beautiful manner, and then was gradually extinguished. The extinction of the light began at the top of the tube, and ended at the bottom.

Exper. 17. The experiment was also made with a tube 19 inches high, $\frac{1}{2}$ an inch in bore, having several curvatures, and sealed hermetically at its lower end. Both the extremities were made straight for a few inches; the one to be immersed in the water, and the other to prevent the liquid running out. The luminous ring being formed as above mentioned, the tube was

put into the gallipot of boiling-hot water; and, in a short time, the light began to descend from the top, and came waving down, in a pleasing manner, to the bottom of the tube in the hot water, and then was by degrees extinguished. The whole length of the tube, including the curvatures, was 26 inches.

The most eligible solutions for this curious experiment, are those made with Epsom salt, GLAUBER'S salt, sea-salt, and sal ammoniac: if either of the two former be used, the proper proportion is, one dram of salt to each ounce of water; if either of the two latter, 15 grains to each ounce of water will be sufficient.

N. B. The experimentalist, before he views the descent of the light in the tube, should always remain in the dark for some little time, in order to get rid of all extraneous light adhering to the organs of vision, and to accommodate the eye to darkness.

SECTION X.

The Effects of the human Body, and of the animal Fluids, upon spontaneous Light.

The living Body.

Exper. 1. On touching the luminous matter of fishes, the light adhered to the fingers and different parts of the hands; remained very lucid for some little time, and then gradually disappeared. But the same kind of matter being applied to pieces of wood, stone, and the like, of the same temperature as the laboratory, continued luminous on these substances for many hours.

Exper. 2. A piece of red blotting-paper, about one inch square, and four times doubled, was finely illuminated by matter from a herring, and applied to the upper part of the inside of the thigh. After the expiration of 15 or 20 minutes, it was taken off; and, on examination, the light was quite extinguished. The experiment was repeated several times, and with the same effect. Another piece of the like paper was illuminated at the same time, and placed in the laboratory; where it retained its light above 48 hours.

Exper. 3. A piece of shining wood was placed upon the palm of the hand, and inclosed therein for some time; on inspection, it was found to be more lucid than before. Many trials of this kind were made, with the like success.

Exper. 4. A dead glow-worm, being but slightly luminous, was breathed upon several times; and its light increased both in magnitude and brightness. The experiment was frequently repeated, with the same result.

Animal Fluids.

Blood.

Exper. 5. A person having received a contusion, but otherwise in health, was bled. The next day, some herring-light was mixed with about two ounces of the crassamentum or red coagulated part of the blood, by stirring them well together with a knife: it caused it to be slightly luminous, but the light was not of long duration. Nearly the same result followed the mixture of lucid matter with the recent crassamentum of persons labouring under inflammatory diseases, as the pleurisy and rheumatism.

Exper. 6. But, when mixed with crassamentum that had been kept for some time, and become black and somewhat offensive to the smell, the light seemed to be more quickly extinguished.

Exper. 7. A singular phænomenon happened several times, on mixing fish-light with putrescent bloody serum. It would not incorporate, but was ejected in globules, like quicksilver when rubbed with any unctuous substance, and afterwards adhered to the side of the vessel in which the mixture was made, in the form of a lucid ring.

Exper. 8. The luminous matter of a herring was mixed with about two ounces of pure serum, from the healthy subject of the 5th experiment: it soon became finely illuminated, and retained its shining appearance for a long time, whenever it was stirred or agitated.

Exper. 9. The recent serum, drawn from patients afflicted with inflammatory complaints, was illuminated pretty much in the same manner as in the 8th experiment; and often retained light above 48 hours.

Urine.

Exper. 10. Mackerel-light being mixed, by strong agitation, with some fresh urine from a healthy person, a glimpse of light was retained at first, and then was gradually extinguished. But stale and pungent urine, being incorporated with luminous matter, had a still greater extinguishing effect.

Bile.

Exper. 11. Some bile, taken from a person who died of a suppression of urine, had herring-light mixed with it, which soon became extinct. Another trial was made, with a different bile, and with the same result.

Milk.

Exper. 12. Human milk not being easily obtained, some mackerel-light was incorporated, by agitation, with two ounces of fresh cow's milk, which was thereby rendered finely luminous, and continued shining above 24 hours. Fresh cream also retained some light; though it was not so visible as with milk, owing probably to its thickness. But, when either milk or cream turn sour, they contract a very extinguishing property. A quart of milk was kept five days, in a moderately cool place, in the month of June; by that time, it was changed into a mixture somewhat resembling curds and whey, that is, into a soft smooth coagulated part, and a very thin one, both which were acidulous. Some fine mackerel-light was mixed with two ounces of each of them, in separate phials, and they extinguished it immediately.