X. *An Account of the remarkable Effects of a Shipwreck on the Mariners; with Experiments and Observations on the Influence of Immersion in fresh and salt Water, hot and cold, on the Powers of the living Body.* *By* James Currie, *of Liverpool, M. D. Fellow of the Royal College of Physicians at Edinburgh.* *Communicated by* Thomas Percival, *M. D. F. R. S.*

Read April 19, 1792.

THE following narrative is submitted to the Royal Society, as containing in itself some curious circumstances, and as having suggested the experiments afterwards to be recited.

On the 13th of December, 1790, an American ship was cast away on a sand-bank that lies in the opening of the river Mersey into the Irish Channel. The crew got on a part of the wreck, where they passed the night; and a signal which they made being discovered next day from Hillberry Island, a boat went off, though at a great risk, and took up the survivors. The unfortunate men had remained twenty-three hours on the wreck; and of fourteen, the original number, eleven were still alive, all of whom in the end recovered. Of the three that perished, one was the master of the vessel; another was a passenger who had been a master, but had lost or sold his ship in America; the third was the cook. The bodies of these unfortunate persons were also brought off by the men from Hillberry Island, and were afterwards interred in Saint

Nicholas church-yard, amidst a great crowd of spectators. The cook, who was a weakly man, died a few hours before the boat reached the wreck, but the two masters had been long dead, and this added to the sympathy for their loss, a curiosity to inquire into its circumstances and causes. When the following particulars came to be known, this curiosity was increased. Both the masters were strong and healthy men, and one of them a native of Scotland, in the flower of life, early inured to cold and hardships, and very vigorous both in body and mind. On the other hand, several of the survivors were by no means strong men, most of them were natives of the warm climate of Carolina, and what was singular enough, the person among the whole who seemed to have suffered least was a negro.

What is extraordinary is seldom long unaccounted for in one way or other, and the death of the two masters was said to have been owing to their having taken possession of a keg which had contained cherry-brandy, and which still contained the cherries;—these, it was reported, they had kept to themselves, and eaten in large quantities after the shipwreck; and this having produced intoxication, was supposed to have hastened their death. Some experienced seamen were satisfied with this account, which indeed seemed very rational; for though spirituous liquors may fortify the body against the effects of heat combined with moisture, and may perhaps support it for a short time under great fatigue, they are, I believe, uniformly hurtful when taken under severe and continued cold. Pleased to see a doctrine becoming popular which has been so ably supported by Dr. AIKEN,* and others, I be-

* See Transactions of the Philosophical and Literary Society of Manchester, V. I.

lieved it might receive a striking confirmation from this catastrophe, into the particulars of which I determined to examine accurately. I therefore obtained access to the survivors of the crew, and from them, but more especially from Mr. AMYAT, the mate, I received the information which I required.

In repeated conversations with this intelligent young man, I learnt that Capt. SCOTT, the master of the vessel, died in about four hours after the ship struck; and that Capt. DAVISON, the passenger, died in about seven: but that the incident of their having eaten cherries infused in brandy was entirely without foundation: of this he was certain, for he saw the keg, which contained the cherries, staved, while Capt. DAVISON was endeavouring to fill it with water to make grog for the crew; the cherries fell on the wreck, and were immediately washed into the sea. Mr. AMYAT expressed his surprise at the early death of the two masters, but could not assign any cause for it. He said there was no liquor of any kind saved, nor any sort of food; that the whole crew were on an equality in all points, except that some were deeper in the water than others, but that the two masters had the advantage in this respect, for they sat on the only part of the wreck that was out of the sea, whereas the poor negro, who escaped almost unhurt, was perhaps deepest in the sea of any. He explained this in the following manner. When the ship struck they cut away her masts to prevent her from oversetting, and after this she drifted over the sand bank, into what he called a "swash" on the other side. Here she floated, and they let go their best bower anchor, but it dragged, and the vessel struck again in a few minutes on another bank. In this situation she lay some time, beating against the sand, and the sea breaking over her. In

a little while Mr. AMYAT saw the tar barrels, which formed her cargo, floating towards the land, and soon after the bottom parted entirely, and was carried in the same direction. Happily for the men, the part of the wreck on which they were lashed was held by the anchor, and floated in the water, a small portion of the after part of the quarter-deck being above the surface. On this sat the two masters, generally out of the sea, but frequently overwhelmed by the surge, and at other times exposed to heavy showers of sleet and snow, and to a high and piercing wind. The temperature of the air, as nearly as can be guessed, was from 30° to 33° of FAH. and that of the sea, from trials in similar circumstances, from 38° to 40°. Immediately before the two masters was Mr. AMYAT himself. As he was sitting, and the deck sloped pretty rapidly, he was generally up to the middle in the water. The situation of the rest may be supposed; some of them were up to the shoulders. They were not at any time able to change their position, but kept their legs in pretty constant motion to counteract the cold, their arms being employed in holding by the wreck.

The master of the ship, Capt. SCOTT, a native of North-Carolina, and about forty years of age, died first. As they were in the dark, Mr. AMYAT could not see his countenance; but he was first alarmed by hearing him talk incoherently, like one in the delirium of fever. By degrees his voice dwindled into a mutter, and his hearing seemed to fail. At length he raised himself up in a sort of convulsive motion, in which he continued a few seconds, and then fell back dead on the deck. This happened about eight in the evening; four hours after the ship went aground. Soon after this, Capt. DAVISON, who

was about twenty-eight, began to talk incoherently, in the same manner as the other. He struggled longer, but died in the same way, at about eleven at night. The cook died in the forenoon of the succeeding day. He was a low-spirited man, and desponded from the beginning. All the rest held out, as has been already mentioned, though sorely pinched with cold and hunger, till they were taken up about three in the afternoon. Mr. AMYAT said that his hands and feet were swelled and numb, though not absolutely senseless; he felt a tightness at the pit of his stomach, and his mouth and lips were parched; but what distressed him most was cramps in the muscles of his sides and hips, which were drawn into knots. Though immersed in the sea, they were all of them very thirsty; and though exposed to such severe cold, Mr. AMYAT himself was not drowsy, nor were any of the men drowsy, nor did sleep precede death in those that perished. These facts are curious.

Reflecting on the particulars of this melancholy story, there seemed no doubt that the death of the two masters was to be imputed to their peculiar position on the wreck. Exposed to heavy showers of sleet and snow, they might suffer from being wet with fresh, rather than salt water: they might also suffer from being exposed to the cold of the atmosphere, probably seven or eight degrees greater than that of the sea. The chilling effects of evaporation might operate against them, promoted as these must have been by the high wind; or they might receive injury from their frequent immersions in the sea, producing an *alternation* in the media surrounding. This last supposition did not, indeed, strike me at this time; the others dwelt on my mind.

Of the powers attending animation, that which seems fundamental, is the capacity of the living body of preserving the same heat in various degrees of temperature of the same medium, and, indeed, in media of very different density and pressure. If a definition of life were required, it is on this faculty that it might best be founded. It is known that some fluids, applied to the skin, vary in their effects according to their impregnation. In the same degree of temperature, pure water on the surface of the body is much more hurtful than water in which salt is dissolved. Seafaring men are universally acquainted with this, and a striking proof of the truth, as well as of the importance of the observation, may be found in the Narrative of Lieut. BLIGH. Probably the saline impregnation may stimulate the vessels of the skin in some way that counteracts the sedative or debilitating action of the cold. At any rate, it seemed not unlikely that some light might be thrown on this curious subject, by observing the effects of immersion in fresh and salt water, of equal temperature, on the animal heat. And this might also assist in accounting for the death of the unfortunate men already mentioned.

EXPERIMENT I.

I placed a large vessel, containing one hundred and seventy gallons of salt water, in the open air. The atmosphere was damp, and what is called raw. The thermometer stood at 44° in the air, and this also was the temperature of the water. The subject of my experiment was RICHARD EDWARDS, a healthy man, twenty-eight years of age, with black hair, and a ruddy complexion. The hour chosen for his immersion was four in the afternoon, about two hours after his dinner; a time

appointed rather for my own convenience, than as being most proper for the purpose. His heat was 98° before undressing, his pulse 100 in the minute. He was undressed in a room where the mercury was at 56°; and afterwards stood naked before the fire till his heat and pulse were examined again, and found as before. He then walked pretty briskly through a flagged passage into an open court, where the north-east wind blew sharply upon him: he was exposed to it for a minute, and then plunged suddenly into the water up to the shoulders. The thermometer, which had been kept in a jug of warm water, at the heat of 100°, was introduced into his mouth, with the bulb under his tongue, as soon as the convulsive sobbings occasioned by the shock were over. The mercury fell rapidly, and a minute and a half after immersion it stood at 87°. He remained motionless in the water, and the mercury rose gradually; at the end of twelve minutes it stood at $93^{\circ}\frac{1}{2}$. While he sat in the water, it occurred to me to examine his heat when he rose out of it into the air: I had reflected on the power that must be employed to keep up his heat in a medium so dense as water, and where an inanimate body, of the same bulk, would have cooled so much more speedily than in air of the same temperature. Supposing that this heat-producing process, whatever it may be, might continue its operations some time after the extraordinary stimulus (the pressure of the water) was removed, I expected to see the mercury rise by the accumulation of his heat, on changing the medium of water for air, and therefore kept him exposed, naked, to the wind two minutes after taking him out of the bath. To my surprise, although the attendants were rubbing him dry with towels during this time, the mercury fell rapidly. He was put into a warm bed, and his heat, when examined under

the tongue, was 87°, at the axilla 89°. Frictions were used, and brandy mixed with water administered; but I found on this, as on all future occasions, that the best mode of counteracting the cold, was to apply a bladder, with hot water, to the pit of the stomach (the scrobiculus cordis), a fact which I think important: this being done, his shiverings, which before were severe, soon ceased, and he became more comfortable. Three hours afterwards, however, he had not entirely recovered his former heat; but by eight at night, he was in all respects as usual.

I have been very minute in detailing the circumstances under which this experiment was made; some of the particulars which, at the time, I thought of little consequence, I found afterwards of importance. The experiment itself I determined to repeat as exactly as possible.

EXPERIMENT II.

On the next day, at the same hour, the same person was again immersed, as before. His pulse previously was 85, his heat 100°. He had been put to bed an hour before, to save the time spent in undressing. The heat of the water and of the atmosphere 44°. The wind north-east, and strong. On this occasion, as before, there was a rapid fall of the mercury; the following table will save words:

	Ther.		Ther.
2 min. after immersion	89° 1/2	9 min. after immersion	95° 3/4
3 ——	90 1/2	10 ——	94 1/2
4 ——	92 1/2	11 ——	95
5 ——	94 1/2	12 ——	95
6 ——	95	13 ——	95 1/2
7 ——	95 3/4	14 and 15 ——	95
8 ——	95 3/4		

At the end of fifteen minutes he was taken out, and stood three minutes, naked, exposed to the north-east wind, at the end of which time the mercury had sunk to 88°. A draught of ale was given him, and he was put into a warm bed; in three minutes after the mercury rose to 93°. An hour after his heat was 95°.

The effects produced by this alternate exposure to water and air of the same temperature, gave a new direction to my thoughts, and determined me to inquire again into this singular phænomenon. The most obvious method would have been to have prolonged the process of alternation, and replunged the person cooled by the external air into the bath; but this was running too great a risk, unless some more sudden and certain method could be found of restoring the heat that might be lost. It was prudent, therefore, to proceed more cautiously. In the next experiment I resolved to try the methods of heating as well as cooling the body.

EXPERIMENT III.

On the following day, at the same hour, the same person was again immersed in the salt-water bath. His heat previously was 98°, his pulse 100. The temperature of the air and the atmosphere, as before, 44°. The mercury sunk rapidly to 90°.

2 minutes after	-	88°	10 minutes after - 94° ½
3 ———	-	88	11 ——— - 94 ¾
4 ———	-	88 ½	12 ——— - 95
5 ———	-	90 ½	13 ——— - 96
6 ———	-	92	14 ——— - 96
7 ———	-	92	15 ——— - 96
8 ———	-	94	16 ——— - 96
9 ———	-	94	

He was now taken out, and stood in the wind three minutes, shivering violently. This circumstance rendered it difficult to ascertain exactly the fall of the mercury, which was, however, considerable. When examined in the room in which he undressed, it stood at 90°. He was now plunged into a fresh-water warm bath, heated to 97°½. What is very surprising, the mercury fell two degrees. The following table will show the progress of the return of his heat.

1 min. after immersion in the warm bath, mercury - 88°	5 minutes after - 94°
2 minutes - 92	6 ——— - - 96
3 ——— - - 92	7 ——— - - 96
4 ——— - - 94	8 ——— - - 96
	9, 10, 11, 12, to 16, 96

If the rise of heat in the cold bath at 44°, and the warm bath at 97°½, be compared, the first will be found more slow; but that after being sixteen minutes in the one and in the other, the heat was the same in both cases, when taken at the mouth. It must, however, be acknowledged, that in the cold bath, the extremities were chilled and cold, while in the hot bath, the heat was equally diffused. When EDWARDS got out of the hot bath, he put on his clothes, and was remarkably alert and cheerful the whole evening. Encouraged by the safety of these experiments, I resolved to increase the time of immersion in the cold bath, and to inquire more generally into its effects on the sensations, as well as heat.

EXPERIMENT IV.

At the same hour of another day, the same person was again immersed as before, his heat previously being 97°½, and that of the water 42°. Wind north-east, and brisk.

1 minute after,	heat 90°	12 minutes -	
2 minutes -	92	13 ——— - -	
3 ——— - -	92	14 ——— - -	94° ½
4 ——— - -	92 ¼	15 to 24, - -	94 ½
5 ——— - -	92	25 ——— -	94
6 ——— - -	92 ½	26, 27 - -	
7 ——— - -	94	28 ——— -	94 ½
8, 9, 10, 11 -	94	29, 30 -	94

It will be observed, that in the above table there are blanks left in the report. At such times the thermometer was taken out of EDWARDS's mouth, to admit of his answering the questions put to him. He said, that on plunging into the water he felt an extreme cold, which he could not but think was partly owing to his being exposed, naked, to the wind before; that this cold diminished, and in a little while he felt comfortable, but that after a while the sense of coldness returned, though less than at first; diminishing again, but in a less degree. At length his sensations became pretty fixed. In this state, when the water was at rest, he should not even have known, by his feelings from the upper part of his chest to the pubes, that he was in water at all. His feet and legs were very cold; so were his hands and arms; and so also the penis and scrotum. He mentioned, likewise, that he felt a cold circle round the upper part of his body, though not constantly. On examining into this, I found it was greatest at first, and that it extended over the space which, from the undulations left in the bath by the plunge of immersion, was alternately above and under the surface of the water: when the bath settled, it was little felt; but by agitating the fluid, I could reproduce it, at any time when the cold in the extremities was not so great as to prevent its being felt. This curious parti-

cular serves to explain a circumstance much dwelt on by Mr. AMYAT, *in giving an account of his sufferings* on the wreck; that what he felt most severely was the cramps in the muscles of his hips and sides, parts which, from his situation on the wreck, already described, must have been alternately under and above the surge. Here I must observe, that the sea did not break over the sufferers all the time they were on the wreck. The wind moderated, as well as the waves, and for the last fifteen hours, they were not at any time overwhelmed, or at least Mr. AMYAT himself was not. The cold never abated. Being all lashed to the wreck, they never changed their positions; the bodies of those who died occupied the space where they were originally placed. Mr. AMYAT, therefore, during the whole time sat nearly up to the middle in water, but subject to the variations occasioned by the motion of the sea.

To return.—When exposed naked to the wind, the mercury, in this case, sunk as usual five or six degrees, and his shiverings were great. Desirous of restoring his heat as speedily as possible, we incautiously heated the hot bath to 104°: but after being half a minute in it, he screamed out with pain, especially in his extremities, and about his scrotum. When taken out, his shiverings almost amounted to convulsion. The bath was lowered to 88°, and he was replaced in it, and its temperature progressively, but pretty rapidly, increased to 100°. He continued, however, to shiver much, his heat remaining about 90°; but a bladder, with very hot water, being introduced under the surface of the bath, and applied close to his stomach, the good effects were instantaneous, his shiverings ceased, and his heat mounted rapidly to 98°.

All these experiments having been made on one person, I determined to repeat this last on another.

EXPERIMENT V.

R. SUTTON, æt. 19, of a pale complexion, and a feebler frame, was immersed in the bath, under the circumstances of the preceding experiment. His heat was previously 96°½.

½ a minute after,	heat 92°	18 minutes	93°¼
1 minute	90	19 ———	93½
2 minutes	88½	20, 21	94
3 ———	89	22 ———	92½
4 ———	90	23 ———	92¼
5 ———	92	24 ———	92¼
6 ———	92¼	25 ———	94
7 to 10	92	26 ———	94
11 ———		27 ———	92½
12 to 15	92	28 ———	92¾
16 ———	92½	29 ———	94
17 ———	93	30 ———	94

Though this person seemed to bear the cold bath well, having lost in 30 minutes only 2½ degrees of heat, yet when exposed afterwards to the wind, he shivered violently, and lost his heat very fast. He was put into a warm bath, heated to 96°, but recovered his heat very slowly, as the following table will show.

1 minute after,	heat 88°	
2 minutes	90	
3 ———	90½	
4 ———	90	great shivering.
5 ———	90	here the bath was heated to 100°.

6 ——	90°	shiverings still.
7 ——	90	ditto.
8, 9	90½	ditto.
10 ——	92	ditto.
11 ——	92	bath heated to 104°.
12 ——	94	
13 ——	93	—— heated to 108°. Shiverings.
14 ——	93	a bladder with very hot water applied to the stomach.
15 ——	94	
16 ——	96	very comfortable.

EXPERIMENT VI.

RICHARD EDWARDS, the original subject of experiment, was again immersed in the cold bath, of the temperature of 40°, and remained in it three quarters of an hour. His heat previously was 97°; his pulse 90 in the minute. The mercury fell to 92°, was stationary for a few minutes, and then mounted, though, as usual, with no regularity. In twenty-two minutes it stood at 96°; it then began to decline, and in twenty-three minutes more had sunk to 94°. Being exposed as usual to the wind, the mercury sunk as usual, and he shivered violently. In the warm bath at 96° his shiverings continued several minutes, his heat remaining at 90 and 91°. In seven minutes the mercury began to rise fast, and five minutes after was at 96°.

EXPERIMENT VII.

The effects of forty-five minutes immersion in the cold salt-water bath, at 40°, were proposed to be tried on RICHARD SUTTON. He was much under the impressions of fear, and his heat previously raised the mercury only to 94°. The mercury sunk, as usual, on his immersion, but to an unusual degree. It did not stop in its fall till it got to 83°, which perhaps might be in part accounted for by the extraordinary chattering of his teeth, admitting some contact of the air. It then mounted in the usual irregular way, and at the end of thirteen minutes had got to 92°. Here it stood for nineteen minutes longer with little variation; at the end of this time it began to fall rapidly, though irregularly, and in three minutes was down at 85°. He had now been thirty-five minutes in the water, and I did not think it safe to detain him longer; we therefore hurried him into a warm bath, heated to 96°, where he shivered much. The bath was heated gradually to 109°, and in this heat he recovered his proper temperature in about twenty-eight minutes. Being then put into a warm bed, he fell into a profuse perspiration, which left him in his usual health.

One general remark will serve for the pulse in all these experiments. It was not possible to keep the subjects of them from some degree of previous agitation, and this always quickened the pulse. The natural pulse of EDWARDS was about 70 in the minute; but it may be observed, that it was never slower than 85 before immersion, and generally more. However this might be, it invariably sunk to 65, or from that to 68, in the water, became firm, regular, and small. After being long in the bath, it could hardly be felt at the wrist, but

the heart pulsated with great steadiness and due force. In the last experiment, when the heat sunk rapidly, SUTTON said that he felt a coldness and faintness at his stomach, which he had not perceived before, and when I felt the motion of his heart, it was feeble and languid. In some future trials of the effects of immersion in fresh water (one of which I shall detail), the same coldness at the stomach preceded a rapid fall of the mercury; and these facts, together with the effects I found from applying a considerable heat to this part when the body was chilled with cold, convince me that there is some peculiar connection of the stomach, or of the diaphragm, or both, with the process of animal heat. Whoever will consider the rapidity with which a dead body would have cooled immersed in water of the temperature of 40°, may form some estimate of the force with which the process of animal heat must have acted in the experiments already recited. These experiments, however, furnish irrefragable proofs of the futility of some of the theories of animal heat. The increase of heat, in fever, has led some persons to believe that animal heat is produced by, or immediately connected with, the action of the heart and arteries; here, however, it may be observed, that while heat must have been generated in the bath with more than fourfold its usual rapidity, the vibrations of the arterial system were unusually slow. Another, and a very beautiful theory of animal heat, supposes it immediately to depend on respiration; but in the bath, after the first irregular action of the diaphragm from the shock of immersion was over, the breathing became regular, and unusually slow. Lastly, the curious phænomenon of the heat rising, and falling, and rising again, in the bath, with the body at rest, and the temperature

of the surrounding medium unchanged, is, I think, fatal to those theories of animation which consider the living body as a mere machine, acted on by external powers, but not itself originating action, and differing from other machines only in the peculiarity of the powers which are fitted to set it in motion. I have said that the temperature of the medium continued unchanged, but it may be supposed that the bath was heated a little during the experiments; it was so; but being exposed, with a large surface, to the open air, the wind blowing briskly over it, its heat was little altered; in twelve minutes immersion it had gained nearly one degree, and in forty-five minutes, the longest duration of any of the experiments, it had gained three degrees. As this accession was regular, if it had been greater it would not have invalidated the foregoing observations.

Many other trials were made on the effects of immersion in water on the human heat, which I shall speak of generally, under the general conclusions which they suggested.

The experiments already recited, suggested to me the notion that in all changes from one medium to another of different density, though of the same temperature, there is a loss of animal heat. I found, however, that this conclusion requires many restrictions.

1. My experiments being made on bodies of such very different density as air and water, do not admit an universal inference of this sort.

2. Being all made in a temperature fifty degrees under the human heat, no certain conclusion can be drawn as to what might happen in degrees of heat much higher, where it is probable, the effects of the change, if it appeared at all, might be

less striking. It would seem, however, that after a person is long chilled in cold water, the first effect of passing through the external air into the warm bath, is first a fall of heat in the air, and after this a still greater fall in the warm bath, followed, however, by a speedy rise.

The air and the water being equally cold, and both 45° or under, I found the loss of heat in passing from the one to the other to be regulated in the following way.

1. If, instead of being exposed naked to the wind previous to immersion in the water, the body was kept warm by a flannel covering, the mercury fell much less on the first plunge.

2. If, after plunging into the water, the person continued in it only a minute or two, a subsequent fall of the mercury did not always take place, on his emerging into the air. On the contrary there was sometimes a rise on such occasions in the mercury, especially if the atmosphere was at rest.

3. In one instance, after continuing in the water fifteen minutes, on rising into the air in a perfect calm, though during a frost, there was little or no seeming diminution of the heat; while exposure under similar circumstances, with a north-east wind blowing sharply, though the air was many degrees warmer, produced a rapid diminution. The effects of the wind in diminishing the human heat are indeed striking, and are not in my opinion explained by the common suppositions.

4. The loss of heat by a change of media, depends much on the rapidity of the change, for the plastic power of *life* in varying the process of animal heat, so as to accommodate it to the external changes, acts for a time with great celerity, though this celerity seems to diminish with the strength.

EXPERIMENT VIII.

I placed in a large room, where the mercury stood at 36° two slipper baths at the distance of six yards from each other. One was filled with cold salt-water of the temperature of 36°, the other with water heated to 96°, which was my own heat. Undressing myself in an adjoining room by a fire, I afterwards slipped on a loose flannel dress, and descended *slowly* into the cold bath, where I remained two minutes; I ascended *slowly* into the air, and then sunk myself in the warm bath, where I remained two minutes also: I returned to the cold bath, where I staid two minutes as before, and removed from it again to the warm bath. But during all these changes of media and temperature, the thermometer with its bulb under my tongue never varied from 96°. I attribute this partly to the heat of my body being in some degree defended by the flannel dress, partly to the calm of the air, but chiefly to the slowness of motion in these changes. It may be said that the time of staying in the different baths was not long enough to produce any sensible change in the heat of circulating fluids of such a mass, but this is not consistent with many of the other facts.

5. The influence of the application of cold water to the surface of the body on the heat, is in some respects regulated by the animal vigour, as the following experiment will show.

EXPERIMENT IX.

In the same room I placed a large empty vessel: in this two young men sat down in succession, each with the bulb of a thermometer under his tongue. A man standing on a bench

with a bucket of cold salt-water containing four gallons, *poured the whole on the head and shoulders,* suffering it to run down on the rest of the body. This process took up nearly a minute, during which I examined the mercury, and found it unchanged. They were both directed to continue sitting without motion for a minute after, during which, in both instances, the mercury rose two degrees. A third, much inferior in vigour, submitted to the same experiment, and the mercury continued during the affusion of the water unchanged, but in a minute after sunk half a degree. In fevers, where the heat is generally increased from two to six degrees above the standard of health, pouring a bucket of cold water on the head always reduces the pulse in frequency, and commonly lowers the heat from two to four or five degrees. Of this salutary practice I hope soon to speak at large to the public.

6. The power of the body in preserving its heat under the impressions of cold, and the changes of temperature, and of media, seems in some measure regulated by the condition of the mind. That fear increases the influence of cold, and of many other noxious powers, will not be doubted; but the state of the mind to which I allude, is that of *vigorous attention* to other objects. This, it is well known, will to a certain degree deaden, or, indeed, prevent the sensation of cold; and what does this, I apprehend, prevents, or at least weakens, its physical action. The astronomer, intent on the objects of his sublime science, it is said, neither feels, nor is injured by, the damps nor the chillness of the night; and in some species of madness, where the ideas of imagination are too vivid to admit the impressions of sense, cold is resisted to an extraordinary degree. I have seen a young woman, once of the greatest

delicacy of frame, struck with madness, lie all night on a cold floor, with hardly the covering that decency requires, when the water was frozen on the table by her, and the milk that she was to feed on was a mass of ice.

7th. There are particular conditions of the atmosphere, not perfectly understood, that seem to have an influence in depriving us more speedily of our animal heat, than others where the cold is greater.

It may seem that by this time I had renounced my intention of trying the effects of immersion in fresh water on the animal powers, and particularly on the heat. Some trials I have, however, made, of which I shall only relate the following.

EXPERIMENT X.

In the same vessel, containing an equal bulk of fresh water, RICHARD EDWARDS, the subject of my first experiments, was immersed, at the same hour of the day. His heat previously was 98°, his pulse beat 92 in the minute: the heat of the air was 41°½, that of the water 40°. The wind was now in the west, so that in the court where the bath stood there was a perfect calm. As I had some fears of the issue of this experiment, instead of exposing him for a minute naked to the wind before immersion, he was covered with a flannel dress from the air till the instant he descended into the water, into which he was suffered to sink himself slowly, with the bulb of the thermometer under his tongue. These are important circumstances. The following table exhibits the result.

Immediately on immersion, heat			98°
1 minute after			97½
2 minutes			97
3 ———			98
4 ———			97½
5 ———			96
6 ———			96
7, 8			96
9 ———			97
10 ———			97
11, 12, 13			
14 min. after,	heat		96°½
15			96
16, 17, 18, 19, 20			96
21, 22, 23, 24			
25 ———			95
26 ———			94
27 ———			93½
28, 29			94
30			93
31, 32			94
33, 34			92½

He now got out into the air very slowly, and stood in it three minutes, the wind *not* blowing on him. He lost one degree of heat at first, which he recovered. He was then put into a warm bath at 90°, which at first *he felt* warm, and his feet and hands were pained: but in two minutes he fell into a very violent shiver, and his heat fell two degrees. The bath was then heated to 95 and 96°, but still he felt cold. It was heated to 99°: he continued in it five minutes, and his heat was 91°. The heat was gradually raised to 106°, when the sense of coldness of which he had complained at the pit of the stomach gradually went off. Before this I had usually kept him in the warm bath till his natural heat was nearly recovered, but after being half an hour in the heat of 106°, his own heat was still 93°. He now became sick and very languid, a cold sweat covering his face, his pulse very quick and feeble. He was removed into bed, but passed a feverish night, and next day had wandering pains over his body, with great debility, resembling the beginning stage of a fever. By cordials and rest this went off.

This experiment clearly enough confirms the greater danger of being wet with fresh than salt water; but in itself points out nothing certain besides, except that it is not to be rashly repeated. I mean to try some of these experiments to a greater extent on the brute creation, when I have procured thermometers better suited to my views. The thermometers I employed had not a sufficient mobility for very nice experiments, and I am well aware that in particular instances this may have misled me, though the general results, which is all that is of importance in such experiments as these, will, I hope, be found just and true.

Before I conclude, I must offer a few observations on the subject that led to these experiments.

1. It is, I think, already well known among seamen, that where there is only the choice of being wet with salt or fresh water, it is always safest to prefer the first. In the heavy showers of rain, hail, or snow, by which gales of wind are generally accompanied, the men that must be exposed to them, ought, like Lieutenant BLIGH and his crew, to wring their clothes out of salt-water.

2. In all cases where men are reduced to such distress by shipwreck or otherwise, that they can only chuse between the alternative of keeping the limbs constantly immerged in the sea, or of exposing them to the air while it rains or snows, or the sea is at times washing over them, it is safest to prefer a constant immersion; because, in the northern regions where the cold becomes dangerous to life, the sea is almost always warmer than the air, as the experiments of Sir CHARLES DOUGLAS shew; and because there is not only a danger from the increased cold produced by evaporation, but also from the loss

of heat by the rapid changes of the surrounding medium, as the foregoing experiments point out.

3. Whether, in high and cold winds without rain or snow, and where a situation may be chosen beyond the reach of the waves, it is safer to continue in the air, or to seek refuge in the sea, must depend upon several circumstances, and cannot perhaps be certainly determined. The motives for choosing the sea will be stronger in proportion as the wind is high and cold, and in proportion as the shore is bold.

The foregoing narrative shows that men may survive twenty-three hours immersion in the sea, of the temperature of 38° or 40° (as great a cold as it almost ever possesses) without food or water, and almost without hope of relief; but that any man ever survived an equally long exposure to the higher degrees of cold of the atmosphere, in the same circumstances, does not appear. Though in the case related, immersion in water did not prevent thirst, yet there is no doubt that it alleviated it, a circumstance of high importance towards the preservation of life.

Liverpool,
December 25, 1791.

P. S. I have purposely avoided any reasoning on the causes of the loss of vital heat on the change of media in the experiments recited. It may be supposed that during immersion, the water immediately in contact with the skin having become heated to a certain degree, the naked body, on rising from it into the air, was in fact exposed to a colder medium, and thus the loss of heat, in this instance, produced. My examination of the heat of the water during immersion not

having been made in contact with the body, I will not deny that there is some foundation for the remark; and the cases, it must be allowed, are by no means exactly parallel between immersion in an open vessel, however large, and immersion in the sea, where the constant undulation may be presumed to occasion a continual change in the surrounding fluid. But whatever allowance may be made for the circumstance mentioned, I am persuaded that the difference between the density of air and water being considered, it is not sufficient to explain the loss of heat in the instance alluded to. The changes of temperature in the living body are governed by laws peculiar to itself. I have found, in certain diseases, greater and suddener variations than any mentioned, from applications of cold very gentle in degree, and momentary in duration.

In his masterly "Experiments and Observations on Animals producing Heat," Mr. HUNTER has objected to taking the heat of the human body by introducing the bulb of the thermometer into the mouth, because it may be affected by the cold air in breathing. The objection is well founded if the bulb be placed on the upper surface of the tongue, but if it be under it and the lips shut, the effects of respiration may be disregarded, as I have found from many hundred experiments. The heat may be observed in this way with ease and certainty, by employing thermometers curved at that end to which the bulb is affixed (the bulb being introduced at the corner of the mouth), some of which have been made for me by Mr. RAMSDEN according to a form given, as well as others on Mr. HUNTER'S plan. From repeated trials it appears to me, that when the usual clothing is on, the heat of the living body may be taken, with nearly the same result and equal

certainty, under the tongue with the lips shut, at the axilla with the arm close to the side, and in the hollow between the scrotum and the thigh; every other part of the surface is liable to variation and uncertainty. It is evident that of these three methods, the first only can be employed (as far as I can discover) when the trunk of the body is immersed in water; and even when the naked body is exposed to the cold air, the first method seems the best, the heat remaining most steady under the tongue: the axilla is the next best in order, and the worst, the lower part of the groin; for the scrotum and the parts of generation lose their heat on the application of cold more speedily perhaps than any other part of the body, the extremities not excepted.

N. B. The water employed in the experiments related, contained salt in the proportion of one to twenty-four.

Instead of saying that the men saved were most of them natives of Carolina, I find I ought to have said, men long accustomed to that country and other warm climates, but not most of them natives.