R. Dunlop

AN ENQUIRY INTO THE CAUSES OF SUSPENDED ANIMATION FROM DROWNING.

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A N

E N Q U I R Y

INTO THE

C A U S E S

OF

SUSPENDED ANIMATION

FROM

D R O W N I N G;

WITH THE

MEANS OF RESTORING LIFE.

BY DAVID HOSACK, M. D.

Utilia selegit, sic utile.

BAGLIVI.

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INTRODUCTION.

As the celebrated Doctor Rush observes, "the present is an age of great improvement. While the application of reason to the sciences of government *and* religion *is daily meliorating the condition of mankind, it is agreeable to observe the influence of medicine in lessening human misery, by abating the mortality or violence of many diseases." Of the truth of this progress of the healing art, we cannot produce a more happy instance than the late improvements for the recovery of the drowned.* It is now but little more than twenty years since the first association for this purpose was formed at Amsterdam, and but fourteen since the first existence of that in London; and yet near one thousand persons have been preserved from death by those two institutions.—Societies for the same benevolent purpose have been established at Paris, Venice, Hamburgh, Milan, and in our own country at Philadelphia and Baltimore. From their reports it also appears, that a very large proportion, not less than* three fourths, *of persons*

* *In the following pages the terms* suspended animation, death, *and* drowned, *are made use of promiscuously.*

persons apparently dead, have been recovered; and that this recovery may be effected after they have been a long time, even hours, in that situation.

Unfortunately, however, in this city we cannot yet boast of such success. To what must we attribute this? I suspect in some measure to our want of perseverance in the use of those remedies which are known to be effectual, and to the unhappy prejudice which prevails among many of our citizens in favour of that most pernicious practice, rolling the body upon a barrel, *and* holding it up by the heels, *immediately upon taking it out of the water; which is done with the view of discharging the water they suppose to have been swallowed. It is at present, however, well ascertained, not only by dissections of drowned men, but also from a variety of experiments upon other animals, that there is very little and frequently no water found either in the* lungs *or* stomach; *except in the former, where there is generally found more or less* froth, *which I conceive does not arise from any water taken in, but is generated there, as in some other diseases where respiration is suspended, or even where it is irregular, as in epilepsy, &c. But admitting there is water both in the lungs and stomach, there could not possibly be devised a method which is more destructive of life, especially in its latent state, than either rolling upon a barrel or hanging by the heels.*

Without

Without particularly enumerating the consequences of these practices, suffice it to remark, that there is scarcely a single instance known of a recovery after these measures have been used. To remove this unhappy prejudice, however, as also the more generally to diffuse among our citizens a knowledge of the most effectual means of recovery, nothing can more immediately contribute than the establishment of a society for this express purpose, which I am happy to add is now in agitation, and which, I hope, will meet with the countenance of the citizens at large.

A N

ENQUIRY

INTO THE

CAUSES

OF

SUSPENDED ANIMATION, *&c.*

THE moſt diſtinguiſhed writers upon this ſubject are Doctors *Cullen*, *Goodwin*, *Kite*, and *Coleman:* the three laſt of whoſe performances met with ſo much applauſe, that each was honoured with a *medal* from the Humane Society of London; but notwithſtanding the reputation theſe performances met with, ſtill each of them I conceive is liable to exceptions: theſe I ſhall endeavour to point out, by an enquiry into the nature and operation of the *cauſes* to which they have differently aſcribed death from drowning, and thence deduce ſome principles upon which to found a more certain mode of recovery than has yet been ſuggeſted. To do this more clearly, I beg leave to premiſe the following firſt principles as relative to animal life:—

1ſt. That

1ſt. That in every animal there is a *living* or *vital* principle, or what Doctor Cullen calls a "certain condition in the nerves and muſcular fibres, by which they are ſenſible and irritable, and upon which the action of the heart itſelf depends:" as to the ſeat or ſource of this principle there have been different opinions;* thus much, however, we know as applicable to our preſent purpoſe, that in many inſtances it ſubſiſts for ſome time after reſpiration and the circulation of the blood have ceaſed. It is alſo well known, that while it exiſts it is capable of being reſtored to all the purpoſes of life, hence (as we are credibly informed) ſeveral perſons have been reſtored after hours continuance under water.†

2d. That

* Some have ſuppoſed it to reſide in the nervous-ſyſtem; but others, with perhaps more probability, that it reſides in the blood; among whom are Harvey, the diſcoverer of the circulation, and John Hunter, the preſent celebrated anatomiſt of London.

† See Medical Commentaries, vol. xvi. p. 190.

In the New-York Magazine, vol. ii. p. 624, there is alſo an inſtance of a recovery after the perſon had been at leaſt an hour under water, and that principally from injections of tobacco ſmoke.

Northcote, in his Marine Practice, obſerves, that he has "generally been able to bring about the recovery of thoſe who had been but from four to twenty minutes in the water." He alſo adds, that "he has known numerous inſtances of recovery though they had appeared to be dead for even five or ſix hours."

Dr. Cullen likewiſe obſerves, "that it has often happened that though means employed for one hour have not ſucceeded, the ſame continued for *two* or *more* hours, have at length had the wiſhed-for effect."

2d. That for the ſupport (if not the very exiſtence) of this vital principle, are neceſſary,

1ſt. Heat;

2d. Reſpiration;

3d. A regular circulation of the blood; and,

4th. A due excitement of the brain and nervous ſyſtem.

Such is the connection between theſe different functions,* and ſuch is their mutual dependence upon each other, that it is difficult, if not altogether impoſſible, to determine which is the cauſe or which the effect. This much, however, I believe is certain, that they are all eſſential to animal life, and that the one cannot exiſt without the other.

B Hence

It ſhould therefore be a conſtant rule (and which I hope our citizens will more particularly obſerve than they have hitherto done) that the proper means ſhould be employed for ſeveral hours together; and if we can credit a caſe recorded in a European Magazine, we ſhould not deſpair of ſucceſs even at the end of *twelve* hours; an inſtance is there recorded of a man who had lain that length of time in the water, and yet was recovered by the warmth of ſheep-ſkins.

* From the importance of heat in the animal œconomy, and its equal importance with the vital functions, I have claſſed them together promiſcuouſly; for to have conſidered heat as diſtinct from, and unconnected with, thoſe functions, would not only have deſtroyed the arrangement I have endeavoured to preſerve, but alſo would have rendered the principles upon which I account for ſuſpended animation leſs intelligible.

Hence then muſt appear the abſurdity of an attempt to explain the cauſe of death from an interruption of any *one* function excluſive of the reſt.

The importance of *heat* in the animal œconomy, and as immediately connected with life, has ever been admitted; nay, ſo intimately are they blended, that the leaſt change of temperature produces, like heat upon the mercury of a thermometer, a ſimilar change upon the principle of life: For inſtance, when the body becomes but a few degrees warmer or colder than its natural ſtandard (from 96 to 98 deg. of Farenheit,) the principle of life becomes proportionably weakened, and upon an increaſe either of heat or cold life is totally extinguiſhed. To produce ſome familiar examples of the truth of this we need but mention the different ſtates of the human body in the different ſeaſons of the year, and in different climates; the ſuſpenſion of the living principle in thoſe animals which are in a ſtate of torpor during the winter; and laſtly, its immediate operation upon the different functions of the animal œconomy, *natural* as well as *vital*; hence then the immediate importance of heat in reſtoring life in caſes of ſuſpended animation, whether from *drowning* or from whatever cauſe it may ariſe.

2d. *Reſpiration.*

2d. *Respiration.* To *live* and to *breathe* are synonimous. It is not my intention to investigate the *physical cause* of respiration (for such an attempt in the present imperfect state of physiology would be as absurd as an attempt to explain the cause of death, from an interruption of the mere *act* of respiration;) but to point out its connection with the other functions, and thereby with the living principle.

In the lungs (the organs of respiration) there are two sets of blood-vessels, the bronchial and the pulmonary; the first, from their size and distribution, are by all admitted as expressly for the purpose of nourishing the lungs; it is also as universally admitted, that the blood, in its passage through the pulmonary artery, is destined to undergo some changes, or to acquire certain essential properties from the action of the air, which it has lost, and at the same time to part with some impurities which it has acquired, in its circulation through the other parts of the body: this is evident not only from the action of air upon the blood out of the body, but also from the changes which is observable immediately upon its passing through the lungs into the left auricle of the heart, viz. from a dark blackish colour to a bright and florid red; as also from the effects of suspended respiration, and breathing an impure air.

air. In this *change* it is by many ſuppoſed reſides its property of ſtimulating the heart to action; but whether it ariſes from new properties which the blood abſolutely receives from the air, or merely from parting with the phlogiſton it acquires in its circulation, or both, we cannot pretend to determine, neither is it neceſſary for our preſent purpoſe. In demonſtrating the effects of reſpiration upon the blood, and upon the action of the heart and arteries, it at the ſame time ſhews its connection with the *nervous* ſyſtem; for it is impoſſible to conceive of the action of the heart excluſive of its *nervous* and muſcular fibres as the *medium* of that action. This connection, however, will be more directly pointed out when treating of the brain and nerves.

From the above uſes of reſpiration and pure air, we learn another indication in the recovery of the drowned, viz. to reſtore the *reſpiration*, as neceſſary to that ſtate of the blood which is eſſential to its circulation and the tone of the moving fibre.

3d. The *circulation of the blood.* This fluid has with great propriety been termed the *magazine* of nouriſhment: in order therefore to afford a conſtant and regular ſupply to the different and minute parts of the ſyſtem, it is neceſſary it ſhould be in conſtant circulation: to this end alſo it is eſſential that the

heart

heart and veſſels ſhould have a due degree of *tone*; for this they are again dependent upon the ſtate of the nervous ſyſtem, and that upon a healthy ſtate of the blood, upon reſpiration, and heat. Flemyng, in the introduction to his Phyſiology, compares the body to a *circle:* we here ſee the beauty and propriety of his compariſon.

A more immediate connection, however, between the circulation of the blood and the living principle, is obſerved in caſes of hemorrhages and ſuſpenſion of the circulation, whether throughout the ſyſtem or confined to a particular part. We alſo obſerve it in a variety of diſeaſes, particularly fevers; and hence learn a third indication in the recovery of the drowned, (independent of thoſe already mentioned) viz. *to reſtore the circulation.*

4th. The *brain and nervous ſyſtem.* Notwithſtanding the important uſes of *heat*, *reſpiration*, and the *circulation of the blood*, in the animal œconomy, ſtill the brain and nerves are indiſpenſibly neceſſary. Upon theſe organs we are immediately dependent for *ſenſation* and *motion*; this is evident from the following ſimple experiment, viz. that if a nerve is tied or cut, the part to which it is deſtined is immediately deprived of its ſenſibility and power of motion. Although we cannot explain in what way

ſenſation

ſenſation and motion are communicated, whether by a *ſubtile fluid* contained in the nerves, (ſuppoſing them *tubular*) or by *vibration* (ſuppoſing them elaſtic cords) or as *electric conductors*; ſtill we have ſufficient *data* for concluding that they are immediately connected with the other functions, and thereby with the living principle. The following familiar examples I preſume will render this connection ſufficiently obvious. 1ſt. The operation of different ſubſtances, which act directly upon the brain, ſuch as opium, the fumes of burning charcoal, and choak-damps. 2d. The operation of cold. 3d. The paſſions of the mind. The fatal effects of all theſe cauſes, and of their immediate action upon the brain and nervous ſyſtem, are too well known to require further demonſtration. We hence learn a *fourth* indication in the recovery of drowned perſons, viz. *to reſtore the action of the nervous ſyſtem.*

Having thus far eſtabliſhed the importance of all the vital functions in preſerving the *living principle*, with their *mutual* dependence upon each other, we will be the better able to point out the errors into which the different writers upon the ſubject of drowned perſons have fallen, as alſo the more ſatisfactorily to explain the cauſes of death and mode of recovery.

Doctor

Doctor Cullen, in his very valuable letter to Lord Cathcart, hints at the connection I have endeavoured to illustrate, expressing himself as follows:—"It is probable that the death which ensues, or seems to ensue in drowned persons, is entirely owing to the stopping of respiration, and to the ceasing in consequence of the circulation of the blood, whereby the body loses its heat, and with it the activity of the vital principle." As the Doctor supposed the vital principle to reside in the nervous system, he hence probably has taken no *direct* notice of the suspension which takes place in the brain and nerves, as one of the causes of death; for it is unquestionable, that the debilitating passion of *fear*, with the *chill* occasioned upon suddenly falling in the water, and the *pressure* of the water itself,* must also tend to destroy the tone of the heart, and consequently of the extreme vessels, and *that* independent of the contraction which necessarily takes place in those vessels from the sudden application of cold. Although the Doctor has said but little in explaining the cause of death, his directions for the recovery of

* If a man's body sustains, as philosophers in general suppose, sixteen ton weight of the *common atmosphere*, and that *its* gravity compared to water, is as one to one thousand, (which is proved by experiment to be the case) it naturally follows, that the pressure upon a drowning man is by no means an inconsiderable cause of death, especially when we observe, that he is already debilitated by *fear* and the *chill* of the water.

of the drowned are upon a much leſs contracted plan, and have been found of much more general uſe, than any which have been propoſed ſince his time.

Doctor Goodwin, who was the next writer of diſtinction upon this ſubject, from a variety of experiments concluded that the cauſe of death was an immediate want of pure or vital air, excluſive of any immediate effects from the loſs of *heat*, the ſtate of the *circulation*, or of the *nervous ſyſtem*. The experiments from which he more immediately drew his concluſion, were thoſe which related to the chemical action of the air upon the lungs in reſpiration.

The preſent prevailing opinion of the chemiſts, as to the compoſition of common atmoſpheric air, is, that it contains nearly two thirds of what Doctor Prieſtley calls *phlogiſticated*, and Monſieur Lavoiſier *mephitic** air, and one third of *dephlogiſticated* or pure air. When it is inſpired into the lungs, and again expired into a receiver, it is found that the quantity of dephlogiſticated air is diminiſhed, and that the quantity of the phlogiſticated is increaſed. He alſo found from experiment, that the diminution

* For the noctious effects of mephitic, or fixed air, ſee Medical Commentaries, vol. iii. p. 256; and Ingenhouſe's Experiments.

tion of the former, and the increaſe of the latter, even in a ſingle reſpiration is conſiderable;* and that this diminution of the one, and increaſe of the other, are conſtant and ſucceſſive in the ſame quantity of air frequently reſpired. Since, therefore, theſe changes are conſtant and uniform, they muſt, he thinks, be connected "with ſome correſponding changes in the lungs equally conſtant and uniform; and there is, he obſerves, no ſubſtance in thoſe organs in which we can expect to find ſuch correſponding changes, except in the blood which circulates through them." From the experiments we have here alluded to, Doctor Goodwin infers, "that a quantity of dephlogiſticated air is ſeparated from the atmoſpheric air in the lungs by reſpiration, and a quantity of fixed or phlogiſticated is added to it; that the dephlogiſticated air exerts a chemical action on the pulmonary blood, in conſequence of which that blood acquires a florid colour; that, in ordinary reſpiration, this florid colour is ſeen diſtinctly as the blood paſſes into the left auricle, and that the heart then contracts with its natural force and frequency; that when reſpiration is ſuſpended the florid colour is gradually diminiſhed, and the

* The late Doctor Keil has calculated that not leſs than 29 ounces of this mephitic air is emitted from the lungs of one man in twenty-four hours.

contractions of the auricle and ventricle ſoon ceaſe; and finally, that this ceſſation of contraction ariſes from a defect of a ſtimulating quality in the blood itſelf." Hence he with great propriety concludes, that the chemical quality which the blood acquires in paſſing through the lungs, is neceſſary to keep up the action of the heart, and conſequently the health of the body. We here ſee he had no idea of the intimate connection and mutual dependence which ſubſiſt between the different functions, or if he had, it was ſo diſtant that it had no effect in directing his plan of recovery, which was merely to reſtore the *heat* and *reſpiration*, without any view to the direct reſtoration of the circulation of the blood, or the tone of the nervous ſyſtem, pointedly diſſuading from *bleeding*, *friction*, and *ſuccuſſion*, as being ſuggeſted by "a falſe notion of the nature of the diſeaſe," and alſo from all *ſtimulating applications*, as being the reſult of a "miſtaken opinion of the principal ſeat of life, and an ignorance of the moſt effectual means of ſoliciting the principle of life into action;" at the ſame time, however, he allows, that as ſome of theſe practices are now introduced on the authority of ſeveral learned ſocieties, *experiment* alone ought to decide concerning their efficacy. Notwithſtanding theſe defects in Doctor Goodwin's Treatiſe, I conceive he has thrown more light upon the

ſubject,

ſubject, as inveſtigating the cauſes of death, than any beſide.

Kite, whoſe performance next followed Doctor Goodwin's, is alſo entitled to great credit. He introduces the ſubject by pointing out the difference between ſuſpended animation and death, as depending entirely upon one circumſtance, "the preſence or abſence of the *principle* of *irritability*, or what amounts to the ſame thing, *the vital principle*." He then proceeds to inveſtigate the "internal immediate cauſe of death, and the manner in which it is effected in thoſe who die by drowning." After ſtating and attempting to refute the different opinions which had been advanced relative to this ſubject, he adopts the following, viz. "A contraction of parts about the *larynx*, preventing the air from paſſing into or out of the lungs." He next enters upon the enquiry, in what manner this ſtoppage of reſpiration acts ſo as to occaſion death? He rejects the idea of Goodwin, that the incloſed air becoming *phlogiſticated*, thereby produces death; or that the *congeſtion* of blood which takes place in the heart and lungs ſhould occaſion it. He then advances his own opinion, which is, that it acts by inducing *apoplexy*. To enter upon an examination of the different arguments which he brings forward in ſupport of this opinion, would be not only tedious but unintereſt-

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ing—*unintereſting*, becauſe there is ſuch a connection (as I have already pointed out) between the *nervous ſyſtem*, *the circulation of the blood*, *reſpiration*, and *heat*, that there can be no doubt but more or leſs obſtruction in the veſſels of the head muſt take place, whether it is occaſioned by the *phlogiſton* retained in the lungs acting upon the brain and nerves, by a *mechanical obſtruction* of the jugulars, or any other blood veſſels, or even by *loſs of heat*; for the one can as effectually produce it as the other: hence then it neceſſarily follows, eſpecially as the preſſure of the water alone, or a mechanical interruption of the *act* of reſpiration, independent of its effects upon the blood, is inſufficient of itſelf to produce apoplexy, that all the proofs Mr. Kite can poſſibly advance, however ſpecious their appearance, muſt be defective, unleſs he can firſt demonſtrate that it is of no conſequence whether we breathe a pure or impure air; and that there is no connection between the different functions, as neceſſary for the living principle, which is impoſſible. This partial explanation of the cauſe of death does not however influence his practice in the plan of recovery as might be imagined, for he has directed almoſt every remedy that has been preſcribed by different writers, let the cauſe of death they eſpouſe be what it may. We will now laſtly make ſome remarks upon the theory

theory advanced by Doctor Coleman, which is the laſt performance that has appeared upon this ſubject.—

He attributes death in all caſes of ſuſpended animation, whether from "*drowning*, *hanging*, or *noxious air*, to a *collapſe* of the lungs, producing a collapſe of the pulmonary veſſels, with want of latent heat in the blood." To eſtabliſh this opinion, he begins by deſcribing the common effects of drowning; after noticing the ſucceſſive *expirations*, and the fruitleſs efforts to *inſpire*, which take place in the act of drowning, he obſerves, that on opening the cheſt the two *venæ cavæ*, the right *ſinus venoſus*, *auricle*, *ventricle*, and *pulmonary artery*, are found loaded with blood; the left *auricle* nearly diſtended, the left *ventricle* about one half; the *aorta* and its branches containing a quantity of blood, which, in all its appearances, reſembles *venous*, the lungs in a ſtate of collapſe, containing a ſmall quantity of water in the form of *froth*, but very trifling when compared to the quantity of air expelled from the lungs in the act of drowning." From this general account it appears, that the quantity of blood contained in the right ſide of the heart after drowning, is greater than that in the left, in the proportion, as the Doctor afterwards found, of three and one-eight to one and five-eights. The ſame effects he obſerved

after

after *hanging*, and alſo after death from *noxious air*; which laſt circumſtance I ſuſpect rather tends to refute than eſtabliſh the Doctor's opinion; for in hanging there are not thoſe "*frequent expirations* and *fruitleſs attempts to inſpire*" which he deſcribes in drowning; of courſe it is uncertain whether the lungs are in a ſtate of *inſpiration* or *expiration* at the moment the rope cloſes the wind-pipe; therefore, the concluſion of Doctor Coleman is not always juſt, neither can it be in caſe of death from *noxious air*, for air ever ſo impure will be capable of diſtending the lungs; and even ſhould it not poſſeſs its natural elaſticity, ſtill it will ſerve that purpoſe, at leaſt there will be a ſufficient diſtention to prevent a collapſe of the blood veſſels, and an interruption of the circulation, if it depended merely upon the *act* of reſpiration (independent of any changes the blood undergoes in its paſſage through the lungs) which at preſent is not admitted.

Again—Doctor Coleman found, from his own experiments, that the irritability of the heart and inteſtines ceaſed ſooner in animals deſtroyed by *noxious air*, than thoſe by hanging or drowning, which is an additional proof that mephitic or noxious air acts *primarily* upon the *nervous ſyſtem*, (thereby occaſioning death) and of conſequence that it is not from a collapſe of the lungs and blood veſſels. Thus far

far then Doctor Coleman's reaſoning from analogy is defective, eſpecially as we can account for the cauſes of death from *hanging* and *noxious air* upon different, and I preſume much more rational principles.

He next proceeds to the eſtabliſhment of a ſecond cauſe, viz. "The want of *latent* heat in the blood." Had he inverted his order, and made this laſt the *primary* cauſe, he might perhaps have been much nearer the truth; but to prove that the want of latent heat is an additional cauſe of death, which he attempts more by ingenuity of reaſoning than experiment, he lays it down as a firſt principle, that the chief uſe of reſpiration is for the generation of heat. He then attempts to prove "that this heat, by being evolved in a ſenſible form, keeps up the irritability of the whole animal; that the blood contains more or leſs latent heat in proportion to the degree of ſenſible warmth applied to the ſurface of the body; that as ſoon as the blood has undergone a change of colour in the lungs, it is rendered fit for ſupporting the heat and irritability of the ſyſtem; and that heat is not only evolved from the blood as it paſſes through the capillaries, but that the ſame proceſs continues through the whole circulation; and that the ſtimulus which excites the heart to action is the ſame in all its cavities, and is principally diſtention."

diſtention." But to proceed to his plan of recovery, which is,—1ſt. By artificial *inflation* of the lungs; and, 2d. Electricity. He oppoſes the practice of *inflating* the lungs, and immediately after preſſing the cheſt, thereby *expelling* the air, which has been ſo commonly recommended. Until, however, the Doctor better eſtabliſhes his opinion that death is occaſioned by a mechanical *collapſe* of the blood veſſels of the lungs, and that the ſtate of the blood and circulation do not depend upon the changes that fluid undergoes from coming in contact with the air, I confeſs I cannot but doubt the neceſſity or uſe of this his ſuppoſed improvement.

2d. Electricity. The importance of this remedy has been warmly urged by Doctor Coleman, but particularly the *electric ſhock*, as being beſt calculated to rouſe the ſyſtem into action. But let us enquire if this mode of adminiſtering electric fire in drowned perſons is not attended with danger? In the firſt place I obſerve, that in every drowned perſon there is an over-diſtention of the *heart* and *neighbouring veſſels*, as alſo of the veſſels of the *brain*; and, 2d. that the vital principle is already *ſuſpended*. It is now a natural queſtion, Is there no danger to be apprehended from the ſuddenneſs of an electric ſhock, of rupturing a blood veſſel? Again, Is it not probable, that the ſuddenneſs of an electric ſhock would

would rather *exhauſt* than give *tone* to the vital principle? I grant it may give *action* to the muſcular fibre, from which Doctor Coleman infers its uſe; but this action, I ſuſpect, like that produced from a ſtroke of lightning, would be attended with *abſolute death.* Independent of theſe dangerous conſequences, to get an electrical apparatus in readineſs requires a conſiderable length of time, eſpecially upon a damp day; in which time the latent ſpark of life may be entirely deſtroyed. I do not aſſert that electricity can never be of ſervice, but that adminiſtered as above, it will be attended with the diſadvantages I have noticed: if, however, it can be ſerviceable in any way whatever, it moſt probably might be ſo, by laying the body upon an *inſulated ſtool*, and charging it *gradually* with the electric fire; and, perhaps, after a little time, by drawing ſparks from it; but ſtill I would not exclude the other remedies I have recommended, particularly *tobacco ſmoke.**

Having thus eſtabliſhed the *connection* of the different functions with each other, and the importance of each in preſerving the principle of life; as alſo having pointed out the errors into which the different writers have fallen, the following concluſions naturally ariſe:—

* See page 32.

1ſt. That in every drowned perſon there is an interruption or ſuſpenſion of *all* the vital functions, which takes place nearly at one and the ſame time.

2d. That this ſuſpenſion of the different functions, and not of any *one* in particular, is the cauſe of death.

3d. That the indications of recovery, (to arrange them in the order they were ſuggeſted in the enquiry upon the different functions) are,

1ſt. To reſtore *the heat of the body*. For this purpoſe it muſt be immediately ſtripped of its wet cloaths, and with warm cloths wiped until it is perfectly dry: It is then to be expoſed to a gradual uniform degree of heat, at firſt ſomewhat below the natural ſtandard, for ſudden violent heat, like an electric ſhock, would rather exhauſt than increaſe the tone of the moving fibre. This may be done in a variety of ways:

1ſt. By placing it before the fire.

2d. Expoſing it to the ſun if it ſhines hot.

3d. By the heat of another perſon's body.

4th. If in the neighbourhood of a brewery, diſtillery, or any manufactory, where a ſufficient quantity of warm water may be immediately procured, by

by immerſing it in a warm bath, or by covering it in warm grains, warm aſhes, warm ſand, or ſalt.

5th. By rubbing it with coarſe warm cloaths, and applying warm bricks, bottles of warm water, or bags of hot ſalt to the feet.

2d. To reſtore the *reſpiration*, and thereby communicate *pure air* to the blood. This is to be done by repeatedly *inflating* the lungs, and as often *preſſing out* the air, thereby imitating the alternate motions of the cheſt in natural reſpiration: to effect this, the lungs may be inflated, either by the air, directly from another perſon's lungs, or by means of a tube inſerted into one of the noſtrils; or, laſtly, by inſerting it into the trachea, and annexing a bellows, which laſt method I ſhould prefer,* and with

* The advantages of this mode of inflation, in preference to the others mentioned, are obvious. Firſt, The air is thrown directly into the lungs, whereas, by the other methods, much of it neceſſarily paſſes into the ſtomach. Second, The atmoſphere contains a proportion of *pure air*, (ſee page 16.) whereas that blown in from the lungs of another perſon, is totally *impure*, and therefore muſt render the blood leſs fit for circulation than before.

I am aware of an objection which may be made to the common bellows, that it muſt be removed after every inflation. This, however, is obviated by the new-conſtructed pair by John Hunter, which conſiſts of *two ſeparate* cavities; upon *expanding* them when applied to the wind-pipe by means of a tube, one cavity may be filled with the *common air*, and the other with *impure air* from the lungs; and upon ſhutting them again, the *common air* may be thrown into the lungs, and the *impure* contained in the

with the following directions given by Doctor Monro, it may be accomplished without much difficulty:—" The surgeon should place himself on the right side of the patient, and introducing the fore-finger of his left hand, at the right corner of the patient's mouth, he should push the point of it behind the epiglottis, and using this as a directory, he may enter the *tube* which he holds in his right hand at the left corner of the patient's mouth, till the end of it is passed beyond the point of his fore-finger;" the bellows may then be annexed by means of a screw, and continued as long as may be necessary. This method will have another advantage, that it supersedes the necessity of bronchotomy, in as much as air may thereby be thrown into the lungs, as effectually as by an opening into the wind-pipe.*

3d. More

other cavity, be discharged into the atmosphere. *Query*. Would not this instrument be a very useful addition to the common apparatus for the recovery of the drowned?

In addition to this improvement for inflating the lungs, was it not a tedious operation, perhaps it would even be a desirable object to separate from the atmosphere, the *dephlogisticated* or *pure air* alone. In some instances we are informed it has been done with success, and perhaps merits further attention. See Encyclopædia, article *dephlogisticated air*.

* For the effects of *artificial* respiration in supporting life, see Doctor Hale's Statical Essays, vol. i. p. 255.

3d. More immediately to reſtore *the circulation of the blood.* This will be in part effected by the laſt and following indication, but more immediately by *blood-letting*, which belongs to the preſent.

Whether *bleeding* be proper in the recovery of the drowned, has been a queſtion of much diſpute; but without entering into a particular detail of the arguments advanced for and againſt it, I am diſpoſed to advocate its propriety for the following reaſon, that it ſerves to *renew* and *regulate* the circulation, which it does by *leſſening the* quantity of blood in the heart and veſſels, and thereby adding to their *momentum*, or in other words, their diſpoſition to contract: this I conceive is abſolutely neceſſary in the preſent inſtance, where both the heart and larger veſſels are diſtended, and where there is a deficiency in the extremities. The objection ſo commonly urged, that the blood is the ſource of heat (which it is our firſt object to reſtore,) and that in proportion to the quantity of blood we take away, ſo in proportion we leſſen its heat, or counteract the means of reſtoring it, I conceive to be no better founded than Doctor Coleman's objection to tobacco ſmoke "in ſuſpended animation, becauſe it is of injury in *ſyncope* and *typhus fever*;" for it is well known, that in many diſeaſes where there is a ſuſpenſion of the vital functions, with loſs of heat, &c.

that

that blood-letting is the only remedy, as in ſome ſpecies of ſyncope, violent falls, &c. and even in ſome diſeaſes where this ſuſpenſion does not take place, we obſerve the ſame effect from blood-letting, viz. that of *regulating* the circulation, as in inflammations of the *abdominal viſcera*, particularly the *ſtomach*, *inteſtines*, *bladder*, &c. They are uniformly attended with a *ſmall* tenſe pulſe at the wriſt, owing to the greater determination of the blood to the inflamed parts: immediately, however, upon opening the vein, it is as generally obſerved that the pulſe riſes, and in a ſhort time becomes *full*. To what are we to attribute this circumſtance? Surely to the determination of the blood to the ſurface and extremities, thereby leſſening the quantity in the inflamed veſſels: and may not the ſame effects follow in the preſent inſtance? Coleman himſelf, who ſo warmly oppoſes blood-letting, acknowledges that the *irritability* of the heart, or in other words, a diſpoſition to contract, continues ſome time after the functions are ſuſpended, and that the heart and larger veſſels are overcharged (independent of the fullneſs of the veſſels of the brain, which bleeding unqueſtionably will relieve,) it therefore follows as a natural conſequence, if the analogy mentioned between a ſuſpenſion of the functions in the above ſtate of ſyncope, &c. and the ſuſpenſion which follows

lows drowning, be well founded, that blood-letting is equally proper in the one caſe as in the other. Great caution, however, is to be obſerved in the uſe of this remedy, leſt we take away a greater quantity of blood than is ſufficient to anſwer the above intention, and run into the oppoſite extreme: to which laſt circumſtance I am in ſome meaſure diſpoſed to attribute the cauſes of the objections which have been urged to this remedy. But to proceed to the fourth indication, viz. To reſtore the tone and action of the *brain* and *nervous ſyſtem*, or, in the words of Doctor Cullen, to reſtore the tone and action of the *moving fibre*. This may be accompliſhed by the following means:—

1ſt. Stimulating applications to the ſurface of the body and extremities, ſome of which have been already noticed. To thoſe may be added, rubbing the wriſts and palms of the hands and lower extremities with ſpirits of wine, hartſhorne, or, which perhaps is moſt powerful, the ſpirits of ſal ammoniac.

And, 2d. By exciting the action of the inteſtinal canal, which may be done by, firſt, pouring warm wine, the ſpirits of ſal ammoniac, or perhaps brandy with laudanum,* into the ſtomach; the quantities of which

* From the good effects of laudanum, (eſpecially when given

which are to be determined by the judgment of the phyſician. Second, by warm ſtimulating clyſters, either of ſimple warm water, or mixed with wine or ſpirits, or, upon which we are to place more reliance, *injections of tobacco ſmoke.* I am aware of the objections made to this laſt remedy, that it is a "poiſon which operates by producing ſuch an extreme degree of debility as no powers of life can ſupport;" and as Doctor Coleman more particularly obſerves, "we might with as much propriety recommend it in ſyncope or typhus fever, as in ſuſpended reſpiration from drowning; and that by diſtending the inteſtines it prevents the eaſy deſcent of the diaphragm."

With all due deference to the aſſertion and opinion of Doctor Coleman, I conceive it neceſſary, before we reprobate this debilitating poiſon, *tobacco ſmoke*, firſt to prove that the ſame debilitating effects will be produced upon a *drowned perſon* as upon one in the uſe of all his functions, and who has never been accuſtomed to its uſe. Analogy proves that they are not the ſame, and that good effects may be produced in the one inſtance but not in the other; for *ſpirituous liquors* and *opium* produce the ſame deliterious

with brandy or ſpirits) in ſuſpended animation from drinking *cold water*, it is probable it may alſo be ſerviceable in ſuſpended animation from drowning. See Ruſh's Medical Obſervations.

rious and debilitating effects upon a perſon unaccuſtomed to their uſe and in health; whereas it is well known to every phyſician, that the ſame perſon when debilitated by diſeaſe, can uſe them without thoſe conſequences, and with advantage. A man who in health cannot drink three glaſſes of wine without inconvenience, when labouring under a typhus or nervous fever, it is well known can drink a bottle a day without knowing from his feelings whether he has taken a ſingle draught. The ſame thing is obſerved in the uſe of that deleterious poiſon *opium*; therefore it is preſumable, from a parity of reaſoning, that tobacco, however deſtructive in health, like ſpirituous liquors, may have good effects in ſuſpended animation, eſpecially when we add that there is ſcarcely a ſubſtance in nature which ſo immediately *ſtimulates the moving fibre*, as is evident from its immediate efficacy when taken into the ſtomach,* or thrown into the bowels by clyſter, in caſe of coſtiveneſs.

The remark of Mr. Coleman, that we might recommend its uſe in typhus and ſyncope with as much

* I am acquainted with a lady, who when occaſionally coſtive, has recourſe to a pipe of tobacco; and before ſhe uſes it one minute, it has the deſired effect; and that too, although ſhe never ſwallows the ſmoke—A proof of its ſtimulating effects upon the nervous ſyſtem.

much propriety as in the recovery of drowned persons, I consider equally futile with that already noticed; for in both *typhus* and *syncope*, vomiting and purging, (which generally follow the exhibition of tobacco) according to my idea of those diseases, would be extremely injurious, whereas I conceive they may be of great service in the recovery of a drowned person, in as much as vomiting directly serves to regulate the different functions,* and open bowels afford the chest a more free action, independent of its stimulating effects upon the moving fibre, which is the great object of Doctor Coleman's warm encomiums upon the use of electricity. It remains to consider his last objection to the use of tobacco smoke, viz. "That it distends the intestines, and thus prevents the easy descent of the diaphragm." I am disposed to think it would have a directly contrary effect, and instead of preventing, *promote* the action of the heart and diaphragm, for we well know that the diaphragm is plentifully supplied with *nerves*, as all, more or less, daily experience, from *sneezing*, *hiccup*, &c. and that tobacco acts chiefly by stimulating the nervous system, as was just demonstrated; it therefore follows, by a natural and necessary consequence, that by distending the intestinal canal, it comes in more immediate contact

* See Cullen's First Lines, vol. i.

contact with the diaphragm, heart, and lungs, and thereby can more directly communicate its warmth, and renew their action; the consequences of which are generally *vomiting* and *purging*, which directly evacuate the water that may have been swallowed, and the fœces with which the intestines may be loaded; if, however, further experience should prove that the distention of the intestines with a warm stimulating *air* is of injury, it can with ease be obviated, by having recourse to clysters made of an infusion of tobacco, which can almost as readily be procured as the smoke.

HAVING thus finished what I proposed, it may not be improper to recapitulate the causes of death and means of recovery, as in the following table, which I shall arrange in the order they were suggested:—

1st. Fear, Chill, and Pressure of the water.	Producing debility in the nervous system, with a loss of tone in the extreme vessels, and together with the

2d. Want

2d. Want of vital air, and perhaps more or leſs collapſe of the lungs.	A congeſtion of blood in the heart, lungs, brain, &c. and thereby univerſal debility, followed with a ſuſpenſion of the vital principle.

Indications of Recovery.

1ſt. To reſtore heat to the body.	1ſt. By placing it before a fire. 2d. Expoſing it to the ſun. 3d. Heat of another perſon's body. 4th. Warm bath, warm grains, aſhes, ſand, or warm ſalt. 5th. Friction with warm cloths. 6th. By applying warm bricks, bottles of warm water, or bags of warm ſalt to the feet.
2d. To reſtore the reſpiration, & thereby communicate pure air to the blood.	By artificial reſpiration, to be done directly by the mouth, or by a tube inſerted in one of the noſtrils; or, laſtly, by paſſing a tube into the windpipe, and then annexing a bellows.

3d. To

3d. To reſtore the circulation of the blood.	By bleeding.
4th. To reſtore the tone and action of the nervous ſyſtem.	By pouring warm ſtimulating liquors into the ſtomach, and by warm ſtimulating injections, particularly of tobacco ſmoke.

FINIS.