

A dissertation on suspended respiration, from drowning, hanging, and suffocation: : in which is recommended a different mode of treatment to any hitherto pointed out. / By Edward Coleman, surgeon.

Contributors

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A

DISSERTATION.

ON

SUSPENDED RESPIRATION,

FROM

Drowning, Hanging, and Suffocation:

In which is recommended a different Mode of Treatment
to any hitherto pointed out.

By EDWARD COLEMAN, SURGEON.

“ Qui studet optatam cursu contingere metam,
“ Multa tulit fecitque puer.”

HOR.

L O N D O N :

PRINTED FOR J. JOHNSON, ST. PAUL'S CHURCH-YARD.

MDCXCXI.

DISSERTATION

SUBMITTED IN CANDIDATURE FOR THE DEGREE OF DOCTOR OF MEDICINE

BY EDWARD C. THORNTON, M.D.

OF THE UNIVERSITY OF TORONTO



LONDON: H. K. LEWIS, 10, BUNYARD LANE, E.C. 4.

1911

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D E D I C A T I O N.

To HENRY CLINE, Esq;

LECTURER ON ANATOMY, AND SUR-
GEON TO ST. THOMAS'S HOSPITAL.

DEAR SIR,

THAT distinguished eminence you have
so deservedly attained in the medical world,
and that gratitude, you might so justly
claim from all your pupils, particularly
from one who is indebted for his chirur-
gical and physiological knowledge, not
only to your public, but private in-
structions;

D E D I C A T I O N .

structions; would, alone prove sufficient inducements for me to address these first fruits of my professional studies to you.

But however powerful these motives; allow me to add, there is another yet more cogent, and which flows more immediately from the heart.

That friendship with which you honoured me while resident under your roof, and which you have kindly continued since I quitted that hospitable mansion, to enter the busy scenes of life; will for ever live in my recollection, and awake the most grateful emotions of a feeling mind.

Permit me then to hope you will receive this Dedication as a small, but sincere testimony of that sense I entertain of
your

D E D I C A T I O N.

your esteem; to merit and to enjoy which,
to the latest period of my existence, is the
highest ambition of,

Dear Sir,

your much obliged

and most humble servant,

EDWARD COLEMAN.

No. 8. FEN-COURT,
FENCHURCH STREET.

A 2 CONTENTS.

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INTRO-

ERRATA.

- Introduction, pa. x. line 12. after *discovered*, read *to depend on*.
- Page 2. line 8. for *progrers*, read *process*.
6. line 15. after *secured*, read *by ligature*.
21. in the note, after *bulk*, read *as is*.
37. line 18. for *by warmtb*, read *in warmtb*.
40. line 12. for *bronchial vessels*, read *bronchial arteries*.
62. line 16. after *Goodwyn* begin a fresh period.
90. line 3. after *irritability*, supply *be*.
113. line 53. for *spirits of nitre*, read *nitrous acid*.
118. line 1. for *a less degree*, read *a more gradual one*.

INTRODUCTION.

OF all the exertions of human skill, there is, perhaps, none which affords us more solid and lasting gratification, than the restoring to life those who are apparently dead; none, surely, more eminently shews the dignity and fruitfulness of Philosophy, or more clearly evinces the benefits that may be derived from the well-directed efforts of human understanding.

This art (if such it might be called in so rude a condition) was, in former ages, guided chiefly by blind prejudice; the knowledge of the animal œconomy, and of life, was not sufficiently extended, to afford maxims of any value to the practitioner;

titioner ; and the causes of death were too incorrectly marked, to shew, with any degree of precision, the means of recovery.

Accidental recoveries had, indeed, shewn that it was practicable ; but Physiological science was unable to explain or prescribe the mode. It was reserved for the eighteenth century, to exhibit, on a large scale, any practical specimens of this mode of benevolence, and to approach, in some respect, to the scientific solution of those principles by which it must be guided. Many societies were formed on the continent of Europe, for the purpose of promoting this kind of knowledge ; and their reports afforded the most mortifying reply to those who had declaimed with such triumph on the vanity of natural science, and the impotence of human art. Their multiplied successes, in so untried a path, awakened a

general ardour on this subject, which was not a little fostered by a cotemporary revolution in natural knowledge: I allude to the philosophy of elastic fluids, which has, during the last part of the present century, received such incredible accessions. The doctrine of *airs* was so intimately connected with the subject of respiration, that it could not fail to fix the attention of Philosophers on those cases where its sudden suspension was the cause of death. It were superfluous to enumerate the various theories offered by the Chymists and Physiologists of this recent period. Suffice it to remark, that the Humane Society of London deemed the subject so perplexed with discordant theories, and so susceptible of farther experimental elucidation, that they published, in 1787, a question on *the nature of the diseases produced by submersion, suspension, and noxious airs.* Two Differ-

tations, of peculiar merit, they honoured with prizes: those of Dr. Goodwyn and Mr. Kite. The same enlightened and benevolent body pursued this enquiry, by proposing a question—“ *Whether Emetics, Venesection, or Electricity, be proper in suspended Animation, and under what Circumstances?*”

To this question, I am about, in the following Dissertation, to attempt an answer. It may be thought, that, as this question is purely *practical*, any investigation of the *proximate cause* of the malady, is superfluous and impertinent, and that our views ought to be limited to the remedies employed in its cure; or, it may perhaps be supposed, that such enquiry is precluded by the successful labours of Dr. Goodwyn and Mr. Kite: but reason, which forbids us to abandon

any

any thing so important, to blind empiricism; the example of these Gentlemen, who had from their pathology deduced their cure, and the repugnance of their inferences to each other, which countenanced a doubt respecting the accuracy of either,—seemed to prove the necessity of reinvestigating, by experiment, the nature and causes of the disease, previous to the delineation of any plan of cure. One of these Gentlemen attributes death in these cases to the quality of the blood in the left side of the heart, which has not received from the air, that stimulant power, which supports the action of that organ. The other attributes it to apoplexy. I was induced, since the appearance of these essays, to attempt a series of experiments on the subject, which perhaps I should not have cultivated with so much ardour, had I not been animated by the example

of Mr. Kite, from whom I received the rudiments of my medical education, and for whom, in combating his opinions, I trust I shall not be deficient in that respect which his talents demand. These experiments presented results which contradicted, in many important particulars, received opinions: but I should not, at so early a period of my life, have presumed to offer them to the public, had I not been emboldened by the approbation of the Medical Society of London, who voted me the Humane Society's Medal. To Mr. Kite, I flatter myself, no apology for the freedom of my strictures on his opinions, will be necessary. Not to have noticed his work, would have been disrespectful; and to have dissembled what I found to be truth, in tenderness to his sentiments, is, I am sure, a sacrifice that his liberality would not exact. He is
acquainted

acquainted with my experiments and conclusions, and has, I apprehend, in consequence, changed some opinions, which, in the hurry of enquiry, he had precipitately adopted.

Dr. Goodwyn has justly and ingeniously remarked, that the expression, "Suspended Animation," is objectionable. Respiration and circulation may be suspended; but the principle of life, or the susceptibility of action, which is the source of these functions, may still remain. Life, therefore, can with no propriety be said to be suspended, when the vital principle is present. The animal must either retain the principle of life, or be absolutely and irrecoverably dead. There is no intermediate state between life and death. The distinction between the actions and powers of life, which, with so many other ad-

mirable observations in Physiology, we owe to the ingenious Mr. Hunter, clearly illustrates the impropriety of the language to which we object. He has proved that in many cases, these powers remain when the actions are suspended. The presence of these powers alone constitute life, and form the sole distinction between inanimate and animated matter. When they cease to be present, life is *not suspended, but destroyed*. Instead therefore of employing the term Suspended Animation, we shall adopt that of *suspended respiration*, which only simply expresses a fact, and is equally applicable to those cases which terminate in death, as to those of which the event is favourable.

The necessity of inflicting a painful death on so many animals will ever be felt by minds of sensibility, as a cruel

alloy to the pleasure of Physiological research. By no other mode, however, than that of experiments on living animals, can any important advance be made in this subject. Such experiments, in a question of mere curiosity, are certainly indefensible; but where, as in the present case, the advancement of truth conspires with the interests of humanity, we must impose silence for a while on the remonstrances of sensibility.

In the conduct of the experiments which form the basis of the following dissertation the most solicitous accuracy has been every where studiously sought.

To those who are in the habits of Physiological experiment, nothing is more familiar than the perplexing variety and repugnance of their results; two experiments, though

though made in the same manner on the same order of animals, will rarely in every particular agree; for it is not only true, that different species of animals, but that different individuals of the same species, possess various degrees of irritability. In some, irritability may be excited for several hours after apparent death, others lose it in less than one. The cause, however, of these variations, where they have been in any respect considerable, we have generally discovered some accidental and extrinsic circumstance, and by multiplying and varying experiment, we have attempted to discriminate between what is made the foundation of *general* principles, and what is the effect of peculiar and fortuitous circumstances. But the enthusiasm which we acquire in the pursuit of a favourite research, and our anxiety to support a cherished opinion, ought ever to make the
expe-

experimental enquirer diffident of the correctness and impartiality of his *own* views. A bias unconsciously taints his judgment, against which the only remedy is, the vigilant eye of acute and intelligent friends, who feel more anxiety for his reputation, than tenderness for his prejudices ; and who have no motives either to make tortured inferences, or to hide unfavourable results.

The same good fortune that has blessed my private life with the friendship of such men, I have also eminently felt in my scientific pursuits. Their acuteness has rescued me from my prejudices ; and their aid has given me a confidence in the correctness of the experiments, which distrust in my own individual skill would otherwise never have permitted me to entertain. I have to mention with particular gratitude, Mr. Astley Cooper, whose anatomical and
phy-

physiological knowledge needs no comment; and Mr. Keir, a gentleman of distinguished ingenuity, who favoured me with his occasional assistance. And it affords me no small gratification, that my much respected friend Mr. Haighton, Teacher of Physiology, in the Borough, has made many experiments which corroborate most of the opinions here advanced.

Though submersion be the most frequent, it is by no means the only case of apparent death worthy the inquiry of the Physiologist, or the attention of the medical practitioner. Nor is the benevolent zeal of the Humane Society confined to it alone; as every case of apparent death arising from a sudden suspension of respiration, partakes equally of its bounty; and

and indeed, agreeable to this extensive view of the subject, the question before us is proposed.

The suspension of vital action from strangulation and noxious airs, exhibit phenomena so nearly similar, and require a treatment so strictly congenial, that any inquiry into the nature of submersion, would be narrow and imperfect, unless illustrated by the investigation of these kindred diseases. To them, therefore, we have thought it expedient to extend our researches; and from inductions founded on a series of experiments and observations on these different modes of death, we flatter ourselves with the hope of having established a general doctrine on premises less ambiguous and unstable, than those which have been the basis of former theories.

To

To ascertain phœnomena is the first duty of every inquirer into nature. We shall therefore, in the three first sections, succinctly describe the usual effects of drowning, hanging, and noxious airs. Having stated these, it will be natural to preface any enquiry into the nature of the disease, by the Physiology of the organs which are its seat; thus delineating their natural actions, before we examine their morbid condition. The Physiology of the heart and lungs therefore will constitute our fourth section.

Having described the phœnomena of departing life, the appearances on dissection, and the natural state of the organs concerned; we are next led to view the subject in a Pathological light, and to consider that peculiar condition of the animal which forms the *proximate cause* of the disease. This will occupy the fifth section.

The

The remaining part, to which the preceding sections are but preliminary, will be devoted to the consideration of the cure: and in order to investigate more at length, the efficacy of those means which have been either suggested by speculation, or sanctioned by experience, we shall dedicate a section to each class; by which we shall be enabled to form a just estimate of their comparative efficacy and importance.

Emetics, Venesection, Electricity alone, or combined with artificial Respiration, Warmth, Frictions, and Clysters will be fairly examined by the tests of experiment, and of reason; and our last section will consist of conclusions drawn from the whole.

SECTION

The remaining part, to which the preceding sections are but preliminary, will be devoted to the consideration of the cause, and in order to investigate more at length the efficacy of those means which have been either suggested by speculation or sanctioned by experience, we shall devote a section to each, so far as by which we shall be enabled to form a full estimate of their comparative efficacy and importance.

It is to be observed, that the sections on the Venereal, Rheumatic, and other diseases, or combined with other diseases, will be fairly examined by the rules of experience, and of reason; and our last section will consist of conclusions drawn from the whole.

whole

S E C T I O N I.

On the common Effects of Drowning.

THE general effects of submerfion have been described by others; and the result of our obfervations will be found nearly fimilar to that obtained by thofe who have already written on this fubject. But, as it was neceffary firft to examine the appearances of animals under that circumftance, before any clear idea could be formed of the proximate caufe of the difeafe, we fhall begin with a description of the vifible effects that ufually arife from drowning.

As soon as an animal is immersed in water, air is expelled from its lungs, and immediate attempts are made, apparently with great difficulty, to inspire; in which a small quantity of water is taken in. The animal betrays increasing uneasiness; again expels air, and takes in water. The duration of this ~~progress~~ *process* varies from one minute to four; when the muscles of respiration cease to act, and all struggling is at an end. Some involuntary motions, however, generally succeed. On opening the chest, we find the two *venæ cavæ*, right sinus venosus, auricle, ventricle and pulmonary artery, loaded with blood; the left auricle nearly distended; the left ventricle about half; the aorta and its branches containing a quantity of blood, which, in all its appearances, resembles venous. The lungs are discovered in a state of collapse, containing a small quantity of

of water, in the form of froth, but very trifling, when compared to the quantity of air expelled from the lungs, during the act of drowning. The stomach, on examination, presents also a little water, which probably passed into the œsophagus when the rima glottidis was closed by the epiglottis; for, as the water contained in the mouth is then refused admittance into the trachea, it should seem, that, at that moment, it makes its way into the stomach; so that, as soon as the animal attempts to inspire, water enters the trachea; but this organ, as if conscious of not receiving its due element, rejects the water, which is then allowed to pass into the œsophagus. Air is again emitted, and new efforts made to inspire, when, upon the same sensation being produced, similar effects arise; and, after the last expiration, no more water enters the lungs, or stomach. If it were not certain,

that the epiglottis closed the rima glottidis as soon as the trachea was irritated, there would be found as much water in the lungs as the animal had expelled air; and if the stomach or lungs continued to admit water after respiration had ceased, we should find them fully distended, where the animal was suffered to remain in water: but, whether our examination be made immediately after the ceasing of respiration, or after the space of several minutes, we find no variation in the quantity.

Mr. Kite has concluded, from his experiments, that no water enters the wind-pipe, until the animal is dead: but the entire result of our experiments, tends to prove the contrary; that water does get into the lungs, during the act of drowning, and that no animal, provided with lungs, can be drowned without this circumstance taking

taking place. Indeed Dr. Goodwyn has proved this to be the fact, in a manner so convincing and satisfactory, that we need only mention, that the whole of our experiments to ascertain this point, have uniformly agreed with his.

It has been mentioned by Dr. Goodwyn, and other Physiologists, that the right auricle and ventricle are found FULL; but there seems to be some degree of impropriety in the expression, for by the term FULL is generally understood, a *cavity replete without vacuity*; and if so, the left ventricle may be said to be *full* when distended only to half its natural size, as it adapts itself to the volume of blood it contains, and in proportion as the quantity encreases, the cavity enlarges, until it attains a certain degree of distention, when it re-acts. If the heart, therefore, contain

but a small quantity of blood, the sides of the auricle or ventricle will be in contact with it, and the cavity be thus obliterated. Hence we prefer the term *dilatation* to that of *fullness*.

The following experiments were made with a view to determine the exact proportion which the quantity of blood contained in the right side of the heart, bears to that in the left, after drowning.

EXPERIMENT I.

A Cat was drowned, and as soon as the usual struggles attending submerfion had ceased, the chest was opened, the two cavæ, pulmonary artery and aorta were secured, and the blood contained in the heart carefully collected; upon which we found the proportions of the right to the left to be as 12 to 7.

The

The next experiment was made to ascertain whether after the action of the heart had ceased, the proportions were altered.

EXPERIMENT II.

A Cat was drowned, and when the heart had ceased to vibrate, the two cavæ, pulmonary artery, and aorta were secured as before. The proportions of the right were to the left as 2 to 1.

These experiments were repeated, and the quantities varied; sometimes being as 7 to 4, at other times as 5 to 2, or as 12 to 7. So that at a medium, the proportions of the right are to the left, as about $3\frac{2}{8}$ to $1\frac{6}{8}$. The lungs were uniformly in a state of collapse.

Dr. Goodwyn has made some experiments to ascertain the precise quantity of air contained in the lungs after death, and they were conducted in the following manner.

“ A dead body of ordinary stature
 “ was procured, and a close compress ap-
 “ plied upon the superior part of the ab-
 “ domen to fix the diaphragm in its
 “ situation; a small opening was then made
 “ into the cavity of the thorax on each
 “ side, and upon the most elevated parts.
 “ The lungs immediately collapsed, and
 “ water was introduced at these openings,
 “ till the cavity was filled. The volume
 “ of the water contained was 272 cubic
 “ inches.

“ The person on whose body this ex-
 “ periment was made had been hanged.

“ In

“ In four fimilar experiments, where death
 “ was natural, he found the medium was
 “ 109 cubic inches of air after complete
 “ expiration.”

These experiments, however, are by no means conclufive, for whatever may be the caufe of death, the animal dies with an expiration, and the tendinous part of the diaphragm is thruft up as high as the fourth, and fometimes as high as the fifth inferior rib; and therefore the application of a comprefs round the abdomen does not feem adequate to prevent the diaphragm from defcending. Could this even be effected, as the ribs cannot be kept at any fixed point, and as the air contained in the lungs was not collected, the experiment can by no means authorife any legitimate conclufion.

Dr.

Dr. Goodwyn observes, that atmospheric air by means of its gravity, will enter into the chest, and by its pressure on the external surface of the lungs, oblige them to collapse. This observation, we presume, is erroneous, for according to a well-known law in hydrostatics, air and all fluids press equally in every direction. However great therefore the quantity of air may be in the lungs after the last expiration, the pressure of the external air cannot be supposed to assist in repelling it. This appears obvious on a common bladder inflated, which the pressure of the external air, by no means contributes to collapse, but in the same manner as the lungs, where the pressure is equal, its evacuation will depend on its own elasticity and weight.

Those

Those who die a natural death must always have a portion of air remaining after the last expiration, since the lungs cannot be thoroughly evacuated by one, but in drowning, &c. repeated expirations are made with attempts to inspire; but the latter are ineffectual. What therefore Dr. Goodwyn has advanced on this head, appears neither established by argument, nor countenanced by fact. But to determine the point, the following experiment was attempted.

EXPERIMENT.

A Cat was drowned, and after the usual struggles had ceased, the trachea was secured by a ligature, the chest opened, and the lungs taken out. A glass tube divided into drachms and half drachms, by measure, was filled with water, and
 inverted

inverted in a basin containing the same fluid. The trachea was then placed under the tube and divided, and the lungs being pressed, not half a drachm of air escaped. The same lungs when distended contained 16 drachms of air.

This experiment was several times repeated on different animals, and sometimes scarce a bubble of air was collected; in no instance was the proportion of air in inspiration to that remaining on the lungs after expiration so small as 10 to 1. The Heart has frequently been observed to contract, or more properly to vibrate, for more than two hours after respiration was suspended, and that from no other stimulus but its own blood; while in other experiments the vibrations did not continue one tenth part of that time. The right side of the heart preserves its action much longer than the
left,

left, and the auricles longer than their corresponding ventricles.

The peristaltic motion of the intestines does not continue as long as the contractions of the heart, and on opening the head, the veins, as in ordinary death, are found rather distended, but without the least appearance of extravasation. Our next enquiries will be directed to the effects of hanging.

SECTION II.

Common Effects of Hanging.

WHEREAS, in the lungs of animals that are suspended by the neck, there is always present a certain quantity of air; the idea has been suggested, that they possessed no power to expel it; and that, as the lungs would then be more or less distended, the disease arising from it, must differ from that produced by drowning. To ascertain this point, the following experiment was made:

EXPERIMENT.

A dog was suspended by the neck. As soon as the struggles became violent, the fæces and urine were discharged. In less

than four minutes, he ceased to move. The air-tube was tied, the chest opened, and we discovered the same appearances after hanging as after drowning; the lungs collapsed; the right side of the heart overloaded with blood; the left auricle not quite distended; the left ventricle about half. The aorta and its branches contained blood, in quantity and colour similar to that from drowning.

Hence it appears, that, when an animal is suspended, the muscles of respiration are capable of performing their functions; nor are the muscles of inspiration deprived of their action: but, as the pressure of the cord overpowers that of the external air, and closes the opening of the trachea, the lungs are not found expanded, but collapsed.

Our

Our next object was, to attempt ascertaining the exact quantity of air that remained after hanging.

EXPERIMENT.

A dog was hanged; and, when all struggle and motion had ended, a ligature was made on the trachea, in the same manner as in the animals that were drowned: the lungs were then removed; and the orifice of the trachea being placed under the glass tube filled with water, the ligature was taken off. On pressing the lungs, somewhat more than a drachm of air escaped. These lungs, when inflated, contained forty-three drachms and one half of air. This experiment was often repeated; and sometimes scarcely any air could be expressed from the lungs. At

other times, the proportions in inspiration were, to those in expiration, as 11 and 12 to 1 : but, in all instances, the quantity of air that remained was very inconsiderable.

In our next experiment, we endeavoured to ascertain the exact proportion of the blood in the right side of the heart, to that in the left, after hanging.

EXPERIMENT.

A dog was suspended by the neck, till he ceased to move. The two cavæ, pulmonary artery, and aorta, were secured by ligatures ; and, after a careful inspection of the heart, it was found, that the proportion of blood in the right, was, to that in the left, as 2 to 1.

The same experiment was repeated on a cat, and the proportion as 5 to 3. On a

D

repetition

repetition of these experiments, it appeared that in some the proportions were as 9 to 4; in others as 5 to 3, and as 7 to 4. So that the medium stands as $2\frac{7}{8}$ to $1\frac{4}{8}$.

The contractions of the heart and the peristaltic motion of the intestines continue nearly as long after hanging, as after drowning, the veins of the pia mater seem more distended, but without any extravasation.

SECTION III.

Common Effects of Noxious Airs.

IT has been generally supposed, that when animals were immersed in any air unfit for respiration, it was both taken into their lungs, and again expelled. During which process a deleterious effect was produced on the system that terminated in death.

This supposition is, however, supported neither by argument, experiment, nor analogy; for we find the lungs equally *collapsed* in those animals destroyed by noxious air, as in those which have been drowned. In both cases, the first expiration is by no means sufficient to exhaust the lungs.

The animals attempt to inspire ; when they become conscious of receiving an improper element, and the epiglottis closes. Air continues to be expelled, and new attempts are made to inspire, when the trachea being again irritated by the noxious air, little or none enters the lungs, and after the last expiration they admit no more.

In order to discover the precise quantity of air now retained, we made the following experiment.

EXPERIMENT.

A Kitten was immersed in nitrous air, and when it had ceased to breathe, the trachea was secured, and the lungs removed. The air was then collected as before, in the glass tube ; and it amounted only to $\frac{1}{2}$ a drachm ;

drachm* ; whereas, in the distended state, these lungs contained 14 drachms and $\frac{1}{4}$.

In the repetition of this experiment, different kinds of impure air were employed ; and the proportion of it in the distended, to that of the collapsed state was generally as 40 or 50 to 1 ; but in every instance the quantity of remaining air was very inconsiderable.

Our next object was to determine the exact quantity of blood in the right and left sides of the heart.

To ascertain this, we repeated the following experiment.

* We here mean the same bulk occupied by half a drachm of water.

E X P E R I M E N T.

A Rabbit was destroyed by nitrous air ; after which, the two cavæ, pulmonary artery and aorta, were secured. The blood, in the right and left heart, was then collected. The proportion of the former, was to that of the latter, not quite as 3 to 2.

From a repetition of this experiment we learned however, that the proportion was sometimes not so much as 3 to 2. In one instance, it was more than 2 to 1.

As a medium, therefore, the quantity of blood contained in the right, may be to that in the left as 5 to 3, or as $1\frac{2}{3}$ to $\frac{3}{4}$.

We here also remarked, that the irritability of the heart continues but little longer

longer than the peristaltic motion of the intestines, and that in these experiments, they both ceased sooner than in animals destroyed by drowning or hanging. Nor was this irritability in any one instance manifest from artificial stimuli after respiration had been suspended one hour and five minutes. In some rabbits destroyed by nitrous air, the heart ceased to contract, from its own stimulus, in less than four minutes.

From the uniformity of these effects, we are authorized to conclude, that the air, in which the animals were immersed contributed to destroy their irritability.

I shall not deny, that this effect is to be attributed to the noxious quality of the air; but should rather suspect, the bulk of this air, taken into the lungs of suffocated,

does not more than equal that of the water admitted by drowned animals: for as the latter, at each inspiration receive only a small quantity of water, it is probable, the former admit only the same quantity of noxious air, which, mixing with what remains in the lungs, is at length nearly all expelled by repeated expirations; and a similar collapse takes place, to that which we have already observed, accompanies hanging and drowning.

It is a remark of Mr. Kite's, that animals destroyed by impure air, do not grow rigid, but remain pliant and flexible. We have however, in the course of our experiments, met with striking examples of the contrary. Animals killed by nitrous air become sooner rigid than those destroyed by drowning; and in two instances, the rigidity of the extremities was remarkable,
even

even before the heart had ceased to vibrate.

On examining the head, we discovered some small distention of the veins.

From this brief inquiry into the visible effects arising from hanging, drowning, and suffocation, we discover these trifling variations. That in one instance water enters the lungs, in the other noxious air; that this air possesses a greater tendency to destroy the action of the heart, than either hanging or drowning, and that after the former, more blood is found in the head, though its proportions in the different sides of the heart, are nearly equal.

The lungs in all these are in a state of *collapse*. These considerations, especially the *last*, incline me to believe, that the cause
which

which produces death in one instance, operates also in the others. But prior to an investigation of the *proximate cause* of the disease, a cursory examination of the physiology of the heart and lungs may not be improper.

SECTION

SECTION IV.

Physiology of the Lungs and Heart.

IT is by no means our design to extend this investigation to every advantage that results from respiration, as our voice, smell, &c. but merely to take a rapid survey of those functions more immediately connected with *life*.

On this subject Dr. Goodwyn has bestowed no small share of attention; and though the result of our own observations does not permit us to yield assent to many of his opinions, yet the resources of his ingenuity, and perspicuity of arrangement ever claim our admiration and applause.

But

But before we inquire into that particular connection which subsists between breathing and life, our first object is briefly to consider the manner in which respiration is performed in health.

The expansion of the thorax in ordinary inspiration is effected by the intercostal and other muscles, and its cavity lengthened by the descent of the diaphragm, but in laborious inspiration, the *serratus major anticus*, *pectorales*, &c. bear a considerable part.

Expiration is said to be both an active and passive process: it is active when the abdominal muscles compress the viscera, and draw the ribs downward and inward; and passive from some of the muscles of inspiration at this time relaxing.

The

The lungs themselves are somewhat elastic ; but are passive in respiration. They may not unfitly be compared to a pair of bellows, and the muscles of respiration to the power that works them : in their state of expansion, or when the muscles of inspiration act, a cavity is formed which admits an influx of air, but when compressed, or by the muscles of expiration acting, the cavity is lessened and the air expelled. Thus, by this alternate dilatation and contraction of the thorax, the process of respiration is supported.

The action of these muscles in a state of health is involuntary, and is less influenced by the will than most of the other muscles in the body : we are able, however, for a short interval, to check or increase their action, but that it should not be wholly subservient to our will, is

very wisely ordained; for otherwise the powers of respiration must cease whenever the senses are suspended by sleep or insanity.

It has been generally supposed that one of the natural functions annexed to the lungs was that of assisting, by their alternate dilatation and contraction, in propelling the blood from the right to the left heart, but in health they seem to possess no such power; for if circulation depended on their mechanical action, suspending our breath for one twentieth part of a minute would produce a cessation of the heart's motion, and we should then have but one pulsation to one expiration, whereas in health we have four.

Let theory devise what principle it may to explain, that in health the lungs possess

no power of propelling the blood from one side of the heart to the other, the matter of fact is clear; (and it will appear so from an experiment contained in the next section) that the right side of the heart, unassisted by the action of the lungs, is capable of sending blood to the left, even after respiration has ceased. If then the heart, in a state of debility, can perform this function independent of the lungs, can it be supposed unequal to it in the vigour of health? Groundless therefore is the supposition that attributes this office to the lungs in ordinary respiration.

But a subject more delicate and abstruse, a subject that of late years has been warmly and ably controverted, now claims our attention; I mean the alteration induced on the blood in the lungs, the cause on which

this alteration depends ; and what effect it produces on the animal œconomy.

To investigate the peculiar change which the air may undergo in the lungs, is but of little consequence to our present inquiry ; but it is absolutely necessary to trace and ascertain the effects produced by the air on the blood, before we can obtain any knowledge of the *proximate cause* of the disease.

We are inclined to the opinion of the ingenious Dr. Crawford, that a principal advantage derived from respiration, is *animal heat* ; that when the blood returns from all parts of the body to the lungs, it has lost a quantity of its latent heat *,
and

* According to Locke's definition, heat is a sensible quality ; and if this definition be admitted, then, properly

and imbibed some noxious quality; that in the lungs it meets with atmospheric air, containing a portion of dephlogisticated air, which is known to possess heat in a latent form; that it absorbs part of this heat, and at the same time imparts to the air which remains, its impurity.

That the blood having thus robbed the air contained in the lungs of a portion of its latent heat, and rendered that which remained sensibly warm, the air is expelled,

perly speaking, there can be no such thing as latent heat, as that must cease to be heat when once it becomes insensible; but as the term appears to convey the idea we wish, that of a principle or quality existing in a body which cannot be measured, but under certain circumstances can produce sensible heat, we have preferred it to others; and perhaps there is a greater impropriety in Locke's definition of heat, than in the term employed.

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and fresh air taken in to undergo a similar process.

Dr. Crawford, in the course of his experiments, had occasion to observe that animals immersed in a warm, did not so soon phlogistificate a given quantity of air as those immersed in a cold medium; nor is the reason inevident; for when the blood arrived at the lungs, it had not lost so much of its heat, consequently did not require to rob the air of so much of its purity; whereas in the other case, the animals being immersed in the cold medium, were obliged to generate more heat; but to effect this, they must consume a greater quantity of dephlogisticated air than those in the warm medium. It is also observed, by the same author, that the difference between the colour of the venous and arterial blood, was diminished by exposing animals

animals to heat, and increased by exposing them to cold.

The object of these experiments was to prove, that in proportion as the atmosphere is cold, more or less heat is absorbed from the air, to keep up an equilibrium of heat; and it is remarkable that the animal in the warm medium died first, notwithstanding the blood was florid, and the surrounding air more pure than that which the animal breathed when in the cold medium.

The one dying sooner than the other probably depended on debility; that the one in the warm medium, from being obliged to generate cold, or more properly *resist heat*, was rendered weaker than the other, from this being a more expensive process to the system than generating heat;

for there appears such a tonic power in cold, that an animal will allow of its natural heat being diminished several degrees without inconvenience, but cannot suffer its sensible heat to be increased more than six degrees at most of Fahrenheit, without death taking place. Hence it would seem that although the fluids of the one contained more of the stimulating quality than the other, yet from the solids not being so susceptible of action, life could not continue so long: and it appears evident, that if the animal in the cold medium, could have exchanged its blood with that in the warm one, the difference in the duration of life would have been still greater.

The objections adduced against Dr. Crawford's truly ingenious theory seem to possess but little weight. It is urged by some, that if breathing be the source
of

of animal heat, how can it happen that the inhabitants of the northern climates breathe no quicker than those of the southern; and yet nearly the same degree of animal heat is present in both? The reason appears obvious; there is always existing in the atmosphere four or five times the quantity of pure air more than we consume by one inspiration; so that those in the colder climates, although they breathe no quicker, nor take in a larger volume of air, yet they rob that air of more of its latent heat.

The cold atmosphere, bulk for bulk, must be specifically heavier than the warm, and, weight for weight, the bulk will be less; so that any given quantity of air, in proportion as it is diminished by warmth, must decrease in volume, and vice versa. Hence in a cold atmosphere, although the

volume of air taken in at each inspiration be the same, yet in that volume a greater number of particles of air are received into the lungs; and it also seems probable, that, weight for weight, this atmosphere should contain more dephlogisticated air than the warmer, since it is generally allowed that in proportion as its warmth is increased, it becomes a better menstruum for foreign matter of all kinds.

Dr. Crawford supposes that heat is given out in the capillaries only; but there is reason to believe that heat is also evolved during the whole of the circulation; for in amputating a limb where the tourniquet has been for some time applied, the first blood issuing from an artery assumes a venous colour; and Mr. Hunter found, from tying up the carotid artery of an animal, that the blood became black; from which it may be concluded

ed that the blood is capable of undergoing the same process in the larger arteries as in the capillaries. In ordinary circulation however the change must be less in degree, from the circulation being here quicker, and a greater quantity of blood being in contact with fewer solids.

It seems also more than probable that the blood still retains a quantity of heat in a latent form after it has passed through the capillaries and entered the veins, for on tying up the arm in common bleeding, the longer a ligature is applied, the darker the blood becomes; and at the conclusion of the operation its colour assumes nearly a florid hue, which corroborates the opinion that it may possess a considerable portion of latent heat, after it has entered the veins; and that this blood is capable of continuing the same process, so long as it contains any

heat to evolve. In fever, the venous blood is sometimes nearly florid, and Dr. Crawford found that when animals were immerfed in a warm medium, the blood paffed through the capillaries without undergoing the ufual change; both which circumftances tend to prove, that the blood contains more or lefs latent heat after it has entered the veins; indeed, were it otherwife, the lungs themfelves could not be fupplied with heat equal to other parts of the body; as the bronchial veffels run chiefly to the bronchiæ, and thefe veffels are found to be infufficient for the nourifhment of the lungs*. But the
 circulation

* It has been obferved by Mr. Cline, whofe accuracy as an anatomift it were fuperfluous to affert, that thofe inflammatory adhesions which obtain between the pleura coftalis and the lungs, and which have acquired vafcularity, are injectable by the pulmonary artery. On the ground of this fact, he conceives it probable, that the blood while circulating
 in

circulation in fishes puts this matter out of all doubt, for the heart of these animals is a single one, consisting of one auricle and one ventricle, both of which contract from the stimulus of black blood ; and as the blood in the coronary vessels is of the same quality, its heat and nourishment must be kept up by that blood only which has passed through the capillaries.

Hence it is obvious, that if this black blood did not possess a quantity of latent heat, the warmth of the heart could not be supported, and the animal consequently must die : notwithstanding therefore that the blood, when it passes through the capillaries, evolves the greatest part of its heat, yet there still remains a portion of it in the ultimate branches of the pulmonary artery, loses the venous character, and assumes the arterial one ; and that in this state it is fit for the nourishment of the lungs.

in a latent state even after it has entered the right side of the heart : and however inconsiderable this may be, yet if it is equal to the demand, the temperature of the whole animal must be the same. With a view to ascertain the comparative temperature of arterial and venous blood the following experiment was made.

EXPERIMENT.

A Dog was hanged, the sternum immediately removed, and the lungs inflated until the blood in the left auricle became *florid*.

The contractions of the whole heart, at this time were powerful, and Mr. Hunter's thermometer being raised to 98° was introduced through an opening in the pericardium, and placed on the right side ; the
mercury

mercury rose to 99° and then became stationary; it was removed to the left, and the temperature was the same; but on making an aperture into the left auricle, and thrusting the bulb down to the ventricle, the mercury fell to 97° ; and on placing it in the same manner within the right ventricle, it rose above 98° .

From frequent repetitions of this experiment it uniformly resulted that although the temperature of both sides of the heart externally was equal; yet the heat of the blood in the right side exceeded that of the left, from one to two degrees.

This observation may appear rather strange, and at first seems to contradict the opinion that respiration is the source of animal heat; but the fact can be readily explained; for the blood in its passage through
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the lungs, being contained in vessels that are in contact with air so much below its own temperature, the colder body must rob the warmer of so much sensible heat as is necessary to make them both equal; and the temperature of the left auricle and ventricle is kept up above that of its contents, and equal to that of the right side from the heat evolved by the blood in the coronary vessels; but if the sensible heat of the blood in its passage through the lungs be diminished, its latent heat is considerably increased.

If however it be a fact, that heat is imbibed from the air during the act of respiration, then should the blood in the left side of the heart retain its heat longer than that in the right, when the change has taken place, though at first its temperature be somewhat inferior.

To

To establish the fact the following experiment was made.

EXPERIMENT.

A Cat was strangled, the chest immediately opened, and the lungs inflated, when the blood in the left side of the heart became florid; an aperture was made in the pericardium, and the mercury of a thermometer being raised to 99° , the temperature both of the right and left sides of the heart was exactly 98 : on opening the left and introducing the thermometer, as in the last experiment it fell below 97° ; but on examining the right internally, it rose to near 99° .

So far does this experiment agree with our last; but the temperature of the blood was re-examined fifteen minutes after, and instead of the right possessing two degrees of

of heat more than the left, it was found, on the contrary, that the right had four degrees less than the left.

This experiment has been repeated by Mr. Astley Cooper, and in different ways, but the result has been invariably the same; that although the venous blood was superior in temperature at first, yet before coagulation was complete, the arterial became from three to six degrees warmer; this, or nothing, affords a clear and decisive proof, that heat is received by the blood from breathing; for if that blood which has passed through the lungs, is at first inferior in temperature, and soon after becomes superior; from what can this variation arise but the heat received from the air in a latent form, and evolved in a sensible one?

We

We scarcely know of any animal, on whose blood the air does not induce some change, either directly or indirectly; and the great object of this change we deem to be the support of animal heat; and from the maintenance of animal heat, that of *animal irritability* *.

There are animals which live in a temperature equal to that of their own; and it has been the opinion of some physiologists that in these instances their heat is supported by the surrounding medium. If this be ever the case, it probably is in ascarides, and other animals of the same species, where the temperature of their medium scarcely ever varies; but I should much

* The term irritability is very often employed in a loose and indefinite sense. We introduce it here to express nothing more than a *susceptibility of action*.

doubt if this is the œconomy of any animal which is placed in an element subject to alterations of temperature. We find that nature has very wisely ordained, that animals should possess a power of retaining their temperature for a time, whether they be exposed to excess of heat or cold ; which in my mind is a satisfactory proof that their heat cannot be communicated by external temperature ; indeed, if animals had not a source of heat within themselves, and yet placed in an element liable to variation, life could not be sustained.

It requires no great strength of argument to prove that animal warmth is not produced by the stomach. The simple observations that, in fevers, when our sensible heat is greater, we take in little or no food, and that sometimes for whole weeks ; and that
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the infant, as soon as respiration commences, and before the stomach receives any nourishment, is not less warm than the adult, are sufficiently convincing that the stomach is not to be regarded as the source of animal heat.

That mere distention is the ordinary stimulus that excites the action of the heart, is the opinion embraced by some physiologists. Nor is it indeed improbable that a certain degree of distention produced by blood of a due temperature, constitutes the principal power which stimulates the heart to contract; for this power of reaction, when stretched beyond a certain tone, seems a property inherent in all muscular fibres.

Nor do we deny that the heart, when void of blood, and separated from the body,

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retains

retains this action ; but this is not peculiar to the heart alone ; muscles, whose natural actions depend on the stimulus of the will, possess it likewise, though in an inferior degree.

That the different sides of the heart require different stimuli, and that there is something peculiar in florid blood, which alone is capable of exciting the left side to action, we cannot with Dr. Goodwyn admit.

An objection presents itself, that strongly militates against this opinion ; which is this, Why should the same fibres, nourished by the same vessels, supplied with nerves from the same source, and *performing the same function*, be excited to action by different causes ? This objection the Doctor is aware of, and attempts to remove it by observing that the animal machine offers

fers instances where muscles of similar structure are put into action by different stimuli; but this is not saying, that muscles *performing the same functions*, act from dissimilar causes; which it is necessary to prove before any analogy can be established to favour this hypothesis.

It is far therefore from being certain that the different sides of the heart derive their action from different stimuli: and let us but examine the foetal circulation, and it will appear that both sides of the heart contract from the stimulus of blood nearly of the same quality; that this blood is not florid in either; for even in the umbilical vein it has undergone but a very imperfect change *, if compared with that induced on
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* We take it for granted that the old opinion, of there

the blood which passes through the lungs of the adult ; moreover, that the greater part of the foetal blood arrives at the heart without passing through the placenta at each circulation ; that is, the blood in the heart, or any other part of the adult, will receive a compleat change in the lungs, before it again returns to the same place ; whereas, the whole of the blood in the foetal heart will not go to the placenta, to receive the alteration at each revolution ; but by far the major part will be sent to the trunk, the head and extremities, and be returned to the two cavæ, without having entered the umbilical arteries.

existing an actual communication between the vessels of the mother and child, is now exploded, as numerous experiments have been made to prove the contrary ; and few at present adhere to that doctrine.

The

The blood in the umbilical arteries, is similar to that in the trunk of the pulmonary artery of the adult circulation ; that is, it is impregnated with phlogiston, and possesses little latent heat ; whereas that of the mother in the cells of the placenta is loaded with heat, and has little phlogiston. In the minute branches of the arteries the change is performed ; that is, *only* so much latent heat is imparted to the foetal, and so much phlogiston received by the maternal blood, as is necessary to restore the equilibrium of heat and phlogiston ; the heat therefore which is received by the foetal blood will be small, in comparison with that imbibed by the blood of the adult in the act of respiration ; as *only* that quantity of heat can be imparted from the maternal to the foetal blood, as can make both their qualities with respect to heat and phlogiston *equal*.

When the foetal blood has undergone this change, it is returned by the umbilical vein ; and part of it will pass through the ductus venosus into the inferior cavæ, and mix with the blood brought from the lower extremities ; but a greater part will pass through the vena portarum to go to the liver, where, by passing through capillaries, it must assume the venous quality before it arrives at the right auricle ; it then unites with the blood sent from the lower extremities and trunk of the body in the inferior cavæ, and on entering the right auricle, it mixes with the stream of blood coming from the head and superior extremities, none of which has been to the placenta to receive the change.

The right auricle propels part of this blood (which must be dark) into the left, and
all

all the blood that passes through the capillaries in the lungs also enters the left, so that the blood which produces the contraction of the left side of the foetal heart must be more phlogisticated than that of the right, as part of the blood in the left auricle has passed through the lungs.

If the quantity of blood conveyed to the placenta by the umbilical arteries, be compared with that sent to the head, superior and inferior extremities, and trunk, it will be found that not one fifth part of the blood goes to the placenta at each revolution, nor can this blood receive but *half the heat* the maternal blood contains; moreover, as the greater part of it must first pass through capillaries before it arrives at the heart; and as that which does not pass through capillaries mixes with venous blood, it is obvious that both

sides of the foetal heart contract from the stimulus of black blood, and that the blood of the left side must be blacker than that of the right.

From the blood in the foetus receiving a degree of change so inconsiderable, when compared to that produced in the adult by the same process, a doubt might at first arise whether in both it was destined to accomplish the same end, the support of animal heat, and from thence that of animal irritability. That it is, will appear even from superficial enquiry; and that the foetal circulation, far from invalidating, countenances the opinion which derives animal warmth from the act of respiration.

The experiments of Dr. Crawford have already enabled us to observe that the quantity of heat absorbed in breathing is proportional

tional to the temperature of the surrounding medium. The observation holds equally good in the foetal circulation; for as the foetus is surrounded by the liquor amnii and uterus of the mother, the quantity of heat carried off must be extremely small; and that which is employed being also trifling, there is no occasion for more being absorbed than is necessary to supply the consumption of foetal heat; and if the whole of the foetal blood went to the placenta at each revolution, the inevitable consequence would be death; for the power of *resisting* heat must then be called forth to action; and this in the foetus is very inconsiderable.

On the adult, nature has wisely bestowed two powers for generating cold; that of evaporation from the surface of the body, and a power independent of this;

but the fœtus can only possess the latter, as no evaporation can take place from the surface of the body; and as the fœtus is deprived of this power, and as the temperature of its surrounding medium, the liquor amnii, is so much above that of our atmosphere, if an equal degree of heat were absorbed in the fœtal, as in the adult circulation, the animal must perish; since the act of resisting heat for a few minutes is very distressing, even where the additional power from perspiration is present, to counteract its destructive accumulation. Admirable therefore is the provision which nature has made, for maintaining a proper degree of heat, both in the fœtus and adult; the former is placed in a warm medium of uniform temperature, which permits but little heat to be consumed, and the circulation is so regulated as only to allow the absorption of a small and *limited* quantity of heat; so that

great

great powers for resisting heat are here unnecessary.

But in the adult, the varying and changeable temperature of the air makes it necessary that more or less heat be absorbed, to correspond with the variation to which it is exposed. We are therefore immersed in an atmosphere supplied with sufficient heat to answer our demand ; and by evaporation, &c. we are enabled to resist heat, so as to prevent its undue and destructive accumulation ; on the other hand, from the warmer medium which encompasses the foetus, we may gather the reason why a smaller portion of heat should be imbibed, and from this being *limited*, why it stands in no need of evaporation for the generation of cold.

Were

Were the change induced on the blood during circulation intended *solely as a stimulus to support the action of the left side of the heart*, then should the alteration produced in the foetus be equal in degree to that produced in the adult ; but that this is not the fact we have already, and we hope not unsuccessfully, endeavoured to prove ; and indeed if this was the intention of nature, it is highly improbable she would have contrived it that the connection between the mother and child should take place at the umbilicus, where a great part of the blood which has been at the placenta, must first have passed through capillaries before it enters the left auricle, and where its purity in the right side of the heart would be superior to that in the left. We might sooner suppose that the umbilical vein would have terminated in or near the left auricle, to supply it with blood thus duly altered,

than

than that the blood contained in the *left side of the heart*, should be *similar in quality* to that in the umbilical arteries which goes to *receive* the alteration ; for, in this circumstance, the vein contains blood that has undergone the change, but the arteries carry blood that is going to receive it.

If therefore the left side of the foetal heart and the whole of the arterial system possess no stimulus but that of black blood ; if the pulmonary artery in the adult be excited only by this blood ; if, in a word, the heart of fishes act on no other blood, is it not obvious (at least as far as induction and analogies can prove) that in the adult also venous blood can excite the action of the *left side of the heart and arterial system*, and consequently that the two sides of the heart do not require to be stimulated by dissimilar causes ?

From

From considering that one side of the heart in the adult circulation contains black blood, and the other florid; and that in suspended respiration the left side first ceases to act, when both contain black blood, Dr. Goodwyn, we presume was induced to conclude that venous blood which supports the action of the right side, was an unfit stimulus to keep up the action of the left.

The observations however we have ventured in support of the idea, that the whole of the heart owes its action to one and the same cause, oblige us to withhold our assent from that of Dr. Goodwyn; but before we attempt an explanation of the cause which protracts the action of the right side of the heart beyond that of the left, we deem it necessary to institute a previous investigation of the effects

effects produced on the heart by blood that has been duly changed, and next enquire into the consequences that must ensue when no alteration has been given.

We have already observed that when the blood arrives at the right side of the heart, it is impregnated with phlogiston; and deprived of the greater part of its latent heat; in health it is to part with its phlogiston or inflammable principle in the lungs, and there also receive a fresh supply of heat; it is then propelled into the left side of the heart, and thence through the whole of the circulating system, to evolve and distribute heat, and receive phlogiston.

In consequence of this process, the left side of the heart and coronary vessels are supplied with blood, which distributes
heat

heat and nourishment to the whole of the heart; and in ordinary circulation it is probable that the heart derives its heat principally from the blood in the coronary vessels; but if the motion of the circulating fluid be checked, or totally suspended, then would the blood in the cavities of the heart, continue to undergo the same process; at least so long as it possessed any heat in a latent form; for it has already been proved, that if blood be delayed in the larger arteries, it is known to assume the same change and appearances as when it has passed through capillaries. The blood within the coronary vessels not only supplies the left side of the heart with heat, but also the right; and if the heart derived heat solely from the blood within its cavities, their temperature in health would be equal; for although the blood in the left side of the heart, might contain 60 degrees of latent heat,

when the right possessed but six ; yet if the *sensible heat evolved* be only equal to two, their temperatures must be the same.

The result of multiplied experiments authorizes the assertion, that immediately after the action of the left side of the heart is increased by florid blood, the right also becomes equally affected ; nor is this effect an unnatural or unexpected consequence ; for as the coronary vessels soon receive this blood, and as these vessels are going to both sides of the heart, the heat and irritability of both must be equally supported.

The great and natural stimulating power that keeps up the *action* of the heart, we have already supposed to be distention ; but this must cease to act as a stimulus whenever the blood becomes incapable of supporting the irritability of the

heart, by imparting to it its wonted and necessary degree of heat. To effect this the blood must part with its inflammable principle in the lungs, and in return imbibe from the air a fresh supply of latent heat.

Dr. Cullen imagined, that the heart's continuing to act after breathing had ceased arose from habit; but were that the case, why should the action of the right side of the heart outlive that of the left; and why should not this influence of habit extend equally to arteries? Inflating the lungs soon after respiration has ceased, generally increases the action of the heart, even from the first expansion; and it seems to arise from the mechanical stimulus, which the lungs apply to the heart by distention; as in proportion to the expansion their surface

face will press upon the two sides of the heart, and thus become an irritator.

If inflation however be deferred for a considerable time, the same effect will not follow; as this degree of irritability is seldom permanent; and distention of the lungs soon ceases to be an adequate stimulus; but by making repeated inspirations to one compleat expiration, the irritability of the heart is soon revived, and an action produced by each inflation. This depends on the process of circulation being duly carried on, and the necessary stimulus imparted from the air to the blood, which increased the living powers of the heart, and rendered it susceptible of irritation from so slight an external cause, as the mechanical action of the lungs.

To this opinion, of the action of the heart

proceeding from mechanical stimuli, Dr. Goodwyn opposes this inference: If it were so, says the Doctor, any aerial fluid would be then equally effectual. But this is rather unfair reasoning; for it is agreed on all sides, that a change in the blood is necessary to the life, and uninterrupted action of the heart: and although the introduction of noxious air may prove as great a stimulus to the surface of the heart as any other, yet if the blood ceases to receive the change when the heart acts, the irritability of this organ must gradually diminish, as the blood continues to evolve its heat, without receiving the usual supply; and what before was sufficient to irritate the surface of the heart, no longer possesses that power. It is true, the heart will act on introducing any air into the lungs for one or two inspirations, if the experiment be made immediately after breathing is suspended; and
 this

this is a circumstance that corroborates the opinion of this action arising from mechanical stimuli. That it is not to be ascribed to any change immediately induced on the blood *already in the left auricle* is obvious; for the right side of the heart must be excited to action before the left can receive blood that has undergone the change; as no alteration can be given to the blood contained in the auricle.

Dr. Goodwyn is of a contrary opinion; for he observes, “ that the contractions of
 “ the left auricle and ventricle are imme-
 “ diately effected by the quality of the
 “ blood passing into them.”

We shall endeavour in the next section, to demonstrate by experiment, that no alteration can be produced on the blood in the trunks of the pulmonary veins and left

auricle, if the communication be cut off from the right side of the heart: and it must be manifest, that if the blood *already* in the left auricle could receive an immediate change, from the air in the lungs, the right, which is equally in contact with them, should also receive it.

This opinion we are therefore disposed to regard rather as one of the many offsprings of the author's fruitful ingenuity, advanced to support a favourite hypothesis, than to evince the genuine dictates of his judgment and conviction.

That the right side of the heart continues to act, after the left has ceased, is a phenomenon that has been noticed by almost every physiologist; but few, if any, have attempted to unfold its cause. Indeed Dr.

Goodwyn

Goodwyn appears to be the only one who has seriously endeavoured to explain its rationale, and attempt its illustration; and though there is no authority to which we would more gladly refer, yet we cannot here adopt his opinion, *that the left auricle and ventricle, first cease to act, from the ineptitude of venous blood to excite their contraction; and that this is the immediate cause that suspends circulation in drowning, &c.*

But in order to explore the true cause of this phenomenon, let us once more recollect that the blood, when it arrives at the right side of the heart, has lost the greater part of its latent heat; that in health it receives this supply in the lungs; but that *in suspended respiration*, the blood passes through the minute ramifications of the pulmonary artery into the pulmonary veins, without receiving this necessary quality,

and instead of discharging phlogiston, and absorbing heat, that it will continue to *evolve its heat*, and receive a new increase of phlogiston.

An essential difference thus takes place between the blood of the two sides of the heart; the right contains a fluid that still possesses latent heat; but the left has little or none; and as the blood in the one is furnished with more heat to evolve than the other, its irritability of course must be greater; and the stimulus of distention is also predominant at the right side, which will consequently support the action of the one, when no effect is produced on the other.

That in ordinary circulation, both sides of the heart might derive their heat principally from the blood in the coronary vessels,

sels, has already been remarked; but as this blood in suspended breathing contains little or no latent heat, from having evolved it in the lungs, the heart must in that case imbibe its heat from the blood contained within the cavities; and that this process can be carried on in them we have already shewn, so long at least as their blood possesses latent heat to give out, and while the circulation is retarded or totally stopt. From which we conclude, that *if the right side of the heart in this disease possessed the blood of the left, and the left the blood of the right, the difference of irritability would be reversed.*

If however, we have succeeded in establishing as facts, that when the blood arrives at the right side of the heart it still contains a portion of heat in a latent state; that this blood in suspended breathing con-

tinues

tinues to evolve heat in a sensible form ; that the inferior degree of irritability in the left side depends on the essential difference in the quality of its blood from that of the right ; that moreover this difference in quality proceeds from that of the left having been robbed of a quantity of its heat in its passage through the capillaries of the lungs ; if, I say, these facts can be established, then the temperature both of the right side of the heart, and its contents, should be greater than that of the left in this disease.

The result of the two last experiments we have mentioned, allowed us to conclude, that both sides of the heart externally are of the same temperature when the blood has received its due change from the air, though the temperature of this blood thus altered is inferior to that of venous ; and

though the blood of the left side be at first lower in degree of warmth, yet its heat soon after becomes predominant.

The next experiment was made, to ascertain the temperature of the two sides of the heart, and their contents; where no change had been given to the blood.

EXPERIMENT.

A Rabbit was strangled, and the chest being opened, a small aperture was made in the pericardium, and a thermometer of Fahrenheit's scale was applied to the right side of the heart. The mercury rose to 96° , where it remained stationary: it was then removed to the left, where it fell to 94° . On placing it within the right auricle, the mercury again rose to 96° , and when applied in the same manner within the left, it fell somewhat below 94° .

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This experiment was repeatedly made on animals that had been drowned and hanged, both without and within the heart, and there occurred a few instances where there was scarcely any difference in the temperature of the two sides at *first*; but in all, the temperature both of the heart and its contents was predominant in the right, before the left side had entirely ceased to act. It appears therefore very evident, that the blood which passes through the lungs into the left side of the heart, without receiving from the air the necessary change, instead of being more tenacious of its heat than the right, on the contrary, loses it much sooner,

Thus we see the result of experiment sanction and justify the predictions of theory, that when blood passes from the right side of the heart to the left, without having been in contact with dephlogisticated air, to

renovate its heat, it must evolve in its passage through the capillaries of the lungs what little it contained in a latent state; and the left side being no longer supplied with its due nourishment and warmth, either from the blood in the coronary vessels, or from that contained in its own cavities, must have its temperature reduced, its irritability decreased, and its action gradually suspended, by the diminution of its stimulus of distention.

But far different is the condition of the right side; for although the blood in the coronary vessels is incapable of supplying it with heat, yet the blood within its own cavities contains a quantity in a latent form, which it continues to evolve; this is its irritability supported, and thus, by continued distention, is its action kept alive.

Dr.

Dr. Goodwyn having observed that in this disease all the cavities of the heart contain black blood, was induced to conclude that its other qualities were exactly similar ; but had it been considered that in these circumstances the blood, in its passage through the lungs, suffers a deprivation of its remaining heat, without the accession of a new supply, the cause whence originates the difference of irritability in the two sides of the heart would have no longer remained obscure, nor would the Doctor, to explain the phœnomenon, have been reduced to the supposition that the same muscular fibres were excited to action by different causes, and that the blood of the same quality that stimulated the right side to contract, was incapable of producing the same effect on the left, but this difference would have been discovered to arise from the left having lost a greater portion of its
heat,

heat, and its stimulus of distention being diminished beyond that of the right.

The advantages derived from this property of the right side of the heart, which supports its action after that of the left is suspended, seem to have escaped the notice and eluded the research of physiologists, yet no provision of nature more deservedly claims our admiration and enquiry; for in no department of the animal œconomy has she managed a wiser precaution for the preservation of life, than by thus, after the last expiration of the animal, prolonging to the right side of the heart a stimulus and power of action superior to that of the left.

Let us but suppose the reverse, that the left had the irritability of the right, and the right the irritability of the left; as it is found necessary to the effecting a recovery, that
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the right should first contract, and supply the left with blood, in order to excite it to action; and as the right, in this supposition, would soon be incapable of performing this function, we should only be enabled to recover those in whom the actions of life had been suspended only a very short time after respiration had ceased; whereas, from the right continuing to contract after the left is motionless, it is thus capable of propelling blood through the lungs into the left auricle, which being once restored by the arrival of duly prepared blood (even though it should have ceased to act from the stimulus of its own) is enabled, by the fresh supply of this stimulating quality, to revive, and the action of the whole heart is increased; but if the irritability of the left side were at first predominant, it would get rid of its own blood, and the feeble action
of

of the *right side* be incapable of supplying it with more.

Thus, at the very origin of the circulation, where the fresh stimulus is last applied, Nature, ever wise in her operations, has prudently placed a superior degree of irritability, while in the left, where the irritability is inferior, the increase of stimulus is first received: nor will this be deemed the result of chance, if we but recall an observation we have already mentioned, that in the foetal circulation, the stimulating quality of the blood is greater in the right side of the heart than that in the left, and that in the adult it is reversed.

But although the blood, in these two states of the animal, possess this difference of stimulus in the different sides of the heart, yet, if an injury threaten the life

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either

either of the foetus or the adult, the right side of the heart will be found to contain blood of a stimulating quality superior to that of the left, and consequently greater irritability; for let us suppose that, at the time of birth, the umbilical chord is prevented from carrying on the circulation to and from the placenta, the blood that runs to the left heart, from its being obliged previously to pass through the capillaries of the lungs, is deprived of a portion of its stimulus: and thus, in the morbid state, is the same provision made for the foetus as for the adult, though their natural circulation be widely different.

There is reason to suspect that in man there does not exist so much irritability as in animals of more simple construction; for it seems that in the more perfect or complicated, as man, whose sentient powers
are

are greatest, the vital are least; and we believe this will hold good in gradation with all the inferior animals, that, in proportion as the sentient powers abound, the vital diminish, and *vice versa*.

This is strikingly exemplified in the polypus, which has been observed to regenerate into as many different polypi as divided into pieces; and these animals have neither brain nor spinal marrow.

It appears therefore not improbable to be the intention of the great Creator, that those animals, whose powers for perceiving danger are less acute, should be capable of receiving greater injuries without the destruction of life, than those that are armed with this faculty in a superior degree.

All impressions made upon superior animals are immediately conveyed to the brain, and this being the great sensorium, the whole animal receives the alarm, and an immediate effort is made to remove the cause of the injury. But inferior animals, that are unprovided with nerves and brain, that are consequently destitute of sensation, and whose powers of instinct are but feeble, Nature, we find, to compensate for this want of sensation, has enabled them to withstand injuries to a greater degree than those that are furnished both with brain and nerves. Animals also that are endowed with superior sagacity, possess but a small degree of irritability; and it seems to be justly remarked, that the irritability of animals decreases as they advance in age. This was certainly intended for the same excellent purpose, that of supplying the defect of sagacity while young; but when the
sensitive

sentient powers became adequate to the necessity, this exquisite irritability, which was so wisely bestowed on them while young, is no longer required.

In different species of animals, we have sometimes observed that after respiration is suspended, from drowning, &c. &c. scarce any action remained in the right side of the heart; but in several experiments, particularly in one, the cause of this phenomenon we discovered to arise from an over distention of the right auricle and ventricle; for when a small puncture was made in the superior cava, and a portion of the blood contained in the right heart expelled, its contraction became extremely powerful.

Here then was indirect debility brought on from over distention; and there is reason to suspect that this may frequently

happen from the method of recovery usually adopted.

There remains a susceptibility of action in almost every part of the body, for some time after the suspension of the sentient powers; but as animals, whatever may be the cause of their destruction, begin to die first at the extreme and exterior parts; so, in suspended respiration, from drowning, &c. we find the irritability of the heart outlives that of any other part of the body. One exception indeed has occurred, where the heart and extremities ceased to act nearly at the same time.

From considering the length of time the heart may be made to contract after breathing has ceased, there can scarce be any doubt, if electricity be unable to excite it to action, but that life is irrecoverably lost;
for,

for, with Mr. Hunter, we imagine life and the power of action to be intimately connected. If therefore we are incapable of calling forth this power into action, by the stimulus of electricity applied to the heart, there does not remain the most distant probability that the effect can be produced by the application of any other stimulus.

In our attempts, however, to restore the life of the apparently dead, we are furnished with no criterion for determining when this power of action is thoroughly extinct; for the exterior parts may have lost this degree of irritability, and the heart still retain it. In some instances, the heart of young animals has been made to act by electricity from ten to fourteen hours; and a gentleman, on whose veracity I can rely, has informed me he has seen it contract even twenty hours after respiration was stopped,

and which is many hours longer than we have been able to excite action in any external part.

It has been observed by Mr. Kite, “ that
 “ the electrical shock is to be admitted as
 “ the test or discriminating characteristic of
 “ any remains of animal life, and so long as
 “ that produces action, may the person be
 “ said to be in a recoverable state ; but when
 “ that effect has ceased, there can no doubt
 “ remain of the party being absolutely and
 “ positively dead.”

With the deference due to Mr. Kite's authority, we cannot but withhold our assent from this opinion, since it appears to be fraught with such imminent danger ; for if we conclude that life is departed when no external action can be excited by electricity, we shall frequently neglect the application
 of

of remedies, when the power of action and life are still present in the heart.

There have been cases, and I myself have seen one, where no recovery was effected, even when contractions were produced externally; but the want of success in this instance is not to be attributed to the weaker powers of the heart, but to the insufficiency of the plan of treatment; for it is probable that a recovery is not only to be effected in most instances where external contractions are visible, but in many where this degree of irritability is destroyed, if *proper remedies* are had recourse to. It appears somewhat extraordinary that Mr. Kite should have recommended so dangerous a prognostic (built merely on hypothesis) as that life was absent when external irritability was not manifested by electricity; for it is observed in the same section, “ that

“irritability and vital heat appear to be co-
 “equal:” which opinion is incompatible
 with the other ; for if heat and irritability
 co-operate, then, as external heat diminishes
 quicker than internal, it must follow, ac-
 cording to the author’s own reasoning, that
 external irritability must sooner cease than
 internal ; and, as internal excitement may
 not produce external action, the conclusion
 that life is extinct, when irritability is no
 longer visible from electricity, must be fal-
 lacious.

We were at first inclined to the opinion
 that irritability and animal heat might co-
 exist ; that, from the latter being present or
 absent to a certain but unknown degree,
 we might be able to draw a prognostic of
 the presence or extinction of the other ;
 but subsequent observations discovered this
 theory of Mr. Kite’s to be likewise erro-
 neous ;

neous; for, as there are few whose solids are not very differently excited to action by the same cause, so the quantity of heat evolved from the blood, that would support irritability in the one, would produce no effect on the other.

This opinion is confirmed by the following experiments:

EXPERIMENT.

A small Puppy was drowned, and on examining the temperature of the two sides of the heart in the pericardium, the right was 98° , the left 96° . The right side of the heart continued to act for more than two hours; and during the last ten minutes, its temperature was 60° , that of the left 57° ; the warmth of the air in the room 55° .

EXPE-

E X P E R I M E N T.

A full-grown Dog was hanged, the pericardium opened, and the temperature of the right side of the heart was 100° , the left 99° . The right continued to act not quite ten minutes, when its warmth was 90° , that of the left 87° and one-half: the temperature of the room was also 55° .

Here then action continued in the one more than twelve times longer than in the other, though with a degree of heat much inferior. We here also had a farther opportunity of being convinced that heat and irritability do not always co-exist, from the bodies of two persons that had been executed. A powerful electrical shock was given, without producing the smallest external action, although three hours after execution

execution the temperature of one was 80° externally, and the other 82° at the expiration of two hours and one-half.

This superior degree of heat, above that of the atmosphere, does not proceed, as Mr. Kite imagines, from the presence of some "internal animating principle;" for the longer or shorter continuance of sensible heat of any animal must always be proportionate to the quantity of latent heat the blood contains, and the temperature of the surrounding medium; whereas the difference of irritability much more depends on the readiness with which the solids act when this stimulus is applied, than on the quantity of heat that is evolved.

Why the fibres of one animal of the same species should more readily act than those of another, from the same cause, and how

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we are to discover the different degrees of this susceptibility of action in each particular animal, is a question not less important, than intricate to unravel. As we have endeavoured to prove that *heat and irritability* do not necessarily co-exist, this may at first seem to militate against the opinion of heat being essential to the support of irritability; but in reality it does not, for altho' the fibres of one animal shall act with its temperature at 60° , the fibres of another shall cease with its temperature at 90° : yet this only proves that the solids of the one act from a slighter cause than those of the other, and not that the stimulus of heat is wanting. A certain quantity of inebriating liquor shall produce violent effects on one person, when a much greater quantity shall have no effect upon another.

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The same reasoning holds good in these experiments; for although the heat of one animal may exceed that of another, and where the inferior degree of heat is present, the greater effect be produced; yet the *stimulus* in *quality* is the *same*, and the difference of action depends on the moving powers of the one being more readily excited to act than those of the other. Nevertheless, though no decisive prognostic can be drawn of the presence of *irritability*, from the presence of *any known degree of heat*, yet the nearer the degree of heat of any particular animal approaches to its standard, the greater must be its irritability; but it will ever be better to fix no criterion of life, and make use of every possible means of recovery, in every instance, than to form a hazardous prognostic, that may prove fatal to hundreds.

Having

Having now examined the common effects that arise from the suspension of respiration in Drowning, Hanging, and Suffocation, and particularized the advantages derived from the Heart and Lungs, we shall, in the next Section, endeavour to ascertain the *immediate cause* of the disease.

SECTION

SECTION V.

*An attempt to ascertain the proximate cause
of the disease produced by Submersion,
Strangulation, and Suffocation.*

TO investigate and establish the proximate cause of the disease arising in suspended respiration from drowning, hanging, &c. is a task that has engrossed the attention, and exercised the pens of several eminent physiologists; but there has been little coincidence of opinion, each seeming to have started, and embraced an hypothesis of his own.

It has been the idea of some, that the air contained in the lungs becomes highly phlogisticated, and that from its deleterious

influence, originates the disease. Others attribute it to a congestion of blood formed in the heart and lungs, while another class suppose death to be produced by apoplexy.

To none of these opinions does Dr. Goodwyn incline; to him it appears that from the privation of the usual stimulus supplied by the air, the blood *contained in the left auricle and ventricle* is rendered incapable of exciting their contraction; and hence he derives the *immediate cause of the suspended circulation.*

From an authority we so highly respect, it is with diffidence we dissent; but argument, observation, and experiment all tend to prove this opinion erroneous.

If the presence of black blood in the left heart was the *proximate cause* of circulation ceasing, then we should certainly find it *fully distended* from the action of the right, but we have endeavoured to prove that this is by no means the fact; and indeed, if the left auricle and ventricle were *fully distended*, and it were necessary for the restoration of life that the blood *already contained* in the left auricle should undergo a change, before it was enabled to empty itself, then every animal would be irrecoverable as soon as this black blood had once distended the auricle; for we can appeal to the test of experiment to prove, that no alteration can be produced on the quality of the blood contained in the trunks of the pulmonary veins and left auricle.

To ascertain if any such change could be effected, the following experiment was made.

EXPERIMENT.

A Dog was suspended by the neck until he ceased to move; on opening the chest, both sides of the heart were observed to contract; but the left ceased in eight minutes, while the right continued to act strongly. The pulmonary artery being carefully separated from the aorta, and secured by ligature, we proceeded to inflation, which was continued fifteen minutes, without enabling us to empty the trunks of the pulmonary veins and left auricle, or produce any apparent alteration on the quality of the blood.

This experiment was repeated on a cat, during the action of the left side of the heart, which became less distended, but

no alteration in the colour of its blood could be produced. The change therefore which the blood undergoes in its passage through the lungs, is effected before it enters the *trunks of the pulmonary veins and left auricle*, and as the air cannot come in contact with *this blood* to produce any chymical alteration, it must be propelled through the system unaltered, whenever an animal recovers; for supposing the blood within the lungs to have undergone its usual change from inflation, as the trunks of the pulmonary veins and left auricle are here understood to be *full*; and as *this blood* can receive no chemical change, the left auricle must act on its *black blood*, and receive the contents from the trunks of the pulmonary veins (which we have said has not undergone the change) before the left heart can contain blood duly prepared by the air. We were, at first induced

to believe that the collapse of the lungs after inflation, might have the power to empty the left auricle mechanically, by propelling the contents of the pulmonary veins onward, and by the pressure thus applied from without, to the blood within the auricle, to stimulate its muscular fibres to react, and so expel a portion of its contents. But there seems an objection to this mode of reasoning; for if the lungs by their collapse had any such power, they must have exerted it at the last expiration, and then those vessels which are affected by this action would be so far emptied as to require a fresh supply of blood from the right side of the heart, before the lungs could by their collapse, have any mechanical effect on their contents; and the next experiment proves, that after respiration is suspended, very little blood is left within the lungs.

E X P E R I M E N T.

A Cat was drowned, and when all motion had ceased, we opened the chest and secured the pulmonary artery. A small ligature was then passed round the trunks of the pulmonary veins, as they enter the left auricle, and both auricle and ventricle were then opened; the blood being all taken up by a sponge, the trunks of the pulmonary veins were divided, and on pressing the lungs very little blood escaped, except that contained in the trunks. The repetition of this experiment afforded the same result. We must therefore look elsewhere for reasons to account for the action of the left auricle in recovery, as experiment proves that by inflation we can produce no chymical change within the trunks and auricle, nor by the mechanical

action of the lungs empty the trunks, if the communication be cut off from the right side of the heart; as this, I say, cannot be effected, it would seem that when the right side of the heart acts during inflation, there is a quantity of blood sent within the lungs; and this contraction, assisted by an artificial collapse* of the lungs, propels a portion of the contents of the pulmonary veins onward, and thus produces such a vis-a-tergo on the blood within the auricle, as to excite it to contract. It has been before observed that the right side of the heart *in health* performs this function independent of any mechanical action of the lungs, and it is

* By artificial collapse we mean emptying the lungs of the greater part of their air, which will compress and evacuate the pulmonary vessels; but collapse from an ordinary expiration has no such effect.

likewise

likewise capable of doing it for some minutes after respiration is suspended; but where the contraction of this organ is insufficient to propel blood through the lungs, producing an *artificial collapse* will have the same effect. This however can only happen where a fresh supply of blood has been produced by the contraction of the right side of the heart; for experiment demonstrated that the quantity of blood remaining in the lungs was too small to enable their mechanical action to have any effect on their contents.

It has been mentioned by Haller and other able Physiologists, that where the lungs are collapsed, an obstruction to the passage of the blood through them will be the consequence; but they have not proved *that the lungs are in such a state of collapse in Drowning, Hanging and Suffocation.*

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We have endeavoured to shew that Dr. Goodwyn's experiments to determine this point were objectionable, and our enquiries presented results very opposite to his, that instead of the lungs being distended that they were collapsed, and contained but very little air. In order, however, to prove that *this degree of collapse* was sufficient to produce a mechanical obstruction in the lungs in Hanging, Drowning, &c. we compared the quantities of blood in the different sides of the heart, where the collapse was removed to that where the collapse existed.

The experiments were conducted in the following manner.

E X P E R I M E N T.

A Dog was suspended by the neck, and in less than a minute the fæces and urine were discharged; his struggles continued for little more than three minutes, when he ceased to move; the trachea was then laid bare, and divided, and the lungs fully distended with warm water (about blood heat) through the medium of a funnel; the trachea being secured so as to permit no water to escape, the chest was opened, and, contrary to all experiments made before, there was found a much less quantity of blood in the right sinus venosus, auricle, ventricle, and pulmonary artery, than in the left, which was loaded with blood, part coagulated, and the whole quite black. The experiment was repeated, and yielded nearly the same result, with this variation, that
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the right side of the heart had a little more blood than before, but the left was again fully distended.

It then appeared evident, that if by an artificial distention of the lungs only, without the admission of air to produce any chymical change on the blood, the right side of the heart was capable of distending the left, and of expelling a part of its own contents, that in suspended respiration there exists such a *mechanical obstruction in the * interior pulmonary vessels from collapse of the lungs*, as prevents the right side of the heart from getting rid of its contents.

* By interior pulmonary vessels is meant those that ramify within the lungs, and are influenced by the air; and by the trunks we mean those vessels that arise from the auricle, and are attached to the surface of the lungs.

The experiment was therefore repeated with some alteration.

EXPERIMENT.

A Cat was drowned, and after the cessation of all struggles, an aperture was made in the trachea, and the lungs distended with air which was retained. On opening the heart we found the contents of the left side were to that of the right as five to four.

EXPERIMENT.

A Dog was drowned; when he ceased to move, cold water was introduced into the lungs. On examining the heart we found the proportions of the blood in the left were to that in the right as six to five.

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These experiments were repeated, and sometimes the proportions were as six are to four; but in one, where the irritability was trifling, the blood was a little predominant in the right. On the contrary, in another, where great irritability was present, the proportions were as two to one.

It may be urged by some as an objection to the above experiments, that water may act as a stimulus to the pulmonary vessels, so as to excite them to act; but it has been observed, that there remains very little blood within the lungs after the last expiration; and if water acted on them as a stimulus, it could not however produce any effect on the trunk of the pulmonary artery, right auricle and ventricle, which we find in part emptied.

We have observed that animals under the common method of suspension, retain the power of expelling air from the lungs; but it was found not impossible so completely to compress the trachea, as to prevent any air from escaping: with this view the following experiment was tried.

EXPERIMENT.

The trachea of a Kitten was laid bare, and a ligature passed round it, that the whole of the air might be confined within the lungs. The animal ceased to move in four minutes and a half; and on opening the heart we found the proportions of blood in the left side, were to that of the right as nine to seven.

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The same experiment was repeated on a Rabbit, and the proportions were as eight to seven.

In these experiments therefore, where the muscles of expiration had not sufficient power to overcome the compressure of the cord, and expel air from the lungs, the blood accumulates to a greater quantity in the left side of the heart, because no collapse takes place, and consequently no obstruction to the passage of the blood through the lungs.

The next experiment was made on an animal that had been suffocated, by distending its lungs with nitrous air.

In order to perform this experiment a common bladder was procured, and a pipe
affixed

affixed to its neck, small enough to be inserted into the trachia of a rabbit. This pipe was introduced through a cork adapted to the size of a wide mouthed bottle, which contained copper with diluted spirits of nitre. The nitrous air arising from this solution, was collected in the bladder, and when a sufficient quantity was obtained, we attempted the following experiment.

EXPERIMENT.

A small Rabbit was destroyed in nitrous air, and as soon as it discontinued to expire air from its lungs, we removed it from the medium in which it was plunged. A small aperture was then made in the trachea, the bladder taken from the bottle containing the nitrous air, and the pipe introduced into the trachea in order to distend the
 K lungs;

lungs; which being effected, the air was prevented from escaping, by tying the trachea. On examining the heart, the proportion of blood in the left was to that in the right as seven to six.

The experiment was again repeated by destroying an animal in fixed air, and distending the lungs with nitrous air; and the proportions in the left were to those in the right as thirteen to twelve.

But these last experiments did not always favour our expectations, a larger portion of blood being found in the right side of the heart, from the slight degree of irritability that remains after respiration had been stopt by noxious air.

Our next attempt was to ascertain if more blood were found in the lungs of an

animal whose respiration was suspended, and then the collapse removed by a fluid ; than where this suspension took place without the removal of the collapse.

We could devise no method to enable us to establish this point with accuracy, but ventured however on the following experiment.

EXPERIMENT.

A Rabbit was drowned, and the lungs immediately distended with air ; after tying up the trachea the chest was opened, the pulmonary artery and aorta secured, as also the trunks of the pulmonary veins. The left side of the heart was then opened, the blood removed, and pulmonary veins divided, the ligature was taken from the

trachea, and the air expressed from the lungs. A large quantity of blood flowed from the pulmonary veins, and in a few minutes, by alternate expansion and collapse, the lungs were emptied of their contents. No accurate comparison however could be drawn between the quantity of blood present in this experiment, and that which they contained in the collapsed state; but it was evidently less in the latter, which tends to confirm the opinion of the collapse of the lungs preventing a free circulation through them; for if more blood is found when they are distended than when collapsed, this it would seem must arise from the presence of an obstruction in the one instance, and its removal in the other.

These, together with the former experiments, conspire to prove that the collapse

lapse forms an impediment to the circulation; for if in an animal that is drowned, hanged or suffocated, the blood be found to predominate in the right side of the heart, while in another destroyed by the same means the contrary takes place merely from the introduction of a fluid into the lungs which can have no chymical effect on the blood; from what can this variation and difference of quantity originate, if not from the mechanical obstruction in the first case, and its removal in the second?

It should however be observed that although repeated experiments prove mechanical obstruction to exist in suspended breathing; yet it must be confessed that the right side of the heart is capable of overcoming in some measure, this obstruction, at least for some little time after

respiration has ceased, and the left of getting rid of *its black blood*; an opinion that is strongly countenanced by the following experiments.

EXPERIMENT,

A Kitten was drowned, the chest immediately opened, and the aorta secured, without including the pulmonary artery; when the heart had ceased to contract, the quantity of blood in both its sides was examined, and it was found that the left contained nearly as much as the right.

This experiment was frequently repeated, and sometimes the quantity of the blood was greater in the left side of the heart than in the right; but in all the experiments the disproportion was lessened by tying up the aorta.

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In the animals therefore subjected to these experiments, the blood must have passed through the lungs in the collapsed state; and if no ligature had been applied, this *black blood* would have been propelled into the aorta, since the period of examination of the heart after respiration has ceased, makes no alteration in the proportions.

These experiments afford a result in direct contradiction to the opinion supported by Dr. Goodwyn, that the left side of the heart is incapable of acting from the stimulus of black blood: for they prove that whenever the right side of the heart is capable of sending blood through the lungs in the collapsed state, the left is also enabled to contract from the stimulus of *black blood*.

The same experiments may also at first seem to invalidate the opinion that supposes the presence of collapse. But every appearance of objection will vanish, if we but reflect that whenever the right side of the heart has the power of propelling blood through the lungs in the collapsed state, the quantity is so small that it can produce no effect; for we find the lungs contain but very little air, and consequently under this disease are nearly in the same state as the foetal lungs; but as only a small quantity of blood in the healthy state of the foetus, can be propelled through that viscus, it appears that the blood passing through it during the collapse in the adult, would not be sufficient for the demand, as very little more blood can be sent through the lungs after the last expiration, than in the foetal circulation; with this material difference however, that in the latter a change
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has been given to the blood (in the [placenta]) while in the other it can receive none.

Now as the left side of the heart soon ceases to possess a stimulus that can enable it to discharge its contents; so also the right can no longer propel blood through the lungs in their *contracted state*: for if the right side of the heart continued to send blood through the lungs when the left was incapable of getting rid of its own, we should then find the blood predominate in quantity in the left.

Were Dr. Goodwyn's assertion true, that after the last expiration in drowning, &c. &c. the lungs contain a greater quantity of air than in *hydrops pectoris*, then an objection would arise to the supposition of their collapse forming an impediment
to

to the free passage of the blood; but of the experiments which he imagined authorised this conclusion, we have already attempted to detect the insufficiency.

It must however be confessed, that Dr. Goodwyn's experiments seem so ingeniously devised, and the conclusions drawn from them so specious, that at first they suspended inquiry; and it was only by subsequent examination that we were able to detect the fallacy of those particular ones, which he adduces to ascertain the quantity of air remaining in the lungs after the last expiration. But by pursuing a mode of enquiry different to his, we obtained a result extremely unfavourable, and indeed contradictory to his conclusion, viz. that instead of the lungs containing a large quantity of air after drowning, hanging, or suffocation, the residuum is very inconsiderable,

siderable, and they are found in a state of collapse.

To this conclusion succeeded an obvious reflection, that if the circulation could be properly carried on during a *collapse* of the lungs, why should the foetal circulation differ from that of the adult? and indeed it appears evidently to be the intention of Nature, that only a small portion of blood should ever pass through the lungs in their state of *collapse*, for she, ever uniform as wise in her operations, would never have provided a different circulation for the foetus, if the vessels of its lungs could have admitted through them a free and uninterrupted passage to the blood; but as a collapse of the lungs was necessary in the foetus, it was indispensable for its œconomy, that it be furnished with a foramen ovale, &c.
&c.

&c. to compensate for the small allowance of blood that is sent through them.

In drowning, &c. &c. as very little air remains in the lungs after the last expiration, the disease must exhibit nearly the same phænomena as the fœtus, whose muscles of respiration have not been excited to act; for in this case, it is nature that effects what we endeavour to attain by art; that is, to remove the collapse of the lungs, and this by the introduction of a fluid that will give the necessary change to the blood.

Haller, Cullen, and others were of opinion that the state of full inspiration was as unfavourable to the transmission of blood through the lungs, as that of expiration; but this supposition appears to be but ill-supported by fact; for there has been the
test

test of experiment to prove, that when the lungs were *completely distended by water*, the blood freely passed from the right side of the heart to the left, and the action of the heart, under this circumstance, must have been feeble, if compared to that which it exerts in a state of health.

It has also been the generally received opinion that where the *motion of the lungs* is by any cause impeded, the circulation, from want of *their mechanical action*, is also suspended; and it is supposed by Mr. Kite, that the accumulation of blood which takes place in the right side of the heart, from drowning, hanging, and suffocation, originates from the same cause.

“As it is generally agreed,” says Mr. Kite,
“that the stoppage of the *motion of the*
“*lungs* is the first internal efficient cause
“ of

“ of death, let us consider the effects
 “ which reason teaches us, must inevit-
 “ ably follow the cessation of that im-
 “ portant action. The blood returning
 “ from all parts of the body by the su-
 “ perior and inferior cava, is collected in
 “ the right auricle and ventricle of the
 “ heart, from whence in a state of health,
 “ it is transmitted through the pulmonary
 “ artery and veins, into the left auricle ;
 “ but in the present instance, the *motion of*
 “ *the lungs* being stopt, only a small quan-
 “ tity can pass through that viscus.

This opinion of Mr. Kite's has been con-
 tradicted by experiment, which proves that
 from the mere removal of the collapse, inde-
 pendent of any *mechanical action* of the lungs,
 the circulation through them was restored ;
 whence it is obvious that the accumulation
 of blood in the right side of the heart
 does

does not proceed from want of *motion*, but from the *collapse* of the lungs.

To the opposite opinion, however, Mr. Kite stedfastly adheres; and in order to ground his assertion, that the circulation ceases in *drowning, hanging, and suffocation*, from want of *motion* in the lungs, and not from their *collapse*, he has recourse to analogy, and observes, “ that in the action of laughing the lungs are *dilated*, and remain almost in the same state until the cause ceases; but while it continues, the blood cannot be transmitted freely through the lungs; hence we easily account for the redness and swelling of the neck, face, and head; and if the passage through the lungs is long impeded, the brain suffers, and apoplexy ensues, which has on many occasions ended fatally.

“ Cases

“ Cases have often happened of violent
 “ straining and fits of coughing, which
 “ are attended with *a full and long conti-*
 “ *nued inspiration*, terminating in the same
 “ manner; and singing or crying produce
 “ similar effects, although it seldom hap-
 “ pens they are carried to any dangerous
 “ excess. Instances almost out of number
 “ might be brought forward in support
 “ of these arguments; but enough has
 “ surely been said to satisfy the doubts
 “ of the most incredulous, and fix the
 “ wavering mind of the most incorrigible
 “ sceptic.”

If Mr. Kite's assertion were true, that in
 the act of laughing the lungs are *dilated*,
 and that coughing, fits of straining, sing-
 ing, &c. are attended with *a full and long*
continued inspiration, this I acknowledge
 would be sufficient to impress conviction

on

on the mind of every sceptic that the want of *motion* in the lungs, from whatever cause, may prevent the transmission of blood from the right side of the heart to the left; but instead of these efforts being, as Mr. Kite states them, acts of *inspiration*, they are all acts of *expiration*, and we might with as much propriety assert, that charging a gun produces the explosion, as that the acts of laughing, coughing, singing, &c. are the effects of *inspiration*. From long continued expirations, as laughing, coughing, &c. when carried to excess, a *collapse* of the lungs must arise, and this, by obstructing the free passage of the blood through them, will occasion an accumulation of it in the right side of the heart, from which apoplexies may sometimes follow. But supposing the lungs were, as Mr. Kite conceives them to be, in a state of *dilatation*, then apoplexy could

I. never

never be the consequence, since a free passage would be then open to the blood, and prevent the possibility of its congestion in the head; so that Mr. Kite's *efficient cause* of death here contradicts *his proximate*.

The argument also adduced from analogy, to support the opinion, that the *want of motion* in the lungs stops the circulation in *drowning, hanging and suffocation*, in reality confutes it, and proves collapse to exist. But had not Mr. Kite seemed to conceive that his arguments were sufficient to satisfy the most incorrigible sceptic, we should not have taken so much pains in endeavouring to disprove them. Indeed, as the plan of treatment recommended by Mr. Kite must be so highly detrimental, if *collapse* does really exist; it appeared of the utmost consequence to determine whether

from *it* arose the suspension of the circulation, or from the want of *motion* in the lungs.

In drowning and in suffocation from foul air, anatomical research has discovered that the veins of the head are not more distended than in natural death; and that apoplexy does not take place as Mr. Kite supposes from hanging, is equally obvious; for if such were the case, never could we be able to effect a recovery, since our endeavours to remove common apoplexy, even while the process of respiration and circulation proceed, frequently prove unsuccessful.

Were it really true that apoplexy took place either in drowning, hanging, or suffocation, we should conceive more sanguine hopes of recovery after breathing

had ceased in ordinary apoplexy than when it arose from drowning, &c. for these latter causes produce their fatal effect in a few minutes; while common apoplexy, even where a predisposition existed, is generally many hours, and sometimes days before death takes place. If, therefore the two diseases be of the same species, that which arises from drowning, &c. must be much the more violent in degree. Were this indeed literally the fact, we should then from drowning, &c. find great extravasation, and no recovery could be effected, and we should have reason to expect a recovery in every instance, where the cause was so slight as to require several hours to stop the natural actions; but as we are able to recover long after breathing has ceased in that disease, which according to this theory, must be the most violent, and as we frequently fail of recovering from

from common apoplexy, even during respiration, it certainly proves that this disease, and that which takes place from drowning, are as essentially different as any two diseases to which the human body is obnoxious.

It has been advanced by some authors, that the mere distention of the vessels, without any extravasation either of blood or serum, is sufficient to produce apoplexy, and this is the species of apoplexy which Mr. Kite conceives to be produced in drowning, &c. as it is acknowledged that no extravasation takes place in the head; but were congestion alone, in these cases, the cause of death, then must it be supposed that the distention alone of the vessels acts much more violently than when attended with actual extravasation; but this is an opinion not only discounte-

nanced by probability, but also flatly contradicted by Valsalva and Morgagni on the stubborn faith of numerous facts. The latter observes “ that those cases are the
 “ most violent, and much the soonest
 “ mortal, which have their origin from
 “ *extravasation* within the cranium, we
 “ not only have daily proofs of ourselves,
 “ but it has also been frequently observed
 “ by others.”

It would therefore appear that though the vessels of the head were fully distended in drowning, hanging, and suffocation, this distention could not here be considered as the immediate cause of death, since at most it can produce but a very mild species of apoplexy; for even when extravasation follows, the actions of life generally continue for hours, while in drowning, &c. it is needless to repeat, the

natural

natural functions are in a few minutes abolished.

There still remains one observation, which proves the impossibility of apoplexy happening from drowning, &c. and that is, that no accumulation of blood can be formed even at the right side of the heart, prior to the commencement of the collapse of the lungs, but as soon as this obstructs the free passage of the blood, then it receives but an imperfect change; and is therefore, in a great measure, deprived of its essential quality. From this circumstance it will no longer be capable of keeping up the full and natural action of the heart and arteries; and as the carotid and vertebral arteries will also have their action proportionably diminished, the impetus of the blood to the head must thereby be checked, and considerably enfeebled. These

considerations make it obvious that apoplexy can only happen where the blood receives its proper stimulus from the air to support the action of the heart and arterial system, and where an obstruction exists to its free return.

In apoplexy that proceeds from distention of the stomach, and other causes, the blood continues to receive its due stimulus from the air; while for want of a sufficient expansion of the lungs, (the diaphragm not being allowed a proper descent,) an obstruction arises to the free return of the blood, which occasions the disease. But even in this supposition, death might not be the consequence, at least for many hours, if at all; although the vessels of the head might have been fully distended, and that by the natural action of the carotid and vertebral arteries; but as in drowning,

drowning, &c. these vessels are soon deprived of their wonted stimulus, no injury whatever can happen to the brain.

From these observations, we trust it has been proved not unsatisfactorily, that apoplexy never happens in drowning, &c. but there is an experiment which must always supersede argument that fully disproves the existence of apoplexy.

This experiment has been mentioned before to prove a different fact; but as it is one that serves our present purpose, the repetition of it will therefore be excused.

EXPERIMENT.

The trachea of a dog was laid bare, and secured by a ligature, and this was endeavoured to be performed at the instant

stant an inspiration was made; in less than four minutes he ceased to struggle. On examining the heart we found the quantity of blood in the left, when compared to that of the right as thirteen are to twelve. A portion of the cranium was removed, and the veins of the head were evidently less distended than *natural*.

Here then there being no obstruction to the passage of the blood through the lungs, it could not be collected in the right side of the heart, and consequently no accumulation was found in the head, and yet this animal died as soon as other animals from ordinary hanging; which carries conviction to my mind, that apoplexy forms no part of the disease.

As

As a further testimony, however, in favour of this opinion, the following experiment was made.

EXPERIMENT.

The two carotids of a dog were secured *, and in half an hour after this operation he was hanged. In less than four minutes he ceased to move ; on removing a large portion of the cranium the vessels were found much less distended than in *ordinary death*.

From this experiment it must appear obvious, that as the principal source of sup-

* This experiment of tying up the carotids has been made both by Mr. Haighton, and Mr. Cooper, in order to ascertain the effects, and in every instance it appeared to produce no injury whatever to the functions of the animal.

ply

ply was cut off; instead of the vessels of the brain being in a state of congestion, the quantity of blood they contained must have been less than natural, and consequently no species of apoplexy could follow. Yet this animal died as soon as other animals which had undergone no such operation.

Mr. Kite, “ from a variety of circumstances, is induced to believe that mercurial air occasions apoplexy and death in two ways; first, by affecting the nerves of the trachea in such a manner as to render the muscles subservient to respiration paralytic; and secondly, by its sedative property, destroying the action of the brain, and nervous system.”

To the muscles of respiration being rendered paralytic, there are two forcible objections

jections; first, that the nerves of the trachea have no communication with the muscles of respiration; and, secondly, that if the muscles of respiration were paralytic, no recovery could ever be obtained. Yet Mr. Kite in the next page observes, that “several have been known to have revived spontaneously;” which certainly proves, that the muscles of respiration could not have been in a paralytic state.

As to the latter opinion, that apoplexy and death are produced by the sedative property of noxious air, destroying the action of the brain and nervous system, it can by no means be reconciled to the idea we have formed of apoplexy; for I believe it is generally agreed that apoplexy must happen from *pressure* on the brain; and we might with equal propriety affirm, that
tobacco,

tobacco, and other vegetable poisons, when taken into the stomach, (which actually do produce a sedative effect on the brain and nervous system,) bring on *apoplexy*, as that this disease is the consequence of the *sedative property* of mephitic air. Indeed it appears somewhat strange, that Mr. Kite, who has paid so much attention to apoplexy, should have imagined that this disease could ever be produced by the immediate effect of any *sedative*.

We also dissent from Mr. Kite in opinion, that a *full inspiration* is ever made in foul airs; for although animals when immersed in such a medium, may have been heard to cry, yet this affords no proof that a full inspiration has been previously made. This is not an uncommon circumstance in drowning animals,

found

found being the immediate act of an *expiration*; and there can be no doubt but all animals have a quantity of air in their lungs when immerfed in a noxious medium. But as foon as the animal on infpiration becomes fenfible of its deleterious influence, it endeavours to expire; and to this endeavour an attempt fucceeds to infpire, when the fame fenfation recurs as permits very little air to pafs into the lungs.

Dr. Crawford's experiments evince, that when an animal is placed in a warm medium, the venous blood becomes nearly florid.

With a view to ascertain if an animal could be drowned, and the blood in the left fide of the heart ftill retain a florid appearance, the following experiment was made.

E X P E-

E X P E R I M E N T.

A kitten was immerfed in a warm medium, a little above its own temperature, and permitted to breathe under a large glafs-bell for twenty-four minutes; it was then drowned in the fame medium.

On opening the cheft, it was found that the blood in both fides of the heart was fomewhat florid, and yet this animal died, which, however, according to Dr. Goodwyn, fhould not have happened. But why this animal did die, can be readily explained; for the collapse of the lungs was here of courfe the fame as in common drowning, and from it arofe the *immediate caufe* that fufpends the circulation; but there was ftill another power
operating

operating upon this animal to destroy life ; for from the intense heat and density of the medium in which the animal was placed, it was compelled to have recourse to the process of generating cold, in order to resist this excessive stimulus ; and the act of repelling heat invariably renders the powers of the animal less susceptible of action : moreover, the power of generating cold by *evaporation*, was here denied. Notwithstanding, therefore, that the blood in the left side of the heart might be florid, yet the susceptibility of action being feeble, the quality of this blood was insufficient to support irritability.

It is worthy of remark, that in this and in every similar experiment, the heart had less action than usual, although the blood had this florid appearance ; which clearly demonstrates, that much heat diminishes

M irritability,

irritability, and this effect is probably produced by the quick action which excessive heat invariably excites, and the debility consequent on the endeavours to resist heat. Hence it must appear evident, that although the blood might possess latent heat in abundance, and what in health would have been a proper stimulus, yet from the solids not being susceptible of action, life could not be supported. The *ultimate effect* of all violent stimuli must be that of a *sedative*; thus heat (which is one of the most powerful stimuli in nature) when applied to a certain degree, acts as a stimulus; but if this be carried to excess, the final effect will be extreme *debility* and death. This is likewise the effect of the use of spirituous liquors, &c. a certain quantity will produce a stimulating effect, without diminishing the powers of the animal; but increase it beyond

this, and *debility* will be the consequence.

It has been several times remarked, from the result of repeated experiments, that where the collapse of the lungs was removed after breathing had ceased, the circulation went on freely through the lungs, and distended the left side of the heart; but when the collapse existed, the left was not distended, which evidently proves that the *collapse of the lungs is the immediate cause of the cessation of circulation*; and not as Dr. Goodwyn supposes, *the presence of black blood in the left side of the heart*; nor, as Mr. Kite imagines, *from want of motion in the lungs*.

We do not, however, establish the collapse of the lungs as the *proximate cause* of the *disease*; for by the term *proximate*

cause is generally understood, that which on being removed, the disease ceases. If this definition of a proximate cause be adopted, then mechanical obstruction in the lungs from collapse cannot of *itself* be considered the *proximate cause*; as by the removal of the collapse, the right side of the heart is merely enabled to empty itself, and, by the vis à tergo, to produce an action in the left. But before the process of circulation can be completed, the animal must be provided with blood possessing an increased quantity of latent heat, as not only the left side of the heart, but the whole system wants blood of this quality; since in the foetal circulation, the change is received before it reaches the heart, and both sides have a like stimulus. As the heart, however, in the adult must be the origin of circulation, so it is necessary that the alteration should be made immediately,

diately, before the blood enters one of these cavities; whereas in the foetus, the heart not being the origin of circulation, the change is given to the blood before it arrives at that organ.

There would appear a more striking impropriety in saying, that *the black blood in the left side of the heart and arterial system was the proximate cause of the disease*, as *this blood* cannot be changed until it has run the course of the circulation, and returned to the lungs; but that cannot be effected without a previous removal of the obstruction formed by the *collapse*, and exciting the left to contract on its *black blood*; and even if the necessary change could be given during the existence of *collapse*, the lungs could not allow a sufficient quantity of blood to pass through them,

them, to keep up the natural functions of the animal.

To us, therefore, the *proximate cause* of that disease produced by *drowning*, *hanging*, and *suffocation*, appears to be *mechanical obstruction in the interior pulmonary vessels from collapse of the lungs, with a want of latent heat in the blood*; for remove this collapse, and induce the necessary change on the blood, and you cure the disease.

Having thus far attempted to establish the proximate cause, we are naturally led to enquire into the usual remedies employed in this disease; and to select such as appear to be the best calculated to produce a salutary effect.

SECTION

S E C T I O N VII.

Effects of emetics in suspended respiration.

THE proximate cause that results from the suspension of respiration in drowning, hanging and suffocation, we have supposed to be mechanical obstruction in the lungs, with a decrease of stimulus in the blood. The remedies employed to remove it are as numerous and different as the theories advanced to explain it; but of them all, emetics, with which we begin, are perhaps the most ineffectual; their administration must even be attended with no inconsiderable injury, if had recourse to before the action of the vital functions is restored, and even then should be regulated by a serious and vigilant regard to particular circumstances.

No salutary effects can be expected from vomits, but in cases where the processes of respiration and circulation have been re-established, and where enquiry informs us that the stomach has been overburdened either with food or spirituous liquors. In these cases there may be no impropriety in emptying the stomach to facilitate the descent of the diaphragm in inspiration; but to *commence* by the exhibition of emetics must be highly improper, as the action and energies of the heart, from its sympathy with the stomach, must thereby be considerably debilitated. And even admitting no such debilitating effects took place, every attempt to empty the stomach must necessarily be futile until the nervous energy be restored in a very sensible degree, when they may be exhibited to more advantage.

To ascertain, however, with some degree of precision, the effects of a powerful emetic, the following experiment was made.

EXPERIMENT.

A Puppy was drowned, and after all struggling had ceased, one drachm of emetic tartar dissolved in two ounces of water, was injected into its stomach. The lungs were then inflated, and other means of recovery employed, until the animal made an effort to inspire; soon after which it appeared perfectly recovered.

In seven minutes from its apparent recovery it began to vomit; in twelve to purge, and continued frequently to vomit and purge for one hour and seventeen minutes, when it died.

On

On examining the stomach, it was found empty, but without the smallest appearance of inflammation.

As a recovery was effected in this animal where so strong a dose of poison had been administered, and that without producing any inflammation, it was deemed requisite to introduce the same quantity of emetic tartar into the stomach of another puppy during the healthy actions of the animal, in order to determine if the effects were similar.

The experiment was made in the following manner.

EXPERIMENT.

Into the stomach of a Puppy of the same litter as that of the last experiment,
was

was introduced one drachm of emetic tartar, while its natural actions remained unimpaired; in two minutes it appeared faint, in less than four vomited; in eleven purged, and in fifty-three minutes died.

The stomach, as in the last experiment, was found empty, but the *whole internal coat was nearly in a state of gangrene.*

The result of these experiments exhibits a truly remarkable circumstance, that an animal should be drowned, afterwards have poison injected into its stomach, and yet be recovered and continue to live longer than another of the same order and age, that had received the same quantity of poison in full health; it tends however to evince and ascertain one fact, that medicines introduced into the stomach do not produce the same effect when respiration

and circulation are *suspended*, as when *these functions* are duly carried on: and this circumstance somewhat accounts for a phenomenon which to me appears extraordinary, that a recovery should sometimes be effected, even after emetics, tobacco, &c. have been administered in quantities sufficient utterly to destroy the life of the same subject, if given in full health.

It may however at first be doubted, whether medicines that possess a sedative property, like tobacco, would not produce their greatest effect on an animal whose powers were weakest, and consequently destroy the irritability of an animal already debilitated by drowning, &c. much sooner than an animal, the vigour of whose powers remained undiminished.

To ascertain this point the following experiment was made.

EXPERIMENT.

A Puppy of about a fortnight old was drowned, and after all motion had ceased, a strong infusion of tobacco (one drachm to two ounces of boiling water, and suffered to cool) was thrown into its stomach; the usual means of recovery were then employed: in fifteen minutes it made an effort to inspire, and soon breathed tolerably well, but in less than ten minutes after, it died.

EXPERIMENT.

An equal quantity of an equally strong infusion of tobacco was introduced into the stomach of another Puppy of the same age;

age; it immediately fell motionless on the ground, and in less than four minutes expired.

These experiments seem to prove that, whether medicines have a powerful stimulant or narcotic quality, their effects are *diminished* in proportion as the powers of the animal are *decreased*.

That medicines however do produce some effect before respiration is restored, has been confirmed by the following experiments.

EXPERIMENT.

A small Puppy was drowned, and the chest being immediately opened, the heart was observed to contract strongly. Six
drachms

drachms of laudanum was thrown into its stomach, and there followed almost an instantaneous diminution of the action of the heart.

This experiment was repeated, by injecting white vitriol, emetic tartar, infusion of tobacco, &c. into the stomach, at a time when the heart was exposed to view; and these were also found to check the force and frequency of its contractions, but particularly tobacco. As it therefore appears that in this disease sympathetic effects continue to arise from the application of impressions to the sympathizing organs, it will at once appear obvious, that any medicine introduced into the stomach which is likely to lessen the power of the heart, must be attended with consequences highly detrimental; and that brandy, on the contrary, or any other warm cordial, which is
known

known to increase the action of the heart, (probably in these circumstances without diminishing its power) should only be employed.

To confirm this opinion, we proceeded to the following experiment.

EXPERIMENT.

A Dog was hanged, and the heart being exposed to view, one ounce of brandy was thrown into its stomach, the actions of the heart were soon quickened, and each contraction appeared more forcible than before the exhibition of this stimulus.

This experiment we frequently repeated, by increasing the quantity of spirit to six ounces and upwards, and it was found that

that so large a quantity quickened the actions of the heart extremely, but they were feeble and of short duration.

From these experiments, however, we can draw only this inference, that a small quantity of spirits here increased *both the power and action of the heart*, while a large quantity quickened the *action*, and *exhausted the powers*. But the analogy will not hold good with the human subject in this particular instance; for as the stomach of the brute is not accustomed to receive so strong a stimulus as that of brandy, its effects will be different *in degree*. Indeed, from observing that all medicines produce a less effect after respiration has ceased, than during health; it is probable that six, or even eight ounces thrown into the human stomach

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would

would not increase the action of the heart beyond its powers, and thus a cordial of some kind becomes one of the necessary remedies in this disease.

From these experiments, however, we can draw only this inference, that a small quantity of spiritus rose maris, besides its power and action of the heart, while a large quantity quickens the action, and ex-
hausts the heart. But the analogy will not hold good with the human subject in the particular instance, because the dis-
turbance of the brain is not attended with relative to things, a stimulus is then of course, its effect will be different in
kind. Indeed, it is not observing that all medicines produce the same effect, since ex-
perience has shown, that during health, it is not probable that the same effect will
be produced, and it is certain, that a
SECTION

S E C T I O N VIII.

Effects of bleeding.

WE do not consider bleeding as a dangerous remedy in every case of suspended respiration from drowning, hanging and suffocation; and were it possible to take blood from the part where we know it superabounds, bleeding would prove one of the most immediate and efficacious means of recovery.

The right side of the heart has been found to be loaded with blood. This universally obtains in this disease; and we mentioned one or two instances in particular, where we had an opportunity of observing that the heart ceased to act from

over distention: but that when relieved from a portion of its burden, its contractions were immediately renewed.

If therefore from the right side of the heart, while thus in a state of violent plethora, a small quantity of blood could be taken; experiment and observation tell that its power and actions would be instantly reinvigorated.

But as this lies beyond the reach of art; the taking of blood from any other part of the body can rarely ever be productive of any advantage, as there is seldom present in the system a greater quantity of blood than is necessary to the due support of the circulation. The diminution of this quantity must consequently be attended with hurtful effects.

From

From bleeding, therefore, as a general remedy, little advantage can be expected; nor can it be employed with success but in such cases, where, from an acquaintance with the complexion and habits of the patients, we may presume that previous to the accident or disease, a general plethora prevailed.

It may then be serviceable to diminish the excess of blood that loads the system; for when the right side of the heart has got rid of its present burden, if an accumulation of blood presses in every direction on the orifices of the two cavæ, and thence on the right auricle, it must tend not a little to enfeeble or wholly destroy its action.

Mr. Kite observes, that in the tonic temperament, every circumstance concurs

which can contribute to the action of the heart and arterial system, and he immediately after adds that “ such people are
 “ also in a state very nearly allied to a
 “ plethora ; hence the blood circulates with
 “ such force as to occasion hæmorrhages
 “ from many parts of the body.” In this opinion we cannot coincide with Mr. Kite, as the tonic and plethoric temperaments appear very different ; for whenever plethora is present, *debility* must be the consequence, there being a greater quantity of blood in the system, than can permit the animal to take on the tonic temperament.

On this state of the body some light may perhaps be thrown, by comparing it with a disease to which young women are frequently exposed, viz. a difference of temperament producing a
 sup-

suppression of the menstrual discharge. The obstruction may arise either from the presence of too much or too little blood in the system; and yet both states may be properly called the atonic, though for the relief in these cases opposite remedies be employed; for in both there is relaxation, inactivity and want of power in the solids. In the first instance we bleed and vomit, by which means the heart and arteries, from having a less burden to propel through the system, will act more forcibly. In the latter case we do every thing to increase the volume of blood, a due quantity of which increases the action, and strengthens the energy of the heart and arterial system. By this it would appear a certain quantity of fluids is requisite to the support of the proper action of the solids; but any thing above or below the standard, will produce

debility. It in the first case it may be called *indirect*, in the other *direct debility*.

Bleeding then should be only employed where the fluids appear too abundant. When the operation is to be performed, I concur with Mr. Kite in advising the blood to be taken rather from one of the jugulars; not however that we expect with Mr. Kite that much advantage is gained by taking blood from the head after drowning and suffocation; but as there is here a nearer connection with the superior cava, the heart would sooner be relieved, than where it is drawn from the arm.

When blood letting is deemed necessary, it is one of the first means of recovery to which we ought to have recourse.

The

The propriety however of bleeding must in every case be decided by the medical assistant; and as we cannot take away blood from the heart itself, it will most frequently be found that the quantity of blood in the system is not so great, as to impede the circulation, and consequently the quantity to be taken away should probably never exceed six ounces.

Blood letting may with advantage be employed where, previous to the disease, the heart might be supposed to have acted more freely from such an operation; but where its powers of action were already feeble, this remedy must necessarily be productive of infinite mischief; for if there is not sufficient blood in the system to furnish a fresh supply to the right side of the heart at each diastole, instead of promoting the good effects of the other remedies,

dies, it may totally frustrate or at least retard them.

After hanging however, there will be a much more frequent occasion for blood letting, than after drowning or suffocation; since the cord must in some measure prevent the free return of blood by the veins; and although we have endeavoured to prove that apoplexy can never happen, yet in these cases as there is more than the natural quantity of blood in the head, it may be of service to lessen it; but the quantity of blood in the head will much depend on the weight of the patient; and as bulk, weight, and general plethora frequently are united in the same person, bleeding becomes here indispensably necessary; whereas, if the patient be tall and thin, the distance from the heart to the head considerable, and the system rather to want blood, bleeding, even

even in cases of suspension, would perhaps do more mischief, by debilitating the system, than advantage could be gained, by relieving the local plethora of the head and heart; for if the removal of the local plethora tends to increase the general debility, this last disease is more dangerous than the one we endeavour to remove.

We shall next enquire into the effects of electricity, together with those of artificial respiration, both singly and combined.

S E C T I O N IX.

*Effects of Electricity and Artificial
Respiration.*

FROM electricity, as it has hitherto been recommended and employed, considerable indeed must have been the mischief that ensued. Agreeably to the method that was to direct its application, it was to be administered as a local and general stimulant, to be transmitted through every part of the body, the heart, brain and spinal marrow, and in all cases where electricity was the remedy principally relied on, it seemed to supersede most of the other curative operations, but particularly that of expanding the lungs. From attending however to the nature of the disease produced

duced by suspended respiration in drowning, hanging, and suffocation, it will evidently appear, that stimulating the heart, without at the same time endeavouring to remove the obstruction of collapse, must be one of the most ill-judged and most dangerous plans of recovery.

I repeat, there is mechanical obstruction in the lungs from collapse. This alone points out the danger of stimulating the heart, when there exists a cause that must impede its action; we are destroying its irritability, without deriving any advantage, as the circulation can go on to no effect, unless the obstruction in the lungs be first removed.

We are, by this plan of treatment, absolutely taking away life.

Mr.

Mr. Kite conceiving *that the stoppage of the motion of the lungs* was the immediate cause of cessation in the circulation, and that the lungs were not in a state of *collapse*, was led to recommend shocks of electricity to be passed through the heart, &c. without the lungs being at the same time expanded. In his essay he advises that artificial respiration, as well as electricity, should be frequently *interposed*, and that when the body is electrified *all the other operations should cease*.

As it has been proved by experiment, that in this disease the lungs are in a state of *collapse*, and that the circulation is stopped from this cause, and not from the want of *motion* in the lungs; it appears obvious, that Mr. Kite's mode of treatment must be highly detrimental. Had this gentleman entertained

entertained the smallest suspicion of a *collapse* existing, I am persuaded he never would have recommended the stimulus of electricity to be applied to the heart during such a state of the lungs; but have concurred with me in opinion, that such a practice was more likely to destroy, than restore the actions of life. When electricity has been employed, the lungs have sometimes been first expanded and *collapsed*, and shocks then passed through the heart, brain, and spinal marrow, but in this case the lungs being also contracted, every electrical shock must diminish the power of the heart. Artificial respiration is again employed without electricity, but this second effort promises less probability of success than the first; for the heart having before received a stimulus, so great as that of electricity, it is not likely that the minor one viz. that of the mechanical action of the

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lungs,

lungs, should have the smallest effect. And as the heart may not naturally act more than once or twice in a minute, there are many chances to one that these contractions do not happen at the instant the obstruction is removed.

Inflating the lungs, and immediately after pressing the chest, is said to be imitating natural respiration, but it appears evident, that this mode of proceeding is very improper, if the heart has not been excited to action during the expansion of the lungs.

Neither is this process an imitation of nature, for in health, the lungs always contain a quantity of air, and we only expel a little, and receive in proportion. But if we discharge all the air as soon as received, it is probable, that the heart may act, when
the

the lungs are contracted, and which action can produce no salutary effect.

Whatever view the operator may have, who pursues this plan of treatment; whether he supposes a change to be produced *in the blood, within the auricle*, or whether he expects to propel the blood within the lungs into the left side of the heart, he will be equally disappointed. For we have observed, that no change can be produced in the trunks of the pulmonary veins; and we have also found that if any alteration in the quality of the blood be made within the lungs, there is not sufficient quantity remaining for their mechanical action to propel this blood into the left auricle.

The advantage we may expect from inflation, is this; *that the right side of the heart may act at the same time the lungs are*
 O *distended;*

distended; but surely suffering them to collapse, as soon as inflated, is very unlikely to ensure success, when the heart has not been stimulated by electricity during the expansion of the lungs. Moreover, as the air can only become vitiated, by the action of the heart propelling blood into the lungs, there appears no necessity of performing a complete expiration after every inspiration, unless electricity has been at this instant employed.

The plan of treatment necessary to be pursued is obviously this. We should *first expand the lungs, and when the collapse is removed, stimulate the heart by a shock of electricity. The heart from this is made to contract, there is a free passage for the blood, and air in the lungs to produce a change*; therefore if any irritability be left in the heart, some blood must enter the lungs. We

now perfectly collapse them, and of course this blood will be conveyed into the trunks of the pulmonary veins and left auricle, and the circulation will go on. The lungs are again immediately distended, and kept so, until another shock be passed as before.

Here then it is necessary, that all the air should be expelled as soon as the heart has been made to act; since this air may have lost the greater part of its purity. But as the irritability of the heart is seldom susceptible of action, from the small stimulus of inflation; this practice can never be proper where electricity is not employed.

It has been observed, that the heart of some animals in suspended respiration, has for a time the power of overcoming this obstruction by its own stimulus, without removing the collapse; and probably in man,

the heart may possess a sufficient degree of irritability to perform the same functions on being stimulated by electricity, agreeable to Mr. Kite's plan. But without considering the powerful stimulus, required to effect this, and the debility which must necessarily ensue; let us enquire, what advantages can be possibly gained by propelling blood from the right side of the heart to the left, during the collapsed state of the lungs. Allowing this could be effected, there is no air in the lungs to produce any chymical alteration on the *quality* of the blood; and were the left auricle and ventricle, in part emptied and again distended with a fluid equally foreign to the wonted stimulus, their power must every time be diminished, and consequently the right, at each contraction, require a stronger stimulus to produce the same effect; when as the left finding an increasing difficulty in propelling
its

its contents; the right would be less capable of overcoming the collapse.

This power therefore could only continue for a short time, and during its existence no better effect could be produced from blood passing through the lungs *without receiving a change from the air*, than when propelled from any other artery into a vein by friction.

If no electrical machine can be procured, the manner of carrying on artificial respiration should be altered; the lungs are to be expanded; and, instead of compressing the air out as soon as received, they are to be kept in a state of moderate expansion for about a minute; so that if the heart acts during this period, there may be no obstruction to the passage of the blood.

To effect this, repeated inspirations are requisite, allowing at each time the superfluous air to escape before the lungs are made to *collapse*, that there may be in some measure a fresh current of air. By this means the surface of the lungs will at each inspiration be thrust against the heart; and if part of its irritability is lost, so that this shall not act as a stimulus; still when the heart does act, there will be air to give the change, and *no impediment to the passage of the blood.*

It was observed that the lungs in ordinary respiration have no active power in propelling blood through them in health. But it seems in the recovery they may assist by their action; for when the heart possesses only power sufficient to send blood within the lungs, without being able to propel it to the left heart, producing an *artificial collapse*
 under

under these circumstances will empty the interior pulmonary vessels of the blood they have received, and excite the left auricle and ventricle to contraction. That the lungs will here produce this effect, there can be no doubt, since we find a greater quantity of blood in them when distended than collapsed; and hence by compressing the lungs, they must act upon all the blood they have received since the last expiration.

Care however should be taken, that the collapse is never suffered to *continue*; for the heart may act at this period and *then* without effect; so that the act of inspiration in every instance should be performed immediately after the last complete expiration.

During the whole process of the treatment, from the first attempt to effect a

recovery, the lungs should never be suffered to remain collapsed, that other curative means may be employed. Without this precaution, we render abortive all our endeavours to remove the cause of the disease; for this end not previously attained, what rational hope or dependance can be placed in the application of any remedy?

Instances of recovery have not been wanting where the lungs were not inflated; but in such it must be attributed to an unextinguished energy of the living principle, which continued in some degree to enable the muscles of inspiration to act so as to afford admittance to a portion of air.

Does it not appear probable that the difference of success which marks the cases reported

ported by the Humane Society, in which the same method of cure was observed; may depend in a great measure on the heart's acting, or not acting during the *expansion* of the lungs? Some patients were irrecoverable after respiration had been stopped for only one, two, and three minutes; whilst the recovery of others who had remained more than half an hour under water was effected by a similar mode of treatment.

The variation of the degrees of irritability in the same order of animals is found to be considerable; but it appears improbable, that one should be destroyed from a cause which, thirty times multiplied is insufficient to take away life from another apparently under the same circumstances. Having been present at several cases of drowning, (in the character of spectator,)

we had occasion to observe one in particular, in which, though the body had not been long under water, yet all the endeavours to restore life proved unsuccessful. The failure of success however in this unfortunate case was evidently occasioned by the means and method pursued to obtain a recovery. The smoke of tobacco blown up the rectum, frictions, and inflations of the lungs were first employed for about ten minutes, when the two latter were suspended to allow the administration of electricity. This stimulus was applied by passing smart shocks through the heart, brain, and spinal marrow; in fact the whole body was electrified. The muscles through which it was conducted contracted powerfully. The shocks were repeated with sanguine hopes of success, but the contractions gradually became more feeble, and in about two hours were totally abolished.

Artificial

Artificial respiration, with frictions, was again attempted, but to no effect. It is obvious that in this case a considerable degree of the vital energy was present, but absolutely destroyed by the means employed to re-establish it; for as the proximate cause of the disease was not removed, every increase given to the action of the heart must have produced debility. But had the collapse of the lungs been taken away when the heart had been stimulated, far different indeed might have been the effects; no impediment would then have existed to the passage of the blood through the lungs, and it would have imbibed from the air its necessary portion of heat.

Inflating the lungs and electrifying the heart at the same instant, may at first view be thought a difficult and embarrassing process; but it will be found that proper
instru-

instruments, constructed for the purpose, will make this as easy, if not more so, than what are now employed.

It will be necessary, however, first to consider the improvements that have been made, and the disadvantages that still attend them.

Mr. Kite has formed a very compact case of instruments for the purpose of inflating the lungs, but not without their inconveniences. They are directed to be thus employed.

“ A proper person stationed at the head
“ of the body to be operated upon, passes
“ the appropriated end of a tube into one
“ of the nostrils, and sustaining it there
“ with the fore finger, compresses both
“ nostrils so firmly between the thumb
“ and

“ and middle finger of the same hand,
“ that no air can pass otherwise than by
“ the tube, and the other extremity of
“ the tube being applied to his mouth, he
“ blows with force through the pipe into
“ the nostrils of the subject.

“ The medical director standing at the
“ right side of his charge, must keep the
“ mouth perfectly closed with his left
“ hand, while with his right, making a
“ suitable pressure on the prominent part
“ of the wind pipe, he prevents the air
“ from passing into the stomach, till find-
“ ing the lungs are properly distended,
“ he is to press strongly upon the chest,
“ removing at the same time his left hand
“ from the mouth, so as to let the air
“ pass out; when by this means the lungs
“ are compressed the process is to be re-
“ peated, that, as far as can be, the
“ manner

“ manner of natural respiration may be
“ imitated.”

We have observed before, that *collapsing* the lungs as soon as distended, is not imitating natural respiration; besides it appears evident that air blown from the mouth of another must be highly improper, as being robbed in some measure of its purity; and if a pair of bellows be used, it will employ three persons, one to inflate, another to secure the nostrils and mouth, and a third to press on the cricoid cartilage, and chest in expiration; and it seems that unless all three perform their respective offices in perfect concord, the artificial respiration will be very imperfect.

There are also two disadvantages attending every instrument introduced into
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the nostrils ; first, the epiglottis obstructs the free passage of the air ; accordingly, part of the air thus repelled enters the stomach, which cannot be prevented by pressing on the cricoid cartilage ; for although pressure applied here may prevent most liquids from passing, yet so subtle a fluid as air blown with force may make its way into the stomach ; not that air is supposed to produce mischief from its quality, but from the mechanical effect it must have in preventing the lungs from expanding. We know the detriment which respiration in health receives from a distended stomach, by its preventing the proper descent of the diaphragm in the act of inspiration ; for the other muscles not being able of themselves sufficiently to enlarge the chest, the right side of the heart is prevented from acting with its usual ease ; and hence
a disten-

a distention of the stomach from air must be attended with the same effect*.

Mr. Hunter has contrived a double pair of bellows with two valves, so that one shall perform the office of inspiration, and the other that of expiration, and these are adapted to an instrument which is to be introduced into the trachea, after bronchotomy has been performed.

This is certainly a most excellent contrivance, but from want of portability, they have rarely been employed.

* From want of proper instruments I once saw the stomach, and the whole intestinal canal very much distended, and a rupture under which the patient laboured, was also considerably enlarged; but the major part of the air may at any time be dispersed, by pressing on the abdomen.

Dr.

Dr. Monro has invented an instrument to be introduced into the trachea, in the form of a common male catheter. This is mentioned by Mr. Kite; but its use is only recommended on particular occasions, and it would seem that the insertion of this instrument into the windpipe, could not answer the purpose so well as at first might be expected; for when introduced, the inferior orifice would be thrust against one of the sides of the trachea, and the curve pressing on the other, would form an obstruction to the air.

There also arises a great difficulty in introducing this instrument, more especially to those who have not been in the habit of employing it, as no guide can be given, by which we may know whether it be inserted into the larynx or pharynx; and as the aperture of the latter is so much larger

than that of the former, it would rather glide into the œsophagus, than into the trachea, and thus inflate the stomach instead of the lungs. The ill consequences arising from such a mistake are sufficiently obvious; and to guard against so fatal an error the following instrument is recommended.

As it has been deemed requisite to introduce some stimulating cordial into the stomach, a vegetable bottle (Fig. 7.) is contrived for this purpose, which is to be attached to the flexible tube, (Fig. 6. at B.) and introduced down the œsophagus, and on this tube is placed a conical piece of ivory, (cc) that is moveable, to serve as a director for the introduction of the pipe into the trachea.

The vegetable bottle being filled, the tube is to be inserted three or four inches

into the œsophagus, and the conical piece of ivory is then to be carried onward by the assistance of the fore-finger, so as to close the superior aperture of the œsophagus.

Having proceeded thus far, the tongue is to be brought as forward as possible, and the inferior end of the curved pipe (Fig. the 1.) passed to the farther part of the mouth, until it meets with the ivory director. The pipe being then brought a little forward, the superior extremity is to be elevated, by which means the inferior will be depressed, and with ease enter the trachea: for as the entrance of the œsophagus is situated immediately behind the larynx, and as the pipe is prevented from entering here by the ivory director, it must pass into the air-tube; so that the vegetable bottle, and its appendages answer a double purpose, that of injecting fluids into the stomach, and as a

guide to the introduction of the other instrument.

* The pipe for the trachea is much larger and longer than Mr. Kite's, and made nearly on an opposite scale, viz. the great curve is given to the superior, instead of the inferior part; from which results this advantage, that when it is fixed in the trachea, it will be nearly in a straight line with that tube; and for the more easy introduction of the instrument, the pipe is made conical, and that there may be no impediment to the passage of the air, two lateral openings are made at the inferior extremity (B.)

* It may perhaps be adviseable, that the ivory director be continued in the œsophagus during the whole process of the treatment, as this will effectually prevent any air from regurgitating into the stomach.

The application of these instruments can not be supposed to embarrass any professional man; if however, any impediment should prevent the insertion of the pipe into the air-tube, bronchotomy should be immediately performed; but the place, and manner of performing this operation, agreeable to the method generally recommended, do not appear the most eligible.

We are advised by authors, to begin it by a longitudinal incision, three or four rings below the cricoid cartilage, and when the trachea is met with, to divide it between the rings.

The performance of this operation, according to this plan, can scarce be attended with danger, when attempted by a skilful anatomist; but it may be embarrassing to a medical assistant, who is obliged

hastily to perform it when perhaps he may not perfectly recollect the situation of the vessels; and it is to be remembered that haste is always particularly necessary on these occasions. Allowing however, that the operation is ably performed, great inconvenience must follow from the situation of the wound; for in the recovery of the drowned, hanged, and suffocated, the head is, and always ought to be, kept a little elevated, the consequence of which must be, that the aperture in the trachea then becoming the most depending part, the flow of blood that follows the operation will principally enter it, and thus prevent artificial respiration from being properly carried on. This is not a theory founded on hypothesis, but on facts; as we have seen two cases wherein this accident actually happened.

Another

An other inconvenience attendant on this mode of operating is, that from the trachea at this part being covered by so much integuments, the pipe for inflating the lungs, cannot be properly secured; and should a recovery be effected, the patient must be under the necessity of keeping his chin directed constantly downward, in order to approximate the cartilages, a position that is not only very disagreeable, but to be continued almost impracticable.

In order therefore to render the operation more simple, less dangerous, and to prevent blood from entering the air-tube; I conceive it more eligible to divide the thyroid cartilage: and that instead of the incision first being longitudinal, and then transverse, both the integuments and cartilage should be cut through longitudinally at once.

Several are the advantages derived from this mode of operating. First, no danger can then arise from the want of anatomical knowledge. Secondly, the covering being here very superficial, little blood will be lost, and the little that does escape, cannot get into the windpipe. Thirdly, the curved pipe can be very well secured, in order to carry on inflation and collapse. Fourthly, if our attempts to recover be successful, keeping the head naturally erect, will be the best position to approximate the divided cartilage; and lastly, that the recurrent nerves are in no danger of being divided. The only inconvenience to be dreaded from this manner of operating, is that of committing an injury on the sacculi laryngis, and thus to incommode the voice; but these are secured from danger, by cutting through the middle of the cartilage; and an union will be

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as completely effected, as if the trachea itself had alone been divided.

The surgeon standing at the right side of the patient, should perform the operation by putting the integuments on the stretch with the thumb and forefinger of the left hand, a longitudinal incision is then to be made immediately over the thyroid cartilage, into which may be inserted the curved pipe that was intended to be introduced into the trachea by the mouth.

Whether this operation has, or has not been performed is of little consequence to the recovery, if an instrument be introduced into the windpipe, that is connected with the other apparatus.

To the curved pipe for the trachea is to be fixed one extremity of the flexible tube,
(Fig.

(Fig. 2. A); and the other end (B.) be attached to the instrument, (Fig. 3. c.) which may be fixed to the nozzle of any pair of bellows.

Every thing being prepared for inflating the lungs, one assistant is to have the direction of the bellows, and to stand at the head of the patient, whilst the other prevents any air from escaping at the nostril and mouth; or from the aperture, if any has been made in the trachea.

The bellows are now to be employed, until the chest is elevated; and the Medical Assistant, having the electrical machine prepared, is to place one director between the fourth and fifth rib of the left side, and the other between the second and third of the right; so that the electrometer may discharge the jar, and the shock be made to pass

pass from the apex of the left side of the heart to the basis of the right.

When the electrical stroke has been once more repeated, the assistant, who has the care of the mouth and nostrils, is now to remove his hands, and press strongly upon the chest; the bellows are again to be immediately employed, and another shock being prepared, the heart is to be thus stimulated twice or thrice, and the lungs collapsed as before.

If the heart retains any irritability, the effect of this treatment must be evident; for the collapse of the lungs being removed, the contractions of the heart are renewed, a free passage is opened for the blood, and air is admitted to give it the change. But as the actions of the heart may probably not be sufficiently powerful

to

to propel the blood completely through the lungs, it becomes necessary to have recourse to the collapse, in order to effect this. We therefore, after having inflated the lungs, and electrified the heart, press upon the thorax, in order to expel most of the air contained in the lungs; for supposing the lungs have received but one ounce of blood from the contraction of the heart, a certain degree of collapse will get rid of half of this blood; but if the collapse is increased, the quantity of blood that will be acted upon will also be greater. This appears therefore a matter of importance, for the greater the quantity of blood that is sent from the right side of the heart to the left, if at the same time it has received the wonted change from the air, the greater undoubtedly is the probability of its exciting the left to action, than when only half the quantity is transmitted.

If

If *natural respiration* be imitated without ever attending to the *collapse* of the lungs, there can be little probability of success, even should the heart be electrified during the expansion of the lungs. For if the pulmonary vessels are distended with blood by the action of the right side of the heart, without producing a collapse of the lungs, sufficient to enable them to act mechanically in emptying these vessels; there will arise nearly as great obstruction to the action of the heart as when the collapse existed; for the pulmonary vessels must then be emptied as well as distended by the action of the right side of the heart alone, which by this disease is soon rendered so enfeebled, as to be wholly inadequate to such an exertion.

By exhausting the lungs, after the heart has been made to act during inspiration, the
collapse

collapse [will in some measure supply the absence of powerful action in the right side of the heart; for all the blood the lungs have received is by that means carried to the left, by which we not only gain the advantage of sending blood which has received its due heat from the air into the left auricle and ventricle, but moreover the pulmonary vessels are again put in a fit state to receive more blood from the action of the right, and even a feeble contraction of the heart will be capable of sending blood into the pulmonary arteries, though a more powerful one would be insufficient to propel it into the pulmonary veins and left auricle.

Mr. Field, a very ingenious mathematical instrument-maker in Cornhill, has invented an instrument (fig. 4.) which may be fixed to the nozzle of a common pair of bellows for the double purpose of
 inflating

inflating and collapsing the lungs. (For a description of which see the explanation of the plate.) But in order to produce this effect, it is necessary that the valve hole of the bellows be closed by the instrument (Fig. 5.) by which means all the air employed must pass through the small aperture (d in fig. 4.) Hence the operation of inflating and collapsing the lungs necessarily becomes a slow and tedious process, and which may be considered as an imperfection in this instrument, particularly if the bellows to which it may happen to be fixed be not air-tight, in which case the external air will find a ready entrance, and its intention as an air-pump will be defeated.

If dephlogisticated air were at hand, there can be no doubt but that it would be far preferable to any other for inflating the

the

the lungs; but to procure it in sufficient quantities at so critical a period is nearly impracticable, we must therefore make use of atmospheric air as pure as can be obtained.

If the jar be not charged to give the electrical shock, as soon as the lungs are expanded, no mischief or inconvenience ensues; for we need only suffer a small quantity of air to escape at the mouth after every inspiration, and immediately throw fresh in by the bellows; and this process is to be continued for about a minute; when, if the shock is not yet ready, we let go the mouth, and empty the lungs. The heart from this may have been irritated by the repeated inspirations, while the lungs have not been suffered to obstruct the free passage of the blood, and a fresh supply of air has been introduced to give

it

it the necessary change; so that if the heart has acted during this period, collapsing the lungs will now convey the blood they have received into the trunks of the pulmonary veins and left auricle. This process is therefore to be pursued where any circumstance prevents the shock of electricity being given as soon as the lungs are expanded, or where no electrical machine can be procured; but as the irritability of the heart cannot long be excited to action by the mere distention of the lungs, we think it of the highest importance that electricity should be employed.

It should however be remembered that every shock given to the heart during the collapsed state of the lungs, tends to rob it of its vital power, without promoting in the least the recovery; and let it

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also

also be repeated, that the lungs from the beginning are never to be suffered to remain collapsed for a single minute; as the heart may act at that very instant, and in this case without effect; for as every contraction is an expensive operation to the heart, if it has got rid of no portion of its burden, the utmost care should be taken that the lungs be expanded at every systole of the heart; and this can rarely happen from the usual method of inflating the lungs without at the same time stimulating the heart. When the heart has been once emptied, occasional shocks may be transmitted through other parts of the body (care always being taken that the heart partake of their influence, and that the lungs be expanded); for stimulating the extremities, may probably produce an action in the arterial system; but it should be ever in our eye that the heart is to be considered

considered as the origin of circulation, and whilst other parts of the body are electrified, care should be taken that the heart at the same time, partakes of the stimulus.

In order to compare the difference of the effects produced by electricity on the heart, when the lungs are collapsed, and those that result from it, when the lungs are in a state of expansion, the following experiment was made.

EXPERIMENT.

A Cat was strangled, and five minutes after the last expiration the chest was opened; the lungs were then alternately expanded and collapsed for five minutes, the heart acted rather powerfully, but no alteration could be observed in the blood of

its two sides; either as to quantity or quality.

The heart was now electrified by small shocks, during the existence of collapse, and this was continued for five minutes, when upon examination, it was observed that its action was evidently lessened; the left side rather more distended than before, but the blood was black in both auricles and ventricles.

The lungs were now expanded, and the heart at this instant electrified; after two shocks had been given, they were collapsed; again expanded and electrified; and this process was likewise continued five minutes. On examining the heart, both sides were now found less distended, their action quickened, and the blood in the pulmonary

monary veins, left auricle and ventricle completely florid.

The result of this experiment, not only proves the advantages of the stimulating power of electricity on the heart, beyond that of *simple inflation*; but also evinces the superiority of administering it in the distended, over the collapsed state of the lungs.

Whatever will excite the heart to expel its black blood, and supply the left side, and the whole arterial system with blood, that has imbibed its natural heat from the air, must be the means of cure, the most efficacious that can be employed; and this last experiment seems to confirm the opinion, that electrifying the heart during the expansion of the lungs, and then collap-

ing them, is the method the best calculated to produce this desired effect.

With respect to the electrical machine the more compact, and at the same time the more powerful it is, the better; for as the quantity, necessary to be applied, must be determined by the jar and electrometer, the more speedily it can be filled, the better. The size of the jar necessary for the purpose, should be about thirty inches of coated surface; and the electrometer placed a little more than one third of an inch from the jar, the distance of which may be gradually increased. It is better that the glass of the jar be thin, as the shock will then be pungent, for if the glass is thick, the stroke will be large and dense; and it appears probable, that the pungent stimulus would excite greater action in the heart than

than one that is dense, without being so liable to destroy its powers.

All that appears necessary in these cases, for the purpose of applying electricity is the cylinder, a conductor, jar, electrometer; wire and directors, in order to convey the shock to the particular parts we wish; and all these may be comprised in a box of twenty inches in length, and twelve in width; and as every medical man may have occasion to make use of electricity for other purposes, the expence will not be thrown away, even should he never meet with this most satisfactory employ of it, the attempting or perhaps the actual restoring of the apparently dead to life.

There appears no necessity for making use of the instrument invented by Dr. Goodwyn, for the purpose of extracting

water from the lungs, as those who have recovered from drowning, must all have taken in water, without its having produced any remarkable inconvenience ; and as the extracting it would take up a considerable time, we think it better as soon as possible to proceed to the distention of the lungs.

We shall now inquire into the effects produced by the application of warmth.

SECTION

2

S E C T I O N X.

Effects of Warmth.

IT has been the uniform opinion of those who have turned their attention and their pens to the subject of suspended respiration, from drowning, hanging, and suffocation; that the application of heat is absolutely necessary, and that it ought to be made with the most gradual, and nearly insensible increases. This idea seems to have been suggested, by attending to the good effects of warmth on torpid animals, and the manner that nature prescribed, was that of its being applied in the most gradual manner; for where the body has been frozen, a sudden application of heat
has

has been found destructive, whereas a less degree has proved beneficial.

It would be presumptuous to deny that these observations and precautions seemed well grounded. But it must however be confessed, that the detection of any strict similitude between the two diseases, would be attended with no small difficulty. In the one, the vital principle is attacked merely by a sedative power, in the other, it is endangered by a collapse of the lungs, which not only prevents the free passage of the blood, but at the same time deprives it of that due degree of heat, which it borrows from the air.

Dr. Goodwyn has particularly insisted on this gradual application of warmth, but his plan of treatment does not coincide with our opinion. He observes, "that to fa-

“ your the recovery most effectually, the
 “ application of heat should be conducted
 “ on the same plan nature has pointed out
 “ for torpid animals. It should be applied
 “ very gradually and uniformly, and it
 “ may be raised to 98, but not further
 “ than 100. When the body is warmed
 “ uniformly, and the heat of the interior
 “ parts about 98, we direct our attention
 “ to the state of the thorax, and if the
 “ patient make no attempt to inspire, we
 “ proceed to inflate the lungs.” Nor does
 this practice appear to be altogether in uni-
 son with the Doctor’s own theory on the
 nature of the disease, for external warmth
 can produce no chymical change on the
 blood; and as he asserts that the heart cannot
 act until a change has been produced, what
 great expectations can we form of its being
 attended with success. Moreover, this gra-
 dual application of heat must engross no
 inconsiderable

inconsiderable portion of time, already too precious, before the external heat can be much increased, and the action also of the muscles of respiration could rarely be restored before that of the heart.

We also are obliged to withhold our assent from Dr. Goodwyn's opinion, where he says, that whilst the circulation of the blood continues, the temperature of the body may be raised many degrees above the natural standard without inconvenience. To this assertion is opposed the result of Dr. Fordyce's experiments, which prove that upwards of two hundred degrees of external heat of Fahrenheit's scale could not raise the animal heat three degrees; and it may be a doubt, whether *internal* animal warmth can ever be raised to 98 or 100 by the application of external heat, in cases where *life is present*, but
where

where circulation and respiration are suspended. The warmth of the body in health may be decreased many degrees without much inconvenience; but never can be raised more than three or four above the natural standard, without producing pernicious effects; which, to guard us against, nature has prudently provided two powers of resisting heat, while she has given us only one of generating it. We however perfectly agree with Dr. Goodwyn, that warmth is essential, and that in its application it should neither be suddenly nor irregularly increased; but we can on no account deem it allowable, to wait for any *increase* of heat in the interior parts, before the lungs are inflated, as it seems impracticable to increase the *internal* heat, before this end is first accomplished, unless irritability be absolutely destroyed.

To regulate the application of this remedy, it does not appear necessary to ascertain the degree of heat on the external surface of the body, and of the rectum, since we can always judge of the warmth of the atmosphere within five or six degrees, and as water whilst in a fluid state must have its temperature nearly equal, we only have to be cautious that the warmth of the room be not at first much greater. But as it may be some satisfaction to the Surgeon to know the degree of heat remaining in the body, (since the greater the degree of heat, the greater must be the irritability;) it may not be improper or unsatisfactory to be furnished with a thermometer, and Mr. Hunter's seems the only one that is any way adapted to the purpose; since ascertaining the heat of any part of the body, except in canals, cannot be of the smallest utility.

A Ther-

A Thermometer seems also necessary for regulating the increase of heat, since our sensations are more likely to deceive us afterwards than at first; and it is of importance that the warmth be not very considerable: perhaps 70 degrees of Fahrenheit's scale, is as much as should ever be applied, since to support any degree above this produces a waste of strength, which on the contrary we should endeavour to obviate.

Warmth thus applied is certainly highly expedient, and its effects on the system are probably these, that the blood in drowning, &c. deprived of the greater part of the latent heat it imbibes from the air, becomes insufficient to stimulate the solids; but by the application of sensible heat to the surface of the body, the heat of the animal is prevented from
being

being so soon carried off; and thus in some measure supplies the place of that latent heat which naturally is absorbed by the blood; for although heat be absorbed from the air in a latent form, it is given out to the system in a sensible one. Let it not, however, be understood that warmth is to effect a cure of itself; for we have repeatedly mentioned that the collapse of the lungs has caused an obstruction to the passage of the blood; and before circulation can go on, this obstruction must be removed, and the blood furnished with its usual stimulus and change.

Various are the modes of applying heat to the body; warm bath, warm grains, &c. but these are means more easily directed than procured or put in execution; and there is only one advantage attending them, that of applying heat
more

more univerfally. Even this is counterbalanced by a greater objection, as it prevents us from having recourse to frictions, and permits fuch a length of time to elapfe before either warm bath, or grains can be procured.

The more advifeable method therefore may be, to place the patient on a mattréfs or bed at a proper diftance from the fire, where every other operation, that is thought proper, can be carried on at the fame time; and the readinefs with which warmth can be thus applied, muft certainly be a convenience.

We propofe next to enquire under what circumftances frictions may be ufeful.

R SECTION

SECTION XI.

Effects of Frictions.

IT is with great propriety Mr. Kite has limited the use of frictions; at the *commencement* of the curative operations they must be productive of infinite mischief: for the right side of the heart being already overloaded with blood, we are by the use of frictions increasing its quantity: and it scarce can be doubted but that this practice has contributed in many instances to frustrate the most successful treatment, by producing an over distention, and consequently indirect debility of the right side of the heart. With a view to ascertain by ex-

periment the effects of early frictions, the following one was made.

EXPERIMENT.

A Cat was strangled; and after it had ceased to breathe, the body and extremities were thoroughly rubbed for ten minutes, the chest was then opened. On examining the heart, the right side was found *fully* distended, and the left rather more so than usual, without any sign of action in either.

An opening was then made in the inferior cava, so as to let out a portion of blood; and the action of the right side of the heart was soon renewed.

This experiment was repeated, and it invariably resulted, that the more

the right side of the heart was distended, the weaker was its action, and that by letting out a quantity of its blood, the action was restored; and where no action was evident, during the distention, it was generally renewed by removing part of the blood from the heart.

It is however with friction as with electricity; if made use of at one time, it may tend to destroy life, and at another it may greatly assist in the recovery.

In our survey of the common effects of suspended respiration, it was observed that the aorta and arterial system contained a quantity of blood; this point being ascertained, and it being likewise known, that the action of the aorta and arterial system is suspended from a decrease of the due stimulus in the blood, and that the veins
have

have little or no contractile power of their own; when once the right side of the heart has been enabled to rid itself of a portion of its contents by the plan mentioned in the eighth section, we should then proceed to frictions, as a substitute to the natural action of the arteries in health, viz. that of propelling the blood onward, and producing a *vis a tergo* on the blood in the veins. The right side of the heart being thus in part emptied, is again pretty rapidly distended by the application of frictions, which should be continued as long as electricity is employed; but when from any cause we are prevented from electrifying, we should be sparing and cautious in the use of frictions, lest by over distention we destroy the action of the heart. From frictions made use of as a stimulant, little or no advantage can be expected.

The excoriations produced by the application of salt, brandy, volatile alkali, &c. must be exceedingly troublesome after recovery ; this objection however should have but little weight were any real advantage derived from their use ; but the application of stimuli to the eyes, noises to the ear, acrid liquors to the tongue and palate, sternutatories to the nostrils, scarifications to the skin, and the actual cautery, are not only horrid in the very idea, but must undoubtedly contribute to extinguish the little that remains of animal life, rather than to rouse or re-establish it into action ; for their effect on the nervous system must be similar to that of electricity when applied to the heart during the collapse of the lungs, viz. the destruction of irritability. The idea that suggested such applications must have arisen from supposing the animal powers to be only in a state of torpor, without

out considering that there existed a cause, without the removal of which all these attempts must not only prove fruitless and abortive, but even destructive to life much sooner, than if no remedy at all had been employed.

There appears to be an objection to the use of vitriolic acid with oil, or any application that produces an unknown and partial degree of heat. It may be preferable as a medium for friction, to make use of a little common oil or lard, which will rather prevent than occasion excoriations, at the same time that it answers every other purpose and intention; for the principal end to be obtained by frictions is by means of their mechanical action, and any medium that will facilitate this, appears preferable to those applications which stimulate and generate heat, for as much warmth as is deemed

requifite may be applied to the body by more certain and lefs difagreeable means. Nor fhould it be forgotten that the circulation even in health, is moft languid at the remote parts of the body ; confequently the frictions fhould be chiefly applied to the upper and lower extremities, and the body fhould be occasionally rubbed, where it does not interfere with the electric fhock,

We fhall next examine into the effects of Enemas,

SECTION

S E C T I O N XII.

Effects of Enemas.

AS tobacco thrown up the rectum in the form of smoke was one of the first remedies employed in suspended respiration, and as we see, to our great regret, that it is still too frequently made use of, we shall endeavour, by a few animadversions on its effects, to proscribe its continuance,

Mr. Kite, I believe was the first who reprobated the use of tobacco; and the arguments he adduces in support of his opinion are truly ingenious.

The

The history of medical errors, scarce affords an instance of a more blind and obstinate prejudice, than that which still induces us to adopt a mode of practice so obviously destructive. It is actually exhibiting a poison, that acts as most other vegetable poisons do, by producing such an extreme degree of debility as no powers of life can support ; and there can be scarce any rashness in affirming that such quantities of tobacco have been administered in this disease in the form of smoke, as would have exhausted the vigour of a healthy horse. And indeed can there be any thing more evidently improper than such a practice ? We might with as much propriety recommend tobacco in syncope, or in a typhus fever, as in suspended respiration from drowning, &c. nor can there be the least doubt entertained of
the

the effects it would produce in either of these diseases.

When we consider the effect that a drachm of tobacco in infusion has upon the system, when given solely to produce a temporary debility in hernia, &c. one would scarcely credit that any person acquainted with this effect, could even think of administering eight or perhaps twelve times this quantity, when the powers of life are reduced to their lowest ebb. It is really an indelible stigma on the profession, that while we cannot but observe the deleterious tendency, even of a small quantity of it, on one disease where we wish to reduce the strength; we nevertheless employ it by wholesale in another, where scarce a spark of life remains unextinguished; with headstrong inattention we
 have

have persevered in its use, without ever asking ourselves this necessary question—What are we rationally to expect from such a remedy? This, indeed, is quackery in the highest degree.

When examining the effects of medicines thrown into the stomach after respiration had ceased, it was found that their action was far less powerful than when administered in full health; and it is a fortunate circumstance indeed, that their operations are regulated by such a law; for if medicines produced the same effect in this disease as during the unimpaired vigour of the natural functions, it may without hesitation be declared, that no one could ever have been recovered where tobacco had been employed in quantities equal to what has been recommended. Tobacco injected
into

into the stomach will of course produce more violent effects than when thrown up the rectum; but when the quantity employed is perhaps equal to two ounces, the effects must be as violent, if not more so, than a sixteenth part injected into the stomach.

In order more accurately to determine the effects of tobacco enemas, the following experiment was made.

EXPERIMENT.

A full grown cat was drowned, and the chest being immediately opened, the heart was observed to act strongly; six drachms of tobacco were thrown up the rectum in the form of smoke, but before the herb was half consumed, there remained scarcely

any action in the heart; and after the whole had been injected, all action ceased to be visible, (without applying the stimulus of electricity.) Mr. Kite has substituted in the place of tobacco, some aromatic herb; if we are to make use of glisters at all, this were certainly preferable, but what great advantages are to be expected from them, is no easy matter to discover.

If the disease is not removed by the means before laid down, we may with as much confidence expect a recovery from injecting a little warm milk and water into the stomach, as from the injection of enemmas of any kind.

It should also be remembered that enemmas ought to be small in bulk, in order to render them innoxious; for smoke and fluids of all kinds, when given in large quantities,

quantities, will distend the intestines ; the result of which will be, that their mechanical effect in preventing the easy descent of the diaphragm, will necessarily be productive of mischief. Warm enemata may have the salutary effect of slightly stimulating the intestines ; and the heart also from sympathy, may possibly have its action in some small degree increased, but if tobacco be employed, the opposite effect must arise, and as sympathy is supposed to be greater between the heart and stomach, than between the heart and intestines, it were better to inject some warm aromatic, into that viscus, than into the rectum ; but inflation, electricity and frictions, ought by no means to be neglected to make room for so ineffectual a remedy.

Having examined the merits of the remedies usually employed in suspended respiration,

respiration, and recommended such as are countenanced by enquiry and experience, it may not be deemed unnecessary to subjoin an account of the method of conducting the treatment.

SECTION

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SECTION XIII.

Method of Cure.

THE plan of treatment generally to be pursued has been laid down somewhat at large in separate sections, but it may not be unsatisfactory to the practitioner, in these cases, to see the whole contracted into an abridged form, and placed in a nearer and closer point of view.

As a few minutes in this disease make a material difference as to the probability of recovery, we think it of sufficient importance to remark, that the electrical machine and the apparatus for artificial respiration, should be kept always at hand, and in readiness.

As soon as we have seen the body, we should request that no more spectators would be present than are absolutely necessary; which we conceive may be eight or nine in all, including the Medical Assistants; two to have the direction of the chest, one to turn the electrical machine, one to direct the shock, four to apply the frictions, and the other to assist occasionally. This number will be sufficient for answering every purpose, and a greater would rather embarrass, and only contribute to phlogisticate and render the air less fit for respiration.

The body, if wet, should be gently dried with cloths, but in such a cautious manner, as to prevent the mechanical effect of the friction from propelling the blood towards the heart.

Having

Having prepared the bed, or mattrafs, on a table of convenient height, the body is to be placed on it with the head a little elevated. Five or six ounces of brandy, rum, or some other warm aromatic should be thrown into the stomach, by means of the vegetable bottle and pipe; and the ivory director passed to the farther part of the mouth, so as to close the superior aperture of the œsophagus.

If the patient seems plethoric, and more particularly if the disease has been occasioned by hanging; bleeding should be employed, and that as one of the first remedies; nor should the application of a proper degree of warmth be neglected.

The curved pipe being then introduced into the trachea, and secured by an assistant, and the flexible tube, &c. being at-

tached, the lungs ought as soon as possible to be inflated ; and the electrical machine being prepared, one director is to be applied between the fourth and fifth rib of the left side, and the other between the second and third of the right ; when the electrometer is to be placed a little more than one third of an inch from the jar, and the stroke given. The electrical shock is to be repeated once or twice, and the assistant, who prevented the air from escaping by the nostrils and mouth, then should remove his hands, and press the chest, and immediately after expand the lungs, for the heart to be again stimulated.

If any impediment should prevent the introduction of the pipe down the trachea, bronchotomy should be directly performed, in the manner described in Section the ninth,

ninth, and the curved pipe inserted into the trachea at this aperture.

When the lungs have been three or four times expanded and collapsed, frictions are to be had recourse to; these, together with the process of expanding the lungs, and at the same time electrifying the heart, and then again collapsing them, are to be continued four hours without intermission, unless natural respiration be restored.

In some cases where the living powers are remarkably languid, it may be adviseable to continue the use of electricity, and gentle frictions, even after respiration is renewed, as there have been instances of momentary and transient recoveries: the ill success of which may be conceived to arise either from the heart not possessing sufficient irritability to carry

on the circulation, or from want of a supply of blood to the right side of the heart after it has been once emptied. Both these obstacles may be removed by assisting the heart and arteries to perform their respective functions, after the muscles of respiration have been stimulated to action.

If unfortunately no electrical machine be in readiness, or at hand, the method of performing artificial respiration should be altered. When the lungs are expanded, the assistant, who has the charge of the mouth and nostrils, suffers a small quantity of air to escape, while the other assistant continues to throw in a fresh supply : this process should be protracted for about a minute, when the hand is to be removed from the mouth, and the chest pressed, to complete the collapse. It cannot be too frequently inculcated,

culated, that the lungs are never to be suffered to *remain* collapsed; for all our endeavours and attempts to effect a recovery, should the lungs be permitted to continue in that state, must ultimately prove fruitless and ineffectual.

We cannot better conclude the present dissertation, than by briefly recapitulating the principles and observations which form its basis and support.

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CONCLUSION.

FROM what has been observed it appears,

1. That during the act of drowning the animal emits air from its lungs, and in its attempt to inspire, a small quantity of water enters the lungs and stomach.

2. That, after the last expiration, the lungs are found nearly collapsed, containing a small quantity of froth, but very little air,

3. That the quantity of blood found in the right side, is nearly double that contained in the left.

4. That

4. That the blood contained in both sides of the heart is of the colour of venous blood.

5. That, whether the heart be examined during its contractions, or after they have ceased, no perceptible difference is found in the proportions.

6. That the action of the heart survives the peristaltic motion of the bowels.

7. That the vessels of the head exhibit no extravasation, nor even distention.

8. That where respiration is suspended, from ordinary hanging, the animal has the power of expelling air from its lungs.

9. That

9. That although the muscles of expiration perform their office, no power can be applied to open the trachea to admit air.

10. That as no air can be received, the animal dies with the same collapse of the lungs from hanging as from drowning.

11. That the quantity of blood in the two sides of the heart bears nearly the same proportion in hanging as in drowning.

12. That there is very little difference in the continuance of the irritability of animals after hanging from its continuance after drowning ; but the vessels of the head are somewhat distended in the former.

13. That animals immersed in impure air do not appear to make a full inspiration,
tion,

tion, but like animals immersed in water reject it, as soon as a sensation is produced in the trachea, which seems to make them conscious of not being in their usual element.

14. That the muscles of expiration continue to act till they have expelled all the air from the lungs, which they have the power of acting on.

15. That the same collapse of the lungs is produced from suffocation, as from drowning or hanging; and the contents of the right side of the heart bear nearly the same proportion to those of the left.

16. That animals destroyed in impure air are sooner deprived of their irritability than when respiration is suspended from drowning or hanging.

17. That

17. That animals destroyed by nitrous air soon grow stiff and inflexible, sometimes even before the heart has ceased to vibrate.

18. That the vessels of the head contain less blood after suffocation from impure air, than after hanging.

19. That in *ordinary* respiration and circulation, the lungs are passive.

20. That the principal advantage derived from respiration, is that of its being the source of animal heat; and this heat, by being evolved in a sensible form, keeps up the irritability of the whole animal.

21. That the blood imbibes less or more latent heat, in proportion to the degree of sensible warmth applied to the surface of the body.

22. That although the temperature of the florid blood in the left side of the heart be at first lower than that of the right; yet its sensible heat soon becomes greatest.

23. That this circumstance favours the idea of heat being absorbed from the air in the act of respiration.

24. That as soon as the blood has undergone the change in the lungs, it is rendered fit to support the heat and irritability of the animal.

25. That heat is not only evolved from the blood as it passes through the capillaries, but that the same process continues throughout the whole circulation.

26. That the stimulus which excites the heart to act, is the same in all its cavities; and this principally is distention.

27. That

27. That in the foetus both sides of the heart act from the stimulus of black blood.

28. That the intent of the foetal and adult change is the same, viz. that of supporting animal heat and irritability.

29. That this change is effected in the foetus, by the blood passing through the cells of the placenta, and the vessels coming in contract with the maternal arterial blood.

30. That so much phlogiston * is imparted to the maternal from the foetal blood, and *only* so much latent heat

* It should have been remarked before, that, whether the doctrine of phlogiston be established or not, the theory of animal heat being derived from respiration, may still be supported, as every phenomenon respecting this doctrine can be equally well explained without employing the term phlogiston.

evolved

evolved from the maternal to the foetal, as is necessary to restore the equilibrium of heat and phlogiston.

31. That as the foetus is surrounded by the warm medium of the liquor amnii and mother, very little heat can be consumed, and therefore an absorption of heat equal to that of the adult is not necessary.

32. That the foetus only possesses one power of resisting heat, and as the heat to be imbibed by the foetal blood is always limited, and as it is always surrounded by an uniform degree of temperature, the foetus stands in no need of the power of resisting heat, or generating cold by evaporation.

33. That the foetal heart contains only a small portion of blood that has been to the
placenta ;

placenta; and as this blood can receive only a partial change, and as even the greater part of that same blood must first pass through the capillaries before it arrives at the left auricle and ventricle; moreover, as that which does not pass through capillaries mixes with venous blood, it follows that the left side of the foetal heart contracts from the stimulus of black blood.

34. That as all the blood which passes through the lungs must enter the left auricle, the latent heat of the foetal blood in the right side must exceed that of the left.

35. That the blood in the umbilical arteries which is to receive the change, being of the same quality with that in the left side of the heart, is an additional proof that this blood must be black.

36. That

36. That although the blood in the foetal heart and arteries be black, yet, like the blood of the adult in the right side of the heart and pulmonary artery, it must still possess a portion of latent heat, which it continues to evolve, in order to keep up the temperature and irritability of the whole animal.

37. That in suspended respiration from drowning, &c. the right side of the heart continues to act after the left has ceased.

38. That the reason of this difference is not that the left side of the heart is incapable of being stimulated by black blood; but from this blood being essentially different in quality from that of the right.

39. That this difference of quality in the blood of the left side of the heart

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depends

depends on its having passed through the lungs, and imparted to them a considerable portion of its heat, without receiving a supply from respiration; while the blood of the right possesses a quantity of heat in a latent form, which it still continues to evolve.

40. That as the blood in the right side of the heart, contains a portion of latent heat, while that of the left is exhausted; and as the sensible heat both of the right auricle and ventricle must consequently predominate, its irritability of course will likewise be greater.

41. That the stimulus of distention being greater in the one than in the other, will tend to produce a difference of action.

42. That

42. That as the right side of the heart possesses more irritability in this disease than the left; and as the stimulus of distention is also more powerful at the right side than at the left, it will be capable of continuing its action when no effect is produced on the other.

43. That although the heart may derive its heat in health, principally from the blood in the coronary vessels; yet the blood in the cavities of the heart will be also capable of evolving heat, and more especially when stagnation takes place in suspended respiration.

44. That if the right side of the heart possessed the blood of the left; and the left the blood of the right, the degree of irritability must be reversed.

45. That if the right side of the heart in suspended respiration, had the irritability of the left, and the left the irritability of the right, we should scarcely be able ever to effect a recovery.

46. That as soon as the action of the left side of the heart is increased by the stimulus of florid blood, the right also acts more powerfully.

47. That this depends on the coronary vessels being supplied with blood, that has received a quantity of heat from the air, and which these vessels distribute alike to the right, and the left side, and consequently give an equal increase to the irritability of both.

48. That the heat and irritability of the heart, being then the same, the stimulus

of distention will produce an equal action.

49. That the heart can be made to act after respiration has ceased, from the stimulus of electricity, while no action can be excited in the external parts from the same cause.

50. That as electricity is capable of producing action in the heart, when it has no effect on the exterior parts, and as life actually exists at this period. It would lead to most pernicious consequences to conclude that life was totally extinct, from no external action being produced by electricity.

51. That as the difference of irritability in animals of the same order, depends

more on the specific state of the solids, than on the quantity of heat evolved from the fluids, no decisive prognostic can be drawn of the presence of irritability, from the heat of the animal being above that of the atmosphere.

52. That as electricity has been found incapable of producing external action, when the heat of the animal was much above the temperature of the surrounding medium, it proves that animal heat and evident irritability are by no means coequal.

53. That although heat and irritability are not coequal, yet the greater the degree of heat, the more will be the irritability of any particular animal.

54. That as the heart is considered as the origin of circulation, there is a probability

bility of recovery, so long as the heart can be made to act; although external irritability may not be manifested by the test of electricity.

55. That it will ever be better to have no criterion to judge of the absence of life, and make use of every means of recovery, in every instance, than to rely on an imperfect and hazardous prognostic.

56. That when the lungs are inflated soon after the last expiration, both sides of the heart will immediately act.

57. That this probably proceeds from the irritability of the heart being still so great as to be stimulated to action by the mechanical irritation of the lungs, as in proportion to their expansion, will their surface press upon the two sides of the heart.

58. That

58. That in suspended respiration, from drowning, hanging, and suffocation, as the collapse of the lungs begins, the impediment to the passage of the blood through them commences.

59. That when the last expiration is made, the interior pulmonary vessels are collapsed, and contain but a small quantity of blood.

60. That if even a change be produced on the quality of this blood, the quantity is so small, that unless the right side of the heart be first excited to action, the motion of the lungs alone will be unable to propel this blood into the left.

61. That by inflating the lungs, we cannot alter the quality of the blood in the trunks

trunks of the pulmonary veins and left auricle,

62. That the right side of the heart can propel blood to the left, immediately after the last expiration, independant of the mechanical action of the lungs.

63. That as the heart can perform this function after respiration has ceased, it appears that the lungs have naturally no active power of propelling the blood onward,

64. That part of the black blood contained in the left auricle and ventricle in this disease, must be propelled through the system unaltered, whenever a recovery is effected, and as a quantity of blood of the same quality has already passed into the arterial system, it evidently follows that the
left

left auricle can and does act from the stimulus of black blood.

65. That as an animal when immersed in warm water, may be drowned with its blood somewhat florid, it necessarily furnishes an objection to the opinion, that the action of the left heart ceases from the presence of black blood.

66. That as in drowning, &c. the impetus of blood to the head is checked immediately after the obstruction to its return takes place, no injury whatever can happen to the brain.

67. That if apoplexy did actually take place, we should never be able to bring about recovery after respiration had once ceased, since we frequently fail of removing common apoplexy during the ex-

istence of respiration ; and in drowning, &c. we find no extravasation. That as no extravasation takes place in the head, if apoplexy were to exist, it should be solely attributed to the distention of the vessels.

68. That as mere distention is capable of bringing on only a very mild species of apoplexy, which does not for many hours, and sometimes for many days, produce its fatal effect; and as on the contrary, apparent death from drowning, hanging, and suffocation, takes place in a few minutes; it certainly follows that this disease and apoplexy are as essentially different as any two diseases to which the human body is exposed.

69. That the immediate cause of the suspension of circulation is not *the presence of black blood in the left side of the heart,*
neither

neither is it the *want of motion in the lungs*, but it arises from a *collapse of the pulmonary vessels, which produces a mechanical obstruction to the passage of the blood.*

70. That the proximate cause of the disease may be said to consist in a collapse of the lungs, producing a collapse of the pulmonary vessels, with want of latent heat in the blood, since unless both these be removed the disease will still continue.

71. That the mechanical obstruction from collapse must first be removed, before the chymical effects can take place.

72. That emetics in this disease are improper, before the circulation is re-established.

73. That

73. That even then they should only be exhibited where the stomach is known to have been overloaded previous to the accident that produces the disease.

74. That all medicines introduced into the stomach, produce a less effect after respiration has ceased, than during the healthy actions of the animal; and that in this disease, all that appears necessary to be done is to inject of some warm cordial, such as brandy, &c. into the stomach.

75. That as in suspended respiration, from hanging, there will sometimes be a plethora in the head, as well as in the right side of the heart, bleeding will then be more frequently necessary than after drowning and suffocation.

76. That

76. That the degree of plethora in the head will greatly depend on the weight and bulk of the subject.

77. That as in drowning and suffocation the right side of the heart only is in a state of plethora, and as this cannot be relieved, this operation should never be performed unless it appears that there is too much blood in the system for the solids to act upon.

78. That when bleeding is judged requisite, it should be performed on the jugular veins in preference to any other.

79. That when bleeding is deemed expedient, it should be one of the first remedies employed.

80. That

80. That shocks of electricity passed through the heart, brain, and spinal marrow, without the collapse of the lungs being at the same time removed, must tend rather to destroy than restore the principle of life.

81. That imitating natural respiration without frequently producing a collapse of the lungs is of little avail; for the distention of the pulmonary vessels occasioned by the action of the right side of the heart, will form nearly as great an obstruction to the passage of the blood, as if the collapse continued to exist.

82. That the uncertainty of success which has hitherto attended the cases reported by the Humane Society, has probably been in a great measure occasioned by the method that was adopted of conducting the artificial respiration.

83. That

83. That the advantages to be derived from artificial respiration, are to procure a contraction of the right side of the heart when the lungs are dilated, and by collapse to excite the left auricle to get rid of a portion of its contents, and supply it with blood that has renewed its stimulus from the air.

84. That in order thoroughly to accomplish this end, we are to expand the lungs, and when expanded, to stimulate the heart by a small shock of electricity; we are then to collapse them, and again to inflate.

85. That from this mode of proceeding, if any irritability remain in the heart, the right auricle and ventricle will be stimulated to act, and propel some of its blood into the lungs, where it meets with
a free

a free passage, and air to impart to it its due stimulus and heat; the blood thus duly changed, will, by means of the collapse, excite the left to get rid of its burden, and furnish it with a fresh supply endued with the proper stimulus.

86. That if no electrical apparatus be in readiness, we should then alter our method of artificial respiration.

87. That the lungs should be distended, and after allowing a small quantity of air to escape, the inspiration should be repeated; and this process of suffering, after each inflation, a little air to escape, (or, in other words, imitating natural respiration) should be continued about a minute, when we are to exhaust the lungs; so that there should be but one complete expiration here to several inspirations.

88. That the intention of this practice is, that as the heart may possibly not contract more than twice or thrice in a minute, the blood may find a free passage whenever it happens to act, and a fresh supply of air to produce on it the necessary change; and likewise that these several inspirations may act as stimuli to the heart, while the collapse helps to remove the blood the lungs have received.

89. That during the whole process of the treatment the lungs should never be suffered to remain in a collapsed state for a single minute.

90. That electricity should never be employed on any account without a concomitant expansion of the lungs.

91. That

91. That if the heart be excited to act during the collapse of the lungs, very little more blood can pass through them than passes in the foetal circulation, and even this small portion receives no benefit from the air.

92. That the application of warmth is necessary, and that when first applied should be about six degrees above that of the open atmosphere, if this be below 70 of Fahrenheit.

93. That we are on no account to wait for any increase of heat, before we inflate the lungs.

94. That placing the body on a mat-
trass or bed at a proper distance from
the fire, is the best mode of applying

warmth; as it neither embarrasses nor prevents any other process that may be found expedient.

95. That the principal advantage to be expected from the application of warmth, is to prevent so much sensible heat being evolved from the blood, and which thus in some measure may supply the defect of the latent heat that should have been absorbed from the air.

96. That frictions made use of as a primary remedy are highly improper, as they tend to destroy the action of the heart, by promoting an over distention.

97. That frictions should never be employed before the lungs have been several times expanded and collapsed.

98. That after the heart has been in part emptied, frictions are absolutely necessary.

99. That a little common oil or lard, as a medium for the frictions, is preferable to either salt or spirits, or any other stimulating substance.

100. That the principal effect to be expected from frictions, is their mechanical action in propelling blood towards the right side of the heart.

101. That tobacco in any form is highly pernicious, and were this medicine to produce such baneful effects in cases where respiration is suspended, as in a state of health; it is more than probable that no one could ever have been recovered where this remedy had been applied.

102. That enemata of any kind are only to be considered serviceable, in as much as they co-operate with more important remedies; and if employed at all, warm stimulating ones should be preferred.

103. That their bulk should be small, lest by their mechanical action they prevent the free descent of the diaphragm,

104. That inflating the lungs, electrifying the heart, collapsing the lungs, and the application of frictions, are to be continued four hours, if our endeavours be not previously crowned with success.

105. That electricity and frictions are to be continued even after respiration is restored, if the powers of life seem unequal to the task.

106. That

106. That the final intention of the whole plan of treatment, *is to imitate the natural circulation.*

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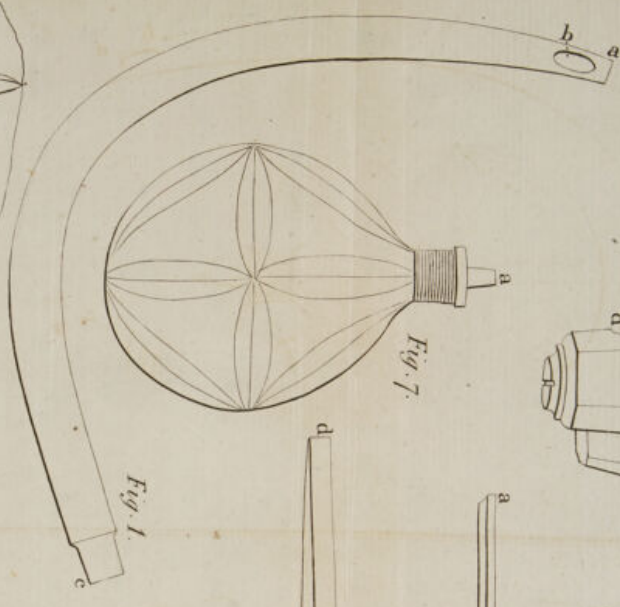
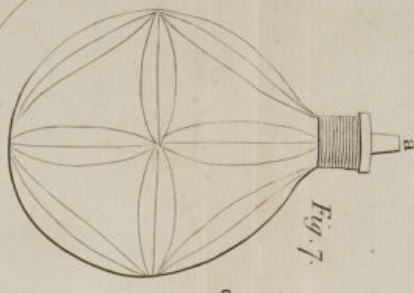
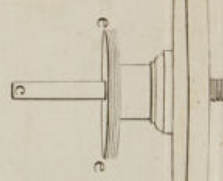
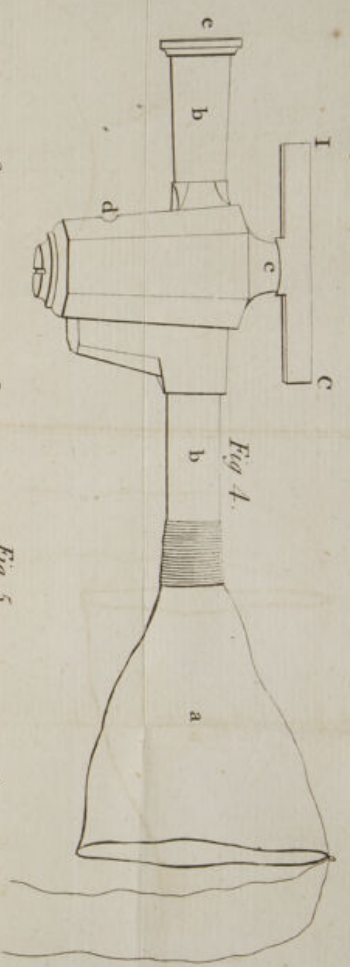
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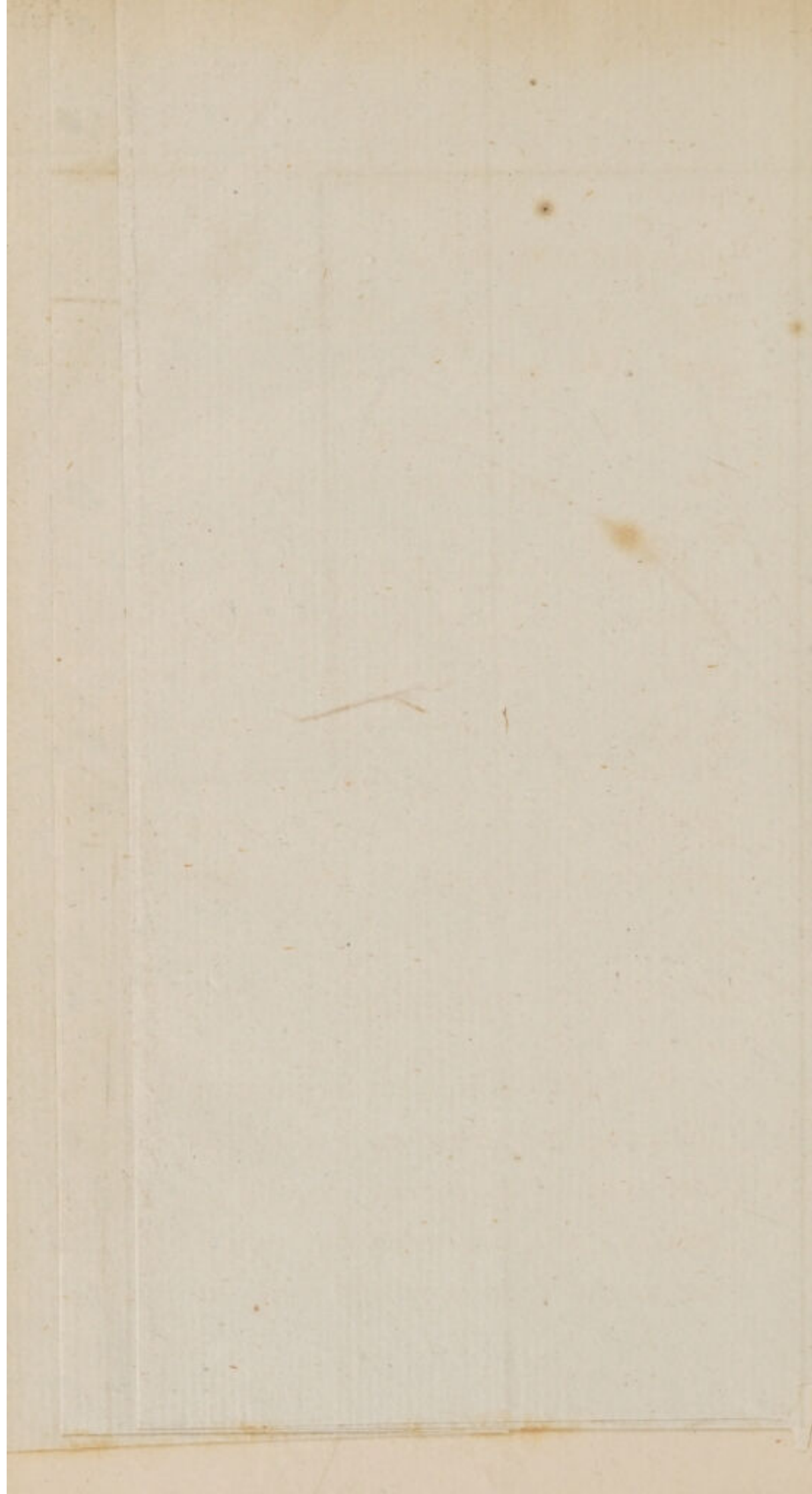
FIG. I.

A large silver conical pipe to be introduced into the trachea, either by the mouth, or by an opening made in the thyroid cartilage. A. the inferior extremity; B. two lateral openings for the passage of the air; C. the superior end of the pipe.

FIG. II.

A short flexible tube for conveying air into the lungs. A. the inferior extremity to be attached to the superior one of the silver pipe; B. the other extremity to be connected





connected with the contrivance (FIG. 3. at c.) or attached to Mr. Field's instrument (FIG. 4 at E.)

FIG. III.

Represents a short conical brass tube connected with a conical piece of leather, to receive the nozzle of any pair of bellows, and by means of packthread to retain it in its situation. A. the brass; B. the leather portion, c. a female screw to admit the superior extremity of the flexible tube.

FIG. IV.

Mr. Field's instrument for inflating and collapsing the lungs. A. is a conical leather tube to be attached to any pair of bellows; B B. is a brass tube; c. is a stopper to the cock in which there are two valves

valves opening in contrary directions; D. is an aperture through which all the air is to pass to and from the bellows, (the valve of the bellows being previously closed by another instrument represented in the next figure); E. the inferior extremity of the brass tube to be connected with the superior end of the flexible tube, (at B.) When the stopper stands as is here represented with I. (signifying inflation) pointing to the inferior extremity of the tube, the lungs will be expanded, and when the stopper is turned half round, so that C. (meaning collapse) will be placed in the same direction, the lungs will be exhausted. In the one instance by the action of the bellows, air is received at the aperture D. and thrown into the lungs, but prevented from regurgitating on account of the valve.

In the other, air will be received from the lungs into the bellows, and thrown out at the aperture D.

FIG. V.

Is the invention for closing the valve of any bellows. A A. is a piece of iron to be inserted into the valve-hole of any bellows, which being placed across, prevents its being drawn out. B. Is a pivot on which the iron part C C turns. D D. is a circular flat piece of wood, (lined with leather,) to cover the valve-hole, with an aperture in its centre, to admit the iron C C. through it. E E is a brass nut, which is made to screw on the iron C C, to retain the piece of wood in its situation.

FIG. VI.

A flexible tube (of the same composition as flexible catheters) to be introduced

duced into the œsophagus, for conveying spirits, &c. into the stomach. A. The bulb and inferior extremity. B. the superior. cc. is a conical piece of ivory, to be passed a small way down the œsophagus by the fore-finger, to prevent air escaping into the stomach, and as a guide for the introduction of the silver pipe into the glottis, when bronchotomy has not been performed.

F I G. VII.

Is a vegetable bottle, for injecting fluids into the stomach through the flexible tube. A. The mouth of the bottle to be attached to the extremity of the flexible tube at B.

F I N I S.

