An experimental enquiry into the effects of tonics, and other medicinal substances, on the cohesion of the animal fibre ... / Edited by Alexander Crawford.

AN

Experimental ENQUIRY

INTO

THE EFFECTS OF TONICS,

AND

OTHER MEDICINAL SUBSTANCES,

ON THE

COHESION

OF

THE ANIMAL FIBRE.

BY THE LATE

ADAIR CRAWFORD, M.D. F.R.S.

EDITED BY

ALEXANDER CRAWFORD, M.D.

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1816.

TO

THOMAS CRAWFORD, B.A. T.C.D.

AND TO

JOHN CRAWFORD,

NOW A STUDENT IN THE COLLEGE OF EDINBURGH.

At an early period of life, uncommon talents, aided by unwearied industry, procured your Father rank and a name in the philosophical world; whilst his inviolable regard to truth gained him the confidence of all who knew him; it was a striking feature in his character, that duplicity in every shape was the object of his abhorrence.

He had, with much labour, so disciplined his mind, that no gust of passion disturbed the uniform tranquillity of his deportment; this was the triumph of reason and principle over constitutional defect; for his temper was from nature extremely warm. In fact, a sense of moral and religious duty seemed so interwoven with his mental frame, that it gave a colouring

to all his opinions, and all his actions, from almost infancy to manhood, and from manhood till death. But you will observe, that although the spotless integrity of your father's life would, under any circumstances, have obtained him general approbation; yet it was the incessant zeal with which he prosecuted his philosophical researches that enabled him to develop some of the most striking phenomena of nature, that induced the first philosophical society in existence to stamp their approbation of his labour, by electing him one of their body; and made his scientific and experimental reasonings the object of much interest to the whole philosophical world.

To be descended from such a parent is an honourable distinction, which to you may be invaluable, if the example shall lead you steadily to emulate his virtues.

ALEXANDER CRAWFORD.

LISBURN,
16th Feb. 1816.

TO

MRS. ELIZA HAMILTON,

MOST EMINENTLY DISTINGUISHED FOR LITERARY TALENT AND PRIVATE VIRTUE.

Madam,

I could not reconcile it to my sense of duty, as Editor of this Treatise, and brother to its author, to allow it to pass into the world unmarked by any sense of that grateful feeling to which you and your excellent and respectable sister, Mrs. Blake, have so strong a claim from the nearest relations of the late Dr. Adair Crawford.

Your cares, so long and so assiduously employed in imbuing the minds of his infant daughters with wisdom, virtue, and knowledge, have not, I trust, been misapplied: it is my

hope and my belief, that their whole conduct through life will mark the hands that fostered them.

In the preceding address to my brother's sons, I have drawn a short sketch of his character; for though I am aware of the veneration in which they hold his memory, yet a public address of this kind, quite unexpected on their parts, must, I should think, in this way come more forcibly home to their hearts and understandings, than by any other in which counsel could be offered. They have before their eyes, clearly delineated, the effects of honourable exertion properly directed.

To you, Madam, whose near relationship and long intimacy with this excellent man gave you ample opportunity of appreciating his moral qualities and conduct, I appeal, whether I have, in the slightest degree exaggerated in the account I have given of him? Had he survived, he would have viewed your progress in life with exultation; his mind, congenial to

your own, would have beheld you with lively approbation, successfully devoting your life, and the rare qualities with which you have been endowed, almost exclusively to the improvement and happiness of your species.

The public has done you justice. To us, the remnant of your family who remain, you are the object of the most profound respect, and the most affectionate regard; for my part, I reflect with pride that our mothers were sisters.

I shall make no apology for this address, because it has been dictated by those feelings and dispositions, which it has been the business of your life to inculcate.

ALEXANDER CRAWFORD.

LISBURN,
16th Feb. 1816.

PREFACE.

It is upwards of twenty years since the following Treatise was prepared for the press by the author, but the publication of it was prevented by his death, which happened immediately after. It is unnecessary to trouble the public with all the reasons that have delayed the publication since, only for the last six years, the time it has been in my possession, a very infirm state of health prevented my attending to any serious pursuit. The copy from which this is printed is in my brother's hand writing, and however it may be received by those who are most interested in such investigations, I believe it will not be thought presumption to alledge that it bears marks of that industry, ingenuity, and just reasoning,

which, in the opinion of the philosophic world, distinguished the former writings of the author.

It is true, had the revolution which chemistry has undergone from the successful labours of so many ingenious men taken place during my brother's life time, it might have influenced his reasonings on the facts that occurred during the course of the investigation.

But these facts still remain; the remarkable changes produced on the animal fibre by the application of so many different substances still remain recorded to excite the attention, and stimulate the industry, of others to prosecute an investigation calculated to throw light on the operation of medicine as it affects the animal economy; and, perhaps, eventually to improve the art of medicine in the cure of diseases.

The premature death of the author, at the age of forty-two, alone interrupted his labours; for his zeal in the improvement of his profession could not be exceeded; it had taken such

exclusive possession of his mind, that neither private interest, nor a weakened constitution, could divert him from the pursuit: it was cause of regret to him, strongly and frequently repeated, that the method of reasoning by induction, which had contributed so much to the improvement of science in modern times, had been applied with so little success to medicine; and he considered this as a reason of the uncertainty that prevails in the practice of physic. He was persuaded that it was by faithful and accurate observation in the course of actual practice, joined to the legitimate method of reasoning from induction, adopted with zeal, and continued with perseverance, that the medical art could alone be finally brought to any thing like perfection.

The field before him was extensive and full of obstacles; yet, an enthusiast in science, he would have explored it with the whole energy of his mind: this was his resolution. The prism and other instruments had so much facilitated the progress of knowledge in the

doctrines of light and heat, that he thought it likely a path might be opened for experiments on the human body by the invention of instruments to determine the quality of the several secretions, the proportion which the various parts of the blood bear to one another, and the state of the fluids, in general, in respect to density, rarefaction, thinness, or viscosity.

In the house of his father, who was a clergyman, and the early instructor of all his children, he evinced a thirst for knowledge at a period when other boys think only of amusement; and from the time he became a man, his active mind was incessantly engaged in speculations, all tending to some important end. When I visited him a few years previous to his death, the functions of the nerves had engaged much of his contemplation. Upon one occasion my attention was particularly arrested, by some observations he made in the course of our conversation; he was convalescent after a severe fever. As I expressed a

wish, he permitted me to take notes, and even assisted me in committing to paper what had then struck me most; this was in the year 1791. And the following is a correct copy of those notes.

"The particles of bodies are placed in a "limit between their attracting and their re- "pelling powers. In solid bodies the attract- "ing powers are greater than the repelling; "in non-elastic bodies these powers are nearly "equal; in elastic fluids the repelling power "prevails. The element of fire is supposed "to be the repelling power; if this be admit- "ted, it follows, that in non-elastic fluids the "quantities of the attractive force are propor- "tional to the quantity of elementary fire. "In simple solids, the quantities of the at- "tractive force should be proportional to their "tenacities; the distances from the melting "point being equal. It seems probable that "this is the law, but the subject requires fur- "ther investigation; admitting it to be so, the "tenacities of the metals at equal distances

" from the melting point, should be propor-
" tional to the quantity of elementary fire
" which they contain; and we have reason to
" believe that this is really the case, for the
" order of the comparative heats of the me-
" tals is as follows: iron, copper, silver, gold,
" tin, lead; and this is very nearly the order of
" their tenacities. In elastic fluids, it is pro-
" bable that the quantity of the attractive
" forces is proportioned to the quantity of ele-
" mentary fire, the distances from the points
" of condensation being equal. And if fixed
" and pure air be equally distant from the
" points of condensation, their attractive forces
" will be proportioned to their comparative
" heats. Since, then, pure air parts with a
" portion of its elementary fire in the lungs, it
" must likewise part with a portion of its at-
" tractive force, and that this separation ac-
" tually takes place, seems probable, because
" pure air contains four times as much ele-
" mentary fire as fixed air; and if the attrac-
" tive forces were the same, the density of fixed

" air should be four times as great as that of
" pure air; but it is only one and a half
" times as great: and since a quantity of
" elementary fire, or the repelling force, is
" introduced into the blood in the lungs, the
" density of the arterial blood should be less
" than that of the venous; but the densities
" of these fluids are equal, and therefore it is
" probable that the absorption of elementary
" fire is accompanied with that of an equal
" portion of the attractive principle.—Does not
" the latter principle exist in two states, a fixed
" and a free state? in its fixed state is it not
" that which unites the particles of bodies to-
" gether? and in its free state is it not trans-
" mitted from the brain along the nerves into
" the muscles, being the medium of sense and
" muscular motion? is not that part of the
" attractive force which is absorbed in the
" lungs employed for the purpose of nutrition,
" and obtaining the cohesion of the fibres?
" and is not the remaining part secreted from

" the blood by the brain, for the purpose of " supplying the nerves?"

Much of what I have written may appear superfluous or irrelevant to the general reader, at the same time it may be useful, for it may possibly excite reflections in some philosophic mind, that in a future period may lead to very important results ; besides, I know that several of my brother's early friends yet survive, illustrious, as philosophers, and ornaments to the countries which gave them birth ; I believe they will look with affectionate veneration upon any memorial, however frail, which may bring to their recollection a man, who in early youth obtained their confidence and esteem, and who, pursuing the same honourable career with themselves, arrived at distinction by the zealous exercise of his intellectual powers.

A. C.

February 16, 1816.

AN

EXPERIMENTAL ENQUIRY,

&c. &c.

In the course of my experiments on the matter of Cancer, I observed, that when the fibres of animals were immersed in this poison, they became tender and flaccid; and that when they were exposed to it in contact with common air, they speedily putrified and lost their cohesion. It appeared that the diminution of cohesion, in this instance, principally arose from the action of a peculiar fluid, which I have termed animal hepatic air.

As this fluid abounds in nature, being found wherever the putrefaction of animal substances exists, it seemed not improbable that many of the morbid appearances in the human body

might be ascribed to its influence. For it is manifest, that whatever has a tendency to destroy the cohesion of the fibre, must, if not counteracted, eventually give rise to disease, or to death.

From these considerations, I was led, in the year 1791, to undertake a series of experiments for the purpose of determining the changes produced in the cohesion of the animal fibre, by the application of various substances, whether noxious or medicinal.

Before I enter more particularly into this subject it may be proper to premise the following definitions.

By the term *cohesion*, I mean to express, not only the power inherent in bodies which resists the disunion of their particles, but likewise that which prevents the particles from changing their relative positions, and from yielding to such forces as have a tendency to separate them to a greater distance from each other.

Hence it will appear, that under the cohesion of the fibre I comprehend its firmness, elasticity, and strength; affixing to these terms the following significations.

By the firmness of the fibre, I mean to express the force with which it resists *impression*; by the elasticity, its power of resisting *extension*, and of restoring itself when the extending cause is removed; by its strength, the force which it is capable of exerting in opposition to such causes as tend to destroy the continuity of its parts.

The first of these properties is known by the touch; the second, by the comparative extensions which the fibres undergo, when they are stretched by equal small weights; and the third, or the *strength* of the fibre, is known by the weight which is required to break it.

In the course of the following enquiry, it will be shown that there are many substances in nature, which have the power of variously increasing or diminishing the firmness, elasticity, and strength of the fibres, in living and in dead animals.

Those substances which diminish the firmness and elasticity of the fibre, I shall call relaxants; those which increase its elasticity, tonics; and those which increase its strength, corroborants.

It is proper to observe, that in the living

animal the tone of the fibre is a compound effect. It depends not only on the elasticity of the simple solid, but likewise, as my learned colleague, Dr. Fordyce, has justly observed, upon the energy of the vital principle; in consequence of which, the approximation of the particles during life is greater than that which would be produced by their elasticity alone. The tendency to approximation which they derive from this cause may, I think, properly be expressed by the term *contractility*. And hence, in the living animal, those substances must be considered as tonics, which increase the contractility, as well as the elastic force of the fibre.

Although it might seem that the elasticity and strength of a fibre should bear some proportion to its firmness, yet it does not appear that any invariable connexion takes place between these properties in nature. We know, that in many cases great strength is united with much softness. Pure gold, for example, is nearly as soft as tin, but its strength, bulk for bulk, is equal to that of iron.

Agreeably to this it will appear, from the following experiments, that there are various

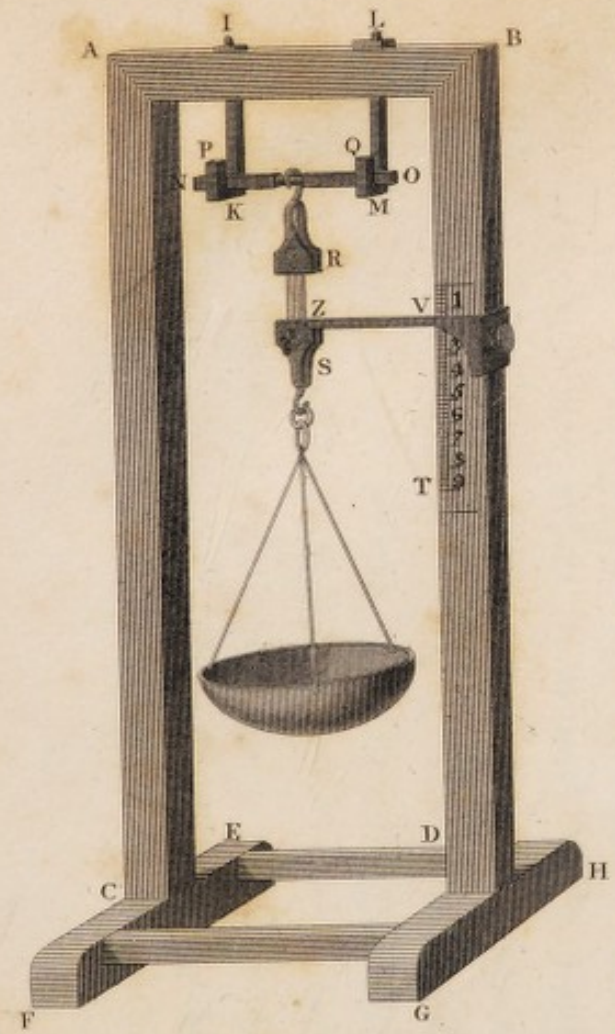


Fig. 1.

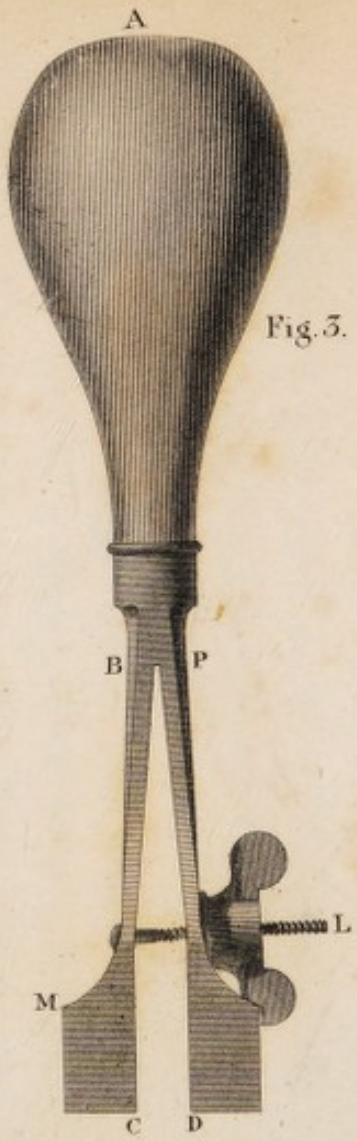


Fig. 3.

Fig. 2.

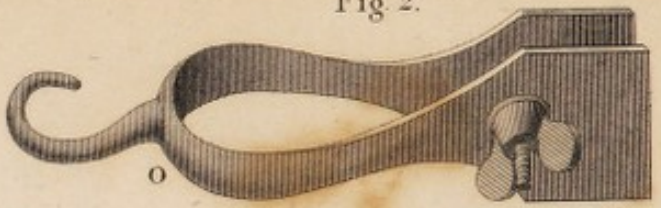


Fig. 4.

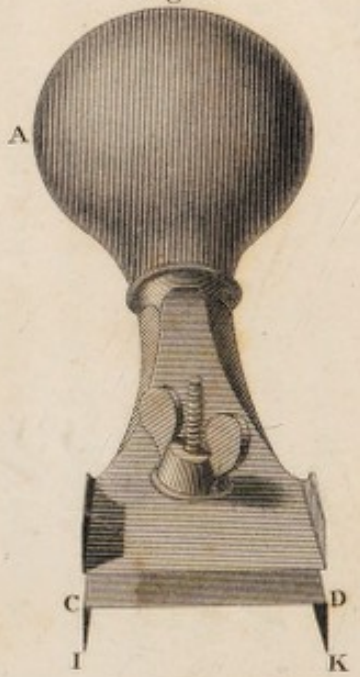
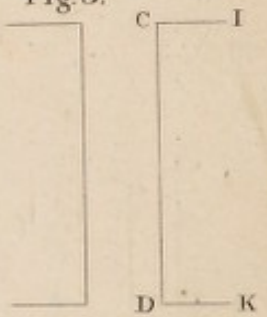


Fig. 5.



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substances which soften the animal fibre, and, at the same time, increase its strength: and instances will likewise occur, in which the rigidity of the fibre is increased, whilst its elasticity and strength are diminished.

Having premised these definitions and remarks, I shall now proceed to state the result of the experiments which I have made, to determine the effects produced by some of the principal medicinal substances upon the cohesion of the animal fibre.

The apparatus with which these experiments were made, is delineated in figures 1 and 2, which I shall briefly explain.

A, B, C, D, (Fig. 1.) represents a wooden frame, supported by the pedestal E, F, G, H. To the upper bar A B, the two iron bars I K, L M, are fixed by screws. These having descended about six inches, are bent forward at right angles. Passing horizontally in this direction about an inch, they are again bent upwards, and, having ascended an inch and a half, they terminate in the points Q and P. In the grooves formed by these curvatures, is lodged the iron bar N O, the middle of which is cylindrical, and supports the spring vice R, contrived for the purpose of grasping the

upper extremity of the fibre, that is to be the subject of an experiment. This vice consists of a hook, (by means of which it rests upon the middle of the bar N O,) and of two springs, which form an arch at the point O, (see fig. 2) where they are welded to the hook and to each other. The springs being separated to a little distance, are carried downwards about three inches. They are oval above, and flattened at their lower extremities, where they are extended to about an inch in breadth, for the purpose of grasping fibres of different dimensions. Through the upper part of the portions that are thus flattened, passes a screw, by means of which, the springs may be made to approach to each other, and to take a fast hold of the fibre that is interposed between them. To prevent the fibre from slipping, the inner surfaces of the flattened extremities of the springs are serrated; and, in order that they may not destroy the cohesion of the fibre, when they are made to press strongly upon it, they are covered with soft pieces of leather. The lower extremity of the fibre is caught by a similar hand vice S, (see fig. 1,) and to the hook which terminates this vice is fixed a scale, for the purpose of receiving the

weights that are employed to determine the elasticity and strength of the fibre.

A little above the middle of the upright bar B D, is placed the scale T V, by means of which, the extensions that are given to the fibre, by different weights, may be known. This scale is nine inches in length, and is divided into decimals of an inch, each decimal being moreover subdivided into four equal parts. When it is proposed to determine the increase produced in the length of a fibre, by means of this part of the apparatus, the hand vices described above are fixed to the extremities of the fibre, and the superior vice being hooked upon the bar P Q, the moveable index V Z, is made accurately to point to a mark in the lower vice. The degree of the scale T V, which it crosses, is then noted down; and the proposed weight being applied as soon as the extension of the fibre becomes stationary, the index is made to descend until it again points to the above-mentioned mark. Hence the increase in the length of the fibre will be accurately known.

It is plain, that by means of the same scale and moveable index, we can discover the di-

minution that takes place in the length of the fibre, when the weight is removed.

As I was in many cases desirous of trying the effects of different substances upon portions of the skin, as well as of other membranous parts of the animal body, it was necessary that these portions should be taken as nearly equal as possible. Two sections of an instrument which I contrived for this purpose are seen in figures 3 and 4. This instrument is a kind of double knife, having two blades M C, D O, terminating in the shanks Q B, O P, which are joined together at an acute angle, and are inserted in the handle A B.

The male screw L O, is fixed in the blade M C, and passes through a female screw in the blade O D. It is plain, that by this means the blades may be made to approach to, or recede from, each other at pleasure.

A front view of the instrument is represented in fig. 4. The blade is composed of a thin plate of steel, the central part of which is about an inch in breadth, and lies in a plane parallel to a corresponding portion of the other blades. At the point C, on the left side, the plate is bent forward at right

angles, and extending in this direction about a quarter of an inch, it terminates in the point I, (see fig. 5.) On the right side it is bent in a similar manner, and extends forwards to the same distance, the bent portion being represented by the line D K.

The edge I, C, D, K, (fig. 4,) is ground very sharp, for the purpose of making incision into those parts of the skin or membrane to which it is applied.

The other blade is formed exactly in the same manner; excepting that the portions which are bent extend in a direction opposite to the corresponding portions of the blade that has been now described. (See fig. 4 and 5.)

When this instrument is forcibly pressed upon a slip of the skin of an animal, it will cut the latter in such a manner, that a part of it shall be left equal in breadth to the distance between the parallel surfaces of the blades. A view of the section which it makes is seen in fig. 5.

I shall now proceed to relate the experiments which I made for the purpose of determining the effects produced by medicinal substances upon the animal fibre.

CHAP. I.

Of the Effects produced by Vinous and Spirituous Liquors.

Experiment I.

With a view to determine the changes which the fibre might undergo by exposing it to the action of Port wine, six portions of the small intestines of a kitten were taken, each of which was 2¼ inches in length. Three of these were introduced into a phial, which was nearly filled with Port wine, and closed with a cork; and the remaining three were immersed in water, as a standard. Being placed in a cool situation during three days, the portions in contact with the wine were found to have greater firmness than those that were immersed in the water.

The sum of the weights required to break the former was . . 9lb. 0oz.

The sum of those required to break the latter . . . . 7lb. 4oz.

Each of the portions immersed in the wine being stretched by a weight of six ounces, the sum of the extensions was six degrees nearly. That of the standard, in similar circumstances, was twelve degrees.

It is proper to observe, that in preparing the intestine for these experiments, a portion of it was taken $4\frac{1}{2}$ inches in length. Having divided this portion into two equal parts, one of them was immersed in the wine, and the other in the water. In this way I proceeded until the six pieces were obtained; and thus I was enabled to determine the comparative strengths and extensibilities of portions perfectly contiguous to each other.

With a view to guard against error in trials of this nature, it is of importance, that the portions of the intestine should be as nearly as possible of the same length. For if two portions be taken, one of which is considerably longer than the other, the latter will require more weight to break it than the former. They should likewise have nearly the same degree of curvature. For a very curved portion of the intestine is more easily broken than a straight one.

The portion of the intestine submitted to the experiment should, moreover, be introduced into the spring vices in such a manner, that the weight shall bear equally upon all its parts. If attention be not paid to this circumstance, the curved side of the intestine, which was attached to the mesentery, being shorter than the opposite side, will first give way, after which the other parts will break in succession. To guard against this source of error, the curved intestine should be laid upon a plain surface, and its sides should be pressed flat, till they are brought into contact with each other. In this state it should be introduced obliquely into the spring vices, care being taken that it be not pulled straight, but that it be allowed, as much as possible, to retain its natural curvature. The vices should be made to grasp its extremities in such a manner, that they may hang in the same direction with a line which tends to the centre of the earth. By this means the weights will bear equally upon the several parts of the intestine, and the whole will give way nearly at the same moment.

If attention be paid to these circumstances,

and the trials be frequently repeated, results will be obtained that approach near to the truth. I may add, that the experiments made with portions of the small intestines next to the colon, are more accurate than those made with portions next to the stomach, because the former are less curved than the latter.

From the foregoing trials, it appears, that the firmness, elasticity, and strength of the intestines of a kitten are considerably increased by immersing them three days in Port wine. I have found, however, that a much less time than this is sufficient for the wine to produce its full effect. In several experiments a manifest increase of cohesion appeared to have taken place in less than an hour; and after ten hours have elapsed, I believe no farther augmentation is produced.

It may be proper to observe, that the preceding experiments were repeated more than twenty times, and that the results were not found to be materially different from those which have been stated above.

Experiment II.

Being desirous of trying the effects of Sherry wine, I took six portions of the small intestines of a kitten as before. Three of them were immersed during ten hours in Sherry, and three in water, as a standard.

The weights required to break the former were, to those required to break the latter, as 14 to 11 nearly.

The extensibilities were nearly as 8 to 12.

Hence it appears, that the strength of the intestine is somewhat more increased by immersing it in Sherry than in Port wine; but that the latter gives rather greater elasticity than the former.

I next made similar experiments upon the stomach of a cat. Portions of that organ were immersed some hours in wine, and corresponding portions, as nearly equal as possible, in water. The former were found, upon examination, to be considerably stronger and firmer than the latter.

It may be objected, that although the wine acted as a tonic and corroborant upon the

stomach of a dead animal, it would not produce the same effects upon that of a living one.

It must be admitted, that the changes which medicinal substances have a tendency to cause in the simple solids, may be modified in a great degree; and, perhaps, in some cases altogether counteracted by the principle of life. But there are many reasons which render it probable that, in this instance, the effects of the wine upon the living and dead fibre are not very dissimilar to each other. We know that Port wine produces a considerable constriction upon the tongue and palate; that when the stomach is much distended with food, a moderate quantity of wine gives it additional tone and vigour; and that it increases the general strength of the body.

The results therefore of the foregoing trials are not inconsistent with the known effects of wine upon the stomach of a living animal.

Being desirous, however, of determining this point with greater precision, I contrived the following experiments, which, I think, afford a direct proof that the tendency of wine to increase the cohesion of the fibres of

the stomach is not counteracted by the action of the vital principle.

Experiment III.

I took two kittens of the same litter, as nearly equal in bulk as possible. They were about a fortnight old. To one of them I gave two tea-spoonfuls of Port wine, mixed with an equal quantity of milk. To the other I gave as much pure milk. At the expiration of an hour they were drowned. The stomach of the kitten that had swallowed the wine was then separated from the duodenum and œsophagus; and an incision being made along the shortest line from the cardia to the pylorus, the coagulum of milk and wine was removed; the stomach was laid upon a flat piece of cork, and was divided longitudinally into two equal parts. These were then cut by the double knife in such a manner that each of the portions should be $\frac{3}{10}$ of an inch broad.

The sum of the weights required to break them was . . . . 24oz.

The same experiments being made with similar portions of the stomach of the other kitten,

The weights required to break them were . . . . . 19oz.

The sum of the extension of the former, when each of the pieces was stretched by a weight of six ounces, was $\frac{6}{10}$ of an inch.

The sum of the extension of the latter, when stretched by an equal weight, was . . . 1 inch.

The stomach that had been exposed to the action of the wine was much firmer to the touch than the other. It contained less gastric juice in a separate state, and it had acquired a faint red colour.

As this appeared to be an important experiment, I repeated it several times with great care, and obtained nearly similar results.

Experiment IV.

I next endeavoured to ascertain the effects produced by wine upon the skin.

For this purpose, having drowned a kitten,

and having separated the skin from it, I made an incision along the space contiguous to the spinal processes of the vertebræ. I then cut off from the adjacent sides corresponding slips of about $\frac{3}{4}$ of an inch in breadth, and $2\frac{1}{2}$ inches in length. These were laid upon a flat piece of cork, and were cut by the double knife described above. The distance between the blades was $\frac{2}{10}$ of an inch. This was therefore the breadth of the central parts of the portions of the skin which were the subject of the experiment.

It is plain, that the portions thus obtained, being equally distant from the spinal processes of the vertebræ, must possess equal cohesions. If attention be not paid to this circumstance, the result of the experiment will be liable to uncertainty; because that part of the skin of a kitten which is contiguous to the back is the strongest, and it gradually becomes weaker and thinner as you approach the belly.

In this manner I prepared six corresponding portions of the skin, three of which were immersed thirty-six hours in Port wine, and three in water as a standard.

The sum of the weights required to break the former was . . . 7½lb.

That of those required to break the latter . . . . . 25lb.

The portions immersed in the wine were softer to the touch, and much more extensible by given small weights than the standard.

I next made similar experiments with Sherry wine, and found that the cohesion of the skin of a kitten was greatly diminished by that fluid, in the course of three or four days.

Experiment V.

With a view to determine the effects produced by ardent spirits, three portions of the small intestines of a cat were immersed during eleven hours in brandy.

The sum of the weights required to break them was . . . . . 50¾lb.

The weights required to break three corresponding portions immersed in water were . . . 42lb.

The extensions of the former, by giving small weights, were to those of the latter as 25 to 37 nearly.

From similar experiments it appeared that the firmness, elasticity, and strength of portions of the small intestines of a kitten were increased by immersing them for a short space of time in rum.

It is somewhat remarkable, that if the intestine of a kitten be suffered to remain in the spirit much longer than three days, its strength gradually diminishes, as appears from the following experiments.

Experiment VI.

Three portions of the small intestine of a kitten were immersed nine days in brandy, and three similar portions were immersed two and a half days in water.

Sum of the weights required to break the former . . . . 7lb. 12oz.

Sum of those required to break the latter . . . . . 8lb. 12oz.

If the intestine immersed in water be kept at the temperature of about fifty, its strength is not sensibly impaired in two and a half, or three days; but after that period is elapsed, its cohesion will be gradually diminished by

putrefaction. This was the reason why in the last experiment the strength of the standard was determined, prior to that of the portions immersed in brandy.

Experiment VII.

Being desirous of learning the effects produced upon the stomach of a kitten by a considerable quantity of ardent spirit, I took two kittens of the same litter, one of which was drowned, and the other was killed by giving it a table spoonful of rum.

I was surprised to find, that in this instance the cohesions of their stomachs were very nearly equal. The stomach of the kitten which had swallowed the rum was much inflamed. It expired in less than a minute, and apparently with little pain.

Experiment VIII.

Three portions of the skin of a kitten being dipped three days in brandy, and corresponding portions being immersed in water as a standard, the strength of the former appeared

to be about one third less than that of the latter. The portions dipped in brandy were firmer to the touch, and less extensible by given small weights than the standard.

I have, moreover, made many trials with a view to discover the effects produced by vinous and spirituous liquors upon the cohesion of the blood vessels and nerves. But as I have not yet been able to obtain results that are perfectly satisfactory, I cannot venture at present to lay them before the public.

Remarks on the foregoing Experiments.

From the foregoing experiments it appears, in general, that the firmness, elasticity, and strength of the stomach and intestines of animals recently killed, are increased by immersing them, for a short space of time, in vinous and spirituous liquors; but that if ardent spirits continue to be applied for eight or ten days, the strength of the intestine is diminished.

It moreover appears, that the firmness, elasticity, and strength of the stomach of a living

kitten are increased by introducing into it wine, diluted with an equal quantity of milk. But if undiluted spirit of wine be given in such a quantity as to inflame the stomach, and to destroy the life of the animal, no augmentation of strength takes place.

Finally, it has been shown, that the cohesion of the skin of a dead kitten is greatly impaired by immersing it a few days in spirituous and vinous liquors.

Since, therefore, it is proved that wine increases the strength of the stomach in a living, as well as in a dead, animal; and since it is found that in a dead animal it diminishes the cohesion of the skin, is it not probable, that when it is mixed with the blood, and carried by the circulation to the surface, it will produce a similar effect upon the skin of a living animal?*

If this be admitted, it will, I apprehend, throw some light upon the mode of operation of wine, when it is employed as a medicine.

* From the experiments of Dr. Monro, it appears that alcohol and opium are capable of being taken up by the absorbents, and mixed with the blood.—*See Physical and Literary Essays.*

There is, I think, no doubt that vinous liquors principally act upon the nervous system. They appear, when taken in moderate quantity, to excite the energy of the brain, and to increase the activity of the vital principle. But, besides these effects, we learn from the preceding experiments, that wine augments the tone and vigour of the stomach, and at the same time relaxes and debilitates the skin. Does it not, by means of these properties, determine from the centre to the surface of the body? And, hence, does it not, when judiciously administered, assist in preventing morbid affections from falling upon parts which are essential to life, and conspire with the efforts of nature in throwing off what is injurious by the pores of the skin?

Although the preceding experiments may appear to throw some light upon the operation of wine, as a medicine, yet I am far from thinking, that they contribute, in any degree, to determine the question respecting the utility of this liquor as a common beverage. For, not to mention the tendency of wine to produce the phlogistic diathesis, we know that when it is taken into the stomach in consi-

derable quantity, it frequently runs into the acetous fermentation. And I have found that vinegar diminishes the cohesion of the stomach and intestines, as well as that of the skin, and of all the other parts of the animal body.

It appears from experiments, third and seventh, that when we give a large quantity of ardent spirit to a living kitten, the effects produced upon the cohesion of the stomach are very different from those which take place when we introduce a small quantity of wine, diluted with an equal weight of milk. For in the latter instance the cohesion is increased; in the former, the stomach is inflamed, but its cohesion does not sensibly deviate from the natural standard. And we know that in a dead animal pure spirit upon its first application to the stomach occasions a very considerable augmentation of strength.

These facts appear to lead to the following conclusions.

Vinous and spirituous liquors, introduced into the stomach of a living animal, have a direct tendency to stimulate the fibre, and increase its cohesion. When these liquors are

diluted to a certain degree, the increase of activity and of tone which they impart are such as can be sustained without injury. But when ardent spirit is given in considerable quantity to a young animal, it violently inflames the fibres of the stomach, and it would appear that the spirit does not possess the power of communicating an increase of cohesion to a part which is highly inflamed.

CHAP. II.

Of the Effects produced on the Simple Fibre by Narcotics.

THE first of the substances of this class which I examined, was Opium.

I began by endeavouring to determine the changes which that narcotic produces upon the cohesion of the intestines, and afterwards proceeded to try its effects upon the skin, the nerves, and the blood-vessels.

EXPERIMENT I.

Portions of the small intestines of a kitten, which was killed by drowning it, were prepared as before, and dipped about an hour in a thick mixture of powdered opium and water; corresponding portions were immersed in pure water, as a standard.

The weights required to break the former

were, to those required to break the latter, as 16.5 to 14.3.

The relative strengths, as determined by these experiments, were the mean result of twenty-four trials.

The portions that were exposed to the action of the opium were much softer than those that were immersed in the water.

Remarks.

It is well known that when an animal is killed under certain circumstances, it retains, for some time, a portion of the vital principle; in consequence of which, its muscles contract upon the application of stimulants. It is owing to the presence of this principle that the fibres become stiff when they begin to cool; for if the animal be killed in such a manner as entirely to destroy the vital principle, and deprive the muscles of the power of contraction, the stiffness does not appear. Hence we may account for the softness of the intestine in the preceding experiment. The opium deprived the fibre of the portion of the vital principle, which adhered to it

after the death of the animal. I was surprised, however, to find that the portions of the intestine exposed to the action of the opium were stronger than the standard.

It will appear, from subsequent experiments, that this effect might possibly have arisen from the bitterness of the opium. But it seemed, moreover, to be in some measure connected with the presence of the vital principle. For when the experiment was deferred until the fibre had lost its stiffness, which, in warm weather, generally happens about ten or twelve hours after the death of the animal, the augmentation of strength did not take place.

Experiment II.

Two portions of the skin of a kitten, $\frac{2}{10}$ of an inch broad, were dipped a day and a half in a thick mixture of opium and water, and two corresponding portions were dipped in pure water.

Sum of the weights required to break the former . . . 3lb. 4oz.

Sum of those required to break the latter 8lb. 4oz

The experiment being repeated in similar circumstances with the skin of a guinea-pig, the strength of the standard appeared to be at least four times as great as that of the portions exposed to the action of the opium. In all cases the opium was found to increase the softness of the skin, and to diminish its elasticity.

Experiment III.

A portion of the sciatic nerve of a kitten, being dipped a day and a half in a thick mixture of opium and water, broke with . . . . . 1lb. 8oz.

A similar portion, taken from the other thigh being dipped in water, broke with . . 2lb. 5oz.

The extension of the former, by a weight of six ounces, was to that of the latter as 75 to 50.

From the mean result of several trials, it appeared, that the natural strength of the nerve was, to that of the portion exposed to the action of the opium, as 2.5 to 1.25, or as 2 to 1.

Experiment IV.

The aorta of an ox was divided longitudinally, and portions being cut off $2\frac{1}{2}$ inches long, and $\frac{3}{10}$ of an inch broad, were exposed for three days to the action of opium. Similar portions were immersed in water, as a standard. The extensions of the former, by given small weights, appeared to me to be a little greater than those of the latter; but of this I am not quite certain. The strength of the vessel likewise seemed to be somewhat diminished by the opium, but the diminution was not considerable.

Remarks.

From the preceding experiments it appears that opium increases the cohesion of the intestines, and that it relaxes and debilitates the skin and the nerves.

Hence we learn the immediate effects which this medicine has a tendency to produce on the simple fibre of an animal deprived of life. There is no doubt that these effects will be

varied and modified by the action of the vital principle in a living animal; and it is of great importance, in the practice of medicine, to be enabled to foresee with precision how far the tendency of this narcotic, to strengthen or relax the solids, will be favoured or counteracted by the principle of life.

The following observations may, perhaps, throw some light upon this enquiry.

It is found by experience, that an increase in the strength of the stomach and intestines actually follows the exhibition of opium in many diseases. Thus, in dysenteric complaints it cannot be doubted, that the strength of the alimentary canal is reduced below the natural standard; and we know that it is frequently restored to a healthy state by the use of opium.

That the alimentary canal is debilitated in dysentery appears both from the nature of the discharge, and from the causes which give rise to the disease.

For the principal causes which give rise to dysenteric complaints, are large quantities of sharp vegetable acids, the effluvia of putrid substances, and the accumulation of fœtid

matters in the intestines from contagion, or from exposure to a cold and damp air in the autumnal season. Now I have found, by experiment, that these causes have a direct tendency to relax and debilitate the stomach and intestines.

It is moreover evident, that in such complaints the alimentary canal becomes unusually irritable, and it is proved by dissections that the large intestines are frequently affected with spasmodic constrictions.

Hence it follows that opium in small doses, after the stomach and bowels have been previously emptied, is directly calculated to counteract the disease; for it has a tendency to diminish the irritability of the canal, and to increase its strength. And agreeably to this it is found by experience, that after gentle evacuations have been premised, dysenteric complaints frequently yield to the exhibition of opium alone; but as opium can be given in small quantities only, it is sometimes necessary, when the debility is very great, to combine it with corroborants, which may be exhibited in larger doses, or which have the

power of strengthening the fibre in a higher degree.

I shall farther observe, that when proper evacuants are not premised, and large doses of opium are exhibited at an early period in dysentery, or diarrhœa, the flux sometimes suddenly ceases, and the stomach and bowels swell to an unusual size. May not this phenomenon be explained in the following manner?

In the ordinary state of health the tone of the stomach and intestines, assisted by the force of the abdominal muscles, and by the pressure of the atmosphere, are a balance for the distending power of the food and air contained in the alimentary canal.*

When powers are applied which weaken the fibres of the stomach and intestines, this alteration is for the most part accompanied with an

* The tone of the fibre in a living animal, as I before observed, depends not only on the elasticity of the simple solid, but likewise upon the energy of the vital principle. It is plain, therefore, that if the elasticity be diminished, while the nervous energy continues the same, or if the nervous energy be diminished, while the elasticity remains unaltered, the fibre will be relaxed.

increased irritability and contractility of the canal; and it is manifest that the unusual influx of the vital power which thus takes place, has a direct tendency, not only to expel what is noxious, but likewise to compensate for the diminished strength of the fibre. Now if a narcotic medicine be exhibited, which lessens the contractility of the canal, and does not increase the strength of the simple solid in a proportional degree, the balance will be destroyed. For in that case a large quantity of air will not only be generated by the retention of corrupted fœces, but, at the same time, the power of the canal to resist the expansive force of the fluid, thus generated, will be diminished. The stomach and bowels will therefore suddenly swell.

When the narcotic is exhibited in moderate quantity, and when it is combined with gentle evacuants, which at the same time possess the power of strengthening the fibre, the above mentioned disagreeable symptom does not take place.

From the foregoing properties of opium, we may, I think, form some judgment of the reasons why that medicine in certain cases

strengthens the stomach and intestines, and in others fails to produce that effect.

Thus it is well known, that if a temporary debility of the stomach be occasioned by over distension, in consequence of the introduction of a large quantity of indigestible food, the exhibition of a considerable dose of opium* will be improper, while the food remains on the stomach.

The reason seems to be, that the powers of nature are now exerted to the utmost, to carry on the process of digestion. And the additional strength which opium imparts to the simple fibre, is more than counterbalanced by the diminution which it produces in the energy of the vital principle. But if the stomach should remain in a very weak and irritable state, after the process of digestion is finished, a moderate dose of opium may then produce salutary effects.

Although in many diseases it is necessary that the stomach and bowels should be emptied previous to the exhibition of opium, yet there are some cases to which this rule cannot properly be applied.

* Young on opium.

In the iliac passion, for example, in which a spasmodic constriction is formed upon a part of the intestines, and the peristaltic motion is inverted, opium may be useful, both for removing the spasm, and enabling the stomach to retain cathartics. But although in this case it may properly precede evacuations, yet it cannot be given with safety soon after evacuations have been obtained. In a disease of this kind, I have known the most pernicious consequences to arise from the exhibition of ten drops of tincture of opium, after the bowels had begun to discharge their contents, and before they had been thoroughly emptied. The evacuations were suddenly suppressed, the pain and vomiting returned, inflammation took place, and the disease proved fatal.*

It has been remarked by Hippocrates, that

* It is proper to observe, that in inflammation of the bowels I have sometimes known opium given apparently with advantage in large doses, soon after evacuations had been obtained. In such cases its action was determined to the skin, and it occasioned profuse perspiration. But we cannot always be certain that it will produce this effect, and it seems much safer in that disease to relax the skin by tepid fomentations and the warm bath.

if a patient be affected with colic pains, which are chiefly felt about the navel, and in the regions of the loins, and if these pains be not removed by evacuants, nor by any other of the remedies usually employed, they terminate in tympanites.

The disease to which Hippocrates refers in this instance, appears to be the spasmodic colic, which sometimes terminates in the tympanites, as I have observed in several instances, but which more generally degenerates into the iliac passion.

The mode in which these changes are accomplished may, probably, be explained in the following manner.

From the remote causes which give rise to the spasmodic colic, it is manifest, that in some varieties, at least, of this disease, the cohesion of the intestines is diminished below the standard of health. Thus it is well known, that the colic sometimes arises from the accumulation of acid in the stomach, and sometimes from the retention of fœtid matter in the intestines; and I have found by experiment that both these causes have a direct tendency to diminish the cohesion of the simple fibre.

We have, moreover, an additional proof that the cohesion of the fibre is diminished in such cases, because it is found that the disease is most effectually removed by corroborants.

If this be admitted, the observation of Hippocrates may, I think, be explained as follows.

I have already briefly pointed out the causes which, acting in opposition to each other, preserve the natural size of the bowels in the state of health. It is manifest, that the causes which oppose distention, are the cohesion of the simple fibre in the intestines, the peritoneum, the abdominal muscles, and the skin, and that these are assisted by the contractile power of the muscles of the abdomen, and of those of the intestinal tube.

It is, I believe, a very general law of the animal œconomy, that a weakness of the simple fibre is, at least for a time, accompanied with an unusual influx of the vital power into the part so affected; agreeably to this, it is found, that when the stomach and intestines are exposed to the action of powers which are known to relax and debilitate, the contractility and irritability of the canal are increased. And hence, although one of the causes which

oppose the distention of the tube is weakened, yet, as there is a proportional increase in the force of other causes, the bowels retain their natural size; but when the patient is much debilitated by evacuations, or by the progress of the disease; the increased influx of the vital power will, at length, cease, and the bowels will become distended.

Now it is found that this event is accelerated by the continued exhibition of large doses of opium; for although that medicine, when given in considerable quantity, may impart strength to the simple fibres of the intestines, yet it seems extremely probable, that the strength which it thus imparts is more than counterbalanced by the diminution which it produces in the energy of the vital principle.

If this view of the subject be well founded, it will follow, that the indications of cure are to remove the remote causes, and to give tone and strength to the intestinal tube.

The first of these objects is most effectually accomplished by regimen, and by gentle evacuants. The second by corroborants, by the warm bath, and by tepid fomentations applied to the abdomen. Among the class of corro-

borants, there are, perhaps, none more efficacious in such cases than camomile flowers and common salt.*

As to the warm bath and tepid fomentations, it may, perhaps, be objected that these remedies relax the skin. But I shall afterwards have occasion to show that a relaxation of the skin, within certain limits, for the most part, gives rise to an increase of tone and strength in the stomach and intestines.

With respect to the effects of opium upon the skin of a living animal, it is well known that small doses of this medicine will, sometimes, excite profuse perspiration, and at other times no perspiration can be excited by the largest dose that can be given with safety: in general we may observe, that it will more readily be determined to the skin if gentle laxatives be premised; for, as I before remarked, its efficacy as a tonic is increased by the previous use of laxatives, and, in many cases, an increase of tone in the stomach gives rise to a relaxation of the skin.

* Baglivi recommends rue and sal. gemmæ.—*Vide Bagliv. Opera. p.* 100.

We may add, that as the activity of the absorbents is promoted by emptying the bowels, the opium will, in this case, be more readily taken up by the lymphatics of the stomach, and carried by the circulation to the surface, where it will produce its proper effects as a relaxant.

There are cases, however, in which the previous use of laxatives will not be sufficient to determine the action of opium to the skin. The reason is obvious: it is necessary that various circumstances should concur, in order that a relaxation of the skin may take place. I shall have occasion to show, in a future publication, that in the animal body there is a certain degree of heat, which may be considered as the point of greatest relaxation; and that, in proportion as you recede from this point, both in the ascending and descending series, the relaxation becomes less and less, till, at length, constriction is produced.

It is plain, therefore, that opium will not act as a sudorific, unless the body be brought to that temperature which is favourable to the relaxation of the skin.

In like manner, in order to the relaxation

of the skin, it is necessary that the blood should circulate with a certain degree of force.

It is well known to every medical practitioner, that if the pulse be either very slow and feeble, or very strong and frequent, sweating does not readily take place. And hence, between these extremes, there must be an intermediate degree, both of force and frequency, which is most favourable to perspiration; it is therefore apparent, that the action of opium on the skin will, in some measure, be regulated by the state of the pulse.

This explains the reason why the power of opium, as a sudorific, is, in some instances, increased, and in others diminished, by the previous use of the lancet. For if the force and frequency of the pulse be such as to raise the momentum of the blood above that point which is most favourable to the relaxation of the skin, bleeding will reduce it to the proper standard, and will increase the efficacy of opium, as a sudorific. But the reverse of this will take place if the lancet be employed when the momentum of the blood is below the sweating point.

Hence, also, we may perceive the reason

why opium sometimes counteracts profuse perspirations. It is found, for example, to diminish the colliquative sweats which take place in pulmonary consumption. In such cases I have observed that it lessens the frequency of the pulse. Whence it is probable that it counteracts perspiration, by reducing the momentum of the blood below the standard which is favourable to the relaxation of the skin.

It has been proved, that opium has a tendency to relax and debilitate the nerves. Does not this account for the train of nervous symptoms which invariably arise when that medicine is exhibited in large doses, and is persevered in for a length of time?

I next examined the effects produced by Hemlock, Henbane, and Belladonna, upon the simple fibre.

The effects of hemlock were very similar to those of opium. It appeared, however, that the former produced a greater increase in the cohesion of the intestine, and a less diminution in that of the skin than the latter. For when the experiment was made by immersing portions of the small intestines of a cat in a thick mixture of extract of hemlock and water, and

corresponding portions in pure water, as a standard, the strength of the intestine appeared to be augmented by the hemlock nearly in the proportion of 15 to 12, which is somewhat greater than the augmentation of strength produced by the opium.

These experiments were made soon after the death of the animal. The time during which the intestine was exposed to the action of the hemlock was an hour and a half. The portions thus exposed were much softer than the standard.

It is proper to remark, that in the foregoing trials, as well as in those which were made with opium, the augmentation of strength did not take place when the experiment was deferred, till the vital principle had entirely escaped from the fibre.

The cohesion of the skin, as I before observed, was less diminished by the extract of hemlock than by opium. For the natural strength of portions of the skin of a guinea pig, was, to that of similar portions exposed a day and a half to the action of hemlock, as 3 to 1 nearly. But we have seen, that when the experiment was made with opium, the

strength of the standard was to that of portions of the skin, which were in contact with this medicine, nearly as 4 to 1.

Remarks.

If we may be allowed to infer from these experiments that hemlock and opium, judiciously administered, increase the strength of the stomach and intestines, and relax the skin in a living animal, we may conclude that the former possesses greater power as a corroborant, and less as a sudorific, than the latter.

It may be proper to add, that as hemlock does not act with so much force upon the nervous system as opium, it may be given in larger doses, and consequently may, in some instances, be employed with greater effect for the purpose of strengthening the stomach.

Agreeably to this, it has been found that hemlock has considerable power as a medicine in some cases of dyspepsia; and particularly in those which are accompanied with flatulency, pain of the stomach, a sense of heat, increased irritability, and costiveness.

With respect to henbane and belladonna,

it appeared, from a variety of trials, that the strength of the alimentary canal was not sensibly increased by these narcotics. It moreover appeared, that they acted with less force upon the skin than opium or hemlock.

I next endeavoured to determine the effects produced by Camphor upon the cohesion of the animal fibre.

With this intention, three portions of the small intestines of a kitten were dipped four days in a thick mixture of the powder of camphor and water, and three corresponding portions were immersed in pure water, as a standard. The latter being tried at the end of three days, the weights required to break them were as follows:

First portion broke with	8lb. 8oz.
Second	8lb. 0oz.
Third	8lb. 14oz.
	25lb. 6oz.

Weights required to break the portions immersed in the mixture of camphor and water.

First portion broke with	9lb. 14oz.
Second	9lb. 8oz.
Third	9lb. 14oz.
	29lb. 4oz.

The effects of camphor were next tried upon the skin, the blood-vessels, and nerves. It diminished the cohesion of the skin nearly one half. It sensibly increased the elasticity and strength of the blood-vessels, but it did not seem to produce any change whatever in the nerves.

CHAP. III.

Of the effects produced by Vegetable Bitters upon the Cohesion of the Simple Fibre.

1st.—Of GALLS.

The alterations which were caused by this substance in the cohesion of the intestines were determined as follows.

Experiment I.

Three portions of the small intestines of a kitten were immersed nine days in a thick mixture of powder of galls and water, and two similar portions were immersed two days in pure water, as a standard.

Weights required to break the portions dipped in the mixture.

First broke with . . .	10lb. 0oz.
Second	8lb. 0oz.
Third	7lb. 8oz.
	25lb. 8oz.

Weights required to break the standard.

First broke with . . .	7lb. 2oz.
Second broke with . .	6lb. 8oz.
	13lb. 10oz.

These experiments prove that the strength of the intestine of a dead animal is much increased by exposing it to the action of galls. From repeated trials it appeared, that the augmentation of strength was a little less than one fourth; for, the mean result of several experiments being taken, the weights required to break the portions immersed in the mixture, were, to those required to break the standard, as $11\frac{1}{2}$ to 9.

It also appeared that the extensions of the former were to those of the latter, when each of them was stretched by a weight of two pounds, as 3 to 5 nearly.

In the foregoing trials the portions of the intestine were kept in the mixture nine days;

not because so great a length of time was necessary to the success of the experiment, but because my affairs did not permit me to make it sooner.

I have found that a considerable augmentation of strength is produced by the galls, in the course of a few hours. But I have not yet determined with precision the time when this augmentation becomes the greatest possible.

It is proper to remark, that the portions of the intestine, in contact with the galls, had not become, in the slightest degree, putrid.

The following experiments were made with a view to determine the effects produced by galls upon the skin.

Experiment II.

Three portions of the skin of a kitten were dipped three days in a thick mixture of powdered galls and water, and three similar portions were dipped in pure water.

Weights required to break the portions immersed in the mixture.

First broke with . . .	15lb. 4oz.
Second	9lb. 0oz.
Third	8lb. 0oz.
	32lb. 4oz.

Weights required to break the standard.

First broke with . . .	6lb. 8oz.
Second	7lb. 4oz.
Third	6lb. 12oz.
	20lb. 8oz.

The portions immersed in the mixture were much firmer and less extensible by given small weights than the standard.

Hence it appears that galls increase the strength and elasticity of the skin, as well as those of the intestines.

The reader will perceive, that in the foregoing experiments the portions of the intestines and of the skin which were exposed to the action of the galls broke more unequally than the standard.

I have not as yet been able to discover with certainty the cause of this inequality; I have observed, however, that the strongest portions were those nearest to the surface of the

mixture; and hence it is extremely probable, that the difference of cohesion arose, in some degree, from the influence of the air.*

Being desirous of learning the effects produced by galls upon the stomach of a living animal, I took two kittens of the same litter. To one of them I gave about two grains of the powder of galls mixed with a tea-spoonful of milk, and repeated the dose three times in the course of an hour. To the other I gave as much pure milk. They were then drowned, and the stomach of the kitten that had swallowed the galls being prepared as described in Experiment III. Chap. I. two portions of it were taken, each of which was $\frac{3}{10}$ of an inch broad.

* In the process of tanning a chemical combination takes place between the astringent principle and the animal substance, and the latter, at the moment of its union with that principle, as Mr. Berthollet has observed, suffers a slight degree of combustion, which could not happen without the presence of pure air. Hence it is necessary, to the success of this process, that all the fatty particles should be previously extracted from the skins, in order that the astringent principle and the pure air may have free access to them: and for the same reason, the abovementioned ingenious chemist supposes that the process could not be conducted properly in close vessels.

The sum of the weights required to break them was . . . 1lb. 11oz.

The same experiment being made with similar portions of the stomach of the other kitten,

The weights required to break them were . . . . . 1lb. 6oz.

This experiment was repeated with the following result.

Two kittens of the same litter were taken as before. To one of them were given two grains of the powder of galls mixed with milk, and the dose was repeated thrice in the course of an hour. Two portions of the stomach of this kitten being prepared as in the preceding experiment,

The first broke with . . .	12oz.
Second	13oz.
Sum	25oz.

Having next examined the strengths of similar portions of the stomach of the other kitten,

First broke with	9oz.
Second	11oz.
Sum	20oz.

The extensibilities of the former were to

those of the latter, when each of the portions was stretched by a weight of $5\frac{3}{4}$ ounces, as 9 to 14.

I next endeavoured to determine the changes produced in the animal fibre by the Peruvian Bark.

Having examined the alterations which this substance caused in the small intestines of a kitten, at different periods, I found that the strength of the intestine was sensibly augmented by it in the course of two hours.

From the mean result of twelve trials, made with great care, it appeared that the strength of portions of the intestine immersed twenty-one hours in a thick mixture of powder of Peruvian bark and water, was to that of similar portions immered in pure water, as 25.5 to 20.7, which was an increase of nearly one fifth.

I have found, however, that a still greater augmentation of strength is produced when the intestine remains in contact with the bark during three days. For, in that case, the increase is nearly one fourth, as appears from the following trials.

Experiment III.

Three portions of the small intestines of a kitten were immersed three days in a thick mixture of Peruvian bark and water, and three similar portions in water, as a standard.

Weights required to break the portions exposed to the action of the bark . . . 7lb. 15oz.

Weights required to break the standard . . . . . 5lb. 6oz.

The experiment being repeated in similar circumstances, with the intestines of another kitten, the strengths of the portions in contact with the bark were, to those of the standard, as 11.75 to 9.7.

From the mean result of the twelve trials, it appears that the strengths are as 9.7 to 7.2, or as 4 to 3 nearly.

The extensions of the portions immersed in the mixture were to those of the standard, when each of them was stretched by a weight of eleven ounces, as 4 to 5.

The portions of the intestine that were in contact with the bark were somewhat firmer

than the standard. They had acquired the appearance of white silk, having a faint yellow tinge.

By similar experiments it was found, that the firmness, elasticity, and strength of the blood-vessels and nerves were likewise increased by exposing them to the action of the Peruvian bark. A very different effect, however, was produced by this substance upon the skin, as appears from the following experiments.

Experiment IV.

Three portions of the skin of a kitten, $\frac{2}{10}$ of an inch broad, were dipped four days in a thick mixture of powder of bark and water, and three similar portions in pure water.

The sum of the weights required to break the portions immersed in the mixture was . 7lb. 9oz.

That of those required to break the standard . . . . . 24lb. 5oz.

The former were more extensible by given small weights than the latter.

Such are the effects produced by the Peruvian bark.

The following experiments were made with a view to determine the effects produced by Camomile Flowers upon the cohesion of the simple fibre.

Experiment V.

Three portions of the small intestines of a kitten being dipped three days in a thick mixture of the powder of this substance with water, and three similar portions being immersed in pure water, as a standard; the strength of the former was found to be to that of the latter as $13\frac{1}{2}$ to $11\frac{1}{4}$.

The elasticity of the intestine was likewise found to be somewhat increased by the action of the camomile flowers. On the other hand, the elasticity and strength of the skin were diminished by this substance, as well as by the Peruvian bark.

This will appear from the following experiments.

Experiment VI.

Three portions of the skin of a kitten being immersed two days and a half in a thick mixture of powder of camomile flowers and water, and three similar portions in pure water,

The sum of the weights required to break the former was . 69lb. 4oz.

That of those required to break the latter was . . . . 25lb. 12oz.

The latter were found to be softer to the touch, and more extensible by small weights, than the former.

I next proceeded to examine the effects produced on the animal fibre by Gentian Root.

From experiments similar to the preceding, it appeared that the strength of portions of the intestine of a kitten, exposed three days to the action of this substance, was, to that of corresponding portions dipped in water, as 11 to 10.

The elasticities of the former were likewise somewhat greater than those of the latter.

It moreover appeared, that the strength of portions of the skin, exposed three days to the

action of the powder of gentian, was, to that of similar portions immersed in water, as $7\frac{1}{2}$ to 22.

The firmness and elasticity of the skin were greatly diminished by the action of the gentian root, as well as by that of the bark and camomile flowers.

I next examined the effects produced on the simple fibre by Colombo Root, Cascarilla, Myrrh, Serpentaria, and Quassia.

I had reason to believe, from a variety of trials, that colombo root, cascarilla, myrrh, and serpentaria, occasioned a small increase in the cohesion of the intestine; but it was so inconsiderable, that I could not determine it with precision. Indeed I cannot affirm with certainty, that an augmentation of cohesion was actually produced, although I think it very probable, from the general result of my experiments.

As these substances have but a slight effect in increasing the strength of the intestines, so they have not a very considerable influence in diminishing that of the skin. In the latter case, however, the diminution of cohesion was

so obvious, as not to leave the smallest room for doubt.

I did not find that the quassia occasioned any augmentation in the strength of the intestines: on the contrary, I had reason to believe that the strength of the intestines was in a slight degree diminished by this substance. Its effects upon the skin were similar to those of colombo root, cascarilla, serpentaria, and myrrh.

Remarks.

From the foregoing experiments it appears, in general, that the bitters which are most commonly used in medicine increase the strength of the intestines in the following order:

Peruvian bark, galls, camomile flowers, gentian root, colombo root, cascarilla, myrrh, and serpentaria.

It is proper to observe, that galls produce a much greater constriction in the intestine than Peruvian bark. They render it firmer to the touch, and less extensible by small weights. It would seem, therefore, that they

act more forcibly as a tonic, although they have, probably, less power as a corroborant. But what constitutes the principal distinction between them is, the difference of their action upon the skin. For the one increases the strength of this part of the animal body in a very considerable degree, while the other acts powerfully upon it as a relaxant and anti-corroborant.

It seems, indeed, probable, that the opposite effects which the Peruvian bark produces upon the stomach and the skin may, in a great measure, account for its febrifuge virtues.

As to the other bitters, compared with the Peruvian bark, it appears that their relative powers in strengthening the stomach and intestines are not accurately proportional to the force with which they debilitate the skin. For when they are arranged according to the latter property, they observe the following order:

Peruvian bark, gentian root, camomile flowers, cascarilla, serpentaria, colombo root, quassia, and myrrh.

It is necessary to remark, that the preceding arrangement was determined by successively comparing together the effects of the several

bitters upon the same animal. Thus three portions of the skin of a kitten were immersed in a mixture of powder of Peruvian bark and water, and three corresponding portions in a similar mixture containing powder of gentian root. At the expiration of two or three days their relative strengths and extensibilities were examined. And it was uniformly found that the cohesion of the skin was more impaired by the bark than by the gentian root. From similar trials it appeared that the gentian root produced a greater effect than the camomile flowers, and the camomile flowers a greater than the cascarilla.

The effects produced by the cascarilla serpentaria, colombo root, and quassia, did not differ very considerably from each other. It is nesessary to remark, that the comparison should be made in the way described above, because the results are liable to be varied by the age and condition of the animal which is the subject of the experiment. I have reason to believe, for example, that bitters act with greater force upon the skins of young animals than upon those of old ones, even of the same species. From this and from other circum-

stances, with the causes of which I am unacquainted, it sometimes happened that the gentian root appeared to produce a greater effect than the Peruvian bark, when the trials were made with the skins of different animals. But when the effects of these substances were immediately compared together upon portions of the skin of the same animal, the results were invariably similar to those which have been stated above.

It frequently happens in febrile diseases that the gentian root, serpentaria, or colombo root, will agree well with the patient, when the Peruvian bark cannot be administered with safety.

The preceding experiments appear to throw some light upon the cause of this difference.

It is proved by these experiments that a much greater increase of tone is communicated to the stomach and intestines by the Peruvian bark, than by the gentian root, colombo, or serpentaria.

In the state of health, the tone and strength of the stomach may be varied to a very considerable degree, without materially deranging the functions of life; and hence, a healthy

man will suffer no inconvenience from the exhibition of the Peruvian bark in large quantities. It is well known, however, to every practitioner in medicine, that there are certain febrile diseases in which this remedy would either be immediately rejected by the stomach, or, if retained, would occasion great disturbance in the system. Thus we are frequently precluded from exhibiting the bark in typhus fever, when we might suppose, from the extreme weakness of the patient, that a powerful corroborant would produce salutary effects. In such cases, as I before remarked, the gentian, colombo, or serpentaria, may be given with safety. And I think I have sometimes observed evident advantage from the exhibition of those bitters in certain stages of that disease. They have relaxed the skin, they have diminished the irritability of the stomach, have increased its tone, and have removed nausea and vomiting.

Now, may not the different effects of the Peruvian bark, and of the gentian, serpentaria, or colombo, in these instances, be explained in the following manner?

When the body is labouring under disease, when the pulse is accelerated, the irritability increased, and when an inflammatory diathesis prevails, the tone of the stomach does not admit of so great an increase as in the state of health. If, therefore, the Peruvian bark be exhibited in such cases, Nature will resist the operation of a medicine which might produce deleterious effects. For we may, with great probability, suppose, that under these circumstances a high degree of tone suddenly impressed upon the stomach would be communicated to the heart and arterial system, that it would increase the velocity of the blood, already too much accelerated, that it might aggravate the inflammatory symptoms, and might, perhaps, endanger the life of the patient.

Do not the gentian, colombo, and serpentaria, on the contrary, produce good effects in these instances, because they are much milder corroborants than the Peruvian bark? They therefore impress a degree of tone upon the stomach which can be borne without injury, and which may be communicated with safety to the other parts of the system.

It is proper however to remark, that there are certain febrile, and even inflammatory diseases, in which the most beneficial effects are produced, by suddenly imparting to the stomach the highest degree of tone. Thus the bark in large doses proves a very efficacious remedy in the cynanche maligna, and in the erysipelatous inflammations which appear in the London hospitals.

CHAP. IV.

Of the Effects produced on the Cohesion of the Fibre by Acids and Alkalies.

I HAVE found that Acids and Alkalies diminish the cohesion of the fibre, as appears from the following experiments.

EXPERIMENT I.

One ounce and a half of water was mixed with 72 grains of common marine acid; in this mixture three portions of the small intestines of a kitten were immersed during half an hour; and three similar portions were immersed in pure water, as a standard.

The sum of the weights required
to break the former was . 16lb. 0oz.
That of those required to break
the latter was . . . . 19lb. 4oz.

The portions immersed in the dilute acid were somewhat more extensible by given small weights than the standard.

I also examined the effects of pure marine acid upon the cohesion of the animal fibre; and found, that when the intestine was exposed for a short time to the action of this acid, it became soft to the touch, it acquired a gelatinous appearance, and its cohesion was much impaired.

Experiment II.

Three portions of the small intestines of a kitten were dipped three quarters of an hour in a mixture of one part of oxygenated marine acid, with two of water; and three similar portions were immersed in pure water.

The sum of the weights required
to break the former was . 5lb. 14oz.
That of those required to break
the latter was . . . . 6lb. 6oz.

The result was nearly the same when the experiment was repeated with pure oxygenated marine acid.

The intestine immersed in the acid at first

acquired a whiteish colour; but after it had remained in it several hours, it became darker than natural.

The acid was obtained by adding common marine acid to the oxygenated muriate of potash.

Experiment III.

Three portions of the small intestines of a kitten were dipped half an hour in a mixture of 108 grains of vitriolic acid, with an ounce and an half of water, and three similar portions were dipped in pure water.

The sum of the weights required
to break the former was . 24lb. 12oz.
That of those required to break
the latter was . . . . 28lb. 4oz.

The extensibility of the fibre did not appear to be altered by the action of the acid in this experiment.

Experiment IV.

Three portions of the small intestines of a kitten were dipped half an hour in a mixture

of 84 grains of nitrous acid, with two ounces of water, and three similar portions were dipped in pure water.

The sum of the weights required to break the former was . 10lb. 12oz.

That of those required to break the latter was . . . . 13lb. 0oz.

The portions exposed to the action of the acid became white in a few minutes. In about a quarter of an hour they assumed the appearance of light coloured silk, having a faint tinge of green. They were surrounded with small bubbles of air.

Thus it appears, that the dilute, vitriolic, nitrous, and marine acids, diminish the cohesion of the intestines of an animal recently killed.

The general results of the experiments with acids and alkalies are comprised in the following table.

Calling the natural strength of the intestine	1
The strength of the portions exposed to the action of the common marine acid mixture . .	0.83
Oxygenated marine acid mixture	0.92

Dilute vitriolic acid mixture . . 0.876
Dilute nitrous acid mixture . . 0.826
Portions exposed to the action of vinegar during nine hours (soft and gelatinous) 0.852
Portions exposed $2\frac{1}{2}$ days to a thick mixture of prepared natron and water (soft and gelatinous) 0.833

It is well known that the pure fixed alkalies dissolve animal substances, and in consequence destroy their cohesion. But I found that the aerated vegetable fixed alkali differs from the aerated mineral fixed alkali in this particular, that it increases the cohesion of the animal fibre, while the latter diminishes it. The increase of cohesion produced by the aerated vegetable fixed alkali was 1.4, reckoning the natural strength of the standard as 1.

CHAP. V.

Of Neutral and Earthy Salts.

1st—Of SEA-SALT.

Experiment I.

Portions of the small intestines of a kitten being immersed from two to three days and a half in a thick mixture of water and sea-salt, and similar portions being immersed in water, the weights required to break the former were to those required to break the latter as 14.2 to 9.6. The strength of the intestine, therefore, was increased by the action of the sea-salt nearly one third. Its firmness and elasticity were likewise much increased.

Experiment II.

To determine the effects produced by this substance on the skin, three portions of the skin of a kitten were immersed two days in a thick mixture of water and sea-salt, and three similar portions in water.

The sum of the weights required
to break the former was 13lb. 8oz.
That of those required to break
the latter was - - - - 9lb. 8oz.

The firmness and elasticity of the skin were also found to be much increased by the action of the sea-salt.

It was moreover found, that sea-salt greatly augments the cohesion of the nerves and blood-vessels, as appears from the following experiments.

Experiment III.

A portion of the sciatic nerve of a kitten was dipped two days in a thick mixture of common salt and water, and a corresponding portion, taken from the other thigh, was immersed in pure water.

The weight required to break the former was - - - - - - - 43oz.

That required to break the latter 30oz.

It is proper to observe that, in making these and similar experiments, one of the sciatic nerves was frequently found to be a little smaller than the other. Lest, however, I should have been led into an error, by ascribing that to the sea-salt which might possibly have arisen from an original difference in the strength of the nerves, I immersed in the mixture the nerve that was sensibly the smallest. When the circumstances were varied, and the mean result of different trials was taken, it appeared that the strength and tone of the nerves were at least doubled, by exposing them to the action of common salt.

Experiment IV.

To try the effects produced by this substance upon the blood-vessels, a portion of the aorta of a lamb, $\frac{2}{10}$ of an inch broad, was immersed three days in a thick mixture of common salt and water, and a similar portion was immersed in pure water.

The weight required to break the former was . . . . . 57oz.

That required to break the latter 11½oz.

The extension of the first, when stretched by a weight of 1¾oz. was $\frac{1}{20}$ of an inch; that of the last, by an equal weight, was half an inch.

These experiments were several times repeated with nearly a similar result. I have also found that the result was not materially different when the trial was made with the aorta of a cat. Hence it appears, that sea-salt greatly increases the firmness, elasticity, and strength of the intestines, the skin, the nerves, and the blood-vessels of an animal recently killed.

Observations.

From the preceding experiments it appears that common salt greatly increases the cohesion of all the soft parts of the animal body; hence, probably, the reason why this salt, which is furnished in such abundance to the inhabitants of the earth, is so admirably calculated to preserve, and, in many cases, to

restore health. We have seen in particular that it possesses the power of augmenting, in an extraordinary degree, the tone and strength of the arterial system. And as during life the force which must be incessantly exerted by the heart and arteries to communicate motion to the sanguineous mass is very great; it is obvious, that if this force be diminished by any of the debilitating causes to which animal life is incident, the general health will be impaired.

Common salt is excellently adapted to counteract the influence of such causes; for it not only acts as a general corroborant, but it is peculiarly calculated to support the tone and strength of that part of the animal body in which the greatest effort is required.

There is indeed reason to believe, that a diminution in the cohesive force of the heart and arteries takes place in many diseases. It has been proved by the experiments recited in page 75, that the cohesion of the arteries is capable of undergoing greater variations than that of any other part of the animal body. For the strength of the portion of the artery exposed to the common salt was five times

greater than that of the portion immersed in water; and the elasticity was increased in a still higher degree. Since therefore the cohesion of the arteries can be so much augmented by medicinal substances, there can, I think, be no doubt, that it may sometimes suffer a contrary change from the influence of noxious agents. And that this change does take place in a variety of instances, seems evident from the history of diseases. A diminution, for example, in the cohesion of the heart appears to take place in those complaints, which are accompanied with a dilation of that organ. A similar change seems to arise in the arteries in cases of aneurism, in passive hemorrhages, and in the species of apoplexy, termed hemorrhagia cerebri. In the latter disease I have sometimes observed that the blood is not only poured into the ventricles of the brain, but that soon after death it flows in great quantity from the mouth and nostrils, and is effused into the cellular substance in most parts of the body. In such cases it is apparent that the effusion must arise from the destruction of the cohesion of the capillary arteries.

If these observations be well founded, it

will follow, that in diseases of this nature it must be an important object to exhibit such remedies as will, if possible, increase the cohesion of the blood-vessels, without augmenting the force of the circulation.

We may indeed observe, in general, that it is in all cases of great moment to distinguish between the debility which arises from a diminution in the cohesion of the fibre, and that which arises from a want of energy in the vital principle. For in the former instance corroborants, and in the latter stimulants, are the proper remedies.

From the facts related by Dr. Russel, and from the trials which have been made since his time, it is, I think, proved, that salt water is an efficacious medicine in certain stages of scrophula.

It has been observed by Dr. Cullen, and by other judicious writers, that this disease most frequently occurs in those children who have a soft fibre, a delicate skin, and a florid complexion. Hence there is, I think, reason to believe, that the species of debility which depends upon a diminution in the cohesion of the fibre, may be considered as one of its

predisponent causes. If this be true, it will explain the reason why the disease is sometimes removed by the external and internal use of common salt; for it not only restores to the fibre the due degree of cohesion, but from the experiments recited in page 76, it appears that it occasions a much greater augmentation of strength in the arteries than in the veins. It will therefore increase the force and freedom of the circulation.

From the abovementioned experiments, compared with those of Sir Clifton Wintering-ham, we may also perceive the reason why common salt frequently removes the glandular obstructions.

For the facts recited by Winteringham prove, that the strength of the larger ramifications of the arteries, compared with their size, is greater than that of the trunks from which they proceed. The same writer has also shown that this difference of strength is not uniform in its degree in all cases, but that it is much more remarkable in those branches which transmit the blood to glands, than in those which convey it to other parts of the body. He found, for, example, that although

the emulgent and splenic arteries are much smaller than the aorta, yet they are greatly superior to it in strength when equal areas are taken; and that although the iliacs in the same animal were likewise stronger than the aorta in equal areas, yet the difference of strength in the latter instance was much less than in the former.

The final cause of this difference seems apparent. From the structure of glands it appears that a greater resistance is afforded to the transmission of blood through them, than to that through other parts of the body.

Hence it is plain, that the vessels which convey the blood to glands should possess unusual strength. For the lateral pressure of that fluid, arising from the force of the circulation, is opposed, partly by the cohesion of the vessels, and partly by the energy of the vital principle. Let us conceive for a moment that the latter forces are precisely balanced by the pressure of the blood. In this case it is evident, that if by any of the accidents to which animal life is incident, the cohesion of the vessels were diminished, and the energy of the vital principle were not proportionally in-

creased, the equilibrium would be destroyed. The vessels would no longer be enabled to sustain the lateral pressure; they would be enlarged in their dimensions, and the functions of the part to which they convey the blood would be impaired.

Hence it is apparent, that if in glandular parts which opposed an unusual resistance to the transmission of the blood the adductory vessels were not proportionally strong, such parts would be more liable to be deranged by the common accidents of life, than those through which the blood circulates with greater facility.

We may add to this, that the circulation is carried on partly by the power of the heart, and partly by the action of the arteries. The momentum communicated to the blood by the heart, is uniformly diffused over the whole aortic system. Hence, if in any particular vessel it be necessary that the blood should circulate with unusual force, this force must be imparted by the superior action of the vessel itself. And it is extremely probable, that all other circumstances being equal, the vital principle is capable of acting with greater

vigour upon a firm and strong vessel, than upon a lax and weak one.

Sir Clifton Winteringham has moreover proved, "that the veins which carry the blood from secretory organs, are as remarkable for their largeness, thinness, and laxity, as the corresponding arteries are for the contrary qualities."*

By this contrivance it is manifest that the return of the blood from the gland is facilitated, and consequently, that the resistance to the artery in performing the secretion is diminished. It is moreover apparent, that by the same contrivance the impediments to the secretion which may arise from occasional turgescence in the vena cava are obviated. For when by exercise, or by any other cause, an unusual quantity of blood is derived into the vena cava, it is plain, that if the reductory veins were not formed in the manner described above, their resistance to the transmission of the blood through the glands would be increased. But as these veins have a large capacity and a loose contexture, they, in cases

* See his Experimental Enquiry.—Page 212.

of unusual resistance, become reservoirs for the returning blood, until it can be received by the vena cava, without any injury to the animal œconomy.

It has been already shown that common salt increases the strength of the arteries in a higher degree than that of the veins: it is probable, that its power of removing glandular obstructions arises from this property. For if in any of the glands the mechanism described above should be deranged—if the strength of the arteries, compared with that of the veins, should be so far reduced below the natural standard, as to render them incapable of resisting the lateral pressure of the blood, the capillary vessels would be enlarged, the force of the circulation through the gland would be diminished, the secretion would not be performed in the proper quantity, and an obstruction would probably take place.

From the preceding experiments there is reason to believe that, by the judicious application of common salt in such cases, the artery would recover its proper tone; it would be enabled to transmit the blood with a due degree of force through the gland, and, as the

change which this medicine produces in the veins is much less than in the arteries, the freedom of the circulation would be increased.

Hence we may conclude, that the utility of common salt, in scrophulous complaints, arises from its power, as a general corroborant, and from its property of increasing the strength of the arteries, in a higher degree than that of the veins.

It may be proper however to remark, that common salt is often found to fail in those cases of scrophula which are accompanied with hectic fever. In such cases, I believe that the most efficacious remedy hitherto discovered is the muriated barytes.

From the tendency of common salt to increase the cohesion of the fibre, we may perceive the reason why that substance, joined to aromatics, is frequently found to remove the gout from the stomach, and fix it in the extremities. For it is probable that, when the gout affects the stomach, it acts as a sedative and relaxant. And we know that a compound consisting of aromatics and of common salt will have the power of stimulating the stomach and of increasing its strength.

It has been observed by Hoffman, that cathartics operate less powerfully when acids have been used freely on the day prior to their exhibition; but that their power is increased by the previous use of meats impregnated with aromatics, and with common salt.* The reason seems to be, that the former diminish and the latter increase the tone and irritability of the alimentary canal.

OF MAGNESIA VITRIOLATA.

Experiment.

To determine the effects produced by this substance upon the small intestines of a kitten, three portions of the intestine were immersed one day and five hours in a thick mixture of water and magnesia vitriolata, and three similar portions in pure water.

The sum of the weights required
to break the former . . 17lb. 14oz.
Sum of those required to break
the latter . . . . . 11lb. 2oz.

* Hoffman opusc. dissert. 5, p. 120.

The portions immersed in the mixture were of a faint red colour, they were in some measure shrivelled up, and were remarkably firm to the touch.

Their extensions were to those of the standard, when each of them was stretched by the weight of two pounds, as 4 to 6.

This salt was likewise found to increase the strength and elasticity of the skin, the blood-vessels, and nerves.

Observations.

We learn from Experiment V. that magnesia vitriolata possesses an extraordinary power of strengthening the intestines.

Hence, probably, the reason why this salt in small doses, frequently repeated, is one of the most efficacious remedies hitherto discovered in constipations, arising from inflammation in the bowels. In such cases it is known that a stricture takes place in the inflamed portion of the intestine, and that the portion immediately above the stricture is distended by the fœces, which are carried downward in consequence of the peristaltic motion. This dis-

tension is counteracted partly by the energy of the vital principle, and partly by the cohesive force of the intestine, assisted by the action of the abdominal muscles. If these forces be insufficient to resist the distending power of the fœces, the superior portion of the canal will be stretched beyond its tone.* But it seems to be a law of the animal œconomy, that when the stomach or the intestinal tube is stimulated by a distending power, or by any other cause, to a certain degree, the peristaltic motion is inverted, and vomiting is produced.

* This may be illustrated by observing the effects which are produced when an animal fibre is stretched by the continued addition of given small weights till it be broken. For it is found, that when the extension passes beyond a certain point, the fibre, upon the removal of the weights, is no longer capable of restoring itself to its former length. Its elasticity is therefore diminished. I have moreover observed, that in this case the law of the extension is varied. For the elongations which, by the addition of given small weights, were at first very unequal, approach more and more near to equality, till at length a rupture takes place. Hence we may infer, that when a fibre is stretched beyond a certain point, a permanent change is produced in the arrangement of its particles, the circulation of the fluids through it will be impeded, and its functions will of course be deranged.

It is plain, that in these circumstances salutary effects must arise from the exhibition of a cooling laxative, which has the property of communicating a sudden increase of tone and of strength to the alimentary canal. For in that case the mischief arising from the distention will be counteracted ; the cause which immediately gave rise to the inversion of the peristaltic motion will be removed ; the canal will be enabled to propel its contents downwards with greater force ; and, consequently, its power of overcoming the stricture will be increased.

Upon similar principles we may, I think, explain the reason why a stricture of the intestines is frequently removed by the application of cold fomentations to the abdomen.

OF GLAUBER SALT.

I had reason to believe, from a variety of trials, that this salt occasioned a small increase in the strength of the intestines of a kitten. But the change was so inconsiderable, that it was difficult to ascertain it with precesion. By the mean result of twelve trials, it ap-

peared that the strengths of the portions exposed to the action of the Glauber Salt were to those of the standard as 23.9 to 23.6.

I next tried its effects upon the skin, but I did not find that it sensibly increased or diminished the strength of this part of the animal body.

OF SAL AMMONIAC.

Three portions of the small intestines of a kitten were dipped two days and a half in a mixture of Sal Ammoniac and water, and three similar portions in pure water.

The weights required to break the latter were

First	5lb.
Second	5lb.
Third	5lb.
	15lb.

The weights required to break the portions exposed to the action of the sal ammoniac were

Fourth	6lb. 0oz.
Fifth	5lb. 12oz.
Sixth	4lb. 12oz.
	16lb. 8oz.

It is proper to observe, that the strongest

portion (No. 4) was immersed in the saturated solution of sal ammoniac, at the top of the mixture; it had acquired a whitish colour. The portion expressed by (No. 5) was partly immersed in the saturated solution above, and partly in the thick mixture below. The part of this portion which was in the solution was white, that in the mixture was red. The portion expressed by (No. 6) was entirely immersed in the mixture, and its whole surface had acquired a reddish colour. The softness and extensibility of the last of these portions appeared to be increased by the action of the sal ammoniac.

The alterations produced by the abovementioned saline substances, and by some of the other neutral salts, in the strength of the intestines and skin, are comprised in the following table.

Calling the natural strength of the intestine..... 1.	Natural strength of the skin.. 1.
Magnesia Vitriolata ..... 1.6.	..... 1.27
Sal diureticus or kali acetatum 1.594	..... 1.27
Sea-salt 1.479	..... 1.42
Oxygenated muriate of potash 1 477	..... 1.06
Nitre 1.3	
Sal ammoniac..... 1.1	..... 0.652
Glauber-salt or natron vitriolatum 1.012	..... 1.

The portion of the intestine exposed to the action of the nitre had a reddish gelatinous appearance.

Observations.

It has been proved in Chap IV. that pure acids and alkalies diminish the cohesion of the animal fibre. It now appears that an opposite effect is produced by some of the neutral and earthy salts most commonly used in medicine. I have repeated the experiment with various medicinal substances of this class, besides those comprised in the foregoing table; and have reason to believe, that most of the neutral salts insrease the cohesion of all the soft parts of the animal body.

I have found, contrary to my expectation, that although alum occasions a constriction in the skin, yet it diminishes its strength; and that it does not produce any sensible change in the strength of the intestines. It seems not improbable that its power of weakening the skin may arise from the following cause. We have seen that acids diminish the cohesion of the fibre; and as the acid of vitriol has a very slight affinity to the aluminous earth, it is pos-

sible that the compound may weaken the skin in consequence of its retaining acid properties.

I have found from similar experiments that the cohesion of the intestines is increased, and that of the skin diminished, by muriated barytes.

It may here be worthy of observation, that the property of strengthening the intestines, and of weakening the skin, is common to all the substances which have justly acquired reputation in the cure of intermittents. This property belongs to ipecacuanha, to emetic tartar, to sal ammoniac, to gentian root, to camomile flowers, and to the Peruvian bark. And it is remarkable, that the latter substance which is the most efficacious remedy hitherto discovered for intermittent fevers, possesses the abovementioned property in the highest degree.

From the tendency of acids to weaken, and that of neutral salts to strengthen the fibre, we may perceive the reason why alkalies are so useful in those diseases which are accompanied with acidity of the stomach. For by the exhibition of alkalies in such cases, the acid is converted into a neutral salt.

CHAP. VI.

OF THE EFFECTS PRODUCED BY METALLIC PREPARATIONS.

SECT. I.

Of the Preparations of Mercury.

IN examining the effects of substances of this class, I began with corrosive sublimate.

As that salt is a powerful caustic, when it is applied in substance to the flesh of a living animal, and as it is known to be a strong poison when it is given internally in a considerable dose, I thought it very probable that it would destroy the cohesion of the fibres of an animal deprived of life. But the result was contrary to my expectation. For I found that when the experiment was made with a dead kitten, the sublimate greatly increased the elasticity and strength of the intestine, the skin, the blood-vessels, and nerves.

This will appear from the following trials.

Experiment I.

Three portions of the small intestines of a kitten were dipped two hours in a thick mixture of corrosive sublimate and water, and three similar portions in pure water.

The sum of the weights required to break the former was . 14lb. 12oz.

That of those required to break the latter was . . . . 12lb. 12oz.

The portions in contact with the sublimate were white, and very firm to the touch. They were much contracted in length, and were less extensible by small weights than the standard.

I next made similar experiments with the skin of a kitten.

From the mean result of twelve trials, it appeared that the strength of portions of the skin of a kitten immersed about an hour in a thick mixture of sublimate and water, was to that of the standard as 14.2 to 11 nearly.

It is proper, however, to observe, that a very different result was obtained when the experiment was repeated with the skin of a guinea-pig. For it was found that the strength of the

skin of this animal was considerably diminished by the action of the corrosive sublimate.

In consequence of the different results of these trials, I was led to repeat the experiment upon the human skin. It appeared that the effects of the sublimate upon the latter were similar to those which it produced upon the skin of a kitten.

To determine the alterations occasioned by this salt in the cohesion of the arteries and nerves, experiments similar to the preceding were made with the sciatic nerve of a kitten, and with the aorta of a lamb. The elasticity and strength of those parts of the animal body were found to be nearly doubled by the action of the sublimate.

Hence it appears, in general, that this salt greatly increases the cohesion of the animal fibre. I may add that the alteration is produced in a very short space of time. Indeed, if the fibre be immersed for a second in a thick mixture of sublimate and water, and be then immediately withdrawn, it will be found to be constricted, and its strength increased.

The following experiment was made with a view to discover the effects which corrosive

sublimate produces upon the stomach of a living animal.

Experiment II.

Two kittens were taken of the same litter, and nearly of the same weight; they were about a fortnight old: one of them was killed by pouring into its stomach a strong solution of corrosive sublimate; the other was drowned.

Two portions of the stomach of the first were then prepared in the manner explained in Experiment III. Chap. I. each of the portions being $\frac{3}{10}$ of an inch broad.

The sum of the weights required to break them was . . . . 17oz.

The sum of the weights required to break two similar portions of the stomach of the other kitten was . . . . . 12oz.

When the portions exposed to corrosive sublimate, and those which were immersed in water, as a standard, were stretched by equal weights, the extensions of the former were much less than those of the latter.

The stomach of the kitten that was killed

by the sublimate was much contracted, but not inflamed.* It had the same white and opaque appearance which the intestines have when dipped in this salt.

These experiments were made as quickly as possible after the death of the animal.

Experiment III.

Being desirous of knowing whether the corrosive sublimate is decomposed by the recent animal fibre, I took a saturated solution of that salt in distilled water, and immersed in it a portion of the intestine of a kitten soon after the animal was killed. It was suffered to remain in this situation several hours, but no precipitation took place; and hence I inferred, that the sublimate was not decomposed. For if it had been deprived of its pure air by the action of the fibre, it would have been converted into calomel, which would have fallen to the bottom of the vessel in the form of a white precipitate.

* That sublimate in a large dose destroys life without inflaming the stomach, has been observed by Dr. Webster, in his Treatise on the Connexion of the Stomach with Life.

It would appear, indeed, that the sublimate enters into a chemical combination with the animal fibre, and that by this combination its particles are more firmly united together.

Experiment IV.

With a view to determine the effects produced by calomel, three portions of the small intestines of a kitten were kept two days and a half in a thick mixture of that salt and water, and three similar portions in pure water.

The weights required to break the former were to those required to break the latter as 12 to 11 nearly.

The extensions of the portions exposed to the action of calomel, were to those of the standard, when stretched by weights of eleven ounces, as 24 to 30.

From similar experiments it appeared that the strength of portions of the intestines of a kitten exposed thirty hours to the action of red precipitate, was to that of similar portions immersed in water as 10.25 to 8 nearly.

Observations.

From the foregoing experiments it appears, in general, that the cohesion of the animal fibre is increased by some of the mercurial preparations most commonly used in medicine.

It seems extremely probable that this increase of cohesion arises from the action of the pure air which these preparations contain. Thus the corroborant powers of red precipitate, which consists of mercury combined with pure air, appear to arise from the union of the semi metal with this fluid, because mercury in its metallic state does not produce any effects whatever upon the cohesion of the animal fibre.

We have, moreover, seen, that corrosive sublimate, when it is applied to the dead animal fibre, is a much more powerful corroborant than calomel. It is well known that the former of these salts consists of mercury combined with the oxygenated marine acid; and the latter of mercury combined with the common marine acid. And since the oxygenated marine acid is composed of spirit of salt united

with a large quantity of pure air, it follows that the superior power of the sublimate arises from the pure air which it contains.

In the last place, there is great reason to believe that a small quantity of pure air is contained in calomel. For calomel, as I before observed, consists of mercury combined with common marine acid; and it is now generally admitted that the latter fluid is composed of pure air united to some unknown basis. Hence it is probable, that calomel derives from pure air its corroborant power, as well as red precipitate and corrosive sublimaté.

The properties of corrosive sublimate, established by the preceding experiments, appear to throw some light upon the mode of action of that salt, when it is used as a medicine.

We know that in the animal body the several organs are composed of a congeries of blood-vessels and nerves, and cellular substance and absorbents. We also know that in those organs the tone and action of the vessels may be varied within certain limits, without materially deranging the functions of life. If the variation of tone be carried beyond these limits, the power of nature will be exerted, to

resist the production of effects which will tend to destroy the harmony of her operations. Thus, if a considerable quantity of corrosive sublimate be taken into the stomach, an effort will be made to throw it off by vomiting. It appears, however, that the force of nature to resist the influence of noxious agents is limited; and hence, if the sublimate be applied to an organ essential to life, in such a quantity as to overcome the resisting power, a sudden constriction will take place; the vessels will become impervious to the fluids, which they were destined to transmit; the functions of the organ will be destroyed, and the animal will perish. See Experiment II.

If the quantity of the sublimate be not so great as to overcome the resisting power, but if, at the same time, it be such as to increase the tone and action of the fibre beyond the healthy limit, an inflammation will be excited in the part; and if this inflammation be carried to a certain point, suppuration or gangrene may take place.

Finally, if the sublimate be dissolved in water, and applied in a very small quantity to a living fibre, it will increase the tone and

strength of the fibre without exciting inflammation.

Hence, I think, we may perceive the manner in which the solution of this salt frequently acts, when it is applied to malignant ulcers. If the solution be so much diluted as not to increase the tone of the fibre and the action of the vessels beyond the limits of health, and if it be applied to an ulcer in which the fibres are relaxed, and are at the same time affected by a morbid irritability, it will impart to them a greater degree of firmness, the irritability will be diminished, the sore will assume a more healthy appearance, and by the continued use of this application, the disease will, in many cases, be removed.

In a paper which I communicated to the Royal Society, on the matter of cancer, I have shown that corrosive sublimate decomposes the animal hepatic air, which abounds in foul ulcers. And hence, in such cases, it not only immediately imparts tone to the fibre, but it indirectly produces a similar effect by destroying a substance which has a powerful tendency to relax and debilitate.

We may, I think, infer from the above ex-

periments that the action of red precipitate and calomel is similar to that of corrosive sublimate. And it is worthy of observation, that the powers which these substances possess of strengthening the dead fibre are, in some measure, proportional to the force with which they stimulate the living fibre; for corrosive sublimate has greater force as a stimulant than red precipitate, and red precipitate greater than calomel.

Sect. II.

Of Tartarized Antimony.

From the experiments recited in the preceding section, there is reason to believe that the preparations of mercury increase the cohesion of all the soft parts of the human body.

The following experiments render it probable that tartarized antimony increases the cohesion of the intestines, and diminishes that of the skin.

Experiment I.

Three portions of the skin of a kitten $\frac{2}{10}$ of an inch broad, were immersed four and a half days in a thick mixture of tartarized antimony and water, and three similar portions were immersed in pure water.

The sum of the weights required to break the former was . 6lb. 14oz.

The sum of those required to break the latter was . . 26lb. 10oz.

Experiment II.

Similar experiments being repeated with the small intestines of a kitten,

The sum of the weights required to break the portions exposed to the action of the tartarized antimony, was . . . . 10lb. 15oz.

That of those required to break the standard, was . . . 9lb. 12oz.

Sect. III.

Of Nitrated Silver.

Experiment I.

Two grains of the chrystals of pure nitrated silver were dissolved in half an ounce of water. Three portions of the small intestines of a kitten were immersed in this solution, and three corresponding portions were immersed in pure water, as a standard.

In five minutes the portions exposed to the action of the salt of silver became white, and acquired a shining appearance similar to that of white satin.

The first portion, which had remained in the solution five minutes, broke with . . .	2lb. 15oz
Second, fifteen minutes . .	2lb. 15oz.
Third, thirty minutes . . .	2lb. 17oz.
	8lb. 15oz.
The sum of the weights required to break the standard was .	9lb. 1oz.

The sum of the extensions of the former, by given small weights, was nearly double to that of the latter.

The experiment was repeated by suffering the intestine to remain in the solution during the space of an hour.

In this instance, also, as well as in the former, the strength of the fibre was a little diminished by the nitrated silver. The portions exposed to the action of that salt had, at the expiration of an hour, begun to acquire a dark colour.

I have also found, by experiment, that the cohesion of the skin of a kitten is impaired by nitrated silver, as well as that of the intestines.

In these experiments a dark precipitate was perceived at the bottom of the glass in which the solution was contained; and hence it appears that the nitrated silver was decomposed by the action of the animal fibre.

Sect. IV.

Of the Preparations of Iron, Copper, & Zinc.

Experiment I.

Six grains of vitriolated iron were dissolved in two ounces of water.

Three portions of the small intestines of a kitten were dipped three days in this solution, and three corresponding portions were dipped in pure water, as a standard.

The sum of the weights required to break the former was . 19lb. 2oz.

The sum of those required to break the latter was . . 22lb. 14oz.

The intestines appeared to be somewhat constricted by the solution of iron. It may be proper to observe, that the portions which were near to the surface of the solution had acquired a greenish cast, those below the surface were white.

It moreover appeared, that the intestine of a kitten was somewhat relaxed by immersing

it ten hours in a mixture of one drachm of muriated iron, with an ounce of water; but its cohesion was neither increased nor diminished.

I was much surprised at the result of this experiment, as the ferrum vitriolatum has an astringent taste, and it is well known that the preparations of iron, when exhibited internally, frequently act as powerful corroborants. In reflecting on these circumstances it occurred to me that the effect produced upon the intestine in the foregoing experiment might, probably, have arisen from the action of the acid. For I have proved that the vitriolic acid is an anti-corroborant; and in the abovementioned salt the acid adheres to the iron so slightly, that the compound retains acid properties. To determine whether this observation was well founded, I made the following experiment.

Experiment II.

A quantity of ferrum vitriolatum was introduced into a crucible, and exposed to a red heat until a part of the vitriolic acid was separated from it in the form of vapour. The

residue that remained in the crucible consisted of a powder that was partly red and partly white. When these were ultimately mixed together, the whole assumed a red colour.

A quantity of this powder was introduced into a glass vessel, and mixed with water; and three portions of the intestines of a kitten being exposed to its action for a sufficient length of time, they were found to acquire from it a considerable increase both of tone and strength.

For they were much firmer than the standard, and the weights required to break them were, to those required to break the standard, as 25 to 23.

It cannot, I think, be doubted, that in this experiment the portion of the acid which adhered to the iron with the least force was expelled from it by the heat. The remaining portion was so far deprived of its acid properties as to lose the power of diminishing the cohesion of the fibre.

As the preparations of iron are very generally found to communicate to the excrements a dark colour, it is evident that they must suffer great changes from the action of the

digestive power in the animal body. In passing through these changes, it is probable, that when they produce salutary effects, they are so altered as to acquire the property of increasing the strength of the fibre.

Experiment III.

Portions of the intestine were immersed as before during two days in saturated solutions of blue and white vitriol, and were compared with similar portions immersed in water.

The sum of the weights required to break the portions exposed to the action of the blue vitriol was . . . . . 10lb. 6oz.

That of those required to break the standard was . . . 14lb. 6oz.

The strengths of the portions immersed in the solution of white vitriol were to those of the standard as $18\frac{1}{4}$ to $20\frac{1}{4}$ nearly.

In both cases the intestine immersed in the solution was relaxed, and its extensibility, by given small weights, increased.

Observations.

From the experiments recited in Section III. it appears that nitrated silver is decomposed by the intestines and the skin. There can be little doubt that this decomposition arises from the affinity of the animal fibre, to the pure air of the metallic salt. For the animal fibre contains certain substances which have a strong attraction to that fluid. It contains the elements of inflammable air and charcoal, termed by the French chymists hydrogene and carbon. Although both these substances have a tendency to unite with pure air, yet the former has a greater affinity to it than the latter. And hence, the pure air of the salt of silver being deprived of its elasticity, and held in a state of slight combination, appears to act in three ways upon the animal fibre.

1st. It unites with the colouring particles, and renders the fibres white.

2d. It combines with the hydrogen, in consequence of which the carbon becomes redundant, and the fibre assumes a black colour.

3. By a farther continuation of the process,

the pure air may unite with the carbon; the compound may be extricated in the form of fixed air; and the fibre may be altogether decomposed.

It moreover appears, from the experiments recited in Section III. that whilst the pure air of the nitrated silver produces the above-mentioned alterations in the colour of the fibre, it, at the same time, diminishes its cohesion.

We have seen, on the other hand, that when the fibre is immersed in a solution of corrosive sublimate, it becomes white, but does not afterwards assume a black colour, as it does when it is exposed to the action of nitrated silver. We have also seen, that although the last of these salts diminishes the cohesion of the fibre, yet the first greatly increases its cohesion, and that this increase probably arises from the pure air which the mercurial salt contains.

Hence it appears, that pure air, under certain circumstances, is capable of producing opposite effects upon the fibres of an animal recently killed; for when combined with mercury it increases, and with silver it diminishes, the cohesion of the fibre.

A similar difference may be perceived in the effects produced upon the fibre by acids, and by neutral or earthy salts.

Thus the vitriolic acid diminishes the cohesion of the animal fibre, and the salt, which consists of that acid combined with magnesia, greatly increases its cohesion. It is probable that in both cases the effects are produced by the pure air which enters into the composition of these substances. For we know that the vitriolic acid is composed of sulphur and pure air; and there can be no doubt that the action of this acid depends upon the latter ingredient, because I have found that the former does not occasion any alteration whatever in the cohesion of the animal fibre. For the same reason we may, I think, conclude, that the acion of vitriolated magnesia is chiefly to be ascribed to the pure air of the vitriolic acid, as the cohesion of the fibre is neither increased nor diminished by magnesia in its separate state. And in this conclusion we have, I think, reason to confide with greater certainty, because, as I before observed, it is a well known fact that pure air has a strong affinity

to some of the ingredients contained in the animal fibre.*

I have, moreover, found, that pure air is capable of producing opposite effects upon the cohesion of the coagulable lymph, as well as upon that of those parts of the animal body which have been the subject of the foregoing experiments.

From the experiments of Mr. Hewson it appears, that blood included by means of ligatures in a portion of the vein of a living animal, is made speedily to coagulate by the contact of common air. But if it be not

* It must be admitted that the properties of simple substances are, in many cases, altered by chemical combination, and hence sulphur and magnesia, by their union with pure air, may acquire affinities which they did not possess antecedent to that event. But if two substances, when combined, act chemically upon a third, and if one of the ingredients in the compound had a strong affinity in its separate state to this third substance, and the other had no affinity to it, we may surely ascribe the action of the compound principally to the first of these ingredients. Thus we may safely attribute the solubility of soap in water to the alkali which it contains; because oil, which is the other ingredient in its composition, has no affinity to water in its separate state.

brought into contact with common air, it does not coagulate for many hours.

Dr. Hamilton has proved, that if, in similar circumstances, the blood be exposed to the action of inflammable air, it does not coagulate.

The effects of this, and of some other kinds of air, upon the coagulation of the blood, will moreover appear from the following experiments.

Experiment I.

A little less than an ounce measure of light inflammable air, obtained by dissolving iron filings in the dilute vitriolic acid, was introduced into an inverted tube over mercury.

About half an ounce of arterial blood, taken in a small glass measure from the carotid artery of a lamb, was instantly introduced in its fluid state into the same tube, by making it ascend through the mercury, in the way commonly practised in such experiments.

In about an hour it appeared to be slightly coagulated. A similar portion of arterial blood, which was placed in an open vessel, as

a standard, had coagulated in about three minutes. The former was a shade darker than the latter. After an interval of about twenty hours, the coagulum of the blood exposed to the inflammable air, was attentively examined; and it was found to be much softer than the standard. The inflammable air did not appear to have undergone any diminution of bulk.

Experiment II.

About three fourths of an ounce measure of nitrous air was introduced into an inverted tube over mercury, and a small quantity of arterial blood, taken from the carotid artery of a dog, was made to ascend in its fluid state into the same tube.

By a similar process, a portion of fluid venous blood taken from the same dog, was placed in contact with dephlogisticated marine acid air over mercury.

The blood which was exposed to the nitrous air soon became black, and remained nearly fluid for several hours.

That which was exposed to the dephlogisti-

cated marine acid air, quickly acquired a florid colour, but in the course of about ter hours its colour became nearly black. It soon began to congeal, but as it was suffered to remain in the tube, the exact time of its congelation could not be determined with certainty.

At the end of twenty hours, these portions of blood were removed from the tubes. That which had been exposed to the nitrous air was found to be slightly coagulated; but it was evidently more soft and flaccid than that which had been exposed to the dephlogisticated marine acid air.

The dephlogisticated marine acid air was obtained by adding common marine acid to the oxygenated muriate of potash; the nitrous air, by dissolving mercury in the nitrous acid.

In these experiments it is manifest that the cohesion of the coagulable lymph of the blood was increased by the contact of pure air, and diminished by that of nitrous air.

Now, although the blood remains fluid while it continues to circulate in the vessels, yet, as it coagulates when brought into rest, it may be considered even in its state of motion, as possessing an unknown property, which gives it a

tendency to congeal when that state is interrupted. It seems probable, by the preceding experiments, that pure air increases the property upon which this tendency depends.* And as the blood is continually exposed to the action of pure air in the lungs, is it not probable that the property, whence the tendency to coagulate originates, is imparted to it in the process of respiration?

Whether this inference be admitted or not, the foregoing trials seem to afford a direct proof that pure air, under certain circumstances, is capable of producing opposite effects upon the animal body. For it increases

* It is proper however to observe, that I could find no difference in the cohesion of arterial and venous blood, obtained in the usual way, by making an opening into their respective vessels; nor was I able to discover any alteration in the cohesions, whether they were exposed to air or not during coagulation. The reader will, however, understand, that in all my experiments the blood was exposed to air in its passage from the orifice to the vessel in which it was received. From these facts, compared with Mr. Hewson's experiments recited above, it seems to follow, that the blood acquires the power of coagulating to its utmost extent in passing from the orifice to the vessel which receives it.

the cohesion of the coagulable lymph of the blood, when it first comes into contact with that substance; and we know that, when it is kept in contact with the lymph for a greater length of time, it destroys its cohesion, by promoting the putrefactive process.

We may, therefore, I think, conclude, in general, that pure air, by varying the mode of its application, may be made either to increase or diminish the cohesion of all the soft parts of the animal body. It is probable that it produces the first of these effects by furnishing the cement which unites the particles of the living body together; and the second by combining with a portion of the ingredients that enter into the composition of the fibre, in consequence of which the union of the particles is dissolved. May we not hence infer, that this wonderful fluid is the principal instrument which nature employs in the growth and nutrition, as well as in the decay and dissolution, of animal substances?

CONCLUSION.

It is a well known law of the animal economy, that when changes are produced in certain parts of the body, there are other parts which undergo corresponding changes. The sympathetic motions which thus take place have been traced with great care by physiologists, and various theories have been formed to account for them.

It appears to follow from the preceding experiments that some parts of the body are so constituted, as to be subject to a different law, which has hitherto been but slightly noticed by physiologists. Thus, from the opposite effects produced upon the intestines and the skin, by the same medicinal substances, it would seem that a change in the one is frequently associated with a contrary change in the other.

There are many facts ascertained by the observation of practical physicians, which appear to confirm the existence of this law of as-

sociation. It has been observed, for example, by Sydenham, and by other writers, that in the beginning of fevers warm clothing and tepid fomentations applied to the skin will frequently remove vomiting and purging. In this case, it is probable, that at the commencement of the disease the skin is constricted and the stomach relaxed; and that by taking off the constriction from the former, the latter, in some measure, recovers its tone. In like manner, a blister applied to the back, by relaxing the skin, will communicate tone to the stomach, and will relieve dyspepsia. On the contrary, a draught of cold water, by imparting tone to the stomach, will frequently relax the skin, and excite perspiration. It is probably owing to the same law of association, that vomiting and purging are often produced by the application of cold air to the skin in the autumnal season.

Dr. Cullen has shown that a constriction of the skin takes place at the commencement of the paroxysm of intermittent fevers. There is, as I before observed, great reason to believe, that this constriction is accompanied with a diminution of tone in the stomach. For not

to mention the facts stated above, which show that the changes in the stomach and skin frequently alternate with each other, the nausea and vomiting, which usually take place upon the accession of the cold fit, render it extremely probable that the tone of the stomach is reduced below the standard of health. These symptoms are alleviated as soon as the skin begins to be relaxed.

Hence we may perceive the reason why substances which relax the stomach, as volatile alkali, and aromatic oils, given during the cold fit, in large doses, increase the violence of the paroxysm. But these substances, on the contrary, which strengthen the stomach, and relax the skin, as emetic tartar, ipecacuanha, and opium, when exhibited at the accession of the paroxysm, generally diminish its violence, and sometimes entirely remove it.

If the state of the skin and intestines at the beginning of the fit of an intermittent be such as we have now described, it will, in some measure, explain the mode of the operation of the Peruvian bark in this class of diseases: for that medicine possesses, in a very high degree, the power of producing changes in the

stomach and skin, directly opposite to those which probably take place at the commencement of the paroxysm.

It seems to be an object of great moment to investigate the extent of the abovementioned law of association; and to ascertain, by experiment and observation, how far the changes which may arise in the several parts of the body are calculated to produce similar or dissimilar changes in other parts. The complete elucidation of this subject must be reserved for future enquiry. I shall only remark, at present, that I have reason to believe, from experiment, that the changes in the skin are frequently associated with opposite changes in the lungs, as well as in the stomach and intestines.

FINIS.

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