LIST OF CANDIDATES

RECOMMENDED TO RECEIVE

The Degree of Doctor of Medicine

AND

The Degrees of Bachelor of Medicine and Master in Surgery,

IN THE

UNIVERSITY OF EDINBURGH,

On MONDAY, 1st AUGUST 1887.

THE DEGREE OF DOCTOR OF MEDICINE,

WITH THE TITLES OF THE THESES.

**** Those who have obtained Gold Medals for their Dissertations.*
*** Deemed worthy of Competing for the Dissertation Gold Medals.*
** Commended for their Dissertations.*

*ARCHIBALD, JOHN, Scotland, M.B. and C.M., 1868. Cutaneous Absorption.

*****ATKINSON, GEORGE ARMSTRONG,** England, M.B. and C.M. (with First-Class Honours), 1882. The Chemistry and Pharmacology of the Nitrites and Nitro-Glycerine.

*BAILEY, THOMAS RIDLEY, England, M.B. and C.M., 1882. Clinical Studies, with Notes on an Epidemic of Typhus Fever.

BAILLIE, PETER, Scotland, M.B. and C.M., 1882. Overpressure in Elementary Schools.

****Batten, George Beckett,** India, M.B. and C.M., 1884. Some Cases of Injuries and Lesions of the Head, with Notes on Treatment.

BOWES, JOHN, Scotland, M.B. and C.M., 1883. Early Puerperal Pyrexias.

*BOYCE, CHARLES, Ireland, M.B. and C.M., 1876. The Artificial Feeding of Infants.

*BREWIS, ROBERT ADAMS, England, M.B. and C.M., 1884. Cases of Occipito-posterior Positions of the Head.

****BRUCE, ALEXANDER,** Scotland (M.A.), M.B. and C.M. (with First-Class Honours), 1879. Studies on Developmental Anatomy of the Human Brain and Spinal Cord.

***Chapman, James Milne,** Scotland, M.B. (with Second-Class Honours), 1877. The Endometrium.

DOUIE, WILLIAM JONES, Scotland, M.B. and C.M., 188[illegible]. Pseudo-hypertrophic Muscular Paralysis.

*Easton, Thomas, Scotland (M.A.), M.B. and C.M., 1884. Massage in the Practice of Medicine.

*Fraser, Alexander Duncan, Scotland, M.B. and C.M., 1874. On the Treatment of the Chronic Indolent or Callous Ulcer.

Gage-Brown, Charles Herbert, England, M.B. and C.M., 1884. A Few Researches in the Development of Thermometry.

**GIBSON, JOHN, Orkney, M.B. and C.M., 1879. Waxy and Hyaline Degenerations.

Gowans, William Bruce, Scotland, M.B. and C.M., 1883. Hemiglossitis: the History of Two Clinical Cases; one right-sided and resulting in abscess, with remarks.

**Grant, David, Scotland (M.A.), M.B., C.M. (with First-Class Honours), 1876. On Movable Kidney. Remarks chiefly Clinical, with four cases.

*Hardcastle, Hugo M'Cauley, Egypt, M.B. and C.M., 1882. Chronic Lead Poisoning.

Heath, James, Ireland, M.B. and C.M., 1883. Remarks on Asthma.

*Helm, Robert Dundas, Scotland, M.B. and C.M., 1883. Empyema in Children.

Hewston, Alexander, New Brunswick (B.A.), M.B., C.M., 1867. A Description of the Malarious Fevers of Wynâad.

Houseman, James Gilpin, England, M.B. and C.M., 1881. Notes on Otorrhœa.

**Hunter, James, Scotland, M.B. and C.M., 1878. Compressed Air; its Physiological and Pathological Effects.

Irving, George, Scotland (M.A.), M.B. and C.M. 1883. The Binder and its relation to Obstetrics.

Kenyon, George Herbert, England, M.B. and C.M., 1884. Practical Observations on the Treatment of Dyspepsia.

Kirby, Ernest Dormer, England, M.B. and C.M., 1882. Chronic Poisoning by Lead.

Laing, David, Scotland, M.B. and C.M., 1884. Two Years' Experience as an Assistant.

*Laurie, Robert, England, M.B. and C.M., 1881. Dietetics in relation to Infant Mortality.

Lightfoot, Charles Lewis, England, M.B. and C.M., 1883. Keratitis.

M'Arthur, Duncan Romaine, Ceylon, M.B. and C.M., 1882. Puerperal Eclampsia.

Mackenzie, Alexander Flyter, Scotland (M.A.), M.B. and C.M., 1882. Some recent Advances in Pathological Research.

Mackenzie, Robert, Scotland, M.B. and C.M., 1883. Ear.

Mackinlay, Robert, Scotland, M.B. and C.M., 1882. The Hæmatinic Action of Iron in Anæmia of Old Age.

M'Lean, Charles James Russell, Scotland, M.B. and C.M., 1885. Obstetric Experiences.

*Male, Herbert Christopher, England, M.B. and C.M. (with First-Class Honours), 1880. On Purpura, with Special Reference to its Pathogenesis.

*Martin, James Williamson, Scotland, M.B. and C.M., 1885. Carcinoma of the Uterus; a Pathological Research.

***MILLER, WILLIAM CORNFOOT STRETTELL, Scotland, M.B. and C.M., 1885. On the Myology of Seals.

*Mowat, Daniel, Scotland, M.B. and C.M., 1884. The Sphygmograph; its Clinical Value in Pharmacology and Disease, with Special Reference to Diseases of the Vascular System.

*Oliver, James, Scotland, M.B. and C.M., 1879. The Epileptic Paroxysm.

*PATERSON, DONALD ROSE, Scotland, M.B. and C.M. (with Second-Class Honours), 1883. On the Etiology, Pathology, and Nature of Tetanus.

*PHILIP, ROBERT WILLIAM, Scotland (M.A.), M.B. and C.M. (with Second-Class Honours), 1882. A Study in Phthisis, Etiological and Therapeutic.

PURVES, ADAM SCOTT, Scotland, M.B. and C.M., 1883. Dietetic Errors of the Northumbrian Agricultural Labourers.

*RITCHIE, DANIEL, Scotland, M.B. and C.M., 1878. An Analysis of 700 Cases in Obstetrics.

*ROBERTON, ERNEST, New Zealand, M.B. and C.M., 1885. The Examination of the Fæces—Macroscopic, Microscopic, and Bacteriological.

*Robertson, John, England, M.B. and C.M., 1884. The Distribution of Phthisis in England.

ROBERTSON, THOMAS MURRAY, India, M.B. and C.M. (with Second-Class Honours), 1883. Hypnotism.

*ROTHERA, FRANK, England, M.B. and C.M., 1883. Simple or Perforating Ulcer of the Stomach.

*SCOTT, HARRY, England, M.B. and C.M., 1885. Relationship of Nasal Inflammations to Pharyngeal and Laryngeal Inflammations.

STAPLETON, JOSEPH, Australia, M.B. and C.M. (with Second-Class Honours), 1882. Gluteal Aneurysm.

*STEVENS, JOHN, Scotland (M.A.), M.B. and C.M. (with First-Class Honours), 1884. On the Tests of the Bile Salts, and on the Renal Elimination of the Bile Salts, Urea, Indican, and Sugar, with a Report of Clinical Cases.

*Stirling, Alexander Williamson, Scotland, M.B. and C.M., 1880. Researches on Cyclic Albuminuria.

*Welch, Henry, England, M.B. and C.M., 1878. On Infant Mortality in large English Towns.

*Welsh, David, Scotland, M.B. and C.M., 1881. On the Rate of Cooling the Human Body after Death.

*WILSON, CLAUDE, England, M.B. and C.M., 1884. The Physiology of Education, being mainly a Study of Cerebral Physiology applied to Education.

*Wilson, Ralph William, England, M.B. and C.M., 1877. On Malignant Tumours arising within the Chest.

E. Wm Hope, C.E. in Public Health

Laurie's

Atkinson's Grant's Miller's

Theses are awanting.

Miller and Tallis gave in Theses, but did not graduate

THE DEGREES OF BACHELOR OF MEDICINE AND MASTER IN SURGERY.

ANTIQUE CAPITALS *indicate that the Candidate has passed the Examinations with First-Class Honours.*

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ROUGET, FRANÇOIS AUGUSTE, Maurtitius.
Rowand, Andrew (M.A.), Scotland.
SAVARY, CHARLES GASTON, Trinidad.
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SCOTT, WALTER, England.
SHAW, EBENEZER (M.A.), Scotland.
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SIMPSON, JAMES BERTIE (M.A.), Scotland.
SIMPSON, JAMES CHRISTIAN, Scotland.
SLOMAN, ARTHUR EDWARD, England.
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SMITH, JAMES LARGUE MURRAY, Scotland.
SMYTH, WILLIAM JOHNSON, Ireland.
SOMERVILLE, JAMES WILLIAM, Scotland.
Sprague, William Carr, England.
STALKARTT, WALTER HENRY SKINNER, India.
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WARD, THOMAS HAMILTON, England.
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WATSON, GEORGE ALFRED, India.
WATSON, JOSEPH RILEY (B.A.), England.
WATT, JAMES PETER (M.A.), Scotland.
WELLS, JOHN WILLIAM, England.
185 WHITE, JOSHUA CHAYTOR, Ireland.
WHITE, PHILIP JACOB, India.
WHITELAW, THOMAS, Scotland.
Whitwell, James Richard, England.
WILLIAMS, ALFRED HENRY, New Zealand.
190 WILLIAMS, JOHN CADWALADR, Wales.
WILSON, CHARLES BLAIR, Italy.
WILSON, GEORGE, Scotland.
WILSON, JAMES, Scotland.
WILSON, WILLIAM, England.
195 WISEWOULD, PERCY, Australia.
Wright, William Fraser, Scotland.
WYNCOLL, JOHN WILLIAM, England.
WYNN, LAWRENCE GABRIEL HENRY PASSINGHAM, England.
YOUNG, EDWARD BROOKE, Scotland.

The MURCHISON Scholarship in Clinical Medicine has been awarded to
WALTER S. COLMAN.

The GUNNING VICTORIA JUBILEE Prize in Chemistry has been awarded to
HUGH MARSHALL, B.Sc., for an Experimental Research on the Oxidation of Cobalt Salts by Electrolysis.

The GUNNING VICTORIA JUBILEE Prize in Anatomy has been awarded to
WILLIAM STRETTELL MILLER, M.D., for his Thesis on the Myology of Seals

The GUNNING VICTORIA JUBILEE Prize in Practice of Physic has been awarded to
ROBERT WILLIAM PHILIP, M.D., for his Thesis on a Study in Phthisis.

The ETTLES Scholarship has been awarded to
GEORGE OWEN CARR MACKNESS (B.A.), M.B., C.M.

The BEANEY Prize has been awarded to
ANDRÉ ARTHMAN BRUÈRE, M.B., C.M., } *equal.*
WILLIAM ALDREN TURNER, M.B., C.M. }

The BUCHANAN Scholarship has been awarded to
WM. FRASER WRIGHT, M.B., C.M.

The JAMES SCOTT Scholarship has been awarded to
JOHN GEORGE HAVELOCK, M.B., C.M.

Graduation Thesis

by

John Archibald M.B.; C.M.

Cutaneous Absorption.

30th April 1884.

Cutaneous Absorption.

The belief that the human skin will absorb is an idea, which has been entertained from the very earliest ages, and this question has long engaged the attention of Physicians & Physiologists, while the interest attaching to it, as well as the great diversity of opinions expressed with regard to the conclusions, which have been already adduced, render it a subject worthy of investigation — & one which it is to be hoped will yet yield profitable results. In holy writ we have reference made to the anointing with oil, whilst among the Egyptians the care bestowed by them in the embalming of their dead points to the skin retaining fatty matters which they used
97. along with spices. Hippocrates alludes to the diuretic effects of baths & he also observes
98. "the soft parts of the body attract matter to themselves both from within & from without — a proof that the whole body exhales & inhales"; upon which passage Galen has the following comment:- "for as the veins, by mouths 'placed in the skin, throw out whatever is 'redundant of vapour or smoke, so they 'receive, by the same mouths, no small quantity 'from the surrounding air;

Note :- Numbers on margin refer to Bibliography.

'and this is what Hippocrates means when he 'says that the whole body exhales & inhales".

101a. The ancient Hindoos used the warm bath accompanied by rubbing & brushing as a means of cleanliness, & the earth bath in beriberi. The Greeks had vapour baths in their temples which were employed for curing various diseases. They also rubbed the body & annointed it with medicated ointments after the bath. Warm baths were consecrated by them to Hercules,

101c. by the use of which new vigour was supposed to be given to the athletes.

101b. The Chinese had recourse to baths for flatulence.

99. Celsus employed baths in injuries of the head, in fevers & hydrophobia.

101d. In the 16th Century a prohibition was issued against the use of public baths in France, which prohibition was afterwards considered to have favoured numerous diseases, especially leprosy.

101e. Asclepiade de Bithynie prescribed warm baths with friction & immunction as a remedy for tetanus & ileus.

101f. Agathinus de Sparta was in favour of cold baths for the preservation of health.

100. Sydenham recommends bathing in the Waters of Bath as a remedy for hysteria, & he makes mention of the warm bath in the following terms:—

"Hoffman likewise observes that warm bath-
"ing cures all distempers as proceed from a
"contraction of the parts of the lower belly. Of
"this kind are pains in the intestines, Gripings,
"violent convulsive colics, heavy pains & con-
"tractions, occasioned by stone in the kidneys,
"& attended with suppression of urine, costive-
"ness, etc., in all which cases the warm bath
"is evidently serviceable".

101g. In 1791 Jackson treated nervous fevers by means of cold effusions.

101h. Rowley in 1793 proposed baths containing hydrochloric acid for the treatment of Gout.

Passing from these references of olden times, we shall now observe the most modern observations made on Cutaneous Absorption, & shall consider them in the following manner:-

I. Absorption of fluids by the human skin.
II. Absorption of Gases by the human skin.
III. Absorption of saline substances in aqueous solution by the human skin.
IV. Absorption of Iodide of potassium & Iodine in solution by the human skin.
V. Do substances, which colour the skin, show their presence in the urine?
VI. Absorption of substances, acting mechanically & chemically in a liquid form on the skin.
VII. Absorption of substances in solution, by the skin, which act physiologically on the body.

VIII. Absorption, by the human skin, of medicated substances in the form of spray.
IX. Absorption of ointments by the human skin.
X. Permeability of the dead skin of man & animals.
XI. Permeability of the living skin of animals.
XII. Electro-chemical methods of introducing medicines through the skin.

I. Absorption of Fluids by the Human Skin.

Opinions are very much divided as to whether the human skin does or does not absorb water. Let us first state some of those holding that it does absorb water:-

1. Kirk affirms that increase of weight and assuagement of thirst have been observed by the use of a warm water or milk & water bath in cases of severe dysphagia, when fluids could not be received by the stomach.
2. Hermann thinks absorption by the skin is proved to be a well established fact & that a warm bath is more potent than a cold one.
3. Wittich considers imbibition more than hydro-diffusion to be the principal factor by which fluids enter the circulation through the skin.
4. Young found that the higher the temperature of the water in a full bath the less was the increase in the weight of the body. He guarded against the possibility of inhaling vapour,

arising from the water, by breathing through a tube led into another room. In a bath @ 36°C. there was an increase in weight of 135 Grammes, & in one @ 32°C. of only 40 Grms. whilst if the temperature was raised to 37°C. there was no increase in weight whatever.

5. Durian after numerous experiments drew the following conclusions:- "1st Water of a lower temperature than that of the body was absorbed." "2nd The urine was always alkaline after either an alkaline or an acid bath."

6. Bracounot on the other hand states that the urine always became neutral after either an alkaline or acid bath, & that it was increased in quantity after a bath.

7. Dill experienced increase in weight after a full bath, & thus inferred absorption of the fluid.

8. Madden tried baths both of milk & tepid water. He was carefully weighed before immersing his body in the full bath, in which he remained half-an-hour, breathing by means of a tube leading to the open air. The temperature of the baths ranged from 29° – 34·5° C.
On coming out of such baths his increase in weight varied from 2½ – 69 Grammes: while in using a bath of 36° C. in temperature his weight was considerably diminished — this decrease was attributed to his perspiring freely in a bath of so high a temperature.

Madden also tried a partial bath & placed his arm only in a vessel having a graduated glass tube attached. The surface of the water was covered by a stratum of oil to prevent evaporation; & as the water in the tube sank in every experiment he thereby concluded that there was absorption.

9. Berthold took baths lasting from 15–60 minutes & found increase in weight. He believed the amount of absorption to be 1/4 grammes in a quarter of an hour.

10. Collard de Martigny immersed his arm for half-an-hour in a vessel containing water @ 85° F. : a similar weight of water at the same temperature was put into another vessel of the same size & shape as that used for the bath — the water in this vessel being allowed to stand & evaporate. The evaporation from both vessels being taken as equal, he found the loss in weight of the water in which his arm was placed to be 2·748 grammes and he thereby inferred absorption.
He adopted another kind of local bath, consisting of a funnel-shaped vessel with a tube attached, & placed it on the skin for half-an-hour. The vessel adhered by suction & as the level of the water in the tube fell, he concluded that there was absorption of the liquid.

11. Falck also employed partial baths — he placed his arm for 30 minutes in a graduated glass cylinder filled with water at a temperature of 20° – 30° C. & calculated the diminution of water in the cylinder to be from 30 – 50 drops per hour.

13. Vierordt & Eichberg found increase in weight after an arm bath. The water being weighed before & after the bath, they calculated there was a gain of 1·6 – 2·1 grammes per hour.

15. Homelle also found the urine more plentiful after a bath.

16. Dupuyes & Chesnais consider imbibitions to be a proof of absorption.

17. Willemin made 31 experiments on himself & students, from the results of which he believes the skin absorbes water.

The following observations affirm the Skin does not Absorb water.

19. Currie of Liverpool had a patient suffering from closure of the cardiac end of the stomach caused by a cancerous tumour; & as nourishment could not be taken in the ordinary way, baths of warm milk, beef-tea, &c. were prescribed, but the patient gradually became thinner & died through wasting & exhaustion.

20. Kuss states no absorption takes place from remaining a long time in a bath as was shewn by experiments in Vienna, where people were immersed for weeks & months & yet suffered from thirst in the same way as if there were no water surrounding them.

21. Seguin weighed the body both before & after immersion & finally concluded that the skin did not absorb water.

22. Klebzinsky made a number of careful observations on himself with baths extending over several hours & concluded the human skin to be impermeable to water when the body is immersed only a moderate time.

23. Poulet experienced after a bath of two hours duration a loss of never less than 50 Grammes.

24. Lehmann L. took his three children, aged respectively 2 : 4 : & 7 years old, & experimented upon them. He found that they all lost in weight & therefore concluded there was no absorption.

25. Fleischer made a series of very carefully conducted experiments on his arm & fore-arm with Mosso's glass cylinder plethysmograph with a glass tube, divided into C.C., fitted on to it, so as to note any rise or fall of the fluid in the vessel.
After a repeated number of experiments extending over several hours, he found that the water in the tube neither rose nor fell to any appreciable extent & was thus satisfied that no absorption of water took place by the human skin.

Let us now consider the evidence of the various experiments, above noted, regarding the Cutaneous Absorption of fluids by the Skin. The ideas in favour of cutaneous absorption are probably founded on the fact of the skin imbibing water. — Who, after having seen the sodden hand of the washerwoman, or the puckered finger ends of an individual on leaving a Turkish Bath, could conclude that there was not imbibition? But is imbibition followed by absorption? We think not, as it would be difficult to prove that the fluid thus retained by the epidermis necessarily enters the circulation, if the fluid imbibed evaporates on exposure to the air. Fleischer noticed in all his experiments that though his hand became wrinkled & swollen, yet the fluid in his graduated glass tube did not fall to any appreciable extent, & that this condition of his hand passed off again in about 15 minutes after the bath. The fluid in the tube remaining almost stationary he attributed to the extra bulk of his swollen hand taking the place of the fluid imbibed from the bath: but had there been actual absorption & free intercommunication between the epidermis & the deeper seated absorbing structures so that the fluid entered the circulation,

would not the level of the water in the tube have fallen in a corresponding degree to its absorption by the circulation? We think it would: but as already stated the fluid remained almost stable, which fact goes a long way to prove that absorption did not actually take place.

Another very strong argument against cutaneous absorption is the fact that patients, who are treated for various skin diseases by the continuous bath, will remain immersed in it for weeks & months — in fact live in it — & yet experience no difference in their desire for liquids by the mouth as their thirst is in no way modified, which seems to shew that water has not been appreciably absorbed into the system. The same may be concluded from the fact that the skins of different individuals differ in secretion & excretion, as seen in the greasy skin of the gouty & the oily skin of the negro, which imbibe very much less freely than those of several of the other Constitutions with regard to liquids, and also from the fact that the skin acts as a protection to the body by preventing the absorption into the system of many irritating and noxious materials, with which it is constantly coming in contact.

18. Though, as Mackenzie seems to think,

"Some parts of the skin may imbibe more readily than others", yet it is very questionable if even such parts absorb with respect to liquids, seeing so many experiments have been tried for nourishing the body through the skin by means of liquids, & as yet no good results recorded.

Now with regard to those observers, who state positive results, & who had the person weighed both before & after the bath, it may safely be said that in many instances their scales were not sufficiently accurate to determine such weights; nor did these observers take all the necessary precautions against evaporation from the surface of the water of the bath & the possibility of inhaling vapour by the lungs: neither did some of them use means to prevent absorption by the anus, prepuce, & umbilicus.

The temperature of the bath plays an important part in determining the weight of the body. A bath below 32° C., as Durian proves, causes an increase of weight due to imbibition, whilst baths at a temperature of 35°-45° C. cause a decrease in weight — sometimes even of 600 grammes in ten minutes — due very probably to the free perspiration taking place in a bath of so high a temperature.

II. Absorption of Gases by the Human Skin.

The power of the uninjured skin to absorb gases, whether they exist in a free state or are found dissolved in water, is a point universally admitted. The average total amount of Carbonic acid gas removed from the body in 24 hours is according to Scharling 10 Grammes, while Dalton estimates it at ¼ oz. : The amount of oxygen absorbed is supposed to be slightly less.

26. The later experiments of Regnauld & Reiset prove that there is a regular interchange of gases going on in the skin — the volume of oxygen, absorbed by the skin, approximating or almost equalling the volume of Carbonic acid gas, exhaled by perspiration.

27. Oxygen, Hydrocyanic acid, Sulphuretted Hydrogen, Carbonic Oxide, Carbonic Acid, & the vapours of Chloroform & Ether are absorbed:- (Chassier & Gerlach.) Sulphuretted Hydrogen in watery solution is absorb-

28. ed, while Carbonic acid gas passes into the water (Röhrig).

29. In the mean temperature the skin excretes 38. hgms. of Carbonic acid & 1·91 hgms. of water per hour. : This is increased by food & also by increase of temperature, as well as by irritants applied to the skin.

Röhrig thinks gases may be absorbed by the sound skin. In an experiment, performed on a rabbit placed in an atmosphere of

Sulphuretted Hydrogen, he found the rabbit died from the poisonous effects of the gas. Chloroform also produced narcotic effects through its absorption by the skin.

16. Herpin has noticed darker colouring of the venous blood after a bath, containing Carbonic acid, of several hours duration.

25. Fleischer also admits (p. 58.) the transmission of Alcohol & Chloroform through the skin in a gaseous form.

3. Wittich also believes that the manner in which Chloroform, Ether, & Turpentine enter the circulation, when applied to the skin, is by their being so easily transformed into vapour at a low temperature.

Sir James Y. Simpson in his lectures to the students of the Midwifery Class pointed out that facial neuralgia might often be relieved by placing a piece of cotton wool, saturated with chloroform, under a watch glass, & applying it to the painful spot. — This method we have often seen attended by good results.

20. Bichat's experiments shew that, if a limb is exposed to an atmosphere of putrescent gas, the gas is absorbed. Miasma appears to penetrate the organism in this way, as it has been noticed that protecting the body with flannel greatly lessens the risk of such poisoning.

III. Absorption of Saline Substances, dissolved in Water, by the Human Skin.

Much difference of opinion has prevailed regarding the power of the skin to absorb saline substances in solution. We have therefore again to consider the question of imbibition, as there is little doubt of the epidermis being capable of giving off whatever it imbibes & the organic substances contained in it.

31. Liebig, after carefully cleansing his middle finger by washing it in distilled water, alcohol, & ether, dried it & placed it again in distilled water, but no cloudiness appeared on the addition of nitrate of silver. The finger was then immersed in a 2% Solution of common salt for half-an-hour, & on being taken out of the solution, it was again washed with distilled water until no reaction took place with the nitrate of silver. The finger was now dried & put into another vessel, containing distilled water, for nearly 30. minutes, when, on the addition of nitrate of silver, a cloudiness was seen.

30. Clemens, in experiments similar to Liebig's, also found common salt deposited in the superficial layers of the epidermis.

32. The following experiment by Bloch seems to prove only imbibition, although he gives it as an instance of true absorption:- He placed his arm in Bordeaux Wine,

wiped it, & then gave it another bath in a solution of Perchloride of Iron, when the brown tannate of iron was observed.

33. Lehmann, we think, only proved imbibition in a series of experiments with salt of lime & strontia in Sitz baths:- He took eight of such baths consecutively day by day & a week after he washed himself with water. He evaporated this water, & in the residue he detected the salts by spectroscopic examination.

34 & 35. Dittrich took the specific gravity of a saline bath both before & after the experiment; & finding the specific gravity less after the bath, he thereby inferred that there was cutaneous absorption.

We have seen that the human epidermis is capable of retaining common salt, &c. and we shall now endeavour to determine if the condition of the urine showed any change after a saline bath.

36. Spengler, noticing a decrease in the acidity of the urine after a bath of Ems Spa Water, ranging in temperature from 24°- 46° R. came to the conclusion that soda was absorbed.

12. Alfter avers that the common salt, in the warm baths of Reynhausens, is soon after the bath excreted by the kidneys.

57. Bainbrigge believes in the curative properties of the salt springs at Droitwich in cases of Cholera.
34. 38. Lehmann, Beneke, & Röhrig, after an alkaline bath, could never detect salts in the urine.
18. Mackenzie thought he could prove the absorption of Caustic Soda by the skin, as the urine was alkaline after such baths.

To determine the power of the skin to absorb by simply considering the acidity or alkalidity of the urine would be rather difficult, as the temperature of the bath plays an important part; because in a warm bath the free perspiration is added to the water of the bath, there is also diminished fluidity of the blood, & consequently less secretion of urine, which is more acid & concentrated than normally. On the other hand if a person has taken much fluid or food, or if he has had active exercise, before having his bath, there would undoubtedly be a difference from the normal in his urinary secretion.

IV. Absorption of Iodide of Potassium & Iodine in Solution by the Human Skin.

This subject is assigned a separate place from the fact that the experiments with these substances have been very numerous, & have been also a fertile field for controversy among observers.

39. Thus Brémond obtained absorption of Iodide of Potassium by applying it in the form of a vapour bath, at a temperature of 113° F., for 30 minutes. Two hours after it was present in the urine as Iodine. He observed that generally no absorption occurred unless the temperature of the vapour bath was one or two degrees above that of the body.

40. & 41. M. Rosenthal, after carefully covering the prepuce, & allowing an individual to remain one hour in a full bath, @ 26° C., with 30 Grammes of pure Iodide of Potassium added to it, always observed Iodine in the urine collected during the succeeding twenty four hours. There was always a decrease of Iodine in the water after the bath, when a known quantity was added to it, & he believed it could not enter the circulation by being inhaled with the steam from the surface of the water.

50. Hoffman thinks that the presence of Iodine in the urine not having been found by some observers was due to the baths being of too short duration.

50. He accordingly extended them over 45 days— each bath containing 50 Grammes of Iodide of Potassium. Iodine was found in the urine on the 6th day & during the remaining days of the experiment.

38. Röhrig took two phials containing Tincture of Iodine & put a finger into each for 15 minutes, taking care not to stop the circulation, & afterwards discovered Iodine in his urine.

8. Madden used arm baths, containing solutions of Iodide of Potassium, & on testing his urine he found traces of Iodine present.

56. Henri believes that a weak solution of Iodide of Potassium penetrates the skin.

42. Geltkowsky, Waller (44), & Willemin (17.) found
44. Iodine in the saliva & urine after a bath in
17. which Iodide of Potassium had been dissolved.

Various observers, as the result of Experiment, deny the possibility of the skin absorbing Iodine.

45. Demarquay had occasion to paint ~~the~~ a part of the skin of a patient with Iodine; & he not only found it in this person's urine, but also in that of every other patient in the ward. [The above may be taken as an example of the difficulty of proving the cutaneous absorption of Iodine].

49. Hebert took full baths, containing Iodide of Potassium for 4 hours in duration, & on afterwards examining the secretions & excretions could never detect Iodine.

46. Ritter immersed his arm in a bath, containing Iodide of Potassium, from ¾ – 1½ hours, & never found the presence of Iodine in his urine.

47. Murray Thomson took full baths, @ 100° F., from 30 – 40 minutes in duration, having Iodide of Potassium dissolved in them, & never could detect Iodine in his urine.

22. & 48. Kletzinsky & C. G. Lehmann (48.), after baths of Iodide of Potassium in solution, could never discover Iodine in the urinary secretions.

18. Mackenzie used six baths, having Iodide of Potassium dissolved in the water, lasting one hour, & ranging in temperature from 90° – 96° F.; and on his evaporating the urine & testing for Iodine, none was found to be present.

18. Similar results were obtained by Braune & Hoenelle.

25. Fleischer made very careful experiments with funnels, filled with Tincture of Iodine & Iodide of Potassium respectively, which were placed on the inner surface of the thighs for periods varying from one to one & a half hours. He took every precaution in conducting his experiments, & in no case did he find the presence of Iodine in the secretions.

We think those experiments, which yielded positive results, were not performed with sufficient carefulness;

as precautions were not always adopted to prevent the possibility of the Iodine entering into the circulation by inhalation.

82. Lauder Brunton thinks that where positive results are obtained that these results are due to the skin not being washed after the bath of solutions of Iodide of Potassium, which crystalises on the surface & is afterwards by the friction of the clothes rubbed into the sub-aceous glands.

In Hoffman's case the salt must have greatly accumulated in the epidermis during the 45 days, he continued taking the baths of Iodide of Potassium in solution: Granting such to be the case, would not the fatty acids of the skin decompose the salt to such an extent that the heat of the body would liberate free Iodine, of which Hoffman must have inhaled more or less? Such, we think, was the case & accounts for Iodine being found in his urine on the 6th day. Neither did Röhrig guard against inhalation from any vapour arising from the Tincture of Iodine in his experiments.

On the other hand the remarkable instances of its volatility, as shown in Demarquay's ~~illustrate~~ experiment, illustrate the careful manner in which experiments require to be conducted with this substance.

The results obtained by Hébert & Murray Thomson are worthy of particular attention; while the care with which Fleischer conducted his experiments, & the results he obtained, do, in our mind, conclusively point to the idea that the unbroken skin does not absorb either Iodide of Potassium or Iodine in Solution.

V. Do substances, which colour the skin, show their presence in the Urine?

Baths, containing solutions of Turmeric, Madder, Rhubarb, & Indigo-carmine, have been employed in order to observe if these substances, applied to the skin, found their way to the urine.

54. Dr. Robley Dunglison, Professor of Materia Medica, University, Maryland, U.S.A., gives instances where in full & partial baths infusions of madder, rhubarb, & turmeric caused the urine to be tinged with their respective colours.

52. Chrzonszewsky caused a person to take a Sitz bath, of three hours duration, coloured with Indigo-carmine: he afterwards observed the urine to have a slightly blush tinge, & to become decidedly blue, if the period of immersion was extended to six hours.

55. Carpenter believes the urine to be tinged with the colouring matters of madder, rhubarb, & turmeric after baths containing these substances.

53. Westrumb asserts that he has obtained the colouring matter of rhubarb in the urine after a hand or foot bath.

18. Mackenzie, on the other hand, did not observe any perceptable change in the colour of the urinary secretions after foot-baths, having respectively turmeric, madder, & Turkey rhubarb dissolved in the water. Temperature of the baths was 90° F. & the time varied from one & a half to two hours. Murray Thomson, Hébert, Jültzer, and Barrisot also obtained negative results from baths containing solutions of rhubarb.

25. Fleischer tested the possibility of colouring matter entering the circulation through the skin:- he chose indigo-sulphate of soda & dissolved 10 Grammes of it in 1200 Grammes of water & used this in the form of an arm bath about 114° F., & into which he placed his arm for 3½ hours. On the expiration of this time & during the following day he found no discoloration of the urine,

and only the superficial layer of the epidermis was coloured, which he proved by excising a piece of the skin & finding its deeper layers to be **normal** in colour.

In Chrzonszewsky's experiment, we think, it is very probable that the colouring matter, he found, in the urine was due to its absorption by mucous surfaces, as he took no precautions against such fallacies; whereas in Fleischer's case, by his using his arm only, no such errors could arise, and had the indigo-sulphate of soda been absorbed into the circulation, it would have afterwards been found in his urine by its having the bluish tinge, spoken of by Chrzonszewsky after a bath of the same duration.

VI. Absorption of Substances, acting Mechanically & Chemically, in a liquid form, on the Human Skin.

No one has denied that, when the epidermis is separated from the true skin, substances, placed upon the raw surface, will be absorbed. This is seen in every-day practice. Cantharides, by being applied to the skin to cause vesication, is often thus introduced into the circulation, & may cause the urine to be tinged with blood, & give rise also to strangury. So is it with anything else, that partly dissolves or in any way displaces the epithelium or tends to remove the fatty matter from the skin. To apply a blister & then sprinkle a little powdered morphia over the denuded corium is quite a common occurrence in order to obtain the sedative effects of morphia.

18. Von Paalzow (Pflüger's Archiv. p. 492 (1872)) finds that baths of water rich in carbonic acid do not increase the respiration; but powerful irritation of the skin, produced by mustard, causes increase both of the carbonic acid evolved & of the oxygen taken in.

20. Colin (Physiologie Comparée des Animaux Domestiques (1873) Vol. II. page 123) produced absorption by mechanical action.

He took a watery solution of Cyanide of Potassium & allowed it to drop on the back of a horse for 5 hours. The sebaceous matter was destroyed by this method, & the horse was poisoned by the cutaneous absorption of the salt.

82. Lauder Brunton (p. 403) says substances dissolved in ether, & especially in chloroform, if painted on the skin are absorbed; but that these substances dissolved in alcohol are not absorbed unless they be well rubbed in, though alcohol as well as chloroform dissolves the sebaceous matter. He attributes the action of the chloroform to its endosmotic power to a great extent.

83. Garrod thinks some of the irritants, such as mercurial & Iodine preparations, probaby induce a specific effect as well as mere local irritation. Iodine is often absorbed owing to the epidermis being destroyed when the tincture is painted over the skin — means being taken at the same time to prevent evaporation, taking place from the painted surface, passing into the circulation through the lungs. Corrosive sublimate, which easily destroys the epidermis, is readily
3. absorbed (Wittich).
57. So also are the salts of iron — Dr Chauvouillon made experiments with the water of the baths of Luxeuil, which contains this mineral,

and the urine of those patients, who had taken a course of baths, was always found to contain iron, which must have been owing to its effect on the epidermis.

58. Richardson has found that the salts of antimony in watery solution are absorbed & their presence detected in the urinary secretion.

59. Bourru experienced nausea, stupor, headache, & pulsation of Carotids & Temporal arteries after rubbing dynamite between his fingers & the palm of his hand.

60. D. Oliver noticed a grayish blue discoloration of the skin amongst polishers of silver, which discoloration could not be washed off.

Although it seems pretty certain from the above observations that an irritant placed on the skin will be absorbed, yet the following experimenters arrived at a negative result with reference to absolute alcohol & Tartar emetic.

62. Mitscherlich affirms that absolute alcohol does not affect the epidermis; & the same belief is held by

25. Fleischer, who made a number of experiments to determine the point:- he took two funnel shaped vessels, both having a graduated pipette, filled them with alcohol, & placed them on the inner surface of each thigh. One was closed & the other left open. The duration of the experiment varied; but in them all the level of the absolute alcohol remained the same in both tubes.

48. Lehmann tried foot-baths of Tartar-emetic, but did not observe the least nausea or vomiting.

VII. Absorption of Substances in Solution by the Skin which act Physiologically on the body.

We have been able to find only a few experiments recorded which bear on the question of absorption of substances in solution by the human skin whose presence in the circulation would have shown that they had acted physiologically on the body. No observer, so far as we know, gives positive results.

69. Zülzer took a foot-bath of an infusion of Belladonna & observed no indication of absorption.

5. Durian experimented with full baths of the same infusion & also that of Digitalis, but he observed no physiological effects.

64. Parrisot also employed baths of these two infusions, lasting from 30 minutes to two hours, & ranging in temperature from 20° – 30°C, with negative results.

18. Mackenzie made three observations on the effects of Tincture of Opium applied for a period of 12. hours to the thorax. The tincture contained 4 grs. to the ℥i & from ℥ii – ℥vi were used: but on the pupils there was no effect.

61. Rocher could never notice the slightest difference on the individual after baths consisting of infusions of Stramonium.

VIII. Absorption by the Human Skin of Medicated Substances in the form of Spray.

Some experimenters have thought absorption of medicated substances could be more readily obtained by using such substances in the form of a Spray. They entertained the idea that, as gaseous bodies easily enter the circulation through the skin, if the liquid were put into the form of a finely divided spray, there would be little difficulty with its absorption. Against this we would state that it is only at the beginning of such an experiment that the Spray, which is acting on any part of the body, is analogous to vapour, as condensation quickly takes place on the surface of the skin, & thus turns the Spray into much the same condition as a liquid bath.

Further, many of the medicated substances, which have been used in Spray form, have an irritating effect on the Epidermis: such being the case, as we have already pointed out in a former section (VI.), substances would in this way easily be absorbed through the skin.

We will state a few of the results obtained; though they are most conflicting & indecisive, yet it is our opinion that substances in the form of Spray are only absorbed while the

spray is analogous to vapour; but this soon passes off, & we believe absorption here ceases unless the substance used destroys the epidermis.

3. Amongst those giving positive results Röhrig's experiments are worthy of notice. A watery solution of Iodide of Potassium was sprayed on the arms, which projected through two holes in the door into another apartment: precautions were taken against the possibility of inhalation by the lungs, but in 20 minutes the presence of Iodine could be detected in the urine & saliva.

4. Reveil & Sereys, after using a spray of water, found the urine more diluted, & thus concluded there was absorption.

6. Juhl V. states that, the weaker the solution of the substance dissolved in water or alcohol, the more doubtful was the result — alcoholic being more readily absorbed than aqueous solutions. Tincture of Iodine (2 & 3%), Ferrocyanide of Potassium, Iodide of Potassium, Salicylic acid, Salicylate of Soda, & Jamin were used, and their presence could be detected in the urine during the next six hours, though great precautions were observed by having the patient placed on a couch with his legs thrust through two holes, made in the door, into an adjoining room, & the apertures around his legs securely closed, while the spray played only on his legs & feet.

68. Günther also took precautions against the inhalation of substances through the lungs, by having the legs of the patient thrust through two apertures in an extemporised door into another apartment, & applying the spray to the legs & feet. He employed aqueous, alcoholic, & Etherial solutions of Iodide of Potassium, Salicylic acid, Salicylate of Soda, Oleum Terebinthinæ, Pilocarpin, & Apomorphia. The urine was collected & tested during the 24 hours after the experiment, & it was noticed that the etherial solutions were most quickly absorbed. 300 Grammes of an etherial solution, containing 0·1 Grm. % of pilocarpin, was sprayed & the characteristic effects of the drug were observed.
Vomiting was never produced by apomorphia, but there was an inclination to sickness.
Negative results have been arrived at by several observers; & amongst
3. these Wittich deserves mention, seeing he performed experiments similar to Röhrig with opposite results:- After spraying his arm from 30-45 minutes with solutions of Iodide of Potassium, containing respectively 1 Grm. & 25 Grms. to 100 C.C. of water, he then dried his arm, and examined his urine every 15 minutes; but no trace of Iodine was found in it.

85. Liebrich repeated Jahl's experiments with negative results.

85. Ritter & Haas, having the arm enclosed in a glass cylinder, performed nine experiments with 5-10% Solutions of Iodide of Potassium extending to 60 minutes each; but in no case could Iodine be found in the urine.

IX. Absorption of Ointments by the Human Skin.

The absorption of Ointments by the human skin is a question which has important bearings in practical medicine, & the different conclusions, arrived at by the various observers, with regard to the manner in which substances in the form of ointments are absorbed, make a consideration of their experiments very interesting:- 49. Randolph & Roussel used cod liver oil as an inunction to 6. adults & 14. children; and after three days the quantity of fatty matter was increased in the faeces in 80% of the individuals subjected to the experiment. The late Sir J. Y. Simpson, noticing the immunity of workers in woollen mills from Phthisis, was led to believe that the oily materials, used in preparing the cloth, found their way through the skin: so he brought to the notice of the Profession the great value of oil as an external application in wasting diseases.

70. Oesterlen & Eberhardt observed metallic
71. mercury in the blood & internal organs after using Blue Ointment.

73. Neumann J. states that, after embrocations with mercurial ointment, mercury was observed in the sebaceous glands & hair follicles for nearly four weeks; but he never observed it in the sudoriperous glands.

74. Voit C. thinks that the protoxide in old
75. mercurial ointment is first changed into calomel, & then into Corrosive Sublimate, after coming into contact with the salts contained in the perspiration. The metallic mercury in the ointment also undergoes this transformation in the sebaceous glands.

69. Zülzer, after rubbing blue ointment into the skin & raising the epidermis with a blister, found mercury in the perspiration glands.

76. Fürbringer, after a series of careful experiments, arrived at the conclusion that the reception of mercurial ointment into the body took place through the hair follicles & sebaceous glands.

80. Marshall & Rüger strongly recommend
81. the oleate of mercury as a suitable & certain preparation for the administration of this drug by the skin.

25. Fleischer took the utmost care to avoid fallacious conclusions in his experiments with mercurial preparations by causing his laboratory assistant, whose arm he embrocated with oleate of mercury, to breathe air from another apartment. Bandages were applied to the arm for 60. hours, & the urine collected during this time was found on testing to contain small quantities of mercury.

Ointments formed with Lanoline have lately found favour with the profession;
84. but Guttmann tried this substance in preparing ointments of Iodide of Potassium & Salicylic Acid, and obtained no more rapid absorption than by employing common lard as the excipient.

Before giving any opinion either on the above statements or the use of ointments generally, We will quote a few authorities, who, in using certain ointments, got negative results thereby:—

44. Primavera employed an ointment, containing Quinine, which did not show its presence in the urine, though it was rubbed into the skin.

48. Lemann 9(48.), Braune (48.) Hülzer (69.), & Thomson (47.)
48. 69. 47. experimented with Iodide of Potassium ointment, & failed to discover Iodine in the urinary secretion.

25. Fleischer carefully conducted ten experiments with the same ointment, freshly prepared, & rubbed it into the back & chest for two hours— the patient did not breathe the air of the room; but no Iodine was found in the saliva after the experiment, nor in the urinary secretion during the next 36. hours. Similar observations made with ointments, containing Veratria, Quinine & Morphia also gave negative results, whilst those performed with Salicylic Acid & Salicylate of Soda were doubtful. In order to test the absorption of blue ointment by the glands & hair follicles of the skin, he caused patients, whose death was imminent, to be embrocated with this ointment on the inner surface of the thigh. After their death the skin on these parts was excised & subjected to minute microscopic examinations; but no metallic mercury was discovered ~~in~~ in the hair follicles, sudoriperous or sebaceous glands, rete Malphigii, or Corium.

It is now obvious with regard to the conclusions, which have been stated, that nearly every one agrees that mercurial ointments are absorbed; but the observers are divided in their opinions concerning the form in which they are absorbed.

Röhrig (38.) supposes the mercury in the ointment may be volatilised at the temperature of the body & enter the circulation as vapour: Some believe this vapour may also be inhaled.
Others point to the absorption of the metal into the corium as a proof of the method by which its therapeutical effects are produced.
The explanation, which seems to find most favour, is that the metal is oxidised to the protoxide, with which the chlorides of the skin form corrosive sublimate; and that this is the active ingredient in mercurial ointments. This view is also held by Baerensprung (88), though he was never able to detect metallic mercury in the hair follicles, sebaceous or sudoriperous glands.
Though Fleischer (25.) was unable to obtain positive results with mercurial ointments, as has been pointed out, yet he agrees with the other observers in stating such results when he employed oleate of mercury.
As we have already pointed out in previous sections, the epidermis & fat of the skin presents serious obstacles to the absorption of substances in solution, yet if such substances be applied to the skin in the form of ointment ——

a method by which they are more likely to mix with the sebaceous matter — they are more readily absorbed, especially if well rubbed in.

As Lauder Brunton (p. 404.) says, absorption is greatly favoured by friction, which not only presses the substances into the sweat glands & hair follicles but increases the circulation, & still more so if the substances used have a tendency to dilate the vessels.

It is our opinion that the absorption of ointments is greatly due to their not only being well rubbed in, but also to their being generally applied to parts where the epidermis is thin - e.g. axilla & inner part of the thighs, & to the mechanical or chemical action of the substance employed.

Regarding the more ready absorption of the oleate of mercury, which has found so much favour, it seems not unlikely that Olein, being a product of the sebaceous glands, gives the ready absorptive power to this preparation.

X. Permeability of the Dead Skin of Man & Animals.

In testing the permeability of the dead skin of either man or animals it must always be borne in mind that the vitality of the structure has been destroyed, that there is no secretion from the sebaceous glands, & that the epidermal layer has become dried & changed through the chemical effects of the substances applied. Its condition is also changed by the degree of stretching to which it is less or more subjected. Therefore we cannot apply with equal truth to the uninjured living skin whatever may be learned from such an investigation.

3. Wittich found that a piece of skin taken from a frog & subjected to a pressure of 85 centimetres of water from within outwards would allow 0·5 Cent. of water to pass through in 7 hours: but if the pressure was made from without inwards, the frog's skin could bear as much weight as that of a similar sized piece of human skin without showing a single drop of water on its under surface. — Wittich thinks this explains the fact of a frog's skin being always moist.

89. A. V. Wolkenstein (Centrablatt, No 26 : 1875) employed the skin stripped from the legs of frogs & found it permeable to weak solutions of Perchloride of Iron, Ferrocyanide of Potassium, & Iodide of Potassium; but to concentrated solutions it was impermeable. The absorptive power of the skin was in direct proportion to the temperature of the liquid, and the skin of young animals (rabbit, cat, & mouse) absorbed more readily than the skin of older animals of the same species. Hair & wool hinder absorption. Atropine, Strychnine, Cyanide of Potassium, & Curara are followed by symptoms of intoxication.

86. Seliger firmly secured parts of a frog's skin with the epidermal layer looking downwards over one end of an open cylinder into which he poured the fluid with which he intended to operate. This cylinder was placed in a wider vessel containing either distilled water or some other solution. The level of the two liquids was the same. Positive results were obtained in two or three hours with the following substances :— Ferro-sulphate of Iron, Ferro-cyanide of Potassium, Iodide of Potassium & Salicylate of Soda.

In observing the endosmotic action of the human dead skin, it must be remembered that the thinner the layer of epidermal cells the more readily will endosmosis take place. The skin of the child allows solutions of salts to pass more readily than the thick skin of the adult hand.

3. Wittich showed how the thickness of the diffusing membrane plays an important part. He covered two test-tubes with pieces of muslin & dipped them into albumen. They were then exposed to the steam of boiling water. The pieces of muslin measured 3 m.m. & 24 m.m. respectively in thickness. A concentrated solution of common salt was then placed in both tubes & allowed to stand in distilled water. The water, in which the tube, covered with the thinner membrane, was placed, showed traces of muddiness on the addition of nitrate of silver in a few hours & gave a dense precipitate in 24 hours; whilst that, containing the tube, covered by the thicker membrane, did not show a decided turbidity for 36. hours.

By placing the solution of common salt into a tube, having a piece of human skin firmly fastened over one end, he could only detect a slight discoloration of the distilled water in 24 hours.

and it required 48 hours to get the same reaction; if the skin were taken from the palm of the hand. Wittich also pointed out an interesting fact in another experiment:- viz:- if pure water were used instead of a saline solution, in two days the epidermis was found to be separated from the cutis vera by a layer of water; & if this epidermis was taken off & used as a filtering membrane, no water would pass through, but solutions of common salt & sulpho-cyanide of potassium would permeate it.

86. Seliger performed similar experiments to those of Wittich on the human dead skin with common salt, sulpho-cyanide of potassium & salicylate of soda, resulting in diffusion taking place in two days.

30. Clemens took a dead body & immersed it for several hours in a bath, containing a solution of salt of lead, & afterwards detected the presence of lead in the corium.

87. Krause, Röhrig (38.), & Fleischer (25.) found that the human dead skin allowed the passage of chloroform, ether, & alcohol, or substances dissolved in them; but water could not be filtered, nor mercury driven through it.

38. & 25.

XI. Permeability of the living Skin of Animals.

The epidermal layer in the skin of animals being so thin, little difficulty has been found in introducing medicines into the circulation, when applied either in the form of a local bath, spray, or ointment. The ease with which the physiological effects of drugs can be observed renders such experiments most conclusive.

90. Wittich rubbed a milligramme of muscarine into the thigh of a frog, whose heart showed 40 pulsations per minute. In two minutes after the application, the heart stood still: half-an-hour after it beat once in 90 seconds: and in two hours there was one feeble pulsation every three minutes. He now brushed 1 c.c. of a weak solution of atropine over the skin of the part, & in a short time the heart completely recovered & beat 36. times per minute.

By dropping an ethereal solution of Strychnine upon the abdomen of another frog, tetanus rapidly supervined & did not pass off for several days.

91. Ferrocyanide of potassium, potash salts, & Conia were also found to be readily absorbed.

91. Müller, in order to test whether a substance, which affects the nervous system, such as Opium, exerts its influence through the nerves of the part or through its being absorbed, took two frogs — one of which had its hind leg attached to its body simply by the sciatic nerve - all other structures being cut through - while all the nerves of the other frog were divided - the bloodvessels being left uninjured. Both of these legs were immersed in a solution of Opium with the result that no effect was produced on the frog whose leg was simply attached by the sciatic nerve while the other frog was poisoned.

93. Lautenbach obtained somewhat different results from Müller. He performed a series of experiments to determine if the nerves in a limb exerted any influence on its capability of absorption, independent of the circulation of the part. He took a frog, ligatured the vessels so as to stop the supply of blood to the limb, but left the nerves in their natural state; while the other leg was not interfered with. Both legs were immersed in water for several days; & it was then found that the leg, to which the ligature had been

applied, was swollen & a watery fluid collected below the skin, while the other leg was unaffected.

The ligatured leg of another frog was placed in a solution of Strychnine, & also became swollen; but no symptoms of poisoning were noticed until the constriction to the bloodvessels was removed.

A solution of Ferrocyanide of Potassium was injected under the skin of a ligatured leg & the wound carefully closed. The limb on being placed in water again swelled & the salt was detected in the water.

This was not due to exosmosis, because no swelling took place when the ligatured leg of a dead frog was immersed in water.

"Section of the sciatic nerve prevented 'the occurrence of swelling: Section of 'all its roots had the same effect: but 'swelling still occurred after section of 'any two of its roots. Destruction of the 'Brain & upper portion of the Spinal Cord 'did not prevent the occurrence of swelling 'in the ligatured leg: Destruction of the 'whole Spinal cord prevented, while 'destruction down to the 4th vertebra only 'retarded the occurrence of the swelling': 'Complete destruction of the cord below the 4th 'vertebra was after 24 hours followed by a mod-'ate swelling in the tied leg."

"Transverse section of the Cord in any "part failed to absolutely prevent the "occurrence of any of these phenomena". The explanation of these experiments seems to be :- "that the nerves exert "an active influence on certain cells "of the skin in enabling these to absorb independently of the circulation" The application of Curara showed that the nerves having this influence were not motor nerves.

92. Stirling observes that the skin of the frog will absorb 25% of the weight of the animal. He obtained the absorption of Strychnine & Ferrocyanide of Potassium.

94. Röhrig shows that many substances are absorbed by the unbroken skin of animals: A rabbit died in 28 minutes after the application of Conia to the shaved skin.

3. Others were poisoned on being sprayed with a solution of Curara & Digitaline— a tube being introduced into the trachea through which they breathed air from another apartment.

95. Waller in his experiments on Guinea pigs & white rats found that alkaloids were much more easily absorbed when dissolved in Chloroform than when he used them in alcoholic solutions.

52. Chrzonszewsky observed that, if the skins of cats & dogs had been previously shaved, absorption & death took place more quickly with solutions of Morphia & cyanide of Potassium than when applied to the normal skin.

96. Brown Sequard mentions partial paralysis, hyperaesthesia, anaesthesia & even sudden death supervening on the application of Chloroform to cats, rabbits, dogs & Guinea-pigs. He points out that Chloroform produces a reflex influence on the central nervous organs.

Conclusions
Regarding Cutaneous Absorption.

I. That the uninjured human skin does not absorb fluids: but gases pass through it.

II. That Saline Substances such as Iodide of Potassium, Common salt, &c., are not absorbed.

III. That Substances, which act Mechanically & Chemically on the Skin, are absorbed simply by denuding it of its Epidermis.

IV. That Substances in the form of Spray are only absorbed while the Spray is analogous to vapour, or if the Substance used acts mechanically or Chemically on the Skin.

C. J. O.

V. That Ointments are absorbed from their being well rubbed in so as to reach the Sebaceous Glands, or from their acting Mechanically or Chemically on the skin.

VI. That the skin of Animals absorbs.

XII. Electro-chemical Methods of introducing Medicines through the Skin

As the numerous observations already recorded have left little more to be done regarding the question of cutaneous absorption it seemed probable that the question of the conveyance of substances through the skin by a stream of electricity would be most likely to afford an interesting subject for original investigation,
102 more especially as Munk in his paper on the Cataphoric action of electricity on the skin states in such a positive manner the results at which he arrived.
26 Priestley appears to be the first who directed his attention to the electrolytic introduction of medicines through the skin. Then Klencke, 63
72 Hasenstein & Clemens (66) took up the subject with little or no good result. Beer of 65
Vienna thought he could force iodine by means of the electrical stream into the deep seated tissues of the body without producing any general action of the drug on the system, but his experiments also failed. The experiments were continued by Eulenburg 26
43 Brückner & others with like negative results.
102 Munk writing on this subject regards the absorption of drugs when aided by electricity as due not to the electrolytic but

to the cataphoric action of the current. He believes that the narrowness of the pores of the body is favourable to the electric absorption of substances deposited on the skin in a liquid form, & that they can thus be introduced into the circulation in an undecomposed condition. He states that the positive electrode is the one by which they enter, but that both electrodes should contain the liquid to be absorbed, for he believes that after a period of from five to ten minutes the electrical absorption begins to diminish and that it is then necessary to reverse the direction of the current so that the liquid may be carried in from the electrode now made positive & which had previously been negative.

Amongst other experiments he narrates one performed with a concentrated solution of iodide of potassium. The current was obtained from ten Grove's cells & the electrodes, consisting of circular pieces of Sculptor's clay from ten to fifteen millimetres in diameter, were placed on opposite aspects of his arm & retained in that position for fifteen minutes. Half an hour after the experiment the urine was found to contain iodine.

1. Electrical absorption of Iodide of Potassium

In repeating this experiment we used somewhat different electrodes from those employed by Munk. Two test tubes about six inches in length & half an inch in diameter were held in a Bunsen flame near their centres until the glass softened. The tube was then drawn out & separated into two parts — the part having the mouth retained, & the attenuated end broken off until it admitted the passage of a platinum wire. To the free end of this wire a piece of platinum foil one inch in length & a quarter of an inch in breadth was attached, bent, & drawn up just within the mouth of the tube so that when it was pressed against the skin the foil did not come into contact with the skin. The glass at the upper portion of the tube was now fused around the wire so as to secure it in situ.

The platinum wires were connected with terminal copper wires from eight middle sized Groves' cells. The tubes were filled with a concentrated solution of iodide of potassium & applied a quarter of an inch apart to the posterior surface of the left forearm — the skin between the tubes being kept

moist with the solution.
The liquid in the tube constituting the positive electrode at once assumed a yellowish brown colour, whilst that in the negative electrode remained unaffected.
On reversing the current the liquid in the now positive electrode also became yellow.
The liquids were tested with starch paste for free iodine & gave the characteristic reaction, though no free iodine was observed by the same test in the solution of iodide of potassium before being used for the experiment.
The tubes were again filled with the same solution & again applied — one on the anterior, the other on the posterior surface of the forearm about two inches above the wrist joint, & two minutes after a yellow discoloration was observed at the positive electrode. On reversing the current the same effect was noticed at the new positive electrode, & the liquids on testing showed the presence of free iodine.
We do not doubt that Munk obtained iodine in his urine, but to conclude that the iodide of potassium entered into the circulation undecomposed was not warranted by his experiment, since it is evident that decomposition of the salt undoubtedly takes place.

In other experiments with concentrated solutions of sulphate of quinine, which he performed by placing the electrodes on the anterior & posterior surfaces of his forearm, & allowing them to remain for from ten to thirty minutes he discovered the presence of quinine in his urine collected during the following twelve hours. But this only proves that the alkaloid entered into the circulation as there is nothing to show that the salt entered the skin undecomposed.

He also took rabbits & after removing the hair from the medial & anterior surfaces of the thigh, applied the electrodes saturated with a concentrated aqueous solution of Strychnia to those parts for 15' to 45' Minutes. An increase of reflex excitability was observed in from 10 — 15' minutes, & by continuing the experiment for 45' minutes the rabbit generally died half an hour afterwards, with the characteristic symptoms of Strychnia poisoning. 18 Grove's cells were employed.

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2. Electrical Absorption of Strychnia

We repeated this experiment on a large sized rabbit, which was tied down on its back, & had the hair clipped from the inner & outer sides of the thigh. A continuous

current was obtained from 8 middle sized cells of a Grove's battery. The positive electrode was a circular brass plate 1½ inches in diameter, while the negative electrode consisted of a small brass tube having a piece of sponge wetted with a saturated solution of common salt projecting from the open end of the tube. A circular piece of sponge wetted with a concentrated aqueous solution of hydrochlorate of Strychnia was placed on the skin of the inner side of the thigh & pressed upon by the positive electrode. The negative electrode was put upon the outer side of the thigh & the current reversed every five minutes. Twenty eight minutes after the experiment was begun, severe tetanic spasms supervened & the animal died in thirty seconds afterwards. Its urine was tested with Sulphuric acid and bicromate of potash, & Strychnia was detected in it. Rigor mortis was observed in the course of an hour — the reaction of the rigid muscle was acid. The skin of the leg was found to be uninjured.

As a control experiment, a small rabbit with a thin transparent skin was taken. The hair was carefully clipped from the inner side of the thigh, & the same sponge saturated with the solution of Strychnia used in the previous experiment was applied to the skin & kept pressed against it with a metal disc

covered with gutta-percha. Half an hour afterwards the sponge was again saturated & reapplied for other thirty minutes. There was no evidence of any absorption of the poison, the animal remaining unaffected. The urine was drawn off & tested for Strychnia, but none was found.

There is no doubt that Strychnia (but whether or not in chemical combination we are unable to say) is readily carried through the skin of a rabbit by a stream of electricity, & that there is no absorption of its solution even when pressed against the skin for an hour, if there is no electrical stream transmitted through the skin at the same time.

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3. Electrical Absorption of Curara.

Positive results were also observed in experimenting with Curara.

A large strong rabbit was tied down on its back & the hair clipped short on the inner & outer sides of the thigh. A circular piece of sponge soaked in a 1·5 solution of Curara was applied to the inner side of the thigh & the positive electrode pressed against it. The negative electrode covered with sponge soaked in a solution of common salt was applied to the outer side of the thigh. Eight middle sized cells of a Groves battery gave the

constant current, which was reversed every five minutes during the experiment, which lasted one hour. A few minutes after the experiment was ended & the animal liberated, its respiration was seen to be accelerated & muscular weakness appeared in the fore legs. The animal was restless & tended to fall down on its breast — it being evidently slightly poisoned.

We think it is clearly proved by the above experiments that some substances in aqueous solution can be made to permeate the skin as Munk has shown, & that in the case of Strychnia & Curara at all events the effects of the electrical transmission are similar to those produced by subcutaneous injection. But to what extent electrolytic decomposition of such substances may take place in the process remains to be shown. The experiments with iodide of potassium however show, in opposition to Munk that electrolytic decomposition of some substances at all events does take place — that the possibility of this, & the possible results of it must always be kept in view.

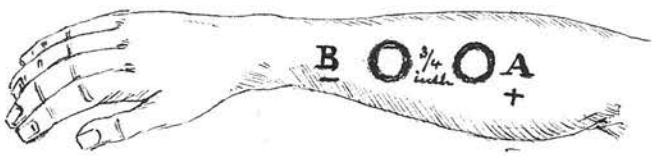
4. Effect of the Continuous Current on Electrical Excitability.

In order to ascertain if the continuous electrical current could of itself exert any anaesthetic effect upon the skin, several experiments were performed of which the following two show the general results obtained.

Experiment (a)

The posterior surface of Mr. Wm. Ramsay's right forearm was taken, & two spots were selected — one an inch above the wrist and the other 4½ inches higher up the forearm. The sponges measured 1½ inches in diameter & were placed on the forearm so as to be ¾ inch apart. Tactile sensibility was ascertained by means of compasses, the points of which could be felt equally well over both areas when 5. m.m. apart. The sensibility of the skin to the Faradic current over the two areas was ascertained by using two Smee's cells with Du Bois-Reymond's induction coil, & applying two pointed copper electrodes to these areas moistened with distilled water. When the copper points were applied to the area A. the secondary coil had to be placed at 100. m.m. distance from the primary coil to give the feeblest current that could be felt by the skin;

but when the electrodes were placed on the area B. the secondary coil had to be placed at 95. m.m. distance from the primary coil — indicating that the area A was slightly more sensitive than B.



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6 medium sized Groves cells gave the constant current.

The sponges were applied at

4-30 P.M. to A and B., wetted with distilled Water.

4-33 Burning sensation at A (+ pole)
Nothing felt at B. (− pole)

4-35 Burning sensation increasing at A (+ pole)
Nothing felt at B. (− pole)

4-40 Points of compasses felt as before at A + B.
Induction coil at A + B. same as at the beginning of experiment.

4-42 Sponges wetted & reapplied.

4-45 Burning sensation at A + B increasing but felt equally at both areas.

4-52 Points of compasses felt as before at A + B.
Induction coil registered at A. 100. m.m
Induction coil registered at B. 95. m.m

The sponges were again applied at
4-55. Burning feeling at A + B. felt at once
+ equally well at both areas.
5-5 Burning sensation equal in both A + B.
Induction coil at A registered 100. m.m +
Induction coil at B registered 93. m.m
being practically the same as at the be-
ginning of the experiment.

The experiment lasted 35 minutes + the current was not reversed.

We may therefore conclude there was no anaesthesia at either pole.

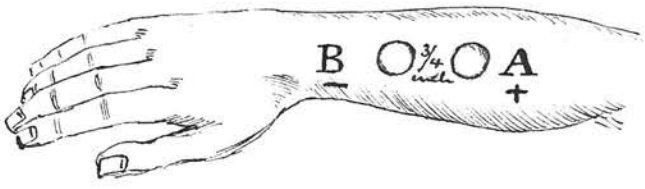
Experiment (b)

The posterior aspect of Dr. Scofields right forearm was chosen, + the same sponges and electrodes as were used in experiment (a) were placed on spots similar also in position to those in the above experiment.

The cutaneous sensibility was tested in the usual way with the points of compasses but the results in this case were so fallacious that we abandoned this method and used the Faradic current as the test of cutaneous excitability.

Two cells of a Daniells battery were used to give a perfectly constant current with Du. Bois. Reymonds induction coil, + the electrodes consisted of pointed copper wires placed at

a distance of 6. m.m apart.



The sensibility was tested at points A + B. The electrodes were held vertically on the skin at B. & then in the same manner at A. & when the weakest Faradic current was felt the secondary coil was 92. m.m. distant from the primary coil in both cases. So the cutaneous sensibility was similar in both areas.
The wire point electrodes were pressed more firmly down at area A + it was found that a weaker Faradic current could now be felt as the secondary coil registered 104. m.m distance from the primary. A similar observation was made at B. + it was found with the points of the electrodes firmly pressed down on the skin that the secondary coil — 108 m.m. from the primary — could be felt.
The continuous current, was now applied. from 8 Middle sized Groves Cells.
The current was not reversed.
The experiment began at 4-1 P.M. The sponges were wetted with distilled water.

A. Positive pole.

B. Negative pole.

At 4. 2 Warmth beginning to be felt at A (+ pole)
There was no pricking or prickling.
At B. (− pole) no warm feeling.

4. 4 B. (− pole) now becoming slightly warm, + warm sensation disappearing from A (+ pole).

4. 6. The warm feeling has now gone from A (+ pole).
B. (− pole) is distinctly warm.

4. 9 Warm feeling is the same at B. (− pole) + has returned at A (+ pole), which is now as warm as B. (− pole).

4. 14 Comfortable warmth at both areas A and B.

4. 17 The continuous current was stopped + the electrodes removed as the current seemed weak.

4. 20 Sensibility tested at B. (− pole) with Faradic electricity. When the points of the copper wire electrodes were pressed gently down as they had been when the sensibility was first tested, the feeblest current as felt by the secondary coil was 100. m.m. distant from the primary.
At the area A (+ pole) the current was felt when the secondary coil

was placed at 110 m. m. distant from the primary. so that both areas had been rendered slightly more sensitive, but particularly that which had been under the influence of the positive pole.

4. 26 Sensibility of Area A (+ pole) tested again, + the current was felt when the secondary coil was at 104. m. m. distant from the primary. Hyperaestheria therefore is apparently diminishing.

4. 28 Sensibility of area B. (− pole) tested again, + current could be felt when the secondary coil was at 102. m. m. distant from the primary.

The commutator was removed from the circuit on account of its weakening the current, and the mixture of Sulphuric + Water in the Grove's battery was freshly prepared. All the junctions were carefully cleaned + the experiment was resumed at

4. 38 and the current was felt at A (+ pole) as a warm sensation: but at B (− pole) it was not felt.

4. 39 Area A (+ pole) is now growing cool + does not feel hotter than the surrounding skin.

Area B (− pole) has undergone no change being neither hotter nor colder.

4. 49. Sponges rewetted.

4. 50 A (+pole) beginning to get warm. again.
No warmth at B. (−pole).

4. 52 Continuous current stopped. The areas were wetted with distilled water, & sensibility tested again. Area B. (−pole). The Faradic current was felt when secondary coil was at 95. m.m. distant from the primary.
Area A. (+pole) The Faradic current was felt when secondary coil was at 110. m.m. distant from the primary.

5. 55 The observation over area A (+pole) was again repeated, & the Faradic current could be felt when the secondary coil was 119. m.m distant from the primary.
Sensibility at area B. (−pole) was also again tested. The electrodes were pressed fairly firmly down, & the Faradic current was felt when the secondary coil was 109. m.m. distant from the primary.

Before the experiment stopped it was observed that the area A, which had been under the influence of the positive pole was slightly

hyperaemic, & this hyperaemia might account for the slight hyperaesthesia that had been produced in that area. The main result of the experiment was: that very little effect of any kind had been produced by a continuous current from 8 medium sized Groves cells when the sponges were wetted with distilled water.

The results of these two experiments on the cutaneous terminations of sensory nerves, were as regards the effect on excitability different from what was anticipated. Judging from the effects of the continuous current on nerve trunks we anticipated that the positive pole would lower, while the negative pole would increase cutaneous excitability. It must be borne in mind however that sensory nerve terminations are affected differently from nerve trunks: for while a continuous current stimulates the nerve trunk only when it begins & when it ends, it stimulates sensory nerve terminations continuously.

A series of experiments was performed in order to determine if drugs of known sedative action could by means of the electric current be made to produce local sedative effects on the superficial nerves.

5. Experiments with Cocaine.

Experiment (a)

The hair was carefully removed from the skin of the second toe of each hind leg of a large rabbit, & a spot the size of a shilling two inches above the toe of one of the legs was also deprived of its hair. A piece of sponge wetted with a 20% solution of Cocaine was tied around one of the bare toes. A similar piece of sponge also wetted with the solution was secured around the other prepared toe, and was held in a small tubular electrode. A circular sponge 3/4 inch in diameter saturated with the solution of Cocaine was applied to the spot above the toe. The continuous current was obtained from a Groves battery consisting of 9 medium sized & 9 small cells. On closing the circuit the positive electrode was at the toe, & the negative electrode on the leg. The current was reversed every 5 minutes, & the experiment lasted 15 minutes.

Complete anaesthesia was produced in the toe to which the electrode was applied, & it presented also a bloodless appearance. This toe was amputated an hour & a quarter after the removal of the electrode & the

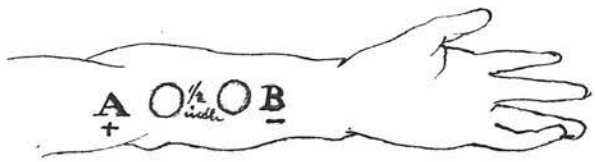
animal shewed no signs of pain.
The toe around which the wetted sponge had been tied was at the end of the experiment quite sensitive to pinching.

Numerous experiments were made on the human forearm to test the effects of Cocaine, & also to ascertain if Munk's assertion that the substance applied enters from the positive electrode — the current in these observations not being reversed. As the experiments gave uniformly the same result we shall record only one of them.

Experiment (b)

The anterior surface of the left forearm was chosen & the areas were 2 inches & 4½ inches above the wrist. Circular pieces of sponge 1¾ inches in diameter wetted with a 20% solution of Cocaine were placed upon these areas & pressed down by two brass discs — 2 inches in diameter. Another piece of sponge of similar size also wetted with the same solution of Cocaine was placed upon the right forearm, at a point corresponding to that of the lower of the two sponges, covered with gutta-percha & secured with a bandage. The continuous current was obtained from a Groves battery consisting of 8

Medium sized cells.
The sensibility to tactile impressions was estimated by applying compasses. The points were felt to be double at 5. m.m. apart over both areas (A + B.) — 4. m.m. giving a single tactile impression.
The sensibility of the skin to the Faradic current over the two areas was ascertained by using two Smee's cells with Du. Bois-Reymond's induction coil, & applying two pointed copper electrodes to these areas moistened with dis. tilled water.



The feeblest current that could be felt at A (+ area) was registered by the secondary coil 130 m.m. distant from the primary; whilst at B (− area) the feeblest current was felt by the secondary coil placed 120 m.m distant from the primary.
The sensibility to tactile impressions over the area where the control sponge was to be placed on the right forearm was ascertained with the compasses to be 5. m.m. and with the

Faradic current equal to 120. m.m.

At 1.24 P.M The sponges + electrodes were applied + immediately a burning sensation was felt at B. (− pole)

1.29 Warmth felt at A (+ pole)
Burning feeling increasing at B (− pole).

1.35 The areas were tested + the two points of the compasses could just be felt at A (+ pole) when 12. m.m apart, while the secondary coil had to be pushed nearer the primary to 80. m.m.
On testing B. (− pole) the compass points 5. m.m. apart were felt double.
Faradic shocks were felt when coil was at 100 m.m. distance.

The experiment was continued and the areas were again examined at.

1-45 when anaesthesia appeared to have taken place, as the two points of the compasses separated gave no tactile impression within in Area A (+ pole), but at 9. m.m they gave a double impression at area B. (− pole).
At A (+ pole) the secondary coil had to be placed at 73. m.m

distance from primary coil.
At. B. (– pole) its shocks were felt when at 100. m. m. distance from primary coil.
The experiment was now continued until

2 - 5"

At. A (+ pole) points of compasses could not be felt.
At B. (– pole) points of compasses could be felt at 9. m. m. apart. & then if pressed down produced a sensation resembling the transmission of electricity.
At A (+ pole) the feeblest current felt was registered by the secondary coil 73. m. m. distant from the primary.
At B (– pole) the secondary coil 125 m. m. distant from the primary. gave the feeblest current felt.
On the sponge being removed from the right forearm the tactile impression & the excitability to the Faradic current were the same as at the beginning of the experiment.

We may therefore conclude that a solution of Cocaine when introduced by the electrical current lowers the excitability

of the sensory nerves at the positive pole, but at the negative pole the excitability of the skin is slightly increased. The dead feeling continued for twenty minutes over the area of the positive electrode. It was noticed on the termination of the experiment that the skin of this area presented a marked bloodless appearance, & felt like leather, which however passed off in a few hours.

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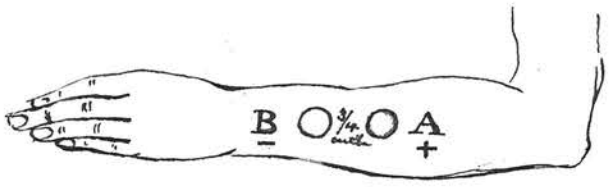
6. Experiments with Morphia.

Three experiments were made with a solution of Acetate of Morphia containing 48 grains to the ounce, but as the results were similar in each case only one of the experiments shall be recorded.
Mr. Wm. Ramsay, Medical Student, kindly allowed the posterior surface of his left forearm to be operated upon. The sponges & electrodes were similar to those used in the previous experiments with Cocaine. Five Medium sized cells of a Grove's battery gave the continuous current. The lower sponge was placed two inches above the wrist & the other sponge.

3/4 inch higher up the forearm.
The positive electrode was placed over Area A.
The negative electrode was placed over Area B.
The current was not reversed.



The compasses 5. m.m. apart gave a double impression over both areas A + B.
The Faradic current, as in other experiments registered the excitability of the skin at

A (+ Area) = 83 m.m.
B (− Area) = 100 m. m.

at 2.38 Contact was made + at
2.40 Warmth felt at A (+ pole)
normal feeling at B (− pole)
2.45 Itching sensation at A (+ pole)
no itching at B. (− pole)
2.55 Same itching still felt at A (+ pole)
Warm feeling at B. (− pole)
2.58 experiment ended having lasted twenty minutes + on testing the

tactile impression over the two areas the compasses at 33. m. m. apart just gave a double impression at A (+ pole); but at 8. m. m. apart a double impression was felt at B. (- pole).

The electrical excitability as ascertained by the secondary coil of the induction machine was at

A (+ pole) = 70 m. m. + at
B. (- pole) = 96 m. m.

The pupils of both eyes had contracted 1 m. m. during the experiment.

The skin where the positive electrode had been applied presented a white sodden appearance + was surrounded by a hyperæmic zone — the spot itself + surrounding skin itching intensely.

Itching + hyperæmia also prevailed at the negative pole, but not so markedly as at the positive. Both of these conditions passed off in the course of a few hours.

From the above we may conclude that the sensibility of both areas was somewhat lessened, but more so at the positive than at the negative pole.

Some days afterwards as a control experiment to the above, a piece of sponge of similar size was soaked

in the solution of Morphia, surrounded by an india rubber pessary, & placed on the posterior aspect of the right fore-arm, about two inches above the wrist joint. The sponge & pessary were then carefully covered with gutta-percha to prevent evaporation & held in situ by means of a bandage for twenty minutes.

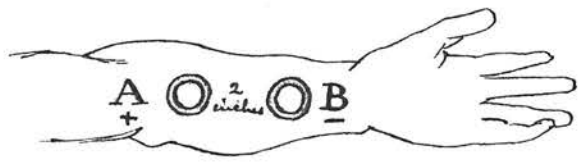
The points of the compasses gave a double impression at 5 m.m. both at the beginning & end of the experiment. The secondary coil of the Faradic current registered 85 m.m. before and after the experiment, while the condition of the pupils was unaffected & neither etching nor hyperaemia prevailed.

It is interesting to note the difference produced by Cocaine and Morphia on the skin at the negative pole — the excitability was slightly increased by Cocaine, but it was lessened somewhat by Morphia.

7. Experiment with Chloroform.

A number of experiments were undertaken to test the effects of pure Chloroform on the skin, when aided by the continuous electrical stream.
As the results were uniform we describe one performed on the anterior surface of our left forearm.
The two spots selected were, one, an inch above the wrist, & the other two inches higher in the forearm.
The electrodes were circular brass discs 1 3/4 inches in diameter, & the sponges were also circular & measured 1 1/2 inches in diameter, & surrounded by india-rubber rings to prevent evaporation when the discs were pressed on the sponges wetted with Chloroform.
5 middle sized cells of a Groves' battery supplied the constant current.
The excitability of the skin as tested by Faradic electricity registered 95. m.m. over both areas.
The two points of the compasses 6. m.m apart gave a double impression also over both areas.
The positive electrode was placed over A.
The negative electrode was placed over B.

and the current was not reversed.



At 3.32 the experiment was begun + on applying the electrodes severe burning pain was experienced at A (+ pole).

3.35 Pain had left A (+ pole) but there was now a burning sensation at B (− pole).

3.42 experiment ended after lasting ten Minutes.

On testing the excitability of the skin by the Faradic shock over the negative area B. It was found that a stimulus of 45. m.m. was just felt on the little finger (ulnar) side of the patch, whilst on the thumb (radial) side of the same patch 95. m.m. were registered; the latter being therefore much more sensitive.

There were also two areas at positive area A. On the little finger (ulnar) side the stimulus from the secondary coil indicated 60 m.m., + on the thumb (radial)

side of same area there was hyperaesthesia.

Tactile sensibility at the negative area (B.) on the little finger (ulnar) side required the points of the compasses to be 15. m.m. apart, while on the thumb (radial) side of the same patch they were felt as two points when at a distance of 7. m.m.

At the positive area (A) an aperture of 7. m.m. felt as two points all over this area.

Two areas existing at each of the two spots where the sponges were applied were evidently caused by unequal pressure.

It may be worthy of observation that the skin on the thumb (radial) side of A (+ area) where the sponge was only barely in contact with the epidermis shewed hyperaesthesia. The question is suggested: May not chloroform before it causes diminished sensibility of a part first produce hyperaesthesia?

It is evident that when pure chloroform is brought into contact with the human skin + a current of electricity passed between the positive + negative electrodes that tactile sensibility + excitability are lessened much more at the negative than the positive pole, + that the effects of the chloroform are only

experienced within the areas covered by the sponges as an aperture of 5: m.m between the points of the compasses gave on testing the skin outside the patches a double impression.

Both spots after the experiment presented a white leathery appearance which lasted for a few hours, & a burning pain was experienced for twenty four hours after. The whiteness of the skin was succeeded by hyperaemia which was more deeply seated over the positive than negative area. A blister formed on both areas on the third day, but healed within a week. The hyperaemia did not pass off for three weeks, & even now six weeks after the experiment the parts to which the chloroform was applied are distinctly visible.

As a control experiment one of the sponges already used was wetted with pure chloroform, encircled with an india-rubber ring, & covered by a brass disc after being applied to a fresh portion of the skin of the forearm, & was there retained for ten Minutes. On the sponge being removed pain was felt, which passed off in six hours, & was not so severe as that felt over

the positive area when the electricity was also applied. The surface was slightly pale, but an hour afterwards a redness appeared + continued for ten days - At the end of a fortnight the skin was much the same as that noticeable in the above recorded experiment at the end of six weeks. A blister which rose on the third day, rapidly healed. The palate was tested for lactile sensibility + excitability both before + after the experiment + no difference was found.

In reviewing the above experiments an important question presents itself — how do the alkaloidal salts enter into the circulation? — as decomposition undoubtedly takes place when such are employed along with electricity, may not the alkaloid alone be absorbed? Or is it possible that new compounds are formed by entering into combination with the fluids of the body? Extreme caution was therefore necessary in performing an experiment for the first time on the human subject; + the late date at which a Vivisection Licence was obtained necessarily limited our observations of the effects of a number

of drugs on the lower animals.
The experiments which I have hitherto done although incomplete + requiring great extension, have served to initiate me in experimental work, + to enable me to perceive the very intricate but deeply interesting nature of the subject, which I hope to pursue in several directions in the Physiological Laboratory during the Summer months.
The value of the continuous electrical current in introducing medicines into + immediately underneath the skin may possibly in some cases be profitably taken advantage of, especially in situations where the needle of the hypodermic syringe causes pain - e.g. about the face, or an ingrowing toe-nail requiring removal: but we regret no opportunities presented themselves for such trials.
It seems legitimate however to entertain the hope that the electrical transmission of substances through the skin may be of service in the treatment of neuralgia + tic-douloureux, and possibly also in some affections of the skin.

In conclusion I beg to acknowledge that the subject of this Thesis was suggested to me by Professor Rutherford; and I take this opportunity of thanking him for his uniform courtesy & kindness, & the interest he ever manifested in directing and superintending the experiments.

John Archibald.

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