The very concentrated solutions of arseniate of soda, employed in the end experiments, containing, viz., 5 per cent. of metallic arsenic, caused a certain amount of shock, following directly on the injection; this occurred in three out of the five cases, but recovery soon followed, and in all a stage of comparative well-being preceded the onset of symptoms.

It having been shown that there is a very decided difference in action between the two oxides, the question yet remains: How does the element arsenic act? The fact of the immediate onset of symptoms, with the lower oxide, proves that one has here an arsenic combination having a direct and powerful affinity for the tissues. The fact of the delayed action of the higher oxide bears two interpretations; the arseniate may still affect the tissues directly, and as such, the affinity, however, being much more feeble; or, it may not act as such, but only after it has suffered reduction to the state of the lower oxide—reduction, of course, involving time.

With reference to this last view, there are certain facts of importance, viz.:

1. The fact that the arseniate is a body which, not unready, suffers reduction to the state of arsenite, under suitable conditions.
2. The fact that the process of reduction is constantly obtaining in the tissues.
3. The fact, according to Binz and Schulz, that such reduction from arseniate to arsenite is actually effected in the tissues.
4. The fact of the qualitative similarity in the symptoms of arseniate and arsenite poisoning—a similarity which might exist truly, though either salt acted as such, but which *à fortiori* must obtain if the arseniate act only after reduction.

It is true that Binz and Schulz also state that the reverse process, viz., reconstruction of the higher oxide from the lower, also obtains in the tissues; but having shown, as these experiments undoubtedly do, that the lower oxide is by far the more active preparation, we should regard such reconstructive process as obviating, rather than as constituting, poisonous action; and we should hold that, if such double process do occur, the explanation of the arseniate action on the reduction-theory will have to be found in that the process of reduction considerably outbalances that of reconstruction. This, according to Schulz (*op. cit.*, Band xv), actually is the case; in the papers just quoted, he gives tables showing the relative powers of reduction and oxidation of certain of the tissues; the former process is there seen to outbalance by far the latter.

These points are by no means mere points of contention; they have obvious practical issue. The element arsenic is a most important therapeutic agent, and a very widely used one; it is clear, therefore, that a scientific use of such demands, in the first place, a knowledge of the relative activities of the various preparations employed. These experiments here relate to the frog, it is true, and, moreover, they refer to toxic doses; but there can be no question as to their indicating which is the more active preparation when thus employed. It may be objected that the rate of tissue-change in the amphibian organism is no measure of that obtaining in the tissues of the warm-blooded animal; and also that the argument from toxic doses to medicinal doses is not necessarily valid. It is precisely these objections which give practical importance to the reduction theory; for, if the arseniate do not act as such, but only after reduction to the lower oxide, why use it at all? It may be that in the small doses employed, therapeutically, the arseniate is practically all converted into arsenite, and the equal dosage, now in use, justified; but we are distinctly dealing with an unknown quantity, for of our definite arseniate dose administered we cannot say how much precisely will suffer reduction, how much will be eliminated as such. Next to qualification, the scientific demand is quantification; and how, in the reduction theory, is this possible? On the other hand, are there any advantages to be claimed for the therapeutic use of this drug such as might outweigh these disadvantages? Garrod states the arseniate to be far less irritant than the arsenite, and these experiments are certainly in favour of this; but, in the very large use of the arsenite now obtaining, is this irritant action practically a source of much trouble? Does it justify us in employing unknown quantities when we have known quantities at hand?

To conclude this subject, the result of some experiments of a different nature may be briefly stated.

The isolated ventricle of the frog's heart was fed with an artificial circulating fluid, and by means of Roy's tonometer the contractions were registered on a revolving blackened cylinder. To the circulating blood-mixture, solutions of arsenite and arseniate of soda were added. The following are the results obtained, given in tabular form. The quantities of arsenite or arseniate employed in each experiment represent the quantities requisite to destroy the contractility of the cardiac tissue.

Both solutions were distinctly alkaline, the arsenite indeed strongly so.

Arsenite of Soda 1 per cent. metallic arsenic=2.5 per cent. about, Na ₃ AsO ₃ .	Arseniate of Soda, 5 per cent. metallic arsenic=11 per cent., about, Na ₂ HAsO ₄ .
May 9th T. of Room=17°C. 29cc.	Aug. 29th T. of Room=18°C. 24c.c.*
" 10th " " =15°C. 38	" 30th " " =15°C. 32
" 11th " " =18°C. 44	" 31st " " =17°C. 28
" 11th " " =18°C. 34	Sept. 1st " " =17°C. 32
" 12th " " =22°C. 32	
" 13th " " =18°C. 44	

* Av.=37c.c.

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* Av.=29c.c.

* This number, 24c.c. was below the mark. The beats on this occasion not being completely abolished.

Again, we see in these experiments a similar relationship between the two oxides to that already found, for, to produce the same effect, viz., abolition of contractility, far larger quantities of the arseniate (compare the percentage strengths) are required than of the arsenite. The arseniate, indeed, is scarcely, if at all, more poisonous than the neutral salts of sodium, the chloride, bromide, iodide*; it behaved, moreover, just like these salts in other respects, and after the contractions had been reduced to a minimum, the substitution of fresh blood for the poisoned blood restored the contractility of the muscular tissue.

These results tend rather to confirm the reduction theory, for the reduction which is effected by the small amount of tissue represented by the ventricle must be very minute, and, when effected, if such do occur, it will be most probably swept away and diluted with the whole mass of circulating fluid, so that, practically, the ventricle would be in contact with the unreduced arseniate, and this these experiments show to be almost inert.

On the other hand, we note that the arsenite is decidedly more poisonous; and, moreover, in two experiments, in which, after reduction of the beats to a minimum, fresh blood was substituted, the contractility showed no recovery.

It will be unnecessary to recapitulate; it is sufficient to say that these last experiments with a single tissue confirm those with the entire organism in their results, and, in particular, they render more probable the reduction theory by showing the absence of direct affinity of the arseniate for certain, at least, of the tissues, ganglionic and muscular.

REPORT OF THE TREATMENT OF A VERY EXTENSIVE OUTBREAK OF RINGWORM OF THE HEAD, IN A SCHOOL: EIGHTY-FIVE OUT OF NINETY-TWO CHILDREN BEING AFFECTED.

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The following is a summary of the management of one of the largest outbreaks of ringworm of the head hitherto recorded. It shows the result of treatment by the compound carbolic acid, citrine, and sulphur ointment (described in the BRITISH MEDICAL JOURNAL, February 25th, 1882), and by oleate of mercury; also the great value of croton oil, when applied to small places of disease which have resisted treatment for some months.

On May 2nd, 1882, I visited a school consisting of ninety-two children, between the ages of nine and eleven years; and, on inquiry, learned that there had been some chronic cases of ringworm in the school, and that an extensive outbreak of cutaneous and scalp ringworm had recently developed.

On careful examination, it was found that forty-six out of forty-seven boys, and thirty-seven out of forty-five girls, had ringworm of the scalp. Some of the cases were chronic and extensive, others were moderate and more recent, while some were only one or a few days old. By far the majority had body-ringworm as well; but, as the scalp-disease was the cause of the cutaneous outbreak, and the latter was of very secondary importance, we did not tabulate the number of the spots on the bodies, nor the results of the treatment. I may just mention that the cutaneous patches were all cured during the first two or three weeks, either by Coster's paste, acetic acid, or the compound ointment; and that, after the heads were well under treatment, and the clothes fumigated, no fresh spots appeared. This leads me to remark that an outbreak of body-ringworm, in a school, is generally due to scalp-ringworm—probably overlooked.

The first precaution taken on May 2nd was the isolation of the nine unaffected children; and the following preventive ointment was ordered to be rubbed into all their heads every day: R Hydrargyri oxidii rubri

* See paper, *Transactions of the Medical and Chirurgical Society*, vol. lxx, p. 151.

gr. v; hydrargyri ammoniati gr. x; olei amygdal. essent. ℥ j.; adipis benzoati ℥j. m.

The infected children were carefully examined, and all the diseased patches were clearly marked by cutting the hair from, and for half an inch, round them; and then all the small and recent places were blistered with glacial acetic acid, containing four grains to the ounce of corrosive sublimate. The large patches, which had probably existed for weeks or for months, were not blistered. The rest of the hair was cut, and kept moderately short during treatment. The heads were then well washed, and the following ointment was ordered to be rubbed into the entire scalp every morning, and into the diseased patches again every evening, while the head was washed twice a week: R Acidi carbonici (Calvert's No. 2) ℥vj; unguenti hydrarg. nitratis ℥x; unguenti sulphurini ℥ij. m.

As the outbreak was so extensive, it was impossible at first to isolate the infected children; so they occupied their usual dormitories and school-rooms till September, when those who were not cured were removed to, and isolated in, the infirmary.

On May 12th, we found, on one of the free cases, a spot of recent ringworm, which had probably developed since the last examination; this case was quickly cured. No fresh spots were to be observed on the infected cases, nor did there appear to be any spreading of the original patches. As the body-ringworm was nearly stamped out, all the clothes were ordered to be boiled, baked, or fumigated; and all the dormitories and school-rooms to have sulphur burnt in them, one at a time.

On May 26th, *i.e.*, in less than a month after treatment, the school was free from body-ringworm, and we classified the cases according to the numbers in the following table, and again on the several dates mentioned in it. It will be well, first, to explain the meaning of the following terms.

"Cured" is only applied to those cases which were perfectly free from all traces of disease. No stumps were to be detected, and, in most cases, the new downy hair was growing on the affected patches. "Probably cured."—The cases under this heading appeared to be well, but as some little scab remained, or the new hair had not then appeared, they were not certified as cured. "Very slight" means that these cases were nearly well, only a few stumps remaining on one or more very small places. "Slight" is applied to those where there were two or more small places, with some stumps still to be seen. "Moderate" is used when the patches were more extensive than in the last class—about the size of half-a-crown or larger—and there were still many diseased stumps remaining. "Extensive and chronic" is employed where the patches extended over a quarter or more of the scalp, and where the disease had evidently existed for weeks or months; and also where the disease was very chronic, but not very extensive.

Table, showing the results of treatment in an extensive outbreak of ringworm of the head, from May 2nd to November 8th: 85 cases out of 92 children.

	Dates of the Special Examinations of the Children.									
	May 2nd.	May 26th.	June 8th.	June 22nd.	July 7th.	July 21st.	Sept. 14th.	Oct. 6th.	Nov. 8th.	
BOYS, 47.										
Free cases	1	1	1	1	1	1	1	1	1	
Cured cases	—	3	11	14	18	22	26	38	37	
Probably cured cases	—	—	6	7	8	4	3	—	1	
Very slight cases	—	—	2	4	—	—	2	1	3	
Slight cases	—	11	7	—	2	2	5	1	—	
Moderate cases	46	20	3	9	9	10	5	1*	1*	
Extensive and chronic cases	—	12	12	12	10	8	3*	3	2	
Recent case, after cure of primary patches	—	—	—	—	—	—	—	—	1	
GIRLS, 45.										
Free cases	8	7	7	7	6	6	6	6	6	
Cured cases	—	1	5	7	13	19	28	33	33	
Probably cured	—	—	—	6	6	4	2	—	1	
Very slight cases	—	—	13	10	10	6	2	1	2	
Slight cases	—	11	4	5	2	3	3	1	—	
Moderate cases	37	18	4	4	3	3	1*	1*	1*	
Extensive and chronic cases	—	7	7	6	4	4	3	2	2	
Recent case detected during the treatment	—	1	—	—	1†	—	—	—	—	

* Two boys and one girl, sent home by request. Treatment unknown after July 21st.

† This recent case was detected among the free girls in June. The disease was acquired, owing to this child leaving off the preventive ointment for a week, through

On referring to the above table, it will be seen that by July 21st (nearly three months from the date of treatment), twenty-six boys and twenty-three girls were cured (and probably cured), leaving twenty boys and sixteen girls under treatment. Up to that date, the cured cases owed that result to the compound carbolic acid, citrine, and sulphur ointment, combined with the occasional use of glacial acetic acid, containing a little corrosive sublimate. All these cases were recent ones on May 2nd, and most of them slight in extent. This shows the good result of active treatment in the early stage of scalp-ringworm.

After the first fortnight, eight cases, which were evidently chronic, were placed under the oleate of mercury treatment, instead of the ointment; and at the end of eleven weeks (July 21st), twelve more cases, which had resisted the action of the ointment, were also placed on oleate, as it did not appear advisable to continue a remedy longer than three months which was not acting satisfactorily. Later on, croton oil was employed in twenty-three of the cases, either to convert small rebellious patches into kerion, or to remove a few remaining stumps. Many of the isolated stumps were loosened by gently pushing the point of a gold pin, dipped in croton oil, into the individual hair-follicles. Here I may draw attention to this very useful and practical method of removing isolated stumps, which often resist all other treatment for months. The pin should have a fine but somewhat blunted point, and should be carefully pushed a little way into the follicle, by the side of the diseased stump. The point will carry a little croton oil into the follicle, and this will generally set up sufficient pustulation to cause the loosening and expulsion of the diseased stump in a few days.

The following Table explains the treatment adopted, and the results (by November 7th), in those cases which were not cured by July 21st, *viz.*, after eleven weeks of treatment.

Cases Cured on or before November 7th.

Boys.	Girls.	Description of the Case.	Treatment the first 11 weeks.	Treatment the next 8 weeks.	Treatment the last 3 weeks.
3	1	Extensive and chronic	Oleate	Oleate	Oleate
2	2	Extensive and chronic	Oleate	Oleate	Oleate and croton-oil
1	1	Extensive	Ointment	Oleate	Oleate and croton-oil
4	6	Moderate	Ointment	Ointment	Ointment and croton oil
1	—	Moderate	Ointment	Ointment	—
1	—	Moderate, now probably cured	Ointment	Oleate	Oleate and croton-oil
1	—	Moderate, now probably cured	Ointment	Ointment	Ointment and croton-oil
12	11	Total 23.			

Cases not Cured by November 7th.

1	—	Extensive and chronic, now very slight †	Oleate	Oleate	Oleate and croton-oil
1	—	Moderate, now very slight †	Ointment	Ointment	Ointment
1	—	Moderate, now very slight †	Ointment	Ointment	Ointment and croton-oil
1	1	Moderate, now very slight †	Ointment	Oleate	Oleate and croton-oil
1	—	Recent case, Nov. 7th, primary patches cured by Oct. 6th	Ointment	Ointment	Ointment and croton-oil
1	1	Extensive and chronic ‡	Oleate	Oleate	Oleate
1	—	Extensive and chronic §	Oleate	Oleate	Oleate and croton-oil
1	—	Extensive and chronic	Ointment	Oleate	Oleate
1	1	Chronic ¶	Ointment	Oleate	Oleate and croton-oil
1	—	Extensive and chronic	Oleate	—	These cases were removed from the school by the parents—still uncured; treatment, since removal, unknown.
1	1	Moderate	Ointment	—	—
8	5	Total 13			

* Cured by kerion, set up by the ointment.

† These cases will soon be cured—only a few stumps to be seen—by the pin-point and croton oil.

‡ Not much influenced by treatment.

§ Better; will be cured in time by croton-oil.

|| Still extensive and chronic.

¶ Better; will soon be cured by croton-oil.

Thus, in six months, seventy-two cases of ringworm of the head have been cured out of eighty-five, leaving thirteen uncured; three out of the thirteen left the school, and discontinued the treatment on July 21st; five out of the ten school cases will soon be cured, leaving five; one with a recent patch, two that may be cured in a month, and two inveterate cases—very doubtful when they will be quite well.

Taking the above facts into consideration, I think the results are good, and fully show the value of the compound ointment in recent cases, the oleate of mercury in chronic ringworm, and the practical value of

croton oil in suitable cases and at the proper time. There is no doubt that very many of these children would still be under care if the oil had not been employed. Yet, as I have before stated, the greatest care must be taken in using it, and some such method adopted as described by me in the JOURNAL for June 12th, 1880.

ON THE FUNCTIONS, CHARACTER, AND POSITIONS OF THE ULTIMATE NERVE-TERMINATIONS IN THE SKIN AND HAIRS.*

By GEORGE HOGGAN, M.B.

THE various forms of the ultimate nerve-endings in the skin and hairs have led histologists to ascribe separate sensory functions to each different form of termination. Most of the opinions thus put on record are almost necessarily incorrect, because they were formed upon insufficient data; and, as almost every year sees some new fact discovered, or some new interpretation given, in this department of research, anything that we can now say has no pretension to finality about it. Our special intention is to place before you a number of new facts, which enable us to place an altogether different functional interpretation upon already well-known structures. We shall then endeavour to trace homology between different nerve-terminations; and, finally, endeavour to trace the causes which have led to the different appearances presented by homologous terminations, and to the different positions occupied by them. In fact, we are making what is probably the first attempt to show the same workings of evolution in altering the forms of the minute histological elements, that Darwin has done for the complete forms of animal life.

For the subject under consideration, we take, not as a matter of precedence, but of convenience, the nerve-endings upon an ordinary hair, as the type to which all the others may be traced; or, at all events, they have their common relationships centred therein. Upon that hair, or rather hair-follicle, we shall find two principal terminal elements: 1, the forked endings, which are probably the terminations of the nerves of touch, and have their metamorphosed homologues in the Pacinian bodies; 2, the ganglionic masses of branched nerve-cells, which probably originate the sensations of temperature, of pain, etc., information of which they telegraph on through the nerve-fibres to the central or cerebro-spinal nerve-centres. These have their homologues in the subepidermic nerve-ganglia situated—*a*, on the lower surface of the epidermic downy growths between the papillæ; *b*, on the feelers on the snout of the lower animals, sometimes called tactile hairs, although all hairs are tactile, and the principal elements upon the feelers can scarcely be called tactile; *c*, on the touch-bodies or corpuscles of Meissner. The secondary nerve-elements on the ordinary hair-follicles are the nerve-fibres, the medullated fibres connecting the primary elements with the central organs, and the non-medullated elements connecting the various cells with each other and with neighbouring ganglia, as well as with the great central nerve-centres. These are also shown by us to ramify between the epidermic lining of the hair-follicle; and they form a circular layer or coil immediately underneath the opening of the sebaceous gland, which may be called Jobert's coil, after its discoverer, who described it twelve years ago. The forked endings were discovered by Arnstein four years ago; but so little is known of them that, when we discovered them independently ten months ago, we remained during six months in ignorance that there had been a prior discovery, although we took every step to inform ourselves upon the subject. The branched cells seem as yet to have been observed only by ourselves upon the ordinary hair-follicles; but, as we have given a detailed description elsewhere† of all these elements, we need not enter into so long a subject in this paper. Upon ordinary hair-follicles we never find beyond a score of such cells, sometimes none at all, and these cells never seem to be in direct communication with a medullated nerve. On the feeler-hairs of the snout several hundred of such cells may be observed to be arranged regularly between the basement-membrane and deep cells of the epidermic lining of the follicle; and they are all seen to be in connection with the medullated nerves passing to them externally to the follicle, and numbering even hundreds; a large number of cells being attached to

each nerve-fibre. In the feelers, therefore, while all the other nerve-elements of ordinary hair are represented, it is the cellular nerve-element which has specially hypertrophied.

While, however, the feeler shows the extreme of hypertrophy from the ordinary hair, the touch-corpuscles show the first step in atrophy; but, as we are only as yet on the threshold of this question, we shall not enter further into it at present than by showing drawings and microscopical specimens of the first stages of separation between the forked tactile elements and the cellular sympathetic (?) elements, as found at different stages in the palms of different animals. In these, as seen in the fringes of the mole, the tactile elements are as yet unchanged in size, and are only beginning to receive the oval coating which distinguishes the Pacinian body. This coating may, however, be seen at various stages of advancement, and covered with several layers of the epithelioid cells which are so well marked in the Pacinian body. In other examples, the termination seems still to be attached to, or lie within, the epidermis. With every little group of such Pacinian bodies may be seen a little clump of cells, forming the ganglion, and either lying apart from the epidermis or lying within it like a nodule of blackened nerve-cells. No one has as yet assigned a function for these forked endings; and although, from other causes, we consider them as tactile nerve-endings, the homology we have discovered between them and the Pacinian bodies lends valuable support to our hypothesis; for the Pacinian bodies have long since been supposed to give the sense of pressure or touch, judging from their presence in the mesenteries of the cat tribe. If anyone, however, will draw the pulp of the finger very lightly over the tips of the hairs on the back of the hand, he will feel the sense of touch distinctly in the hairs, when no sensation whatever is received upon the surface of the pulp of the finger, which is specially provided with the so-called touch-bodies. It is evident that, as a consequence of heredity, the hairs, which, owing to continual friction on the palms and soles, have been prevented from growing, have at last existed only in an abortive condition; the tactile terminations in some cases sinking more deeply into the dermis, becoming larger and more largely covered, as they do so, by the same agency which covers the ends of cut nerves in an amputated stump, constituting the so-called neuromata. On the other hand, the cellular elements remain as the so-called touch-corpuscle; or they may remain still attached to the epidermis, forming one of the subepidermic ganglia, to which we shall now specially direct attention, as upon it we can best demonstrate the changes in position which form the chief point of this paper.

These ganglia were first described by Professor Merkel of Rostock, who, by means of osmic acid preparations, discovered, on the lower surface of certain of the interpapillary epidermic down-growths, peculiar groups of cells, some of which cells appeared to be in direct continuation with some of the medullated nerves of the skin. Misled, however, by his faulty processes of preparation, he gave descriptions of these cells which are very wide of the mark. He called them *oval*, and under no circumstances branched; and figured them as oval dilatations on the very points of the nerves. In fact, as it was almost impossible with the osmic acid process to see the connection between the cells and the nerves, he has simply drawn them as he thought they ought to exist. To these cells he applied the name of terminal tactile cells; and he considered them to be identical with the cells which had already been discovered on the follicles of the whiskers or feelers of most animals by Dietl, Sertoli, and others. He even extended his hypothesis to the touch-bodies on the palms and soles of man, monkeys, and other animals, and to the more simple structure of the same kind in the beak and tongue of birds. In each case, he draws the so-called tactile cells to correspond with those he had found on the epidermic down-growths, and consequently he was led into error in each case. Bonnet, who took up the question after Merkel, agrees throughout with the functional interpretation applied by Merkel to these bodies, only he retrogrades in the question by calling them, not terminal cells, but terminal buds (*End-knospen*). He, however, used the gold process of Löwit, which ought to have shown him the condition we have found. Let us return to Merkel's interpretation. After giving a careful description of these different structures, with copious illustrations, but with which we are not in accord with him, he sums up his important article with the following conclusions.

"I may, therefore, express as a fact, that only one kind of nerve-termination in cells occurs in the skin; that is to say, the termination in tactile cells. . . . In the skin of birds and mammals, two entirely different kinds of nerve-termination, differing in their original plan of construction, occur side by side; the termination in tactile cells and the termination in free ends (*i.e.*, intra-epithelial fibrils). One feels inclined to make an attempt to utilise the difference physiologically; and I believe, indeed, that I have grounds for considering the termination in

* Read in the Section of Anatomy and Physiology at the Annual Meeting of the British Medical Association in Worcester, August 1882.

† See *Journal of the Linnean Society, Zoology*, Vol. xvi., pp. 546-593, plates xiii-xvi.