postures; is alternately erotic and religious in her conversation, love, however, being her chief theme. Pulse 130; tongue clean; bowels have not acted for two days. On October 3rd, Has had some broken sleep; very incoherent and mischievous; raves mostly about some one named "Cavosa," to whom she refers in amorous terms; pulse 120. On October 4th, Is a little quieter; pulse 123, and irritable; pupils much contracted; face pale; tongue clean. On October 12th, Is decidedly improved; capable of rational conversation; has not menstruated for six weeks. On October 23rd, Still improving, but very weak; is quiet and downcast; employed in sewing. After this she gained ground steadily until the date of her discharge.

No difficulty attends the differential diagnosis of hysterical mania. It could only be confounded with acute mania, and the excited stage of acute dementia. From the former it is distinguished by its history, by the less deep and universal involvement of the mind which characterises it, by the character of the delirium, by the moisture of the skin and comparative cleanness of the tongue and unaltered state of the secretions, by the absence of great muscular strength or rigidity and of rapid emaciation, and by the slightness of the modification of the pulse and temperature; from the latter it may be known by the absence of the stupidity and fatuity which mark the delirium of acute dementia, and of that chilled and livid state of the hands, feet, and features, which accompanies it.

The prognosis of hysterical mania is equally simple with its diagnosis, and is invariably favourable. The tendency of the disease is to end in recovery. But this tendency may be fostered and encouraged, and the duration of the disease much curtailed by judicious treatment. The only danger to be apprehended is that of relapse; but this is sometimes considerable, as many as five and six relapses taking place in one case.

Fortunately, there is no morbid anatomy of hysterical mania. In one case only have I seen death occur in consequence of an intercurrent condition. That, however, was the most inveterate and distinctive case of hysterical mania that I ever encountered, and I shall therefore read to you the notes of the *sectio cadaveris* as far as they bear upon our present subject. The skull was of average thickness, but unsymmetrical, bulging posteriorly to the left. On removing it, the dura mater was seen to be tense, without folds or wrinkles, as if it were tightly stretched over the brain. On opening it, the brain expanded and bulged over the sawn edge of the skull as if it had been subjected to compression. The whole brain weighed forty-six ounces. There was very slight thickening of the arachnoid. The gyri were plump and in close apposition to each other. The grey matter was extremely pale, especially in its deeper layers, which were scarcely distinguishable from the medullary substance, which was of unusually firm consistence. The ventricles were of average size and contained no fluid. A small round body, of firm gelatinous consistence and about the size of a pea, lay imbedded at the anterior end of the third ventricle, fastened there by little fibrous attachments. The middle commissure was of extraordinary thickness and strength. The floor of the fourth ventricle was congested. The neck of the uterus was much enlarged and indurated. The left ovary was of the size of a large walnut, and was converted into a fibrous capsule containing dark fluid contents and one large clot. There was a cyst at the outer extremity of the left Fallopian tube.

The treatment of hysterical mania requires a careful adaptation to varying conditions. Its occasionally transitory nature justifies a trial of home-treatment before an asylum is resorted to; but if under home-treatment it remain unabated at the end of fourteen days, then removal should not be any longer delayed. The most protracted and troublesome cases that have fallen under my observation have been those in which home-treatment had been persevered in for months, until patience had been exhausted. The prolongation of the disease increases the risk of relapse, so that it is of much importance to cut it short at the earliest possible moment. During the maniacal condition there is not much room for moral treatment. A conciliatory and yet firm manner on the part of the physician, however, is not without its effect. Quietness and rest are also advantageous, and any simple occupation, such as sewing, if its adoption can be secured during an interval of tranquillity, is often very useful. It fixes attention, and by its very monotony soothes the perturbed mind. Exercise in the fresh air ought to be taken daily, and nourishing food must be administered. The medical treatment I generally begin with is a mixture containing bromide of potassium and tincture of valerian—forty grains of the former and a drachm of the latter in each dose, to be taken three or four times a day. This has sometimes a most gratifying effect, as in the case of A. H., who was perfectly well four days after her admission here. If, however, its beneficial action be not very speedily manifested, no good will result from continuing its employment. I should recom-

mend you, then, to resort to morphia and assafoetida. From a quarter to half a grain of the muriate of morphia with from ten to thirty grains of assafoetida may be given twice or thrice a day. The tincture of assafoetida is not objected to in pauper asylums. This treatment is generally successful; but should it fail, as it sometimes will, then cannabis Indica with bromide of potassium ought to be tried. This valuable combination was brought into notice in the *Annales Médico-Psychologiques* in 1867. We have employed it here constantly since then, and with decisive benefit in many cases. The use of narcotics is not contraindicated in hysterical mania. Warm, tepid, and even cold shower, baths are sometimes composing and useful. During convalescence, iron is almost always required, sometimes quinine also. I have a particularly high opinion of the value of Easton's syrup of the phosphates of iron, quinine, and strychnia, during recovery from hysterical mania. Of course, menstrual disorders must be subjected to their appropriate treatment.

THE HASTINGS PRIZE ESSAY, 1870.

ON DIGITALIS: ITS MODE OF ACTION AND ITS USE.*

By J. MILNER FOTHERGILL, M.D.,
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Drugs of similar Power.—The whole question of agents acting upon the heart so as to increase its power of contraction is comparatively new. With the exception of digitalis we are, generally speaking, scarcely acquainted with their names. The agents are either entirely new, or nothing has hitherto been known of their secondary effect upon the heart. The list of them is a short one, and will not take up much space in the enumeration. Thus Dr. Clifford Allbutt has advocated the use of Virginian cherry-juice (*Prunus Virginiana*) in cardiac affections; Dr. John Harley has investigated the action of belladonna; Dr. Braidwood the action of dajasek, or arrow-poison of Borneo (*Tanghanina venenifera*); Drs. Hilton Fagge and Stevenson have investigated the action of the *Scilla maritima* and the *Helleborus viridis*; and Leven has investigated caffeine and thein. Of these, the writer has only experimented on digitalis, belladonna, and caffeine. There is thus plenty of opportunity for investigating further the action of these drugs, and adding to what we already know of their action; while there is a ground for hope that to this list may be added new agents more certain, more effective, and more manageable than those we as yet possess. It is, then, with the hope and expectation that such will be the case that the writer has devoted so large a space to the consideration of the mode of action of digitalis. He has striven to aggregate what is known of the subject, and his own more recent conclusions, in order that the question may be regarded as broadly as possible. The frequent digressions and the consideration of the action of the morbid process have sometimes been considered at greater length than the administration of the agent; as, once admitting the increase in the activity of the ventricular contraction as the chief therapeutic action of the agent, the question of the value of the agent must rest on the question as to how far increased ventricular contraction may or may not be beneficial. By thus treating digitalis as a member of a class of agents, it will much facilitate the investigation into the usefulness, or uselessness, of a drug as a cardiac neurotic. It is obvious that other agents which increase the ventricular contraction and bring the heart to a standstill in systole, must necessarily possess a therapeutic value allied to that of digitalis. In prosecuting such an inquiry, it will be easy to ascertain to what extent the action is common to that of the whole class, or in what it is singular. This grouping of agents as to action will assist us in aggregating a number of agents with either a primary or secondary effect upon the heart; in time this will constitute a group, and in practice the remote effect of an agent upon the heart will be taken into consideration in the choice of therapeutic agents. Thus, we as yet can merely guess to what extent the different actions of opium and belladonna, as hypnotics, may be dependent, as regards the success or non-success following their administration, on the vascularity of the brain. How far the beneficial effect of belladonna, at times when opium has failed to relieve, may rest directly, not on the different hypnotic alkaloid, but on the vascular supply of the brain being augmented by its use, we know not. Thus a series of experiments with belladonna in

* Concluded from page 116 of last number.

delirium tremens, similar to those of Mr. Jones of Jersey with digitalis, when the pulse is feeble and fluttering, would be of the greatest practical interest. These might then be contrasted with a series with opium; and thus from a few facts we might attempt to build up a principle, and the application of that again to cases would in time furnish us with a law worth any amount of empirical guessing. It is only by the grouping of agents and then testing them by clinical experience and physiological experiment, observing the successes, the failures, and their causes, that we can expect to emerge from our present therapeutical chaos. Thus, under our old plan of empirical testing of agents, colchicum has six or eight (I forget which) times been removed in and out again of our *Pharmacopæia*. The same, to a less extent, has occurred to numerous other agents of no trifling activity. It is obvious that the use of these agents has been conducted on nothing approaching a law, else some definite conclusions one way or the other must have been arrived at. Without some definite idea of what it is we want exactly to attain, and by what action our agent is likely to achieve the desired result, we cannot be said to do anything more than—to use a vulgarism—“make shots.” The experiments of Crum Brown and Frazer into the physiological and chemical agency of drugs, and Broadbent’s valuable speculations on chemical tension, and the question of the retardation or aiding of oxidation as a mode of explaining the action of many agents, are steps in the right direction, the value of which we are scarcely yet in a position to correctly estimate. The advance of therapeutics hand in hand with increasing knowledge of physiological and pathological processes is much to be desired. It is scarcely cheering to find men who are teachers telling us that they have found rest in bed the only useful treatment in diseases of the heart. What, then, must become of those who must work or hunger? A hopeless therapeutical scepticism will never solve the problem how to enable those injured by rheumatic fever to be still useful members of the community. If rest in bed were all that modern medicine can do for these supplicants, many of them valuable lives, with good work in them, then we need not wonder at their regarding it as giving them a stone when they ask for bread, and at their trying hydropathy or homœopathy in sheer despair. The question is, how far can we not only enable them to live, but endow them with capacity to labour. This utilising a large number of lives which would otherwise be rendered inutile, is a problem which it is in the province of medicine to solve. That even with our present imperfect knowledge of these agents, much has been and is being done by numbers of enthusiastic workers at this field of inquiry, is unquestionable. In the present consideration of the mode of action of digitalis, the writer has striven so to arrange his materials as not only to elucidate the agency of it, but also to establish some broad rules applicable to the agents as a class, if once the action of the drug, as being capable of increasing ventricular contraction, be established. In order, then, to elucidate as far as possible this subject both particularly and generally, the action of morbid processes and the mode by which Nature proceeds to spontaneously repair them, or to compensate the lesions, have been subjected to critical review, and their indications recorded. The subject is one which must necessarily require great labour and pains to bring to anything like perfection, and anything written here must be considered as necessarily incomplete. The consideration of the question of increased ventricular contraction has been so conducted as neither to include nor exclude the question as to whether this group of agents are cardiac sedatives or tonics; in fact, it becomes more and more difficult to draw a distinction betwixt the two. The writer has thus striven to avoid all controversial inquiry on these heads, and by laying down the increased ventricular contraction as the action *par excellence* of digitalis, has striven so to conduct the investigation as not only to fix, to some extent at least, the action of the agent, and to demonstrate how it affects morbid conditions, but also to clear so much ground towards the successful investigation of allied agents, and the establishment of a new class of agents whose importance in the future we cannot estimate, but about the value of which we may at least be permitted to hope.

Its Action in Nervous Affections.—From the unquestionable benefit resulting from the administration of digitalis in some nervous affections, an impression has existed that it exercises a neurotic action, or to be more explicit, that it has some specific action over the nerve-centres. Like all powerful therapeutic agents, it has enjoyed an ephemeral reputation in the treatment of epilepsy; and from the undoubted influence it possesses over the vaso-motor system from the heart to the capillaries, it is conceivable enough that in some cases, its use was followed by benefit, but only it is improbable that it possesses any influence other than that it exerts over the circulation. Serré used Debout’s pill, consisting of four-fifths of a grain of digitalis, and one grain and a half of quinine, in the treatment of hemiplegia, continuing it for long periods together. The success which followed the treatment was greatly influ-

enced no doubt by the quinine; in fact, it is difficult to rid oneself of the impression that the quinine had the most to do with the result. Lockhart Robertson found that in certain cases of maniacal excitement in general paresis of the insane, its use was attended with marked benefit. He states: “It acts in every case of the kind in which I have given it as a specific, calming the excitement, and enabling the patient to pass without wear or irritation through this stage of the malady. Its action has been to steady the pulse, and thus apparently to supply the brain better with blood, and so obviate the tendency then existing to effusion of serum.”

In Delirium Tremens.—The use of digitalis in heroic doses by Mr. Jones, of Jersey, with marked success, is one of the extraordinary facts of therapeutics. The administration of the tincture in half-ounce doses, and repeated, too, at short intervals of time, was found to exercise an action that was almost amazing in delirium tremens. It was attempted to make out that this was due to the half ounce of proof spirit; but that was simply preposterous. The amount of digitalis in four drachms of the tincture must have exercised an influence of some kind. Neither has it been found universally successful in attaining the desired result. From personal experience, I may state that it is when the pulse is compressible, rapid, fluttering—in fact, when there is evidence of cardiac distension accompanied by great nervous prostration, that its administration is followed by beneficial results. The condition of the brain is one of anæmia from cardiac feebleness; while that feebleness is no doubt occasioned by the exhaustion of nerve-force, by the continued administration of the alcoholic stimulus. The sympathetic is exhausted, and cardiac distension follows; from that, again, imperfect circulation and cerebral anæmia; the exhausted brain is deprived of its blood-supply to a great extent; less and less nerve-force is evolved; the sympathetic is still further enfeebled; and the condition of a complex cerebral anæmia, called delirium tremens, ensues. The administration of digitalis in heroic doses produces a decided effect on the circulation, and that, again, relieves the brain, in a manner strictly analogous to that described above by Dr. Lockhart Robertson. When the pulse is full and sustained, and there is no great prostration, its use is not followed by any desirable result.

In Anæmia of the Brain.—In some conditions of cerebral anæmia dependent on disease at the aortic valves, digitalis exercises a decided beneficial action; so much so, indeed, that it is easily conceivable that it might be regarded as a nerve tonic. In speaking of anæmic conditions of the brain, Todd, in his *Cyclopædia*, Art. Abnormal Anatomy of Nerve-Centres, states—“It is also present when the heart, oppressed by some disease affecting its own structure, fails to propel the blood with its proper force into the brain.” A most interesting instance of this has fallen under my own notice. An old and visibly feeble lady of 70, was subject to attacks coming on suddenly, during which she fell, but did not lose consciousness. This at once cleared away any suspicion of epilepsy, and suggested the condition of acute cerebral anæmia. That is, the supply of blood to the brain became so interfered with, that the brain was unable to evolve the normal amount of nerve-force, and the patient fell just as in swooning; in fact, it was syncope. The falling thus took off the weight of the blood-column above the heart, and thus gave relief to it; while at the same time, the head falling as low as any other part, the blood gravitated into it as readily as into the rest of the body. There was aortic obstruction, and, after some careful watching, it became apparent that the attacks came on whenever there was any approach to exhaustion, either from physical or mental effort. That is, the amount of blood passing out of the narrowed outlet was sufficient to maintain a species of integrity of nerve-manifestation for the wants of the system when all was quiet; but exertion, by overtaxing the power of the heart, led to anæmia of the organ placed highest up in the organism; and then the fall, by restoring the circulation through the encephalon, and permitting to the heart a period of comparative rest, comes to the rescue and allows of readjustment. The administration of digitalis and consequent improvement of the heart’s action, invariably gave her relief, and enabled her to undergo more exertion without the attacks of syncope, and relieved her from them when recurring after any exhaustion. The period of benefit lasted for some time—in fact, as long as any evidence of its action on the heart remained. The beneficial effect of its use in cerebral affections can only, I believe, be explained after this fashion. Cerebral disorder is frequently due to cardiac disease; and when it is so related, and the nervous affection can be regarded as a sequel to the cardiac impairment, whether to persistent disease or debility referable to passing circumstances—when the head-symptoms can be clearly attributed to failure in the heart’s power of blood-propulsion—then the administration of digitalis may fairly be calculated upon to be beneficial. When cerebral anæmia has a cardiac origin, then, and then only, I believe that digitalis is of service.

Is Digitalis a Diuretic?—If by a diuretic is meant an agent eliminated by the kidneys, and producing increased secretion in the true sense of the word, then certainly digitalis is not a diuretic. If by a diuretic is meant an agent which increases the renal secretion by some special action, as juniper or cantharides, irrespective of an alteration in the arterial tension, digitalis can lay no claim to the appellation. Digitalis is not a true diuretic, though perhaps no material in the *Pharmacopœia* produces such decided increase in the renal flow as it does; but only under certain conditions. An alteration in the blood-pressure on the glomeruli of the kidney affects the flow; if that pressure be decreased, as in advanced cardiac disease, with enfeebled circulation, then a small quantity of urine is passed. If that pressure be increased, no matter how, increased flow follows. Thus, for instance, a large imbibition of water, by passing into the circulation and producing increased pressure on the glomeruli, will soon affect the renal flow unless some other excretory organ be very active. When the skin is acting freely, and a large quantity of blood is located in the vessels of the skin, a sudden cooling of the skin is followed by diuresis, the cold contracting the cuticular vessels, and thus driving the blood internally, and increasing the pressure on the vessels of the viscera. Interstitial nephritis or cirrhosis of the kidney acts as a diuretic in the same manner. So much of the structure of the kidney is destroyed for all useful purposes; and therefore, as no diminution takes place in the calibre of the renal artery, there is increased pressure on the remaining uninjured portion, and thus there ensues increased diuresis—one of the prominent early symptoms of cirrhotic kidney. So, also, the flow of limpid urine in hysteria. We know that in hysteria there is a diminution of the calibre of the arteries, due to derangement of the vaso-motor system, and accompanied by increased action of the heart to overcome that condition, so much so as often to bring out palpitation; thus the pressure is again increased, and diuresis follows. But these conditions, though producing an increase in the renal flow, are not true diuretics. Digitalis in a similar manner acts as a diuretic in enfeebled conditions of the circulation, by increasing the arterial tension, as described in a preceding section. When administered to people in health, it does not increase the flow of urine proper—that is, of salts as well as water. Stadion put himself upon a strict diet, and took digitaline, and his urine was diminished. Winogradoff gave digitaline to several persons for five days, and found no results, except in one, and then there was diminution. Brunton, who experimented on himself freely, found increased diuresis; but on the day marked “intoxication”, there was a distinct fall. The case of poisoning related by him illustrates the effect of digitalis well. He says: “The amount of urine in my own case was markedly diminished during the period of intoxication, when the gastrointestinal canal was most affected; and in the case of Daniel G., when the pulse was most affected, it fell from an average of between 40 and 50 ounces to 30 ounces on December 2nd, 25 and 26 ounces on the 3rd and 4th, and 18 ounces on the 5th and 6th; again slowly rising, till on the 10th it rose from 25 to 44 ounces, and then remained at its normal standard.” Christison and Mazel both noticed suppression in cases of poisoning by it. Bouly and Reynal found a temporary suppression in the horses experimented on by them. In fact, when digitalis is producing those symptoms of intoxication which accompany a too firmly closed ventricle, a diminution in the flow of urine is one symptom. But then that is merely again a question of arterial tension. If a small quantity of blood only be thrown into the aorta at each ventricular systole, it makes no difference whether it be due to a state of over-contraction and imperfect distension of the ventricle, or to an imperfect systole. The effect is the same, whether due to the imperfect contraction of distension, or to the imperfect dilatation in the unnaturally contracted condition of the ventricle, which takes its rise in the excessive administration of digitalis. When the digitalis is given beyond the point of maximum, arterial tension resulting, then the urine is diminished in quantity; the flow and the arterial tension being indissoluble. Thus, when given in cardiac disease, when an imperfect systole does not produce arterial tension, it increases the flow of urine which had previously been defective. When administered to poisoning, even total suppression may follow. In fact, my opinion is identical with that of Dr. Germaine: “there is no proof that digitalis possesses diuretic properties, the reputation conferred upon it to this effect by Withering having been accepted without discussion; and the diuresis which often follows when an amelioration of the condition of the circulation has been produced by it in organic disease of the heart, is only a mediate effect, resulting from the return of the circulation to its normal condition.” On the other hand, the flow of urine following its administration in enfeebled conditions of the heart, is so affected as to be, in one case at least the writer knows of, in itself to be a source of danger.

The Use of Digitalis.—Like other vegetable substances, digitalis is prepared for use by either tincture, infusion, extract, or separation of the

active principle digitaline. The extract is little used, and personally I know nothing about it. The tincture is the most convenient form ordinarily, but throws down a dark green precipitate with iron, which detracts from its desirability. For general use, it can be given along with the ammonio-citrate of iron, or, still better, the potassio-tartrate. It is better kept in a dark cupboard or wrapped in a dark coloured paper, as light is supposed to act deleteriously upon it, weakening it and lowering its activity. The infusion is a good preparation for use along with potash or diuretics, and is conveniently added to vegetable infusions. Digitaline in solution may be the most elegant form, and perhaps may be found ultimately to be the most exact form for accurate administration; but a strong impression against it was left on my mind from experiments on frogs, when a solution of digitaline did certainly not produce such a decided effect as the tincture upon the ventricular contractions. It is certainly possible that the other constituents, digitalose, digitalic acid, etc., may possess properties peculiar to themselves; and when the importance of a knowledge of the action of different agents on the heart-walls becomes fully recognised—for as yet we are only on the threshold of the inquiry—a careful investigation of them may not be barren in results. This field of inquiry is a most promising one; and no more important addition could be made to the present usefulness of medicine than a perfect knowledge of the action of agents on the heart, either in the chronic condition of persistent alteration—either as a primary or secondary lesion, or in passing conditions. We have long been acquainted with the frequency with which cases occur when, in chronic disease, the question of the integrity of the muscular walls of the heart, or of structural change in them, guides our prognosis as to how long the struggle may be maintained. We are, too, gradually recognising the failure of the right side of the heart in asthenic disease or affections of the respiratory organs, as the channel through which death commonly approaches; we can calculate how certainly the right ventricle, taxed to the utmost, becomes gradually paralysed by the carbonic acid of its contained blood anæsthetising its action. If we can find means to keep up its action, we may tide that patient on to recovery; while in the present state of our knowledge, the condition is only recognised by a few, and the means of producing any impression upon the condition by therapeutic agents confined to the hopefulness of only a very few. In the treatment of chronic conditions, when it is necessary to keep up the administration of digitalis until structural changes are produced, perhaps the powdered leaves are the most desirable form. In this form, it can be given in pill with the dried sulphate of iron, carminatives, laxatives, or both, and in this form will keep some time, and can be given twice a day without causing the patients to revolt at its nauseous taste, or creating any aversion, on æsthetic principles, to its muddy-looking combination with iron. For long, a favourite form of pill with me for persistent use has been a combination of half a grain to a grain of powdered digitalis, with an equal quantity of the dried sulphate of iron in powder, and a morsel of cayenne, in extract of gentian, or aloes and myrrh pill. Thus we secure at once cast an action on the circulation, the addition of iron in a form which will act locally on the stomach, and thus act as an astringent in the gastric catarrh so common among the sufferers from heart-disease; while the carminative action of the cayenne is useful, and also takes off the griping from the action of the laxative, when an action is also necessary, as is commonly the case, on the bowels. I have had patients for months, and in some cases even years, thus under its influence in the most satisfactory manner. With their box of pills they can go anywhere, can take them about, and have a reserve stock if necessary; and then, twice a day or so, a pill can be taken without any inconvenience or parade of medicine-taking. One point of some importance must not be forgotten in this mode of its use, viz., that the pill must be taken shortly after food, otherwise it may be pouched in a fold of the stomach, and lie dormant, or it may be passed at once into the bowels, and its good effects lost. The pill is an artistic application of scientific research to the food, and must be regarded as such essentially, as, in fact, must all restorative remedies. In the use of digitalis, the addition of iron is of great importance. Some may raise objections that the good effect is due solely to the iron; but surely the constant administration of so potent an agent as digitalis cannot be without some effect. The results thus attained appear too early to be the mere effect of the iron. While the attempt to produce better nutrition of the heart from its use, as we saw in a preceding section, does actually succeed, the addition of iron, from its hæmatic properties, aids us most materially. From the cheering results which I have witnessed in numerous cases of chronic cardiac disease, and the great alteration effected in the patient's condition, both as regards comfort, or, rather, relief from discomfort, ability to take more exercise, and even to undergo more exertion in those cases where the patient's circumstances necessitated labour, I can urge most honestly and conscientiously its use, and especially in this combination.

Another application of it is very important, and that is its absorption through the skin. In many instances, it is desirable to bring out the action of the digitalis when the risk of disordering the stomach may act as a check, or even when there is already great gastric disturbance. Here it may be used by either poultices of the leaves, or flannels soaked in the infusion, or a mixture of the tincture and water applied to the abdomen and thighs. Cases are given by Christison of such use of it. Trousseau relates a very interesting case where very decided results were thus obtained (vol. i, chap. xxxv). Some cases were recently detailed in the journals of such use of it. This manner of administering digitalis should never be lost sight of, as it may now and then enable us to do what we cannot accomplish by the mouth.

Hypodermic injection is another mode of administering it which should not be overlooked. Certainly, in the experiments on frogs, this was chiefly resorted to on account of its convenience. Bouillaud pursued an endermic treatment by dusting a blister over the heart, with from six to fifteen grains of powdered digitalis. These various modes of administering digitalis have each their advantages according to peculiar circumstances. No one plan of action must bind the practitioner's mind in fetters. He must be ready and willing to use each in its place, or even to substitute for digitalis some drug of similar action. From the known intolerance of mercury in some constitutions, and notably in those suffering from cirrhosis of the kidney, which is often followed by consequent heart-mischief, with its train of sequelæ, the old combination of digitalis, squill, and blue pill may have to be abandoned, and for the blue pill iodide of potassium substituted. Patients' prejudices, as well as their needs, must be consulted. It is much to be desired that some drug may be discovered with equal properties to digitalis, and about whose action no preconceived opinions, based on imperfect observation, may bias the minds of medical men. It would be easier to establish the use of such an agent especially in this experimental age, than to war against a settled impression. And though at present the list of agents possessing an action on the heart, and through it a control over the circulation, may be a very limited one, but at the same time very important, the day is not far distant when the importance of inquiry in this direction will make itself felt. I have not claimed for digitalis anything for which it cannot fairly substantiate its claim, nor have I accorded to it any mystical action, differing from that of any other therapeutic agent. I have striven, as far as possible, to exercise the functions of a judge, as well as of an advocate, and tried fairly to lay down what, in the present state of our knowledge, digitalis can do, and what it cannot. And I am quite willing to labour under the disadvantage of being regarded as an enthusiast, if only the subject can get that attention paid to it that it deserves; and my experience tells me in language that is unmistakable, that the effect of agents upon the heart, of which digitalis is the most powerful one with which we are yet acquainted, can no longer be overlooked by any one in the profession who regards either his own interests or those of his patients.

TELEOLOGY AND EVOLUTION.

BY THE

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WITH permission, I shall take advantage of the opportunity offered by Dr. T. Clifford Allbutt's letter of the 12th instant, published in the BRITISH MEDICAL JOURNAL of the 15th instant, to make a few brief remarks on Teleology and Evolution.

There is no necessary opposition between these expressions; and it is quite possible, perhaps even probable, that Teleology works out its purpose by means of Evolution. If the Evolution be the result of foresight and contrivance, it becomes merely the expression of the chain of Second Causes by means of which the purposes of the great First Cause are harmoniously carried out. But if, on the other hand, Evolution admit of chance combinations, capable of becoming permanent, and not foreseen, then it is irreconcilable with the fundamental hypothesis of Teleology.

Dr. Allbutt has, I believe, correctly interpreted what I intended to show in my occasional references to Teleology during my lectures on the Principle of Least Action. I illustrated this principle by means of the limbs of the tiger and the wing of the albatross, and endeavoured to show that the several conditions which combine to produce the action of those members are so related to each other as to fulfil the requirements of the principle of Least Action; or, in other words, that these conditions are so related to each other that, if all of them

save one be given, we can calculate with certainty the remaining condition.

This remarkable fact is, in my judgment, irreconcilable with the hypothesis of Evolution, by means of slow variation of the conditions, which is the fundamental idea of Mr. Darwin's hypothesis.

Let us suppose, in fact, that the exercise of any complex organ of an animal depends upon a certain number of conditions, which we may call a, b, c , etc.; then the result may be expressed as a function of those conditions,

$$F(a, b, c, \text{etc.}, x, y, z).$$

The principle of Least Action requires this function to be a maximum, which will be the case for certain definite groups of values of the elementary conditions on which the complex function depends, and for no others. We shall, therefore, have the principle of Least Action fulfilled for certain groups of values.

$$F(a, b, c, \text{etc.}, x, y, z).$$

$$F'(a, b', c', \text{etc.}, x', y', z'). \text{— And so on.}$$

I showed in my lectures that, if certain conditions, a, b, c , etc., be given, the other unknown conditions, x, y, z , can be calculated on the hypothesis of Least Action; and I verified this statement by several remarkable examples. We may therefore consider it as proved, or at least admitted, that the existing arrangements of Nature fulfil the conditions imposed by the principle of Least Action. This admission is fatal to the hypothesis of Evolution by slow variation. For, let us suppose the two functions F and F' each to satisfy the conditions of Least Action, each of these will represent a complex result which is stable, and which will refuse to vary indefinitely from its original value. Let the quantities x, y, z , etc., vary by slow degrees in any direction whatever, I assert that the principle of Least Action, which requires the function F to be a maximum, will prevent x, y, z from varying indefinitely; or, in other words, that the controlling influence of the remaining conditions, a, b, c , etc., will compel x, y, z to return back to their original values; which values, in conjunction with those of a, b, c , etc., rendered the function F a maximum. In like manner, F' is another maximum; and its elements, $a', b', \dots x', y'$, etc., cannot vary indefinitely by slow degrees.

The conditions involved in F and F' are each stable; and, when variations of small extent occur, there is a necessary return to the condition F , or F' , which involves the maximum effect; but it is absolutely impossible for F to be transformed into F' by slow variations of its elements, without losing that property of being a maximum on which its continued existence depends.

The function F is a maximum only for certain definite, and often far removed, groups of values of a, b, c , etc., x, y, z ; and we cannot transform F into F' without making the hypothesis of *abrupt* changes in the values of the elements, for any small slow changes will reproduce F again and again.

The force of this argument will remain unchanged, if by F and F' we mean two species, instead of two arrangements of organs.

An illustration from physical astronomy will clear up this point. If there were only one planet revolving round the sun, it would describe an ellipse which would remain the same at each revolution; but, as there are several planets, each exerting a *small* disturbing force, the planet describes an ellipse which differs slightly at each revolution from its predecessor and from its successor. Still the path is always an ellipse, and never shows any tendency to become an hyperbola or parabola, for the simple reason that all its elements change *slowly*. Let us now, however, take the case of a comet, moving in an hyperbolic path round the sun, and coming into close proximity to a large planet: the elements of the comet's path, a, b, c , etc., are now *abruptly* changed, and we find the hyperbolic path changed in a few hours into an ellipse.

The Evolution of one species from another must, in my opinion, be the result of *sudden*, not of *gradual*, changes of conditions; and no scientific attempt has as yet been made to show how such evolution of species may take place.

The concluding portion of Dr. Allbutt's letter, respecting the *surplusage* of force sometimes found in Nature, opens up a subject of discussion on which I could say much, were I not afraid to weary by my much writing, as I have already offended some by my much talking.

In conclusion, I would remark that, in the supposed slow passage of an organ or species from the *maximum* F to another *maximum* F' , it must necessarily pass through a *minimum*, which will exhibit in an extreme degree want of contrivance and imperfection. Where are these imperfections? They ought vastly to exceed in number the perfect types which have reached the *maximum* effect. Where is the evidence of the endless succession of blunders which blind Nature has used as stepping-stones to produce her few happy successes? I cannot find them either in living nature or in the records of paleontology.