also a batch of twenty-five animals used for various inoculation and drenching experiments. Deaths from lamziekte occurred only in the control lot; eight animals contracting the disease, and of which number seven died. The control and the muzzled animals were watered together, the latter drinking through their muzzles, proving at the same time that water of whatever description, river or rain water (so-called "paddawaterjes") could not be responsible for the disease. This experiment definitely proves that the disease does not enter through the skin and it would be too ridiculous to suppose that the muzzles acted as a filter for such micro-organisms, visible and invisible ones which could only produce diseases if they entered through the mouth. The animals were able to come in contact with the soil by means of their tongues through the mesh of the muzzle, although they were not able to pick up food they were able to snuffle at each other. Taking all this evidence together, we may therefore accept it to be proved that lamziekte is not a disease caused by a micro or any other organism. *In other words it is neither contagious nor infectious.*

II.—The Poisonous Plant Theory.

Many farmers hold that the disease is due to the eating of some plant which causes the disease. Hutcheon, as we have seen, considering the absence of phosphates in the system as the primary cause, thought of a plant as the exciting cause. In view of the definite outcome of our muzzling experiments we were inclined to the same view for some time. The poisonous plant theory is capable of explaining many of the facts known to be connected with the appearance of lamziekte. We could understand why the disease appears at certain times of the year more than at others, and more particularly in the dry season, if we accepted a drought resisting plant as the cause. We could also understand why pregnant animals and cows with calf are more subject, since such animals with a greater and depraved appetite would look for such a green plant. The fact that trekking off a farm, or rather trekking about, should have an influence, could be explained by a change to new pastures where such a plant is absent or not frequent. We could also understand the supposed spreading of the disease which is said to have taken place in a certain direction. The so-called werf theory would find an explanation, inasmuch as on one werf the plant might be present and not on another. But not only poisonous plants were thought of but also smuts, rusts, and fungi on plants which could be eaten or which could grow on such things as bones, rags, manure, etc., which the cattle were obtaining when showing the depraved appetite. But the majority of the facts known in connection with lamziekte did not find an explanation. If indeed a definite plant would be the cause, then such a plant would represent the common factor on all lamziekte farms. Reasoning in this way, Mr. Burtt-Davy and myself travelled over a large area of farms, examining the veld, meeting the farmers, and we were able to induce a good many of them to send in plants which they or natives had reason to suspect. Mr. Burtt-Davy then classified the plants according to their geographical distribution, and such plants as were common to all of them were submitted to feeding tests. A number of different plants were fed to animals, and all failed to produce

the disease lamziekte. In travelling from farm to farm and speaking to a great number of the farmers we came to the conclusion that if a definite poisonous plant would be the cause of the disease, it could not have escaped the notice of some farmers during the many years the disease was known, and during such a period as the last two years when the disease was more prevalent than at any other time within the recollection of man. All the poisonous plants known to exist in South Africa were found out by farmers and before experts began to investigate them, and when there was doubt the doubt was only about the exact species out of a number of plants which experience had connected with a certain disease. I do not think half a dozen farmers pointed out the same plant to us as being responsible for lamziekte. Another fact speaks against a poisonous plant, viz., that by feeding of "pensmist" we were never able to produce the disease. It may rightly be expected that in some instances some material of the plant would be left over in the rumen. *The poisonous plant theory must accordingly be given up.*

III.—The Want of Nutrition Theory.

This is a theory brought forward by many farmers, and it is indeed capable of explaining many observations in a satisfactory manner. It is to the effect that there is something wanting necessary for the nutrition of the animal. This want should then explain the craving of the animal, trying, of course, instinctively to find that substance. The fact that animals fed on cultivated foodstuffs while running on lamziekte veld do not contract the disease so rapidly is considered to be in support of this theory, the animal obtaining the substance that is required from the food and which is not present in the grass. This is also the objection made to our muzzling experiments. It was pointed out that the muzzled animals had not fed on the in-nutritious grass of the veld over which they are running, but were on the grass from Pretoria, and for this reason remained healthy. This objection would, of course, hold good as soon as it can be shown that the nutrition theory explains the rest of the observations satisfactorily.

The reason why animals that come from a healthy area do not contract the disease so readily is said to be that such animals still retain a considerable amount of that material in their system which is gradually utilized and reduced as time goes on. The main support is found in the observation that the disease is principally found in dry and hot years when the grass had but little chance to develop, and naturally is thought not to have reached the state of maturity that is wholesome for cattle. The fact that farms on sweet veld show no disease, or to a much lesser degree, could also find an explanation in this way. The observation that animals, such as heifers and tollies, and cows and heifers in calf, were most liable to sicken, also found a satisfactory explanation. Growing heifers and tollies did not obtain sufficient nutrition for their growth, and in an animal in or with calf that material was withdrawn by the growing calf. That sucking calves did not contract the disease showed that they obtained the nutritious substance from their mothers through the milk. The objection to this explanation is, how can the calves take

away that which the mothers do not obtain? If there is a lack of nutrition it must be in the food. Cows fail to obtain it, and what they do not obtain they cannot give to their calves. Of course this objection is met by pointing out that there is not a complete lack of the necessary material, but only a shortcoming. Admitting this to be the case, then it is still a difficulty to explain why fully-developed calves are born, and the calf, so long as it is on the udder of its mother, is healthy, therefore obtaining the full quantity of nourishment required for its growth. The main objection lies in the fact that the fattest animals and the best milkers are more subject to the disease than those in such good condition. Whatever substance would be lacking in the nutrition, we could not understand that with the lack of something of vital necessity such a good condition could be obtained. It would be contrary to all physiological knowledge. A good condition of an animal is the result of all foodstuffs, organic or inorganic, being present and in proper proportions; the lack of one of them would never allow the animal to get into a first-class condition.

There is another difficulty to explain, viz., the recovery of the animal. If something is missing, how can an animal recover after it has sickened without that something being supplied; nothing additional is supplied, as the recovering animals remain under the same conditions under which they contracted the disease.

The want of phosphates also belongs under this heading. We have shown that the want of these minerals can produce a disease, but it does not resemble our lamziekte. There exists, however, the possibility that there is indeed a want of phosphates in the soil, and accordingly in the food, but the shortage as such is not the direct cause; there is still sufficient material for the animal, but it may indirectly contribute to the cause of the disease in some way or another. These points require naturally extensive comparative chemical analysis of soil and plants.

The want of nutrition theory does not explain one important fact, viz., the influence of trekking. The moving and driving of cattle stops the disease. To understand this we would have to accept that by trekking every time fresh and healthy pasture was found, which is decidedly not the case. It fails completely to explain the fact that animals, oxen and cows, which are worked hard and whose food supply is only the grass of the lamziekte veld, are less susceptible. Hutcheon, who tried to meet this objection by his want of phosphates theory, says that in working animals the increased metabolism liberated the phosphorus required for the nutrition of the animal and thus meets the demands. But he failed to explain to show how phosphates get into the muscular system when they are not present in the food which primarily was accused to be lacking in them. The main support, of course, for the want of phosphate theory was the observation that in all experiments where bonemeal was supplied at short intervals the disease was not noted. This fact cannot be overlooked, but will find a different explanation. It will, however, be wrong to conclude that because the administration of the phosphates prevents the disease the want must be the cause of it. To illustrate this fallacy I have only to refer to drugs which have preventive effects, such as for instance Cooper's Dip has on geilziekte

in sheep, the protection is apparently due to the presence of arsenic. But nobody has yet drawn the conclusion that the want of arsenic in the system is the cause of geilziekte in sheep.

The want of nutrition theory is therefore not capable of explaining all the observations connected with lamziekte.

IV.—The Accumulative Vegetable Poison Theory.

The data collected and all experiments made in connection with lamziekte allow of a theory by which it is possible to explain, if not all observations, at least the great majority. This theory is as follows:—

Lamziekte is primarily a disease of the muscular system caused by a toxin which accumulates in the muscles and is obtained from grasses of certain regions where it is produced under the influence of certain climatical and tellurical conditions.

There is no difficulty in accepting such a possibility, because, as shown before, we have an analogy in the so-called pica of eastern Prussia, which disease has been proved in a definite and conclusive manner to be produced by grass alone. Certain tellurical conditions were necessary to produce the toxins. They were present in the grasses of the moorlands, and when, through the amelioration process, these lands were dried up, their quantity increased. The disease did not appear every year equally, because the climatic conditions acting on the grasses in the various years were different. If we consider the fact that lamziekte only occurs in a definite area, and not in years with plenty or normal rainfalls, but in years of drought, we have similar conditions to those produced by the amelioration process in eastern Prussia. There are evidently differences in the climate concerned, the difference is probably only one of degree. A good many of our farmers say that lamziekte is more prevalent on shallow soil and less so on deep or moist soil; the latter condition prevailed on the moorlands before amelioration, another point of resemblance to pica. The analogy goes still a little further. The main symptom in pica is the abnormal craving, hence the name "Licking Disease." It was shown in some of the experiments that when hay of the aftermath was used nothing further was noted than a little depraved appetite, without loss of condition. This shows that the grass of the moorlands contained more than one kind of poison, at least two of them, one being responsible for the craving, the second one causing disease and death.

All farmers agree that a depraved appetite is connected with lamziekte. Some farmers go so far as to state that when the craving of cattle begins, lamziekte is approaching. I believe this view to be correct, and I consider the depraved appetite as the first symptom of lamziekte, as already Spreull has done in the publication mentioned, and it is perhaps sometimes the only one, the disease not developing any further. But there are different degrees of craving. We know that all cattle are fond of bones. Some farmers think they chew bones to sharpen their teeth. We further know that all cattle are fond of salt, and it is a regular farm practice to give cattle salt. The reason for the salt craving is explained by the

famous physiologist, Professor Bunge, to be due to the presence of an abundance of potassium salts in the grasses whose effects are neutralized by sodium salts, the former acting as a poison on the system, the latter being the substance necessary for health and development. *The normal taste for salts, and probably also for bones,* finds therefore an explanation. In sour veld we know of another and more increased craving which is already, according to all statements, strongly pronounced, and which does not yield, or at least not readily yield, to the salts and bone meals, whereas it stops as soon as a movement is made to sweet veld. In sweet veld no craving, or but little, is observed. This normal craving in the sour veld cannot be connected with lamziekte. It is due to the sour veld, viz., to the presence of certain substances in certain grasses, sour grasses, which may be considered to be toxins of a non-dangerous nature. On lamziekte farms the craving is abnormal. All lamziekte farms are sour grass farms; some contain mixed grass-veld, and the opinion of many farmers, particularly the Free Staters, are so definite that they accuse the grass bults as the only places where the disease is contracted. Some farmers go so far as to accuse the "rooi" grass, the "beeste" grass, or the "zuur pol" to be the cause. That the disease does not occur either in the Karroo veld, sweet veld, or river veld gives a strong support to their view. In addition, therefore, to a harmless toxin causing craving, there exists in the grasses of lamziekte farms other toxins which attack the animals and are the cause of the disease. It is possible that these toxins have also the faculty of causing craving, which would explain that on lamziekte farms the symptoms are more pronounced than on healthy farms. The presence of such toxic grasses, grown under favourable conditions of the soil, explains the presence or absence of the disease from certain parts of the farm and of certain areas within the lamziekte region. The statements as to the actual places, their altitudes, peculiarities, geological formation where the disease is contracted, vary very much, showing, in my opinion, that the conditions under which lamziekte is contracted vary very much on the different farms. The change in the climatical conditions, viz., the drought, together with certain conditions of rainfall, followed by increased heat acting in a manner not yet fully understood, explain the apparent spreading of and the temporary absence of the disease. The climatic conditions have, in the last few years, been more or less uniform over the north-western lamziekte areas and those adjoining them. Accordingly, the conditions necessary for the disease being so prevalent caused its appearance also on such places when the disease did not show itself before. We do not think that one particular species of grass alone is responsible, although such may be the case, and, if so, a spreading could be traced by that grass. We think there are a number of grasses responsible which, again, are irregularly distributed; of these a certain quantity must be eaten; although the responsible grasses are present on all farms they do not always grow in such close proximity and are therefore not consumed in sufficient quantities to allow of an increased accumulation of the poison. In addition to the presence of poisonous grasses another condition seems to be necessary —that of causing the wilting and withering when perhaps more of

the poison is found than under the usual conditions. Under the influence of the warm weather of the spring, and under such conditions as would cause the grass to spring up, a more rapid production of toxin takes place. In the pica disease we have seen that the grass is not always poisonous, but only that of a certain growth, and such may also be found to be the case with lamziekte. It is not even necessary to assume that the poison is formed only under the conditions of drought and heat. We may accept that certain sour grasses are always poisonous, but under the conditions of good years, cattle do not eat them, and in dry years, when the sweet grasses have but little chance of developing, cattle are forced to eat them.

This toxin is stored in th emuscular tissue, having a definite affinity to it, and when the maximal dose has accumulated, the protoplasm is attacked and altered. I admit that in the acute stages the nervous system may be involved to a certain extent.

We can now understand why one particular class of cattle, heifers and cows in calf, and cows with a calf, are more liable than oxen, simply because the former animals have to eat a much greater amount of food to obtain sufficient nourishment both for themselves and for the calves, and in doing so accumulate a greater amount of poison. According to Krumacher (Stoff und Energie Wechsel) a stall-fed ox consumes 15-21 kilo. of dry substance, an ox doing average work eats 22-28 kilo, and milk cows consume 25-29 kilo. It is generally stated that working oxen, and also cows, which are put in the plough, do not contract the disease, whereas oxen and tollies not working are more liable. This fact we can explain. The muscular system of the animal represents about 59 per cent. of its whole weight. When an ox or a cow is worked, such work can only be obtained at the expense of energy which is obtained by the increased oxidation taking place in the muscular system. The increased oxidation also involves the toxin, and which, being of an organic nature, must undergo the process of metabolism and thereby is destroyed. We can therefore understand why the trekking, driving, and swimming of cattle can act as a temporary check. We even are able to explain the paradoxical fact that shifting cattle from an unhealthy area to another unhealthy area can bring the disease to a standstill. Through the trekking the metabolism was so increased that the poison present was more or less completely oxidized. We know that trotting a horse for a short while raises its temperature to one degree and heavy work causes such high temperature as to simulate fevers. The total production of carbonic acid and the consumption of oxygen measured in the expired air may be ten times greater whilst the animal is working (A. Durig, Algemeine Muskelphysiologie). More or less freedom from the disease after trekking probably depends on the degree of exercise the animal has been put to whilst worked or driven. The observations that during the cold winter months the disease is less noted may be due to increased oxidation as well. Heat has to be formed for the maintenance of the animal's functions, and the oxidation takes place at the expense of the tissue, particularly the muscular tissue in which the poison is accumulated, there being not sufficient food to replace the increased requirements for the metabolism. The poison being of an accumulative nature, we can explain why cattle which are brought from healthy parts of South

Africa into lamziekte areas do not contract the disease so rapidly as cattle born and bred on the place or cattle which have been on the farm for some time. The poison is present in the grasses in such small quantities that it requires feeding over a very long period before there is sufficient accumulation to cause any damage. There is no difficulty to accept this. I have only to refer to the analogy in pica where it took at least six weeks as a minimum and as many months as a maximum before any symptoms were noticed. The changing into Karroo veld or into sweet veld and the subsequent apparent immunity for a while when the cattle are brought back under the old conditions means that no further accumulation of toxin took place, and the system had a chance to free itself of what had already accumulated and thus was able to return to normal conditions. In a similar way we can explain the fact that animals fed on foodstuffs contract the disease to a lesser extent. These foodstuffs can even be grown on the unhealthy areas again in accordance with the experience in pica disease. Such foodstuffs may have a greater oxidizing power, or what is more likely, the nutritive material assimilated from them into the protoplasms dilutes the toxin to a certain extent so that only a slow accumulation takes place. The fact that calves, as long as not weaned, do not contract the disease, finds an explanation that their food, the milk, is not poisonous, the toxin being retained in the body by the muscles to which it has a greater affinity. If it is passed into the udder with the blood it is oxidized in that gland or the metabolism of the fast growing calf destroys the rest as it comes along. In fat adult animals the metabolism is naturally reduced otherwise no fat could be collected, and this is in favour of storing the poison in the best conditioned animals. The accumulative poison theory explains further another paradoxical fact, viz., freedom of disease for a certain time after inoculation with anthrax, redwater, and bacterial cultures because such organisms or their toxins produce fever in the animals which are not already immune against them. In fever, as a result of an increased oxidation, the process of metabolism takes place more rapidly and involves the toxins which it destroys. This oxidation largely takes place in the muscular system, everybody knowing how in a disease accompanied by fever rapid loss of condition is noticed. Therefore it can be also understood that the injection of bile or blood (or even "muck," as has been the case in some instances) can temporarily render an animal apparently immune, the blood usually containing redwater, gallsickness, and other organisms which cause febrile reactions in susceptible animals. We also understand why, at the time of the rinderpest, the bile inoculation stopped lamziekte in the Eastern Province. The apparent immunity can therefore be explained to be due to increased oxidation by which the animal is freed from the poison and may go on for a certain time collecting it before the disease reappears. Some animals are more susceptible to such toxin than others, and animals which have recovered from an attack of the disease have an increased susceptibility probably due to some lesion left behind in the cells. Half the dose of the toxin, or even less, may only be required to upset the balance the second or third time. When an animal sickens from the disease then it means that the attacked protoplasm of the muscle cells has been partially

or totally destroyed by the toxin, but in cases of recovery could be replaced quickly enough to maintain the necessary vital functions. Through the recovery the protoplasm freed itself of the poison. There is, accordingly, a break in the accumulation.

Special attention must be drawn to the experiments with the feeding of bonemeal as they were undertaken in Witte Clay Rug and supervised by Borthwick, in Koopmansfontein by Spreull, and in Yarrow by Robertson. In all these experiments the bonemeal was given to each animal separately, and at intervals of one and three days, and the results in all cases were uniformly excellent. The control animals which received no bonemeal died in large numbers. So striking is this result that I am not inclined to consider it exclusively in the light of a coincidence. Although a good many farmers up to the present time adhere to the practice of giving bonemeal and attribute their freedom from the disease to it, yet a greater majority consider it to be useless. What is the reason for this discrepancy? What does the supply of bonemeal amount to under the conditions of the practice? Do the animals which have free access to the bonemeal partake of a quantity equal to that given forcibly in the experiments quoted above? Is the administration of one dose per animal per week, as is usually the case, sufficient? I do not venture to pass an opinion as to the reason why bonemeal failed in the hands of so many farmers, as I do not yet know how it was given and how much the cattle actually consumed.

The grass toxin theory allows of an interpretation that bonemeal may have an influence, not because it adds something to the system which was wanting (phosphorous oxide), but because something is incorporated with it which either helps to oxidize or neutralize the poison, and it may enter into chemical combination with the toxin and render it harmless. And like bonemeal other substances may act as well, and seeing that, after an administration of certain drugs, the disease stopped temporarily, a similar process may have taken place. In connection herewith more careful observations will be wanted.

The accumulative poison theory explains the majority, if not all, of the observations in connection with lamziekte.

The Cure and Prevention.

At the outset I must make it clear that I do not know yet of a certain cure or of a simple preventive which would solve the question. These notes are only meant to indicate in which way attempts should be made, and will be made, to find a cure and a preventive for the disease.

If the theory of a poison accumulated in the muscular system is correct, then it follows that medicine only intended to clear the intestinal tract cannot help much, although such medicines are usually resorted to. The toxin is already fixed to the cells, and when the disease is noted it has already acted on the cells. Whether an animal will now recover or not depends on the resistance of the protoplasm of the cells, on the dose which has been acting on it, and on the degree of the lesions produced. It follows therefore that when the disease is recognized it is already decided whether the animal is going to recover or not. Hence the fact that so many medicines help sometimes and at other times not at all.

The removal of the poison can probably only be done by increasing the oxidation processes of the system, by trying to raise the body-heat, to increase and accelerate the metabolism in the muscles. Perhaps some of the medicines which have been used successfully have had such an effect, and when they failed did so because the lesions produced by the toxin were irreparable.

Although there is little hope for a cure there is more prospect for a preventive, but we must clearly understand how much we are entitled to expect in this connection. All farmers agree that cattle which recover do not "salt" from the disease, in other words, there is no immunity, and when there is no naturally acquired immunity there cannot be any produced in the sense in which we understand immunity. We notice, however, one important fact, that animals which are brought from a healthy to a lamziekte farm contract the disease only after they have been for a more or less longer period on that farm, and the majority of cattle which have recovered go down again only after varying intervals. There is accordingly an apparent immunity, and it is in the interval in which the animal is free of the disease. Our theory explains it. It is the length of that period which shows what we can expect. But we have it in our hands to lengthen this period, and the farmers have found it out by actual experience. A certain exercise of the cattle in the way of trekking, if periodically carried out, will prolong it, but it must be done in a systematic manner. Then again we can produce a break in the accumulation of the toxin by changing the pastures, as has also been found out by experience. Perhaps it will be advisable for a farmer to provide his farm lands with culture grasses or to break up some veld and turn it into sweet veld; when the abnormal craving indicates the approach of the disease he can put his cattle into such lands periodically. Perhaps this is the best way to prevent the disease. The question of preventing lamziekte therefore appears to be one not for a veterinary surgeon but for the farmer himself. Perhaps it means that the method of farming will have to be changed and extensive cattle-raising will give way to intensive stock farming. There is some prospect that tramping out of the veld by sheep will render it fit again for cattle. Opinions of coastal farmers are much in its favour, and according to our theory we can understand it. There is no doubt that anthrax inoculation, redwater inoculation, and other inoculations have, in many instances, checked the disease. We understand now why an immunity for life, or at least for a year, was too much to be expected. A second inoculation of the same material has no longer the same effect, because the cattle were rendered immune by the first inoculation, and on the second occasion they no longer react and accordingly there are no fevers and no oxidation going on. These observations indicate the way how to proceed. We can expect that any substance which causes fever will temporarily free the system of the poison, but we must not expect that such an animal is now immune for ever—it will only be free of the disease temporarily. It returns to a normal state of affairs, but remains subject to the disease all the same. Accordingly it would have to be reinoculated at intervals. If we attempt therefore to treat the cattle with pyrogenous substances we must be ready to inoculate at short intervals, and very likely each time with a different material.

There is no difficulty in finding such material. Almost any bacterium or the toxin produced by a bacterium will have such an effect. The object is to find a toxin which produces a high fever without doing damage to the animal itself. There are observations to this effect which promise to be successful. Mr. Robertson, Acting Assistant Director of Veterinary Research, at one time thought he found the cause of the disease in a bacterium belonging to the colon group—cultures of these bacteria of some weeks' standing produced, when injected, symptoms somewhat resembling lamziekte. Mr. Robertson noticing that a subsequent inoculation of the same culture no longer produced a similar effect in the same animal, concluded quite rightly that some immunity was produced. On the strength of this deduction he proceeded to produce a toxin and tried it in an experimental way in a number of cases which the farmers placed at his disposal. The results were decidedly surprising. Meanwhile, however, Mr. Robertson came to the conclusion that his bacterium, which was also known as a pasteurella, was in no way connected with lamziekte, and therefore he expected recurrences of the disease in the inoculated cattle at any time. These recurrences did occur, and Robertson gave up the idea of further inoculations. In the light of our theory we now understand the results; the bacterium, although in no way connected with lamziekte, produced an apparent immunity by its pyrogenic effect on the system. We intend to continue similar experiments. For this we require the assistance of the farmers who will place some of their cattle at our disposal, and we shall experiment with several toxins now to be prepared in the laboratory.

In concluding, I cannot help expressing my opinion again that the proper treatment of lamziekte will finally rest with the farmer himself in adopting more advanced methods of food supplies. All other means, dosing, and injection of toxins will only be of a temporary nature. I know perfectly well that many of my farmer friends will feel disappointed at this my finding, but after all we must apply our treatments according to the nature of the disease. We cannot fit a disease into a treatment. Scientific research means to find the cause of the disease, and in that chain of many conditions which lead to the cause we try to find the weakest link we can break. In connection with lamziekte this can be done in preventing and intercepting the accumulation of toxins. The prevention lies mostly with the farmer himself.

In conclusion, I wish to express my heartiest thanks to the many farmers who replied to the query-sheets, who allowed me personal interviews or gave me their experiences by letter, and who sent specimens of plants for observation and experiments. The conclusions I have arrived at represent the opinions of a great many farmers who, although not in the position to put them in scientific language, came to similar deductions. The foregoing article therefore is nothing else than the result of a hearty co-operation between farmer and expert, a condition of affairs which I hope will continue.