CLINICAL TRIAL OF DIPHENYL THIOUREA COMPOUND SU 1906 (CIBA 15095E) IN THE TREATMENT OF LEPROSY

PROGRESS DURING THE FIRST YEAR

T. F. DAVEY, O.B.E., M.D., M.Sc., and
GORDON CURRIE, M.B., CH.B., M.C.H.F., D.T.M. & H.
From the Nigeria Leprosy Service Research Unit, Uzuakoli.

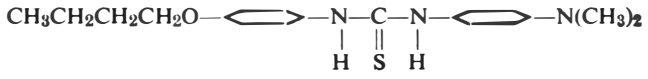
Introduction

The fact that certain compounds of thiourea exhibit anti-tuberculous activity, but *in vitro* and *in vivo*, was noted by Mayer, Eisman and Kokopka (1953). The clinical trial of three of these compounds in the short term treatment of tuberculosis was reported by Schwarz, Owen and Gierson (1954), who found one of them, a derivative of diphenyl thiourea, particularly promising. After the administration of this substance for periods up to four months in a group of 20 patients suffering from tuberculosis, of whom 19 were in an advanced stage of the disease, and 11 were resistant to other forms of therapy, improvement as shown by X-rays was evident in 16 patients, sputum had become negative for M. tuberculosis in 10 patients, and cultures were negative in 6 patients. There was no appreciable evidence of toxicity at the dosages employed. As a result of these findings a pilot trial of the drug in

leprosy treatment was undertaken, and has been in progress for 16 months. Findings recorded here are in the nature of a progress report, the period of trial sufficing to make some assessment of toxicity and of short term activity against *M. leprae.*

Chemistry

The substance concerned is 4,butoxy-4',dimethylaminodiphenyl thiourea (or thiocarbanilide), and has the following structural formula.



It is a white, almost tasteless, powder, melting at 91-94 degrees C., sparingly soluble in water, but very soluble in acetone. There is as yet no ready means of estimating its concentration in body fluids. It is prepared in the form of tablets containing 250 milligrammes.

Choice of Patients

The drug was administered in the first place to a small group of able-bodied adult leprosy patients who had had no previous chemotherapy. The group was made up of lepromatous cases, either early or of moderate severity, and an approximately equal number of patients with active spreading tuberculoid lesions, the latter being included to give speedy evidence if the drug proved inactive. As evidence began to appear that the drug was not unduly toxic and also possessed activity, patients with lepromatous leprosy of greater severity were added, and the group further expanded by the addition of children and a few borderline and indeterminate cases. A biopsy was taken in all cases to remove any doubts as to classification and also to provide a check on progress. In addition, each patient was matched against a control patient who was taking routine DDS treatment, and was comparable in age, sex, type and extent of leprosy and also in reaction to lepromin.

Dosage

In treating patients with tuberculosis, Schwarz and his colleagues commenced with a dose of 3 gm. of SU 1906 daily, given orally in three divided doses, and then increased this by 1.5 gm. at weekly intervals up to a maintenance dose of 6—9 gm.

daily. During the short period of trial reported, no significant toxic effects were encountered on this dosage.

In leprosy patients, with limited supplies, and a possible long term experiment in prospect, it was thought desirable to commence treatment at a lower level, and increase it more slowly. A daily dose of 1 gm., given undivided, was selected empirically, and this was increased by 0.5 gm. daily at fortnightly intervals, a close watch being kept on tuberculoid cases for signs of resolution as a group. Such signs did in fact begin to appear on a daily dose of 1.5 gm., and double this dose, i.e. 3.0 gm. daily was chosen as the standard maximum maintenance dose. Dosage has been maintained between these two levels in the case of adults, and children have received 0.5, 1.0 or 1.5 gm. daily according to age. In all cases there has been a rest from treatment on one day a week.

Toxicity

As information regarding SU 1906 was meagre, caution was exercised in the early stages of treatment, and careful laboratory control was maintained, with special attention to the blood, and to liver and kidney function. This drug has now been given to over 40 patients for periods of from 4 to 16 months, and has been well tolerated. There have been no signs of gastric or intestinal irritation, and up to the present there has been no evidence of any kidney damage, hepatic insufficiency, or blood dyscrasia for which the drug could be held responsible. These findings agree with those of Schwarz. In addition there has hitherto been no case of drug fever or dermatitis. In view of the relationship between this substance and thiouracil, a watch has been kept for any sign of thyroid insufficiency, but none has been found. All patients, apart from intercurrent infections, have remained in good health, and it has not been necessary to withdraw anyone from treatment with this drug. Occasional complaints have been made of a mild but irritating papular skin eruption, but this has always been of short duration, and it has proved impossible to relate it definitely to the taking of SU 1906, in that it disappeared within a few days regardless of whether the drug was given or withheld, and also it was seen among control patients. This, together with mild degrees of anaemia and urticarial eruptions, which have also been seen from time to time, must be regarded as inevitable in an area where malaria, filariasis, and virus infections are rife. These incidentals have not modified the opinion that this drug is markedly free from toxic action at the dosage levels employed, and in that respect

it compares favourably with the sulphones and with thiosemicarbazone.

Progress of Leprosy

In assessing the progress of leprosy during treatment with SU 1906, 31 patients were available for study, none of whom had had previous chemotherapy. Of these, 21 had received SU 1906 for more than 12 months, 27 for more than 6 months, and all for more than 4 months. They are classified as follows:

Lepromatous	17
Tuberculoid	8
Indeterminate	3
Borderline	3

(a) *Lepromatous cases*

The 17 cases formed a mixed group, sub-classified as follows:

Advanced diffuse or nodular leproma ...	3
Moderately advanced ditto	7
Early diffuse leproma	2
Lepromatous macules	5

The average age of this group was 29 years, the average duration of the disease, as given by the patients, was 15 months. Although some infections were very recent, the group also included two which were of quite exceptional severity.

Without exception, every patient has shown clinical improvement, with reduction in infiltration, flattening of nodules, and loss of erythema and fading of macules. In twelve cases (over 60 per cent), clinical improvement could be detected within three months of starting treatment, and was evident in all cases within six months. In two cases with ulcerating nodules, healing of the lepromatous ulcers occurred rapidly.

Details of changes in the number of bacilli in routine smears are given later. Here it suffices to say that a reduction in numbers of bacilli in smears has taken place in every patient, and has followed the pattern familiar in the chemotherapy of leprosy. In patients with a bacterial index of less than the maximum, bacteriological improvement kept pace with clinical improvement. Patients with maximal bacterial index demonstrated the usual time lag before a decline in numbers of bacilli became evident in routine smears, but changes in the morphology of bacilli became evident early in these cases as it did in others.

Progress in these patients was particularly marked during the first nine months. After that time, although with the exception of one case, clinical progress has continued uninterrupted, there has been a perceptible falling off in bacteriolgical improvement in a few cases. The matter is considered in greater detail later.

(b) *Tuberculoid cases*

All eight patients have markedly improved. In seven, skin lesions have become flat and inactive (1 after 4 months, 1 after 6 months, 2 after 10 months and 3 after 12 months). Signs of resolution in macules appeared early, in two cases within one month of starting treatment, and were apparent in all cases within four months. The process of resolution did not in some cases appear to be identical with that seen during sulphone treatment, loss of erythema being a prominent early sign, associated with or followed by a fine desquamation and gradual flattening and loss of thickening in macules. Signs of neuritis took longer to resolve, but in all cases had disappeared by the end of one year, in five cases after a period of exacerbation.

(c) *Borderline and Indeterminate cases*

All have shown improvement. The three indeterminate cases displayed early loss of erythema and fading of macules, which are now considered residual in all cases (1 after 6 months, 2 after 10 months). Borderline cases have shown dramatic improvement, with marked decline in bacilli and resolution of skin lesions, in two cases following an acute exacerbation.

All the 31 patients have thus shown improvement. Biopsies repeated after 6 months in 12 cases yielded convincing evidence of resolution in every case. Photomicrographs from two of these are illustrated in Figures 1 to 4.

The series has included eight children. All have tolerated the drug excellently and without exception have shown gratifying improvement. Three of them were lepromatous cases, already of some severity.

Complications during treatment

Erythema Nodosum Leprosum

Only one lepromatous case suffered from typical erythema nodosum. It appeared at the third month on a dose of 3.0 gm. daily, and was of moderate severity and short duration. There-

after progress was accelerated for a time in spite of reduction of dose to 1.0 gm. daily. Three months later, following a severe attack of influenza, the same patient showed some exacerbation of his condition, but this was again of a temporary nature only, and on increasing dosage again, ground lost was made up.

Increased activity in lesions

Two patients, classified as macular leproma both clinically and histologically, after showing clinical improvement and a reduction of bacilli in routine smears, underwent a phase of heightened activity in the third month, with the eruption of fresh lesions of borderline type, and confirmed as such histologically. Thereafter resolution was rapid. Cases borderline at the outset proceeded to resolve without any preliminary phase of increased activity, but one of them, at the seventh month, when routine smears had become negative, had an eruption of flat well defined macules, which then proceeded to resolve rapidly. In two of these patients the shift in clinical appearances towards the tuberculoid form was accompanied by lepromin conversion from negative to a mild positive. These changes are of interest though of no direct importance from the standpoint of this trial. Apart from these cases, resolution of skin lesions has been uninterrupted in all patients.

Neuritis

Twelve of the 31 patients have complained of neuritis at some time or other during treatment. It was seen as early as the 3rd month, but was most prominent between the 7th and 10th months. In one case this was a sudden acute neuritis developing in a patient with previously unthickened nerves (a borderline case at the third month). In nine patients it represented an exaggeration of thickening and tenderness in nerves already involved before treatment started. In the remaining two cases it was associated with no detectable pathological changes. This complication is common in all forms of chemotherapy in leprosy. What was notable about it in patients on SU 1906 was its frequency during the first year of treatment, and the fact that at the end of one year it had ceased. This may be a chance finding, but if later it proves to be more generally applicable, it is a fact of importance. In our cases neuritis was either mild or of moderate severity, and though in two patients it led to some degree of foot drop, this was only temporary.

Neuritis was relieved following a reduction of dosage in five patients, and in the remainder it disappeared on its own. After one year's treatment no patient complained of it.

Rate of Progress: Comparison with controls

The progress of patients receiving SU 1906 can be compared with that of matched control patients receiving DDS as follows.

(a) *Lepromatous cases*

(i) *Clinical improvement*

Considering firstly the 12 patients who have had treatment for more than 12 months, results are as follows:

	SU 1906	DDS
Much improved	7	6
Improved	5	6
Slightly improved	0	0
Stationary	0	0

The remaining five patients in the series, with periods of treatment ranging from 4 to 9 months all show good progress, with little difference between trial patients and their controls.

(ii) *Bacteriological improvement*

This is by far the most important aspect of this trial, and it is worth while giving details of changes which have occurred patient by patient. These are presented in Tables I and II, the former giving the results in patients on SU 1906, the latter giving corresponding figures for control patients placed in the same order. The tables give a bacteriological index for each patient, taken at the onset and at three-monthly intervals during the period of trial. The figure given for Bacterial Index is simply the calculated average of the findings of multiple smears, in which the maximum degree of positivity has been recorded as 4, indicating a slide with innumerable bacilli in every field, 0 represents a negative finding, 1 a slide in which bacilli are scarce, and 2 and 3 are intermediate between the extremes. The figure given at each quarterly interval is the average of *all* smears undertaken on the patient during the three months ending at that date. This method of calculation offers a fair and simple means both of registering progress and of comparing one individual with another. It can also be applied to complete groups of patients.

TABLE I

BACTERIAL INDEX, SU 1906 TREATMENT

SU 1906 No.	Months of Treatment						Decrease
	0	3	6	9	12	15	
1	3.3	2.8	2.0	1.9	1.7	1.4	1.9
2	3.2	2.2	2.1	1.6	1.3	1.4	1.8
3	2.3	1.8	1.4	0.9	0.8	1.1	1.2
4	0.8	0.2	0.1	0	0	0	0.8
5	4.0	3.8	3.2	2.8	3.0	2.9	1.1
6	2.8	1.8	1.4	0.6	0.4		2.4
7	3.8	2.8	2.5	2.4	3.1		0.7
8	3.8	2.8	2.3	1.4	1.8		2.0
9	3.5	2.2	1.6	2.0	1.5		2.0
10	4.0	4.0	2.8	3.5	2.3		1.7
11	4.0	2.8	3.1	2.3	2.5		1.5
12	2.3	1.0	0.2	0.2	0.2		2.1
13	2.0	2.0	1.8	0.6			1.4
14	3.5	2.8	2.0				1.5
15	2.0	1.8					0.2
16	3.5	3.0					0.5
17	2.0	1.2					0.8
						Group decrease	23.6
Group average	3.0	2.6	1.9	1.6	1.6	1.4	

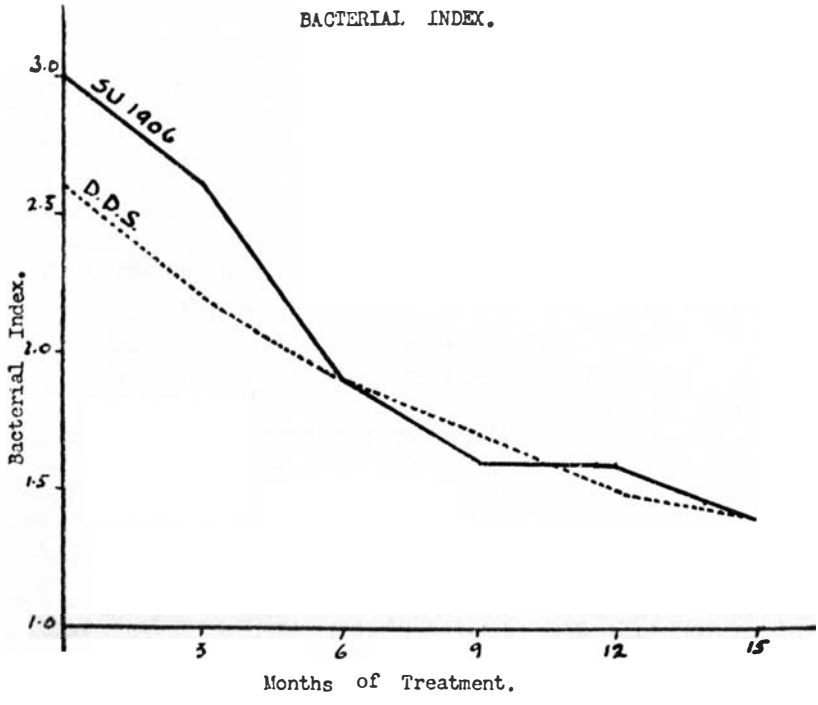
TABLE II

BACTERIAL INDEX, CONTROLS ON DDS TREATMENT

Control No.	Months of Treatment						Decrease
	0	3	6	9	12	15	
1	3.0	2.8	2.3	2.1	2.0	2.7	0.3
2	2.5	2.5	1.5	2.0	1.5	1.3	1.2
3	2.0	2.3	1.7	1.1	0.8	1.1	0.9
4	0.6	0.3	0	0	0	0	0.6
5	3.0	3.3	2.3	2.0	1.3	1.8	1.2
6	2.3	2.3	2.3	2.3	2.3		0.0
7	3.0		2.3	3.0	3.0		0.0
8	2.8	2.3	1.5	1.5	1.4		1.4
9	2.5	2.8	2.3	1.8	1.1		1.4
10	4.0	2.0	2.8	1.4	1.4		2.6
11	4.0	2.3	2.3	2.0	1.5		2.5
12	2.3	2.3	2.7	0.9	1.7		0.6
13	2.3	2.5	1.8	1.8			0.5
14	2.8	1.8	1.4				1.4
15	1.5	0.9					0.6
16	3.3	2.8					0.5
17	1.8	1.3					0.5
					Group decrease		16.2
Group average	2.6	2.2	1.9	1.7	1.5	1.4	

A comparison of Tables I and II is of interest. It will be noted from the first column that at the outset the trial patients were as a group more heavily infected than the controls, who thus had a slight bias in their favour. At the end of the period covered by this progress report, both groups had shown considerable progress, but trial patients showed a corporate fall in Bacterial Index which exceeded that exhibited by controls by nearly 50 per cent.

In neither group was progress maintained at a steady level. This is clear from Figure 5, in which the quarterly indices of each are consolidated as a single average figure, so that it is possible to compare the progress of the two groups quarter by quarter.



This graph illustrates the very good progress displayed by trial patients during the first nine months, progress decidedly greater than that shown by control patients taking DDS treatment during the same period. It also illustrates a falling off in progress in both groups, especially noticeable after the ninth month, and thrown into greater relief among trial patients by their earlier progress. Of the 12 lepromatous trial patients who have completed 12 months or more of treatment, 7 have continued to show uninterrupted progress, while 5 have shown a falling off. Heavy infections are found in both these groups. but it is noticeable that the latter group contains the patients with the longer histories of infection. Recent infections, regardless of their severity, have continued to do well.

(b) *Tuberculoid Cases*

Improvement among the two groups was very similar.

	SU 1906	DDS
Becoming residual:		
at 4 months	1	0
at 6 months	1	1
at 10 months	2	3
at 12 months	3	2
Still active:		
after 6 months	1	2 (At 10, 12 months)

(c) *Borderline Cases*

Improvement was almost identical between the two groups.

	SU 1906	DDS
Skin lesions residual, bacteriologically negative	1	1
Much improved	1	1
Improved	1	1

N.B.—As noted above, one trial patient underwent an eruption of flat macules during the seventh month. Her control patient did exactly the same!

(d) *Indeterminate Cases*

Progress was almost identical between the two groups.

	SU 1906	DDS
Residual	3 (At months 7, 10, 10)	3 (At months 6, 9, 9)

Reviewing the two groups as a whole, it may be stated that where tuberculoid, borderline, and indeterminate cases were concerned, progress during SU 1906 therapy was closely comparable with that exhibited by controls receiving DDS treatment. Where lepromatous cases were concerned, the clinical progress of patients receiving SU 1906 was as good as that exhibited by controls, and during the first nine months bacteriological improvement was in fact better; and though some slackening in progress became evident in some patients later, progress after 15 months was still as great as that seen in controls.

SU 1906 in patients already treated with DDS

As a supplementary to these findings it may be of interest to record the progress of a separate group of 10 patients who were given SU 1906 therapy after varying periods of treatment with DDS. These belonged to the small minority of leprosy patients whose progress under DDS is not entirely satisfactory. They were given SU 1906 experimentally either because resolution was unduly delayed, or on account of frequent erythema nodosum, or nerve involvement which was advancing in spite of treatment.

1. A group of 5 severe lepromatous cases who were making little if any progress after 45 to 57 months of DDS treatment, all of them still showing normal looking bacilli in routine smears, were given SU 1906 in doses not exceeding 1.5 gm. daily for periods of 9 to 15 months. In two cases DDS was given concurrently. Although erythema nodosum occurred from time to time in these patients, this dose was tolerated, and all five cases have shown continued improvement both clinically and bacteriologically. In three of them progress has been accelerated during this period.

2. Two indeterminate cases exhibiting fresh macular activity after 40 and 50 months respectively of DDS treatment, have shown marked improvement after 6 months treatment with SU 1906.

3. Three patients suffering from persistent neuritis, two of them during DDS treatment, with advancing involvement of both ulnar nerves in spite of treatment, were given SU 1906 therapy in doses not exceeding 1.5 gm. daily. Over periods of 5 to 8 months all have shown improvement in the leprosy condition generally, and also in the neuritis, with cessation of subjective symptoms, decline in swelling and tenderness, and arrest of the advancing muscle involvement.

These results are given for what they are worth. The good results may be a coincidence, but they do at least indicate that previous DDS treatment does not inhibit the therapeutic activity of SU 1906, and that small doses may have virtue.

Discussion

Caution is needed in assessing these findings. This is a progress report in a pilot trial, and neither numbers of patients involved nor the period of observation are adequate to permit anything more than a first impression. It should also be noted that leprosy in E. Nigeria is notoriously amenable to treatment, and it does not follow that such satisfactory results are to be expected everywhere. Nevertheless, patients were chosen with care, and are a fair selection of the clinical varieties of leprosy as found anywhere. Also, any local advantages possessed by the trial patients were also shared by their controls. In view of these considerations it may be stated with confidence that this drug introduces a class of therapeutic agents urgently needing further study by those interested in the treatment of leprosy.

SU 1906 is not the only member of this family to possess activity against mycobacteria. *Buu-Hoi, Nguyen-Ba-Khuyen, and Nguyen-Dat-Xuong (1955) report good results in 13 leprosy patients treated for six months with the 4,4′-diethoxy compound of diphenyl thiourea. Schwarz and his colleagues also used a more complicated derivative of this substance in four tuberculosis patients with good effects. All three compounds appear to possess the property of low toxicity. It is evident that this class of compounds is potentially of great promise, and if a member of it can

* See pages 126-7.

be discovered which can be produced cheaply, and which on a long term basis maintains the promise shown so far by SU 1906, a real advance will have been made.

It has been suggested that the biological activity of SU 1906 is similar to that of thiosemicarbazone. Differences in molecular structure between the two substances are considerable, and evidently sufficient to provide a wide difference in toxicity, but if there is any basis of truth in this suggestion, the possibility that drug resistance will develop to SU 1906 cannot be ignored.

The falling off in rate of progress in some lepromatous cases after the 9th month of SU 1906 treatment needs to be considered against this background. In so small a group it may have no permanent significance. In our experience, relatively few heavily infected lepromatous cases proceed by a process of steady improvement to complete resolution. Those that do are generally infections of short duration. Progress more commonly has its ups and downs, and the reasons for this have not yet been fully studied. Several workers have described seasonal variations in the progress of leprosy. They are seen also in Nigeria, and it is noteworthy that with the onset of the rainy season our trial patients have entered the least favourable period of the year. Also, the influence on leprosy of intercurrent virus infections has not yet been assessed. Such infections are common in West Africa and may have some bearing on seasonal variations in progress. One trial patient reacted badly to an attack of influenza during a small epidemic in which several others were involved. Furthermore, there is surely significance in the fact that the longer a leprosy infection has been established, the less likelihood there is that improvement under chemotherapy will be steady and uninterrupted. Nevertheless, the possibility cannot be excluded that we are witnessing the beginnings of drug resistance in a few of our patients. For them the next six months will be the crucial period of this trial.

It is worthy of note that SU 1906 can have virtue in patients in whom the response to DDS has left something to be desired, and can help both in the direction of hastening resolution and in relieving persistent neuritis. The further study of this drug in conjunction with DDS is needed. Its lack of toxicity and its early activity would appear to make it suitable for initiating treatment, and its use in alternation with DDS may possibly be preferable to its use in combination with it. This is one of the matters worth considering in the wider trials which are now called for, along with

the study of the optimum range of dosage and the use of SU 1906 in combination with drugs other than DDS.

Summary

A progress report is presented of a clinical trial in leprosy treatment of SU 1906, a derivative of diphenyl thiourea.

This substance was administered in doses of 1.5 to 3.0 gms daily to 31 leprosy patients, none of whom had had any previous chemotherapy. Patients were matched individually against controls receiving routine DDS treatment, and a progress report written when the trial had been in progress for 16 months, and 21 of these patients had received SU 1906 for one year or longer. A brief supplement reports on the progress of an additional 10 patients who were given SU 1906 during the same period of trial, but who had previously received DDS treatment for varying lengths of time.

The drug was found to have negligible toxicity at the dosages used, and to possess activity against *M. Leprae* during the first year of treatment very similar to that displayed by DDS. In lepromatous cases progress during the first nine months was greater than among controls, but in some patients it was not subsequently maintained at this level. The possible implications of this are discussed, and the use of the drug in combination with DDS and other chemotherapeutic agents advocated in wider trials.

ACKNOWLEDGEMENTS

This trial was undertaken at the suggestion of the late Dr. J. Lowe when Medical Secretary of the British Empire Leprosy Relief Association. Both at its inception and during its progress valuable advice and encouragement have been given by Dr. F. Hawking of the Medical Research Council, and grateful thanks are due to him. We also acknowledge with gratitude the gift by CIBA Laboratories Ltd. of the SU 1906 used in this experiment.

Thanks are also due to the World Health Organisation, whose grant of a Fellowship enabled one of us (G.C.) to share in this work.

It is also a pleasure to acknowledge the help given by many friends and colleagues, and especially Dr. D. Cannon, Chief Pathologist Federal Government, and Dr. G. T. Barnes, Senior Pathologist Western Region, Nigeria, for expressing an opinion on progress as shown in histological sections; Dr. A. Kissaun and Dr. G. Moneta for the critical assessment of controls in relation to corresponding trial patients; Dr. G. T. Barnes and Mr. S. Drewett for photomicrographs; Mr. S. Drewett, laboratory Superintendent and his staff, especially Mr. G. O. Okezie, for a great deal of laboratory work and personal interest in the patients; and also Mr. L. Anyanwu and the patients themselves for their constant cheerful co-operation.

Thanks are also due to the Secretary for Health, Federation of Rhodesia and Nyasaland, for permitting Dr. Currie to associate his name with this paper; and to Dr. K. Seal, Leprosy Adviser, and to Dr. McLetchie, Director of Medical Services, Ministry of Health, E. Region, Nigeria, for permission to publish.

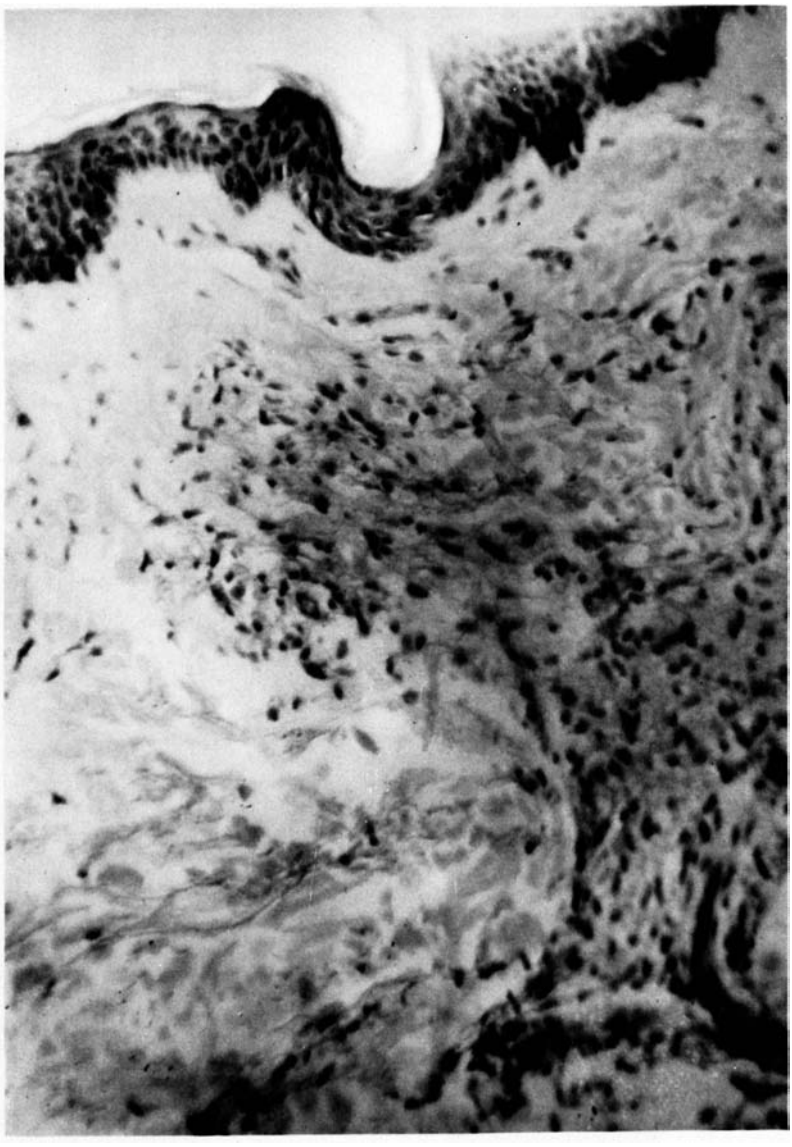


Fig. 1

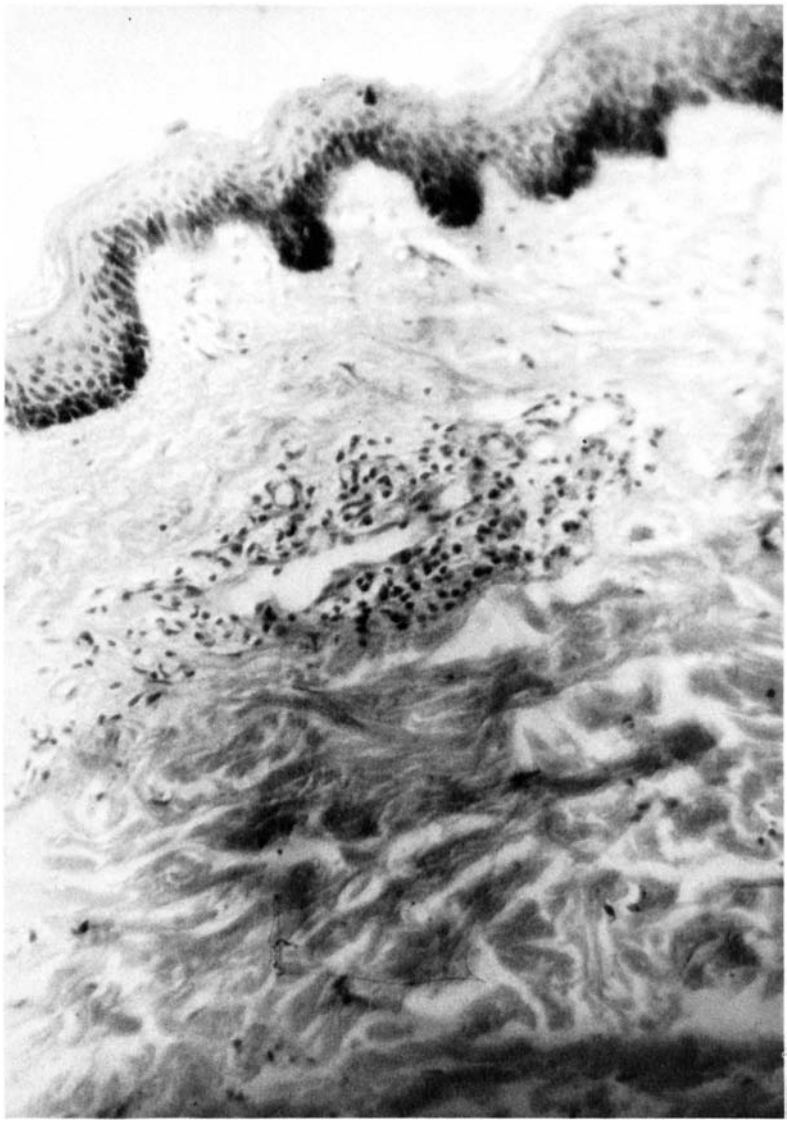


FIG. 2

Fig. 3

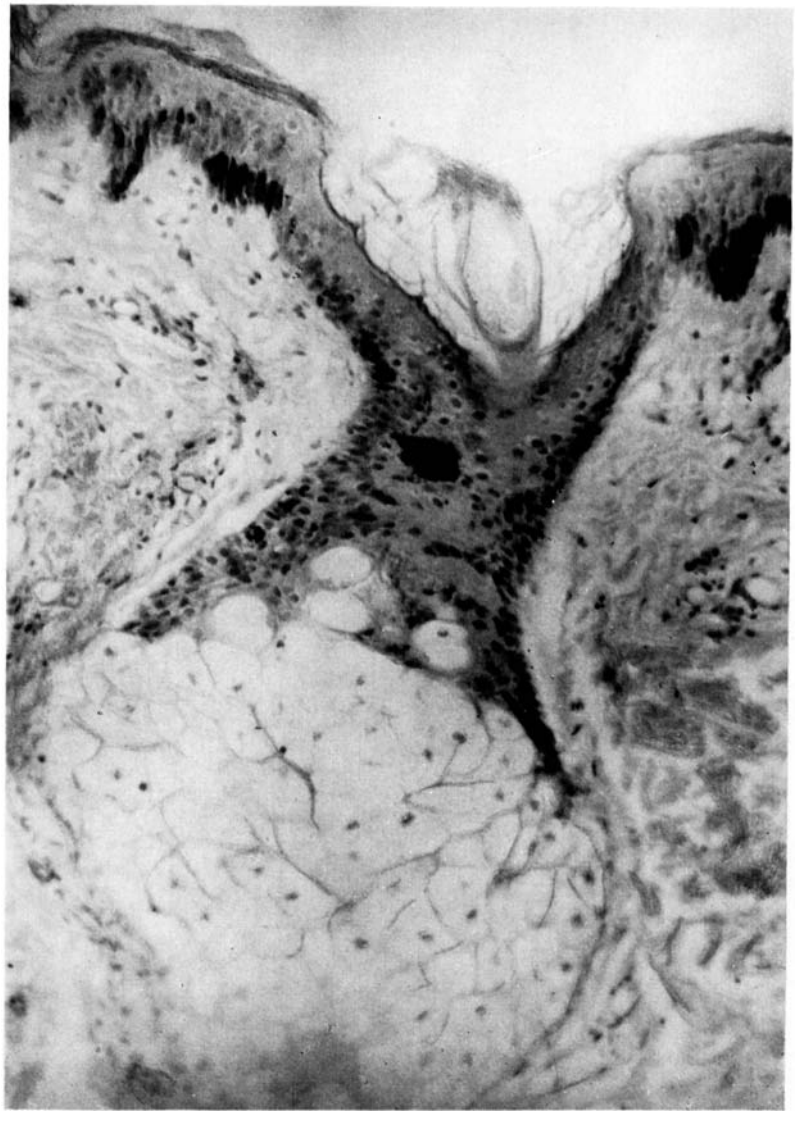


FIG. 4