Africans without the sickle-cell trait, whereas in a comparable group of 15 Africans with the trait only 2 developed parasites.

It is concluded that the abnormal erythrocytes of individuals with the sickle-cell trait are less easily parasitized by *P. falciparum* than are normal erythrocytes. Hence those who are heterozygous for the sickle-cell gene will have a selective advantage in regions where malaria is hyperendemic. This fact may explain why the sickle-cell gene remains common in these areas in spite of the elimination of genes in patients dying of sickle-cell anaemia. The implications of these observations in other branches of haematology are discussed.

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In 1950 a mass-miniature-radiography survey was undertaken in Los Angeles County, California. The population concerned numbered over three million, and more than half —1,736,703—responded and were *x*-rayed satisfactorily. This was the largest survey undertaken up to that date in the United States. Abnormalities were found in 67,966 individuals, of whom ultimately 2,404 were classified as tuberculosis suspects. 1,857 previously unknown cases of active tuberculosis were discovered—a rate of 1.08 per 1,000. Among 10,899 cardiovascular suspects the diagnosis of heart disease was confirmed in 3,388, but of these only 697 were previously unknown : the discovery rate for cardiac cases was 0.4 per 1,000. Exactly 3,500 lung cancer suspects were registered. Ultimately neoplasms were confirmed in 329 cases, of which 246 or 0.14 per 1,000 were malignant. (*Los Angeles County-wide Chest X-ray Survey of 1950*, by G. J. Drolet. Published by the Tuberculosis Control Foundation, Los Angeles, 1953.)

THE VARIABILITY OF SICKLE-CELL RATES IN THE TRIBES OF KENYA AND THE SOUTHERN SUDAN

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We have recently completed a survey of the distribution of sickle cells in the blood of 44 tribes and subtribes in Kenya, and 26 in the southern provinces of the Sudan. The results are given in Tables I and II. In a certain number of tribes the ABO blood groups were also done, the results being given in Table III.

In the present communication we wish to stress that, while the sickling phenomenon is very widespread throughout Africa, south of the Sahara the most striking

TABLE I.—*Sickle-cell Trait (Kenya)*

Race	Tribe	Tribal Division	Location	No. Examined	Positive No.	Positive %
Bantu (North-East, Coastal)	Kikuyu	Fort Hall	Nairobi	67	1	2
" "	Teita	Dabida	Wesu	127	0	0
" "	Pare		Taveta	40	2	5
" "	Chagga		Kibo	75	0	0
" "	Taveta		Taveta	154	37	24
" "	Kamba		Machakos	134	2	1
" "	Nyika	Giriama	Malindi	150	16	11
" "	"	"	Ganda Kilifi Jaribuni	39	4	10
" "	"	Kauma				
" "	"	"				
" "	"	Chonyis	Kaloleni	90	23	26
" "	"	Jibanas	"	119	16	13
" "	"	Rabais	Rabai	48	5	10
" "	"	Ribe	Ribe	50	13	26
" "	"	Kambe	"	78	27	35
" "	"	Digos	Msambweni	50	11	22
" "	"	Durumas	"	68	7	10
" "	Pokomos	Ngatana	Garsen	102	27	27
" "	Boni		Bargoni	81	0	0
" "	Sanya		Witu	61	0	0
" "	"		Adu	68	8	12
Bantu (North Kavirondo)	Maragoli		Majengo	100	9	9
" "	Bunyori		Kimba	100	6	6
" "	Nyangori		Kapsengeri	44	2	5
" "	Kitosh		Bungoma	100	21	21
" "	Kakamega		Kakamegas	50	6	12
" "	"		"	46	0	0
" "	Marama		Buteri	100	10	10
" "	Wangas		Mumias	96	19	20
" "	Kisii (Bantu-Nilote?)		Kericho	100	3	3
Bantu (South-East, Coastal)	Makonda		Porto Amelia	100	40	40
" "	"		Vipinco	50	2	4
E. Hamites	Masai	Kaputei Lodokelani	Kajiado	100	0	0
" "	"	Purko Loita	Narok	82	0	0
" "	Galla		Garsen	30	0	0
" "	Kipsigis		Kericho	100	2	2
" "	Somalis	Adjuran		14	0	0
" "	"	Degodia		20	0	0
" "	"	Ogaden		16	0	0
" "	"	Gurren				
" "	Boran	Sakuya		6	0	0
Nilo-Hamites	Turkanas			50	0	0
Nilotes	Luo	S. Kavirondo		100	28	28
Mixed Arab–Negro	Bajuns	Lamu		45	1	2
" "	Swahili	Ganda		50	2	4
" "	"	Kakounyi		50	5	10
" "	Arabs	Malindi		61	1	2

TABLE II.—*Sickle-cell Trait (Southern Sudan)*

Race or Language Group	Tribe	Subtribe	Location	No. Examined	Positive	
					No.	%
Nilotic ..	Dinka	Bor	Malek	87	0	0
,, ..	,,	,,	Cattle Post	77	2	3
,, ..	,,	Duk	,, ,,	22	0	0
,, ..	,,	Melut	Melut ,,	20	0	0
,, ..	,,	Toich	Sobat	38	0	0
,, ..	Nuer	Adok Ler	Adok Ler	100	1	1
,, ..	,,					
,, ..	Shilluk	Tonga	Tonga	110	0	0
,, ..	,,	Malakal	Malakal	56	0	0
,, ? ..	Mandari	Terakeka	Terakeka	105	18	17
,, ? ..	,,	Tali Post	Tali Post	98	7	7
,, ..	Acholi	Torit	Torit	54	6	11
,, ? ..	Lango	,,	,,	30	1	3
,, ..	Anuak	Lafon	Lafon	96	8	8
,, ? ..	Madi	Opari	Opari	71	13	18
Nilo-Hamitic:						
Bari-speaking group	Bari	Bari (true)	Rejaf	100	7	7
	Fajelu	Fajelu	Lainya	100	9	9
	Kuku	Kuku	Yei	39	3	8
	Kakwa	Kakwa	,,	76	6	8
Bongo-Mittu-speaking group	Baka	Baka	,,	105	9	8
	Moro	Moro	Juba	71	2	3
	Mundu	Mundu	Yei	80	13	16
Lotuku-speaking group	Latuka	Latuka	Lambalua	72	0	0
	Dongotona	Dongotona	Isoke	70	0	0
	Lokoiya	Lokoiya	Liria	98	5	5
Didinga-speaking group	Longarim	Longarim	Wathit Forest	73	1	2
	Logia	Logia	,, ,,	38	0	0
Western Bantu?	Azande		Juba	28	3	11

TABLE III.—*ABO Blood Groups (Kenya)*

Tribe or Subtribe	No. Examined	Distribution Blood Groups (%)			
		A	B	O	AB
Taveta	56	30	22	44	4
Teita	27	41	7	45	7
Jibanas ..	72	22	28	47	3
Chonyis ..	55	22	5	73	—
Kambe ..	77	25	16	57	3
Giriama ..	100	22	26	50	2
Durumas ..	37	24	16	43	16
Kauma ..	27	8	36	56	—
Rabais ..	50	14	20	60	6
Ribe	50	10	10	78	2
Pokomo ..	42	29	26	38	7
Boni	50	6	50	34	10
Sanya (Witu) ..	61	64	2	34	0
,, (Adu) ..	65	23	31	37	9
Bajun	37	30	16	52	2
Swahili ..	98	10	46	35	8
Arabs	61	33	10	54	3

variations are found in its frequency and in that of the ABO blood groups; we also suggest reasons for this variability. Although the rates are based on relatively small samples, the differences noted are statistically highly significant.

We have previously suggested (Foy and Kondi, 1951; Foy, Kondi, and Alexandrides, 1951; Foy, Kondi, and Brass, 1951) that the sickling characteristic cannot be regarded as a peculiarity of the negro race, and that its ethnological significance may have been overrated. The studies reported in this paper seem to substantiate this view, but until further work has been done it is better not to draw any conclusions.

Our work in the Sudan confirmed what we had already found in Kenya and Portuguese East Africa (P.E.A.)—namely, that there are great variations in the percentage of sickling and ABO groups, not only among different tribes but also in subgroups within the same tribe, although such subgroups speak the same language, have the same cultural and social characteristics, and now intermarry freely (Foy and Kondi, 1951, 1952; Foy, Kondi, and Alexandrides, 1951; Foy, Kondi, and Brass, 1951; Foy, Kondi, and Hargreaves, 1952; Foy, Kondi, *et al.*, 1952). These variations may be conveniently classified as follows.

Variability in Sickling Rate

(*a*) Differences between groups of the same tribe, living in different areas, as exemplified by the Mandaris in the Southern Sudan. From Table II it will be seen that the Mandari of Terakeka have a sickle-cell rate of 17%, whilst the Mandari at Tali Post have a rate of only 7%, although both groups speak the same language, are said to be ethnically similar, and are surrounded by Dinkas, whose rate is less than 1%. Similarly, the Makonda in North P.E.A. have a rate of 40%, whilst a group of them who have migrated from P.E.A. for temporary work in Kenya have a rate of 4%. These Makonda all speak the same language, and have the same social and cultural background; both sexes have extensive geometrical tattoo marks on their faces and bodies, and all the women wear the hideous upper-lip plug. The Acholi of Uganda (Lehmann and Raper, 1949) have a sickling rate of 27%, while those of the Sudan have a rate of 11%. The Madi of Uganda have a rate of 3% (Lehmann and Raper, 1949), while those in the Sudan have 18%. The Wasanya of Witu have a rate of nil, those of Adu have 12%.

(*b*) Variations within subgroups of the same tribe living in closely contiguous areas, as among the Nyika, a Bantu-speaking people inhabiting the coastal regions of Kenya. The nine subgroups of this tribe that have been examined for sickling have shown variations from 10% to 35% (Table I), although they occupy locations that abut on each other, speak the same language, and have the same customs and environment. These variations among the Nyika seemed to us so striking that it was decided to take further samples to check the results. Every care was taken to ensure that only the parents and one member from each family were examined, as the examination of "family groups" might have added to the variability and thus have led to differences which were apparently significant but in fact not so. The results of the second survey agreed so closely with those of the first that the two sets of results were amalgamated in Table I.

(*c*) Variations between different tribes occupying the same area, as shown by the inhabitants of the triangle of country between Voi, Mombasa, and the Kilimanjaro foothills. In this region there reside several different Bantu-speaking tribes, the Kamba, Teita, Pare, and the Chagga, none of whom, as will be seen from Table I, have sickling rates above 5%. Yet in the centre of these groups of people are the Taveta, who have a rate of 24%. Another example is found in the Galla, Pokomo, and Boni. The two former occupy the right and left banks of the Tana River, the Boni the area adjacent to the Pokomo. The sickling rates for these three are nil, 27%, and nil respectively.

It may also be noticed that the Anuaks of the Sudan, at Lafon Hill, generally regarded as Nilotic and related through the Acholi to the Luo, have a rate of only 8%, indicating that their affinities with the Luo are not as close as generally supposed on a linguistic basis.

It occurred to us that since the sickling rate showed such great variability this might also obtain for the ABO blood groups. Samples were therefore taken in a number of tribes, particularly amongst the Nyika subtribes, and the results are given in Table III. From this it is evident that variability also exists in the frequencies of the ABO blood groups, notably among the Sanyas of Witu and Adu, as well as in the Nyika as a whole.

Causes of the Variability

The causes of this great variability within tribal groups is difficult to explain, and we suggest the following possibilities:

1. All the evidence available indicates that the genetical hypothesis explains the inheritance of sickling in the great majority of cases and that the incidence of sickle-cell anaemia is more likely to be correlated with high incidence of sickle-cell trait than with

any admixture of Caucasian blood as suggested by Lehmann and Raper (1949). We think, however, that the simple homozygous-heterozygous hypothesis may not take into consideration all the known facts, since it is not uncommon to find cases of sickle-cell anaemia, only one of whose parents have the trait, or only one the anaemia. It should, however, be remembered in this connexion that daily variations sometimes occur in the sickling of the same individual, especially in the trait condition, for reasons which at present are not clear. Further, we have noticed in our surveys that some individuals may have large numbers of sickle cells, whilst in others only one or two characteristic sickle cells can be found in the whole film. In view of this, it is possible that internal or external environment has some effect on the manifestation of the condition. However, since wide variations are found between tribes and subtribes occupying apparently similar external environments, this possibility appears to us to be rather unlikely, and, so far as we are aware, external environment has not been shown to effect the frequencies of ABO groups, yet similar variations occur, as with sickling.

2. Intermarriage of neighbouring tribes with different rates in certain areas might produce groups with rates intermediate between them. If this were an important factor, then one would expect it to operate in the subgroups of the same tribe living under similar conditions and related geographically and culturally. Thus, the Mandari of Tali Post, who might originally have had a high sickling rate, could have intermarried with the low rate Dinkas, yet similar Mandari of Terakeka, also surrounded by similar Dinkas, have a high rate. The Nyika subtribes living in the same location and in the closest proximity have very different sickling rates. For example, the contiguous Durumas and Digos have rates of 10% and 22% respectively, and, similarly, the rates for the Ribe and Jibanas are 26% and 13%.

It is also difficult to imagine how intermarriage could have caused differences as large as those found. For example, among the Makonda, where the rates in the two subgroups are 4% and 40%, the original racial strain with a high sickling rate must, on this hypothesis, have been diluted, in the low-rate group, to one-tenth by intermarriage, and have very little "Makonda" left in it.

In addition, if racial or tribal mixtures were the complete explanation of the variability, we would expect differences in the blood-group frequencies to be associated with the sickling rate, but this does not occur, as will be seen from Table III. For example, a low frequency of the B blood group is associated with a high sickling rate among the Chonyis and Ribe, but with a low rate of sickling among the Sanya of Witu.

3. If sickle-cell anaemia often causes death among Africans before the reproductive period, how is it that the trait condition is so common? Our own experience in Kenya is that mortality in the anaemic condition is high, especially in the age group of 0–10 years. This being so, there must be some counteracting factor which prevents reduction in the gene frequency. This maintenance of a high gene frequency may indicate: (1) spontaneous mutations; this would seem unlikely in view of the probable rarity of mutation compared with the rate of mutation necessary to replace the genes lost by death. (2) Heterosis, in relation to reproduction, the heterozygote being more fertile than the homozygote (Boyd, 1950). Although no direct evidence of this is available for the sickle-cell trait, it is perhaps worth while to note that the effect of deaths in young children—or *in utero*—on the gene frequency might not be as large as would be expected, since the African woman would then be able to bear another child at a shorter interval than normally, this being linked with the custom, almost universal in East and Central Africa, of long periods of lactation, during which coitus is prohibited. If hybrid vigour is a factor in the situation, it might be affected by environment, and this would introduce a further source of variation in the incidence of the trait rate. It seems improbable, however, that these considerations could apply to blood-group variations; and if we are searching for a common cause for the variability in the two characteristics (blood groups and sickling), then this suggestion must be ruled out.

4. Genetic drift may be a factor where small groups of people are virtually isolated genetically—that is, they marry almost entirely within their own small group. In such small groups purely chance factors operating over a long period may cause the gene frequency to change greatly. If the population of such a small group then increases, the changed gene frequency will remain fairly stable unless intermarriage or other factors are introduced to upset it. The discussion under intermarriage, above, indicates that inbreeding may have been the rule among the groups examined. Our knowledge of African conditions of living and the effects of famine, epidemics, etc., leads us to suppose that the present tribes and subtribes may have been very small in number at some period in the past. It seems reasonable, therefore, to suppose that conditions suitable for the action of genetic drift may have existed among these tribal groups, and that the variation thus introduced has not yet been equalized by widespread intermixture of tribes. Such genetic drift would affect the genes both for sickling and for blood groups, but each one independently, so that, while variability would follow in each case, there would be no association between the drift for sickling and that for blood groups. The situation that would develop would be precisely that found to exist in our surveys.

In short, it is evident that there are variations in the rate of sickling (*a*) among what are generally regarded as the major African races, such as the Eastern Hamites, with rates below 1%, and the Nilotics and Bantu, sometimes with high rates; (*b*) among individual tribes within the major African races—for example, among the Bantu group of East Africa, such as the Taveta, Kitosh, Pokomo, etc., which have high rates, and the Teita, Chagga, Pare, Boni, etc., who have almost no sickling; and (*c*) between subgroups of the same tribe as described above for the Nyika.

Ethnological Significance

In view of our findings, what can be said regarding the ethnological significance of sickle-cell trait in Africa—or, in fact, about the significance of the ABO blood groups?

It would appear from our results that rates taken from only one group of any particular tribe cannot be regarded as characteristic for the tribe as a whole, nor can the overall rates for a tribe represent the situation in a major African race.

If the hypothesis of genetic drift is applicable, then it follows that the present sickling rate in a tribe or subtribe may not bear much relationship to the frequency of the trait as originally introduced. Rates for individual tribes would therefore have little significance ethnologically. On the other hand, random drift is as likely to increase as to decrease the rates, and averages over a number of different tribes which originally had much the same sickling frequency would tend to approximate to that frequency. It is possible that widespread and detailed information on the sickle-cell distribution might give important ethnological information. Such detailed information is not at present available.

Nevertheless, we feel that some of the results presented here may be of ethnological significance. For example, the widely distributed Nilotes in Central Africa are divided according to sickling rates into two main groups—namely, the Dinka, Shilluk, and Nuer of the Sudan, with very low rates, and the Jaluo, Lango, Alur, and Acholi of Kenya and Uganda, with medium to high rates. We do not think that these differences can be ignored ethnologically, although the languages of the two groups have close affinities. It may be worth noting that the frequency of sickling in the Dinka, Nuer, and Shilluk resembles closely that of the Eastern Hamitic races, such as the Masai, Galla, Turkhanas, etc., as do their pastoral and dietetic habits. On the other hand, the Luo, Lango, and Alur have high sickling rates, and are a predominantly agricultural people, with dietetic habits that are unlike those of the Eastern Hamites.

Unless it has a selective value, the frequency of a gene, appearing by mutation in an isolated population, has a negligible probability of increasing. The sickle-cell gene may have been introduced into Africa from outside, perhaps from the East, either overland or by sea. The sea route seems to be the more likely, considering the high rate among the riverine Pokomos and the Makua and Makonda, and the very low rate among the Eastern Hamites, through whose forebears, if it came overland, the gene would have to pass; and it would have persisted among their present-day descendants. The high frequencies found in certain tribes indicate that the proportion of invaders carrying the gene to the invaded was high.

This relation between the invaders and the original population probably varied from place to place as communities became established; and the variation, together with the influence of genetic drift, could, we suggest, account for the widely different incidences that we have found from tribe to tribe. These differences would persist only if relative isolation continued, and it is generally believed that intermariage is now common and probably always occurred to some extent.

With these facts in mind, it is of interest to note the suggestion of Lehmann (1953) that the sickle-cell condition may have been introduced in Africa and the Mediterranean region by migrating Veddic peoples.

Intermarriage would tend to reduce the variability caused by genetic drift: although variations in A and B frequencies were also found they did not present the sharp contrasts in contiguous areas shown by the sickling trait, and this may suggest that the A and B genes were introduced earlier than the sickling one. The spread of the B gene in Western Europe has been described by Candela (1942), and similar postulates may apply to the diffusion of the sickle-cell trait in Africa.

Conclusion

At present there is little to suggest that the possession of the sickling gene has any selective value, and the A and B blood groups which show similar though unrelated variations to those of the sickling frequency are also believed to have no survival value, although it has recently been shown (Aird *et al.*, 1953) that some correlation exists between carcinoma of the stomach and the A blood group, and between acquired haemolytic anaemia and group O (Hunt and Lucia, 1953). It is not impossible that sickling may be related to hookworm or malaria or other tropical condition, but so far as our studies have gone we have not been able to show any such relationship. Until some such factor is demonstrated it would seem to us that genetic drift is the most probable explanation of the variations in both sickling and the ABO blood groups in Africans.

Summary

The incidence of sickle-cell trait and the distribution of the ABO blood groups in certain tribes in East and Central Africa are reported.

Considerable variation was found in different tribes and even between subgroups of the same tribe, indicating that surveys done on large heterogeneous groups of Africans are unlikely to give useful information.

Possible explanations for this are considered, and genetic drift is suggested as the most likely.

The question of the introduction, maintenance, and spread of the sickling gene in Africans is discussed.

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ACUTE RESPIRATORY INFECTIONS IN EMPHYSEMA

AN ACCOUNT OF 118 CASES

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The advances in the physiological and pathological understanding of emphysema have not been paralleled by equal success in its clinical management. There may be three reasons for this. First, chronic bronchitis, without doubt the most important single factor in the production of emphysema, is, because of its ubiquity and apparent benignity, regarded as a tolerable evil; secondly, as a result of this the patients are unlikely to consult the physician in the early stages; and, thirdly, as it is a disease which would seem to be both irreversible and progressive, treatment is unrewarding. Because of these considerations the emphysematous patient in a general hospital is usually seen for the first time when suffering from incapacitating dyspnoea, congestive cardiac failure, or an acute respiratory infection. The latter, responsible for about 4% of the total admissions to my wards, may cause sudden and serious illness which is eminently treatable. This paper is concerned mainly with this aspect of emphysema. Similar cases have been studied at necropsy by Spain and Handler (1946) and Scott and Garvin (1941). Fulton (1953) emphasizes that chronic pulmonary disease is an important cause of mortality and morbidity in middle-aged men in the industrial area of Manchester. The diagnosis and treatment of acute respiratory infection in emphysema have been discussed by Cardon *et al.* (1951).

Material

Between March, 1947, and May, 1952, 118 patients with long-standing bronchitis and emphysema have been under my care because of acute respiratory illness. In all but one, progressive dyspnoea was a prominent feature. This one patient, a man aged 63, said that he was not short of breath as a rule, but physical examination, response to oxygen therapy, and respiratory function tests all indicated emphysema.

Of the 118 patients (100 men, 18 women), 48 died—41 as in-patients and 7 within one year of leaving hospital. The remainder were alive and well in the summer of 1952.*

Age Groups.—The ages of the patients were 30–39 years, 3; 40–49, 12; 50–59, 39; 60–69, 49; 70–79, 15.

Previous Medical History

A history of bronchitis of more than 10 years' duration was given by 100 of the 118 patients. There can be no doubt, therefore, of its importance in the evolution of emphysema.

Most patients said that their bronchitis began insidiously in the past and guessed at its duration. Some were more definite and chose as landmarks either the first world war or a previous attack of pneumonia. Sixteen males fixing upon the first world war attributed their bronchitis to gassing, yet only one had been admitted to hospital because of it. Their memory was probably playing them false. The same criticism might be applied to those who dated their bronchitis from a long-distant pneumonia. There were, however, others whose pneumonic illness was more recent, but here again caution must be exercised in relying on the patient's memory, as is illustrated by the following case of

*Since this article was submitted for publication a survey made in December, 1953, reveals that 75 patients are now dead, 25 are alive and well, and 18 have not been traced.