OBSERVATIONS ON ENDEMIC GOITRE IN THE CHITRAL AND GILGIT VALLEYS

BY

R. McCARRISON, M.B., CAPTAIN I.M.S.

AGENCY SURGEON, GILGIT, KASHMIR

(COMMUNICATED BY JAMES BERRY)

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HAVING been stationed for the past three years in two districts of Northern India in both of which endemic goitre is extremely common, I have had the opportunity of making the following observations, which I trust may be of use in helping to elucidate the obscure and difficult problem of the causation of this disease.

In recording these observations the two districts of Chitral and Gilgit will be dealt with separately.

(*A*) OBSERVATIONS IN THE CHITRAL VALLEY.

Introductory—Country, Climate, People.

Chitral lies between the parallels of latitude 35° and 37° and meridians of longitude 71° and 74°. The valley through which the Chitral River—of glacial origin—flows is narrow, being not more than one mile broad at any part. It is

bounded on either side by high hills, ranging between 10,000 and 15,000 feet. It runs due north and south. The ranges bounding the valley are intersected at intervals by narrow nullahs, or valleys, each with its mountain stream, derived from the melting of the snows above. At the mouths of these nullahs alluvial fans stretch with a gentle slope towards the river. These alluvial formations, composed as they are of a porous soil, are the only habitable portions of this mountainous country; on them we find villages and a considerable amount of cultivation.

The climate is a temperate one, never excessively hot nor excessively cold. Snow covers the ground during the winter months, usually up to the end of February. The rainfall is small.

The hills in the northern part of the valley are poorly wooded. Fuel is scarce. During the winter months the people live crowded together in small stone-built huts, of which the only ventilation is a hole in the roof. The average cubic space per individual is 200–250 cubic feet. The people are, for the most part, poor. Food is plentiful, comparatively speaking, from July to February, after which the people are obliged to live on the poorest grains, dried fruits, and the green stuffs of the spring. Their food is entirely vegetable. Flesh meat is an article of diet far beyond their means, while salt is a luxury to all except the richest families.

There are certain local beliefs as to the causation of the enlargement of the neck which are not without interest. The people say that their necks increase in size when food is scarce—that is, in the spring months after February; others that the increase takes place in the mulberry season (May, June, July), or when the water turns grey from the presence of fine sediment, or when the snows begin to melt (May, June, July). All local authorities agree as to an observed increase in May, June, and July. Curiously enough, it is only in certain villages that water is believed to cause the disease. The water of the village of Awi (see map), has a goitre-producing reputation, while it is

affirmed that Sanoghar water does not cause the disease. There is a belief in the district that goitre is not so common as it was.

(1) *Prevalence of Goitre.*

Goitre occurs all over the district; no village appears to be entirely free from it. It is, however, most prevalent in certain situations. Four villages are notoriously goitrous, namely Sanoghar, Miragram, Awi, and Morai; their situations are shown on the sketch-map. The percentage of the population suffering from the disease in these villages will be found in Table I. The figures for certain other less goitrous villages are given for the purpose of comparison.

(2) *Water Supply.*

The water supply is in all cases derived from the melting of the snows on the hills above. It comes from the nullah at the mouth of which the village stands, and is the only supply of that village. As a rule the water from the melting snows runs down the nullah as a turbulent mountain stream, taking up what matter it may on its way either in solution or suspension; in other cases it percolates into the soil and appears lower down in the form of a spring, as in the case of Awi. In the summer months the water is invariably grey from the presence of fine sediment. There are no real glaciers in the district under observation; the water is snow water rather than glacier water.

There are no wells in the villages, and, owing to the slope of the ground and the nature of the soil, water does not and cannot stagnate.

The sketch-map indicates the source of supply of the different villages mentioned in Table I. For an analysis of these waters see also Table I.

(3) *Rocks associated with Water Supplies.*

The rocks of the district are everywhere metamorphic; Gneiss and slate form the large proportion of them. Lime-

stone is less common. There are, however, in certain situations large tracts of limestone and sandstone (see diagrammatic sketch-map showing observed outcrop of these formations). Roughly speaking, it may be said that from Chitral to Baranas on the left bank of the river the prevailing rocks are schists and slates. From Baranas to Mastuj the prevailing rocks are limestones and sandstones. If the sketch-map is compared with the figures in Table I, it will be observed that the limestone areas correspond in a very striking manner with the notoriously goitrous villages. The hills behind the village of Morai are largely composed of limestone, and a reference to the table of analysis will show that the water is very markedly affected thereby. It is interesting to note that Morai occupies a more or less isolated position in respect of its goitre-producing powers, the villages on either side of it not being markedly goitrous.

The diagrammatic sketch-map showing the distribution of limestone in Chitral is taken from the 'Geological Magazine,' decade iv, vol. ix, "Fossils from the Hindu-Khoosh," by General MacMahon, F.R.S., F.G.S.

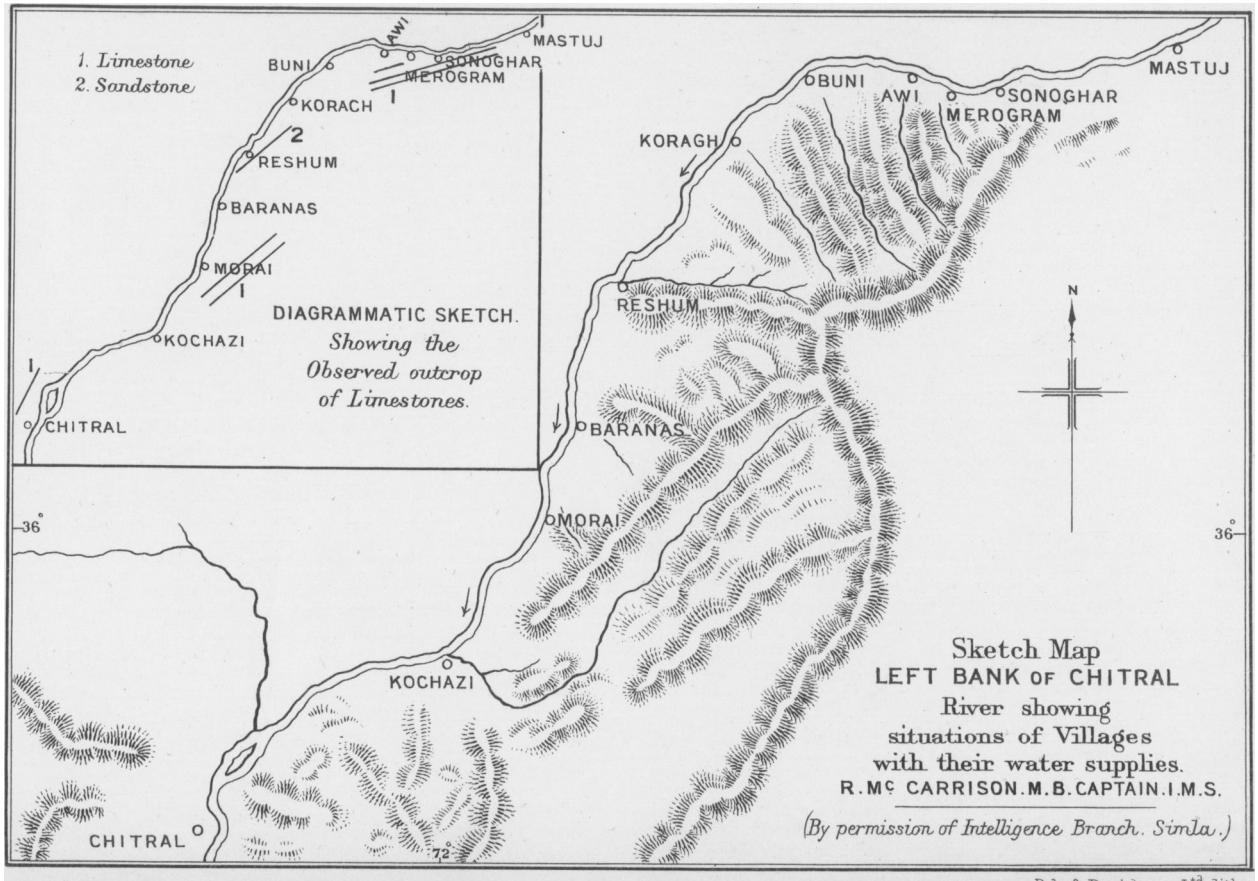
Notes on Table I.

(1) The waters were taken at different seasons of the year. The results are the averages of several analyses.

(2) All the waters were examined at the same time.

(3) The amount of fine sediment varies with the season of the year. In winter the water is perfectly clear. In summer it is grey from the presence of very fine inorganic sediment.

(4) The water of Awi comes from a spring from among limestone rocks; it contains so much lime in solution and suspension that the branches of shrubs which the water touches are coated with lime half an inch thick. The microscopical examination of the sediment of this water shows it to be composed chiefly of inorganic matter in a very fine state of division, with vegetable *débris*. The



Bale & Danielsson, Ltd. lith.

TABLE I.—*Endemic Goitre in the Chitral Valley.*

Village.	Height in feet.	Population.	Percentage goitrous.	Cretins.	Source of H_2O and associated rocks.	Qualitative analysis, grains to gallon.							Remarks.
						Total solids.	Total hardness.	Calcium.	Magnesium.	Iron.	Sulphates.	Chlorides.	
Sanoghar	7650	629	41·8	None seen	Snow water from nullah, limestone, gneiss	8·54	5·2	3·6	Present	Trace	3	*Nil*	Iron can be detected in very concentrated solution only.
Miragram	7350	275	56·5	One seen, two reported	Snow water from nullah, limestone, gneiss	5·68	3·5	3	Trace	Trace	3	Trace	Iron can be detected in very concentrated solution only.
Awi	7000	426	47	4	Spring from among limestone rocks	115·75	35·05	16 and over	Present marked	Trace	3 and over	*Nil*	Iron can be detected in very concentrated solution only; much inorganic matter in suspension.
Morai	5753	196	58	3	Snow water from nullah limestone	45·5	15·75	10	Present	Trace	3 or over	*Nil*	Iron in concentrated solution only; considerable suspended matter and vegetable *débris*.
Reshan	6480	870	10	–	Snow water, red sandstone mainly, and gneiss	11·375	9·1	3-6	Not found	Trace	3	*Nil*	Village stands on red sandstone; large amount of suspended matter in H_2O.; iron in concentrated solution.
Buni	6860	1100	15	None seen	Snow water, gneiss, and some limestone	15·4	7·5	3·6	Trace	Not found	3	*Nil*	Considerable amount of suspended matter in H_2O.; inorganic and vegetable.

diatoms eucyonema and navicula are present in considerable numbers.

(5) Iron is found only when the water is evaporated to dryness and the residue re-dissolved in a small quantity of distilled water. It is present in very small amount, and is found equally in practically all the villages given in the table.

(6) The figures are based on those given by Notter and Firth ('Theory and Practice of Hygiene,' 2nd edition, p. 60), and are, of course, only approximately correct.

(4) *Conclusions from the Analysis of notoriously goitrous Waters.*

If the table of analyses is referred to, it will be observed that no definite relationship can be traced between the amount of goitre present in any one village and the amount of any single dissolved ingredient in its water supply. The amount of total solids also and the total hardness of the water seem to bear no relationship whatever to the amount of goitre in the village.

Iron is present in such small quantities that it can hardly be said to have anything to do with the production of the disease.

Nor can any relationship be established between the total amount of matter in suspension in these waters and the amount of goitre present. Awi, for example, contains by far the largest amount of inorganic matter in suspension, yet it is not the most goitrous village in the district. This remark does not, however, apply to suspended matter of any one particular variety, for it is possibly quality, not quantity, which is important.

Also in the Chitral Valley I am unable to bring forward any observation dealing with the amount of organic matter, living or dead, to be found in these waters.

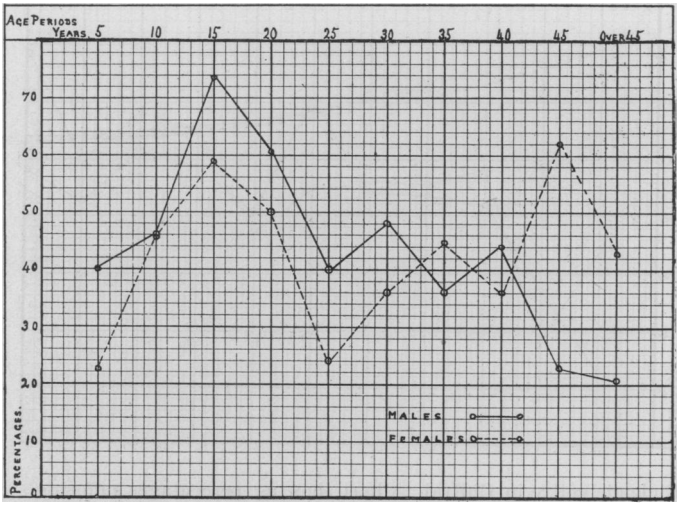
It is interesting to note that in the waters of Awi and Morai, the only two examined microscopically, the diatoms eucyonema and navicula were present in large numbers,

which fact supports the observations of Bircher on this subject.[1]

(5) *Age Incidence of Goitre.*

Two charts are appended to illustrate this observation (Charts I and II). From these it will be seen that goitre is very common in children of all ages. The swelling in children is, as a rule, slight but evident. Children at the breast are not free from the disease, as will be seen from

CHART I.



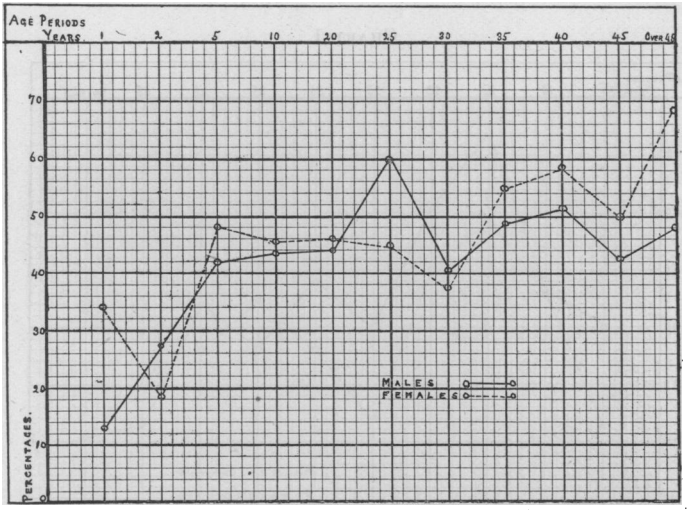
Endemic goitre in Chitral. Chart showing percentages suffering at different age periods in village of Sanoghar. Total population examined, 646; children under 15, 277; adults, 369.

the chart of Awi (Chart II); children are suckled for two years in Chitral. Twenty-three per cent. of children under one year of age who are still being suckled suffer from this disease in the village of Awi. In Miragram the percentage figure is even higher than this, reaching 61·5. In Miragram, of five female children under twelve months, four have thyroids larger than normal, while of eight male children

[1] 'The Thyroid Gland,' Berry, 1901, p. 66.

four have the gland enlarged. The mothers have in all cases been the subjects of the disease, and frequently the fathers also. What proportion of these cases is congenital, what acquired, it is difficult to determine. The fact of the high percentage of children suffering from the disease in these villages is one of great interest, and will be referred to later when these charts are compared with a similar chart for Gilgit.

CHART II.



Endemic goitre in Chitral. Chart showing percentages suffering at different age periods in village of Awi. There are no children in village, either male or female, between the ages 10 and 15 years. Total population examined, 426; children under 15, 269; adults, 157.

Other points of interest will be observed in these charts. In Sanoghar, for example, the marked rise in both males and females at the age of fifteen may bear some relation to sexual activity.

(6) *Length of Residence necessary in which to acquire the Disease.*

Seventeen individuals (two Europeans and fifteen Hin-

dustanis) resided in Sanoghar for four months; of these three, or 18 per cent., showed an increase in the size of the thyroid gland. In one case the swelling was a unilateral one about the size of a walnut. Although the fact that the swelling was a unilateral one (right-sided) detracts from the value, from an etiological point of view, of the case, still, it is worth recording. The swelling made its appearance after one month's residence in the village; the sufferer was then put on filtered water for two months, but no diminution in size having taken place, he, of his own accord, took only boiled water for the remaining month. He was certain the swelling had not increased in size, but was equally so that it had not diminished.

In the other two cases, who drank the ordinary water of the village during the whole period of their residence in Sanoghar, the gland was uniformly enlarged. The swelling was just sufficient to cause discomfort in wearing shirts, the necks of which had previously fitted well.

These men were all natives of the plains of India, who did not come from a goitrous area. They were strong, young, healthy individuals, non-commissioned officers engaged in the instruction of local levies. They lived in tents during the four months, and were not intimately associated in their daily life—sleeping, eating, etc.—with the natives of the country, a fact which points strongly to the water of Sanoghar as the vehicle of infection.[1]

In this connection also it is interesting to note that 32 per cent. of male children under one year of age of the villages of Sanoghar, Awi, and Miragram, taken together, have enlarged thyroids. These may, of course, be all congenital, but it is reasonable to suppose that some are acquired.

[1] Since this paper was written I have been informed by my friend Capt. O'Grady that during this summer (1905) two out of his ten "instructors" (young natives from the plains of India) have developed goitre after a residence of two and a half months at Sanoghar. The goitres disappeared after treatment with thyroid tabloids.

(7) *Variations in Size of a Goitre caused by leaving the District in which it was acquired.*

Symmetrical goitres diminish in size, except in old cases—that is to say, in cases of individuals past the prime of life—when the sufferer leaves the area where the disease was acquired. They again increase in size on his return to that area. This rule would appear to apply, speaking generally, even when the sufferer goes to another goitrous district and before he has had time to come under the new influence for any length of time. Of twenty young men all having enlarged thyroids who came from a different valley, also goitrous, to reside at Sanoghar, sixteen were found to have the thyroid gland diminished in size after a residence of two months, as determined by measurements, while four had the gland increased in size. Though the method of examination by measurement is subject to many errors of technique, still, the results are, I think, worth recording.

The natives of all the districts where I have made observations on goitre are well aware of this fact regarding the diminution in size of a symmetrical goitre which takes place when the sufferer leaves the area where the disease was acquired; it was first brought to my notice in the Kangra Valley (Punjab).

(8) *Experiments bearing on the Influence of boiling and filtering Waters supposed to be capable of causing the Disease (carried out in the Autumn and Winter of* 1903–1904).

(1) In the village of Awi two dogs were tied up in a house in which all the inhabitants were sufferers from the disease. The two dogs were fed alike—that is, on bread made from the flour of the country. To one boiled water was given, to the other the ordinary water of the Awi spring. The dogs were selected for me and tied up by my assistant

Khan Sahib Pir Bakhsh, in charge of the Mastuj Dispensary, on whose judgment I can rely. After fourteen days I visited Awi. The dog which was drinking only boiled water was unaffected and remained so for two months, when the experiment ceased. The other dog, drinking the water of the Awi spring, had a swelling of the thyroid as large as a new-born baby's fist. It was a uniform swelling. The gland diminished in size when I brought the dog for observation to Drosh. This experiment was carried out in the months of August and September, 1903, when the water was still turbid.

(2) This experiment was repeated in the same house on two other dogs, but with negative results. The duration of the experiment was again two months.

(3) A like experiment was carried out in the villages of Sanoghar, Miragram, and Maroi and continued for two months, but with negative results in all three cases.

(4) I have referred to the cases of the Hindustanis who developed goitre after having resided in Sanoghar for four months. In one of these, who developed a unilateral swelling of the gland, filtered water only was used for two months and afterwards boiled water for one month. The swelling did not increase in size neither did it diminish.

There is nothing in the results of these experiments which affords much help in determining the influence of boiling the water supposed to cause goitre. The first experiment suggests that boiling is beneficial, but it is just possible that it may not have been through the medium of water that the disease was acquired. The number of dogs experimented on also is too small to allow any conclusions to be drawn from the result of the experiments. In the case of the man it is regrettable that the swelling, being unilateral, was not of such a nature as to afford much help.

Conclusions from the foregoing Observations.

(1) It would seem that water is the chief vehicle by means of which this disease is conveyed.

(2) There is no evidence to prove that goitre is caused by any of the following dissolved ingredients in the water: total solids, total hardness, magnesium, lime, iron.

(3) The disease can, by susceptible individuals, be rapidly acquired in a highly goitrous locality.

(4) There is a marked association of this disease with limestone rocks.

(*B*) Observations in Gilgit and Nagar.

Gilgit lies between the parallels of latitude 35° and 37° and meridians of longitude 74° and 75°. It is only, however, with Gilgit proper, the capital of the district, and not with the whole of this district, that these observations deal. Gilgit is situated on an alluvial fan on the right bank of the Gilgit River—a tributary of the Indus. This fan is roughly ten square miles in extent and has a gentle slope from its apex, in the nullah from which it derives its water supply, to the river. On this extensive fan eight villages are situated; collectively these are known as Gilgit. The remarks which I have made as to the climate and people of Chitral apply equally to Gilgit. The valley runs east and west. The height of the fan above sea level is 5105 feet.

(1) *Water Supply.*

Appended is a rough diagrammatic sketch which shows clearly the water supply of the different villages of the Gilgit fan.

The water comes from a single source and is conveyed to the different villages in open kūls, or channels. From the diagram it will be observed that there are two main channels, an upper (2) and a lower (1). The upper channel has no villages on its banks till it joins the lower kūl, at the village of Majinpharri, marked (3). All these seven villages are situated on the banks of this lower Kūl, or are supplied by lesser channels branching from it. Each village in this way receives the drainings of the village or

McCarrison: Endemic Goitre in Chitral and Gilgit. Plate II.

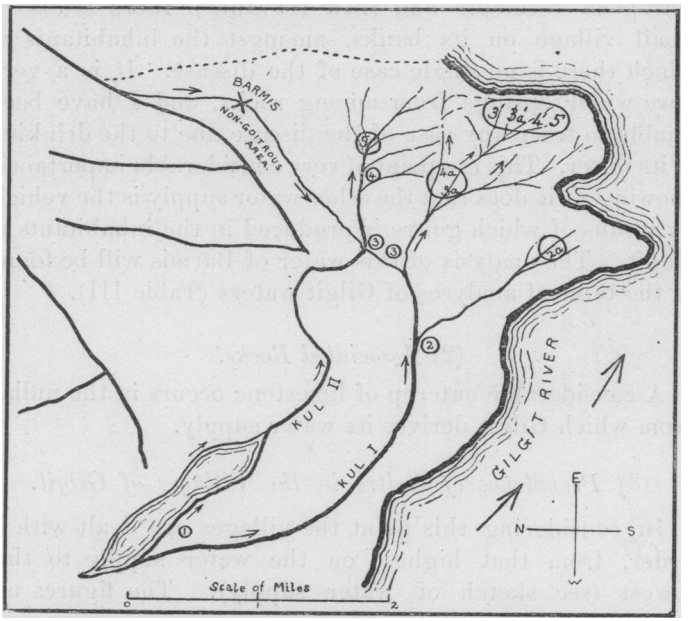
Lent by Mr. John Murray.

From Col. Durand's "Making of a Frontier," 1900.

GILGIT VALLEY: WESTERN END.

villages above it, till at the last village, Kashrote, the drinking water has been polluted by the six villages above.

The water in these open channels not only supplies the inhabitants with drinking water, but it irrigates their extensive crops, serves as an open sewer, is used for the cleansing of their bodies, household utensils, and wearing



Diagrammatic sketch of Gilgit water supply. 1, Basin; 2, Umphris; 2*a*, Damyal; 3, Maginpharri; 4 and 5, Kyk; 3*a*, 4*a*, Sonyar; 3′, 3*a*′, 4′, 5′, Kashrote.

apparel. It can readily be imagined, therefore, that considerable organic impurities find their way down to the lower villages; yet, being fed as these channels are by a purer supply, little organic impurity can be detected by qualitative tests.

The water is, during the winter months, at its source clear and sparkling, but at the village of Kashrote (see diagrammatic sketch of water supply and plate of "Gilgit Valley: Western End") invariably grey from the presence of fine sediment and impurities derived from the villages

and lands irrigated by it. During the summer months when the snows are melting it is, of course, much worse.

If the sketch of the Gilgit water supply is referred to, it will be observed that a spring (the Barmis spring) joins the supply already described at (3), Majinpharri. This spring does not produce goitre; it is the supply of all the European residents and their servants; there is also a small village on its banks, amongst the inhabitants of which there is no single case of the disease. It is a very pure water, springs from among rocks, and I have been unable to trace any case of the disease due to the drinking of its water. This is a point of very considerable importance, showing as it does that the other water supply is the vehicle by means of which goitre is produced in the inhabitants of Gilgit. The analysis of this water of Barmis will be found in the table of analyses of Gilgit waters (Table III).

(2) *Associated Rocks.*

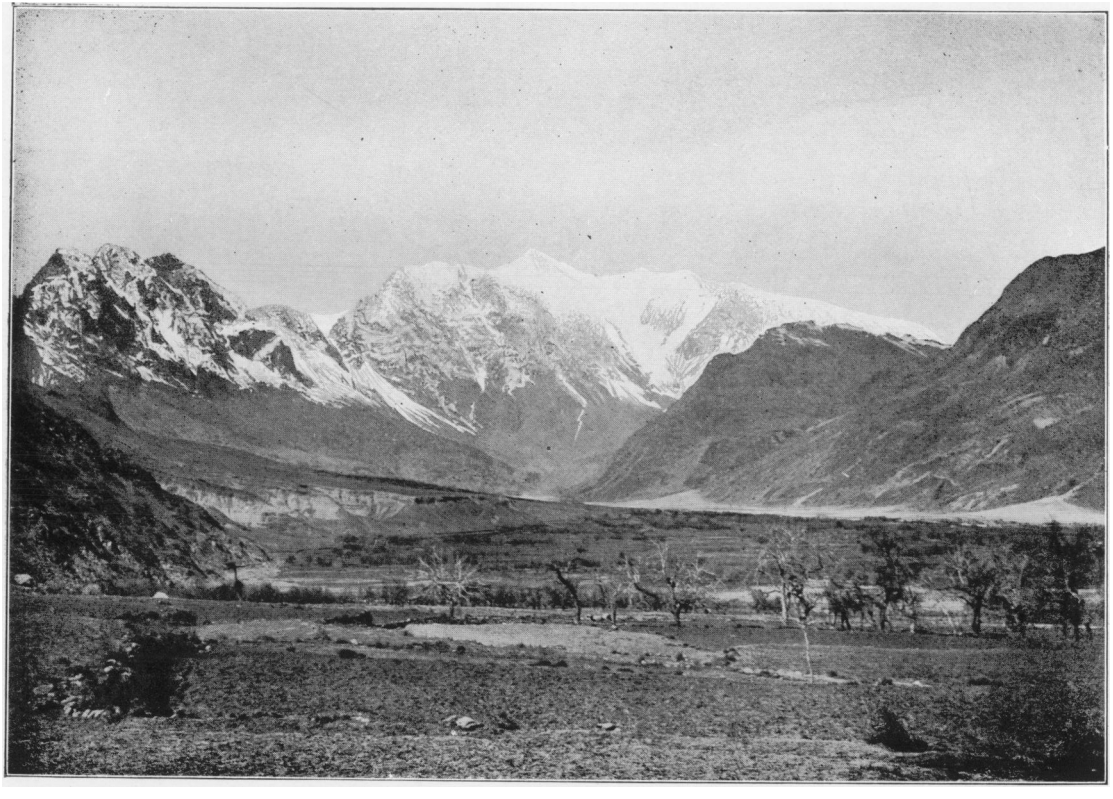
A considerable outcrop of limestone occurs in the nullah from which Gilgit derives its water supply.

(3) *Prevalence of Goitre in the Villages of Gilgit.*

In considering this point the villages are dealt with in order, from that highest on the water supply to that lowest (see sketch of water supply). The figures are given in the following table:

TABLE II.

Village.	Population.	Houses.	Infected houses.	Per cent. of infected houses.	Per cent. of persons infected in infected houses.	Per cent. of total population goitrous.
(1) Basin . .	93	15	9	60	21·2	11·8
(2) Umpharis .	385	66	42	63·6	28·3	20
(3) Damyal .	181	30	20	66·6	30·3	18·8
(4) Majunpharri	718	108	68	63·2	24·2	20
(5, 6) Kyk .	229	33	23	71·5	30	26·9
(7) Sonyar .	458	63	52	82·5	30	24·5
(8) Kashrote .	128	24	21	87	36	45·6



Lent by Mr. John Murray.] [*From Col. Durand's "Making of a Frontier,"* 1900.

THE GILGIT VALLEY FROM THE EAST.

From this table it is seen that:

(1) The percentage of infected houses goes on steadily increasing from Basin to Kashrote.

(2) The percentage of infected individuals in these infected houses also shows a steady increase towards Kashrote.

(3) The percentage of the total population suffering from the disease shows also a steady increase towards Kashrote.

(4) Although the increase in the percentage of infected houses and of infected individuals in these houses is a steady one, this increase is not observed between Umphiris and Maginpharri. This may be accounted for by the facts that at Maginpharri (see sketch of water supply) the main supply is joined by the purer supply from kūl 2, which has no village on its banks, and is, therefore, freer from pollution than kūl 1, and, perhaps, also to the fact that it is here also that the Barmis spring—a water which is known not to produce goitre—joins the main channel. The volume of water from the Barmis spring is not great, but it may possibly have a slight influence in diluting the more or less polluted waters of the main channel.

(5) It will be observed that at Damyal and Sonyar a slight fall occurs in the percentage of the total population suffering from goitre as compared with the village above. This is due to the fact that these two villages are an exception to the general rule that females suffer more than males, a rule which holds good for the other six villages under observation. The percentage of adult males suffering from goitre in Damyal is 30·5, while of females it is only 21. In Sonyar the percentage of males suffering is 43·5, while of females it is 29.

Although this steady increase in the percentage cases of goitre is observed to occur, the increase is confined entirely to individuals over the age of fifteen years. It is not observed in children, so much so that were children under fifteen years removed from the calculation, the increase would appear more regular and striking. This is a point of very considerable interest and possibly importance.

It appears to me also noteworthy that although 45·6 per cent. of the total population in Kashrote are sufferers from the disease, 13 per cent. of the houses in the village should be entirely free from it, when it is remembered that it is by means of the water that the disease is conveyed. One would almost expect to find that there would be at least one individual in every house a sufferer, were the disease caused by such means as dissolved ingredients, or even by such mechanical means as inorganic matter in suspension.

TABLE III.—*Analyses of Gilgit Waters.*

	Total solids, parts per 100,000.	Total hardness, grs. to gal.	Calcium, grs. to gal.	Magnes., grs. to gal.	Iron, grs. to gal.	Sulphates, grs. to gal.	Chlorides, grs. to gal.	Free, NH^3.	Organic matter.	Other metals, lead, copper, zinc.
Gilgit supply	30 21 grs. to gal.	7·143	6	Trace	Trace	3	*Nil*	*Nil*	See Note 2	*Nil*
Barmis supply	19 13·3 grs. to gal.	9	8–10	Trace	Trace	3 or over	*Nil*	*Nil*	*Nil*	*Nil*

Notes on Table of Analyses.

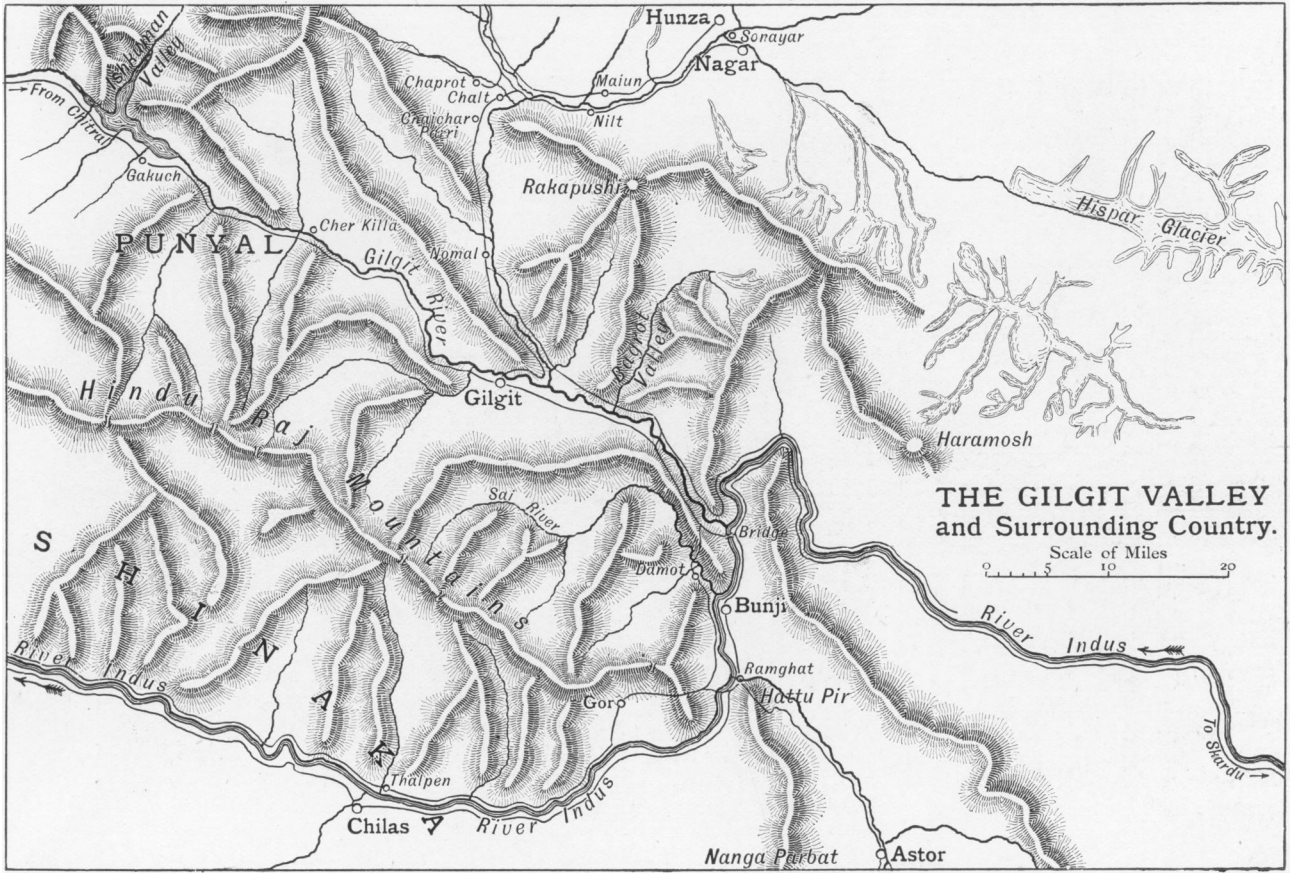
(1) Iron is found only in concentrated solution.

(2) In the water of Kashrote a faint coloration is observed with Nessler's reagent, but organic matter cannot be detected by the gold or silver tests, a fact to be explained, I think, by the continual replacing of the water by a purer supply from above.

(3) As no difference could be observed in any of the waters of the eight villages of Gilgit, it was thought unnecessary to note separately the analysis of the waters of each village.

The analysis of the Barmis spring is given for the purpose of comparison.

McCarrison: Endemic Goitre in Chitral and Gilgit. Plate IV.



Lent by Mr. John Murray.]

[*From Col. Durand's "Making of a Frontier," 1900.*

(5) *Microscopical Examination of Gilgit Waters.*

By the naked eye one difference between the water of Basin and the same water when it reaches Kashrote is at once noticeable; this is the large amount of suspended matter in the waters lower down the channels as compared with those higher up. The water was examined at different points—

(*a*) At its source (Basin). The water is clear; on standing for twenty-four hours a few flocculi are seen at the bottom of the vessel in which the water is contained. Examination of deposit under a magnification of 600 diameters after decanting shows:

(1) Small amount of mineral matter, sand or clay particles.

(2) Small amount of amorphous matter.

(3) Small amount of vegetable *débris*.

(4) Minute motile organisms, not to be differentiated by the power used.

(5) The flocculi consist of masses of diatoms joined together by some material, the nature of which is not evident; attached to the mass of diatoms are particles of sand and vegetable *débris*. By far the greater proportion of these diatoms are eucyonema. The following were also identified, though in small numbers: Navicula viridis, amphora, cymbella, cocconema, Navicula gracilis, Navicula rhyncocephera, gamphonema, fragilaria, epithemia, pleurosigma. Of these naviculæ are most common after eucyonema. Broadly speaking, therefore, the chief characteristic of the water is the presence of large numbers of diatoms having a boat-shaped or spindle-shaped outline. These organisms were identified by means of the description of them in Whipple's 'Microscopy of Drinking Water.'

(*b*) At its termination (Kashrote). The water is turbid and contains a large amount of sediment on standing. Examined under a magnification of 600 diameters shows:

(1) Large amount of mineral matter in a very fine state of subdivision.

(2) Much vegetable *débris*.

(3) Considerable amount of amorphous matter.

(4) Single flagellated protozoa, etc.

(5) Contains large numbers of diatoms of the varieties mentioned above but chiefly eucyonema. It appeared to me, however, that diatoms were present in fewer numbers than in the water at its source.

(*c*) Barmis spring. The deposit is almost *nil*; on examination a few particles of sand and clay are observed with a very little vegetable *débris*. Diatoms are very few; those observed were: (*a*) Navicula viridis; (*b*) one resembling in shape and size Tabillaria flocculosa, girdle view (Whipple's 'Microscopy of Drinking Water').

The only differences, then, between the waters of Basin and Kashrote, as revealed by a magnification of 600 diameters, are the presence in the latter water of:

(1) Much greater amount of mineral and dead organic matter in suspension, also of amorphous matter in suspension.

(2) Fewer diatoms apparently.

(3) More impurities, owing to pollution.

(6) *Deductions from the above Examinations.*

Having considered now the analysis of the waters of Gilgit and their microscopy, it will be interesting to consider how far these help us in determining what the factors are which are at work in causing this increase in the prevalence of the disease as we approach Kashrote.

There appear to be three possibilities:

(1) An increase in the amount of dissolved ingredient.

(2) An increase in the amount of matter in suspension in the water, organic or inorganic.

(3) An increased pollution of the water and a consequent increase in the numbers of its micro-organisms.

With regard to the first of these the table of analysis

shows that neither total solids, total hardness, calcium, magnesium, or iron, show any increase whatever. These have at one time or another been credited with the production of goître. There is no evidence from these analyses to show that such is the case. The first possibility may, I think, be put out of court.

With regard to the second—namely an increase in the amount of matter in suspension. This matter may be:

(*a*) Organic: (1) dead, (2) living—bacteria, diatoms, other organisms.

(*b*) Inorganic: fine mineral matter.

While it would appear evident that the water became polluted on its way to Kashrote, still, organic matter was not readily detected, as I have already pointed out. As a causal factor of the disease, the fact of the greater impurity of the water may, for the present at least, be put aside. How far it is of importance in favouring the action of the real causal factor is another matter.

There remains, therefore, only suspended matter to be considered; for living organic matter, such as bacteria, diatoms, and other organisms, is "suspended matter." Later I shall return to the final analysis of this subject.

(7) *Experiments dealing with the Influence of boiling and filtering the Gilgit Water* (*February—June*, 1905).

(1) Five puppies, age varying between three and six months, were confined in netted wire pens on land supplied by the Barmis spring. They were fed liberally on Kashrote water; all their food was prepared with it. The puppies were well fed and healthy. This experiment was continued for one hundred and thirty days. Result negative. No enlargement of the gland could be detected.

(2) Five puppies as above were fed on boiled Kashrote water, under precisely similar conditions to those in the first experiment. The result was negative. The experiment lasted one hundred and thirty days.

(3) Five puppies as above were fed on filtered water of

Kashrote for one hundred and five days with negative results.

(4) Five puppies six months old were taken from a house in Kashrote in which 50 per cent. of the inhabitants were goitrous. There was no enlargement of the gland in any of them.

(8) *Experiment having for its Object the Determination of the Capability of suspended Matter in Gilgit Water of causing Goitre* (*February—June*, 1905).

(1) Five young puppies, aged three to six months, were fed on the residue after the filtration of four quarts of Kashrote water. The water was collected daily and was purposely made muddy while it was being collected. The residue after filtration was collected, mixed with milk, and the mixture given to the puppies while still hungry. They were confined in netted wire pens, and were well fed and healthy. The experiment lasted one hundred and five days. The results were negative.

(9) *Age Incidence of Goitre in four of the Villages of Gilgit.*

The appended chart is of considerable interest, contrasting as it does so markedly with the charts of Chitral villages. From it it is found that females suffer somewhat more than do males (Chart III).

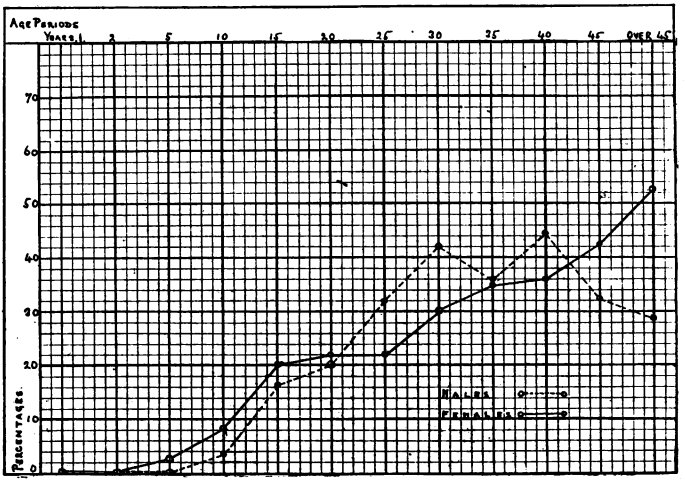
(10) *Goitre in Nagar.*

In the village of Nagar goitre was unknown six years ago. Nagar is a small State situated up one of the many side valleys on the left bank of the Gilgit River. It will be remembered as the scene of a smart frontier rising in 1893. It was after this year that the little State of Nagar began to be opened up; previously, jealous of its independence and at war with its immediate neighbours, it was careful to exclude foreigners. During recent years intercourse with the

outside world has become more free, but still there is a decided prejudice against the settling of foreigners in this little hill State.

Some five years ago certain cases of goitre were introduced from without, and since then the disease has begun to gain a footing. It may be as well to indicate clearly that there can be no doubt about the fact that goitre was

CHART III.



Endemic goitre in Gilgit. Chart showing percentages suffering at different age periods in villages of Majinpharri, Kyk, Sonyar, and Kashrote, taken together. Total population examined, 1533; children under 15, males 375, females 330; adults, males 447, females 381.

quite unknown six years ago. The fact that it has gained a footing in his territory is a matter of very considerable anxiety to the present rajah, and through his help I was enabled to go into the matter with great care. All the important men of the State, the Rajah himself, councillors, priests, etc., assure me that no case of goitre ever originated in Nagar till within the last six years.

There is a family at present at Nagar which consists of nine souls; of these three came from Gilgit some years ago,

all suffering from goitre. Two, the father and the mother, have no goitres; the father came from Gilgit. The remaining four individuals have never been outside Nagar. Three are high-caste Mohammedan girls (16, 15, and 10 years of age), which makes the statement the more likely to be accurate. The fourth individual is a boy aged 12; he has never been outside Nagar. All these four have developed goitre lately, about two years ago. This family live in the same house—that is, the same room—eat out of the same vessels, etc. It is to be observed that these, the first victims, are all young.

Another family consists of a man, his wife, and son, aged 2, and the man's brother, aged 20. The man brought goitre with him from outside five years ago. Two years later his brother developed the disease, though he had not been outside Nagar for five years. The little boy, aged 2, developed the disease one year ago; the wife is free from it.

Another man, aged 23, brought the disease from Gilgit one year ago; it is increasing in size here.

Twelve children, all under 10 years of age, were brought to me having marked enlargements of the gland. There are no other cases of the disease in Nagar. The children were from different houses scattered over the village. The first family to which I referred lives at the head of the spring which supplies the village with drinking water.

(11) *Water Supply of Nagar and spread of Goitre.*

The village supply consists of a spring which comes out of the hills; it is not the only supply of the village. The cases I have referred to all drank from this water. This spring is said to have been in existence from time immemorial; the chemical composition of its water has presumably not altered. The conditions of life of the people are the same. The only added factor in the case is the introduction of the disease from without. That it is spreading there can be no doubt, and that the course of the spread is a typically epidemic one is equally evident. It is easy to

understand why the disease should not have reached Nagar earlier, as it is only within recent years that the communications of Nagar with the outside world have become free.

It appears also evident that it is by means of the spring-water that the disease is now spreading, for the twelve children are residents of that part of Nagar supplied by the spring, and their homes are scattered here and there among the houses of the as yet unaffected inhabitants. Further, the fact that the first family referred to lives at the head of the spring is of importance, and also that no cases of this disease were observed where water from other sources only is drunk—that is, in the distant parts of the village where the nullah water or the river water is used.

It seems likely, therefore, that some poison—goitre-producing in its powers—has been introduced into a water supply which happened to be a suitable one for the conveyance of this disease. For the analysis of the Nagar spring see Table IV.

The cases of the two families mentioned are of very great interest, pointing as they do to the possibility of the disease being capable of spreading by other means than water. It will be remembered that of nine individuals three had the disease and four acquired it in a locality where it was previously unknown. It is possible that it was due to an infection of the water by these three that four other inhabitants of the same house developed the disease, but in that case why should there be such a high percentage of infected individuals in this infected house as compared with other houses in the village? Although the figures in the second family are smaller, it is a no less striking case of the possibility of infection by means other than water.

This case of Nagar can not be explained by any theory which attributes to dissolved ingredients in a water goitre-producing properties; nor can inorganic matters in suspension account for this outbreak, for it cannot be supposed that from causes in the water which have existed from time immemorial a disease should suddenly spring. There is, to my mind, only one explanation—

namely the introduction of an organism into the water supply.

The course of the disease in Nagar is that of a typical infectious disease. Presumably the organism is of slow growth, which may account for the slowness of its spread and for the long-drawn-out nature of an epidemic of this disease. One sees that a series of single cases introduces the epidemic, that the goitre-producing poison requires a suitable soil in which to develop, cases of the disease to originate it, a suitable vehicle in which to spread, and susceptible individuals to acquire it. The fact that the disease requires a calcareous soil is not peculiar. Other diseases of an infectious nature are equally peculiar in their requirements. Malaria flourishes best in marshy districts, where the mosquito, on which it is dependent for its existence as a disease, can live. It is not, therefore, to be wondered at that the micro-organism of goitre—if such there be—requires a calcareous soil to enable it to flourish.

TABLE IV.—*Analysis of Nagar Spring.*

Water.	Total solids, parts per 100,000	Total hardness, grs. to gal.	Calcium, grs. to gal.	Magnes., grs. to gal.	Iron, grs. to gal.	Sulphates, grs. to gal.	Chlorides, grs. to gal.	Suspended matter.
Nagar Spring	168	51·5	16 and over	Very plentiful	Trace	3 and over	1	Very slight.

Notes.

(1) Water clear, strong taste of magnesium.

(2) Deposits slight, examination under 600 diameters showed little sand and clay particles, vegetable *débris*, fungi, diatoms apparently absent.

(3) The water is so hard that it is impossible to wash in it. Soup made from it resembles in taste a weak solution of Epsom salts.

Boiled water is never used by the natives of Nagar,

even for culinary purposes. The *sole* food of the people besides fruit is chupatties (flat cakes of unleavened bread baked before an open fire.)

The case of Nagar appears to me to throw a very considerable light on the differences observed in the age incidence curves of the disease in Gilgit and Chitral. From Nagar we learn that when the disease is epidemic the most susceptible individuals are children. Now, although a steady increase in the percentages of goitrous individuals occurred between Basin and Kashrote, children were seen not to participate in this increase. These facts taken together appear to me to justify the belief that the disease is subsiding in Gilgit, and that the factors formerly at work in producing it are ceasing to operate among the indigenous inhabitants. The disease is dying a natural death owing to the fact that the new generation is not readily acquiring it.

Final Conclusions.

There is considerable evidence to show that it is to the increase of a something in the water supply of Gilgit—a something which is capable in its unassisted state of producing 11·8 per cent. of goitre—between the villages of Basin and Kashrote that the increase in the prevalence of goitre in the latter village is due. That this something exists in a state of suspension in the water appears to be fairly evident. It is possibly one of two things, inorganic matter or micro-organisms.

To my mind the balance of evidence is in favour of the view that it is to micro-organisms that the increase is due between Basin and Kashrote, and that micro-organisms are the causal factor in the disease. The most striking case of Nagar can only be explained on this assumption, namely the introduction of a micro-organism into the water supply, and the consequent spread of goitre in a typically epidemic form. Further the fact of the large percentage of goitrous children under one year in Chitral can be explained

in this way without having to conclude that these cases are congenital. It accounts also for such instances of the disease as cannot be traced to a water supply, and admits of the broader view that water, if it is the chief vehicle of infection, is not the only one. It explains readily the instance before us of the increase of the disease between Basin and Kashrote. It explains also the differences in the charts for the villages of Gilgit and Chitral, which to my mind seem to indicate the natural, if slow, end of an epidemic of this disease.

Exophthalmic Goitre.

I have observed no case of this disease in Chitral or Gilgit.

Treatment.

Thyroid extract was used in selected cases and caused very marked and very rapid improvement. The cases require to be symmetrical enlargements of recent development, and the subjects require to be young. The administration of thyroid extract is useless, as far as my experience goes, when the patient is beyond the prime of life, or the swelling of considerable standing, or caused by cystic or tumour growths.

As regards the effect of local applications, the following figures are those of the Mastuj Dispensary, in charge of Khan Sahib Pir Bakhsh. The total cases treated in the years 1900, 1901, and 1902 were 566. He sends me the following results:

Age.	Per cent. cured or improved markedly.
12 years	80 per cent.
12 to 30 „	50 „
30 to 50 „	20 „

The applications used were the red iodine of mercury ointment and liquor epispasticus. Painting the skin over the gland with strong iodine solution is not so satisfactory, but is attended with favourable results. In using external

remedies, to obtain good results it is necessary that the skin be blistered by them.

[I desire to express my indebtedness to my friend Mr. James Berry for the help and advice I derived from him in carrying out these observations and experiments.]

DISCUSSION.

Mr. JAMES BERRY thought that Captain McCarrison was to be congratulated very warmly upon the admirable piece of work that he had been carrying out. He thought it the most valuable contribution to the literature on the causation of goitre that had appeared for many years. Considering the very large extent to which this fell disease, with its accompaniments of physical and mental degeneration (cretinism and deaf mutism), was met with in various parts of the world, it was a matter of much importance to discover the true cause of it. Passing on to the consideration of the paper itself, it was noticeable that the districts in which Captain McCarrison had worked were similar to those in other parts of the world where goitre was most common. If a general review be made of the distribution of goitre over the world's surface, two facts stood prominently forward: first, the association of the disease with mountainous regions; secondly, its relation to limestone and other calcareous rocks. The Himalayas, Alps, Pyrenées, Andes, Cordilleras, and many other mountain chains were all noted haunts of goitre. On a smaller scale in our own country the occurrence of goitre was especially noticeable in many hilly districts. In the valleys on either side of the great Pennine range of hills, in the Cotswolds, and in the Mendips he had himself seen many cases of goitre. The speaker showed the Society a map of France published by the French Commission on Goitre. This showed clearly that the ten departments of France in which goitre was most prevalent were almost without exception those in which great mountain chains were found (Savoie, Haute Savoie, Hautes Alpes, Hautes Pyrenées, Vosges, Basses Alpes, Ariège, Aisne, Jura, and Alpes Maritimes). The close association of endemic goitre with calcareous rocks would not fail to strike any observer who had personally visited many districts in which goitre was common. In this respect the author's observations confirmed those of other investigators. McClelland's researches, carried out in another part of the Himalayas some seventy years ago, had illustrated this association in a very striking manner. Speaking of the inhabitants of the Valley of Shore (Kumaon) he had shown that 50 per cent. of those who lived upon and drank water from limestone rock were afflicted with the disease, while only $1\frac{1}{4}$ per cent. of those inhabiting the same neighbourhood, but living upon clay slate, were affected by it. In those parts of the same mountains where limestone did not exist he found the disease so rare that only one in five hundred of the population was subject to it. In most parts of the world it was noticeable that villages situated upon primitive rocks, such as granite, gneiss, schists, etc., were, as a rule, exempt from the disease. In dealing with the difficult

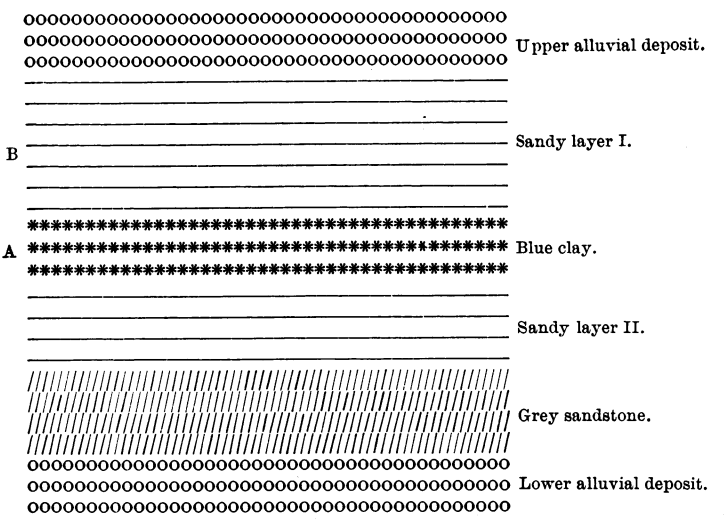
problem of the relation of geology to goitre in our own country, it was well to bear in mind the glacial drift which covered so large a portion of England. Conclusions drawn from consideration of ordinary geological maps upon which the drift was not marked might easily be fallacious. He mentioned a district in Cheshire in which he had found much goitre upon rocks not usually associated with the disease. Examination had shown, however, that the water supply of the district was derived from wells in the glacial drift, which itself was, in places, as much as 60 feet thick. He was glad to see that Captain McCarrison had accepted the view that the essential cause of endemic goitre was something contained in the drinking water, and that he had not thought it worth while to discuss any of the numerous other theories that were to be found in many text-books. He thought that the water theory of goitre was the only one that could be seriously maintained. He considered that the truth of the "water" theory of goitre had been proved up to the hilt. He cited various instances in which it was clear that the goitre-producing poison was to be found in the water, and referred also to the monumental works of St. Lager, Baillarger, and others, for abundance of evidence on this point. What it was exactly in the water that caused goitre was a vexed question, and one that had not as yet been satisfactorily answered. It was a noticeable fact that goitre was infinitely more common in country places, in villages, hamlets, and isolated houses than in large towns. He thought the explanation lay in the fact that large towns as a rule had public supplies of drinking water which, as a rule, was of good quality. A noticeable feature of goitrous villages in Savoy and on both the Swiss and Italian sides of the Alps that he had personally visited was that the inhabitants derived their water supply in so many cases from streams containing mineral matter in suspension. The grey nature of the waters at Gilgit alluded to by Captain McCarrison agreed exactly with that of so many goitrous waters that had come under his own observation in different parts of Europe. He cited the well-known goitre-producing water of the Buthier stream near Aosta, and showed a specimen of "grey" water taken by himself from this very stream. It was often said that goitre-producing water did not contain any undue amount of suspended matter. He was inclined, however, to the belief that most, if not all, goitrous waters were liable to contain much suspended matter, especially after rainfall, although such waters might be quite clear at other times. Captain McCarrison's remark about the supposed greater prevalence of goitre during the spring and early summer when the waters were grey—that was, contained more mineral matter in suspension—agreed in the main with the observations of Nivet in Auvergne. Referring to the old theory about goitre being due to snow water and to glacier water, he

thought that there was some truth in them. But care should be taken to distinguish between the water running on the surface of a glacier and that which came from under its snout. The former was a singularly pure water which could not possibly cause goitre. The latter was always a turbid, muddy stream containing a large amount of mineral matter in a very fine state of subdivision, just such a water that might be expected to produce goitre were anyone to drink it. Time did not permit of any review of the various theories which attributed goitre to various substances dissolved in the water. Lime and magnesia certainly could not be held responsible, and although much could be urged in favour of the iron theory, yet he was unable to accept it as a satisfactory solution of the problem of the causation of goitre. He agreed, therefore, with Captain McCarrison in believing that the goitre-producing poison existed in suspension in the water, and not in solution. Whether this poison in suspension was inorganic or organic was a point upon which he had not been able as yet to come to a definite conclusion. The author's observations with regard to Nagar and the supposed infectivity of goitre were most interesting. In the absence of further confirmation he preferred at present to keep an open mind on the subject. The observations seemed to him to be opposed to the facts observed in numerous other goitrous districts where evidences in favour of infectivity seemed to be quite wanting. Captain McCarrison had pointed to the village of Kashrote, where the water seemed most exposed to organic pollution, as one in which the disease was most prevalent. But this village was also that in which the greyness of the water, due presumably to mineral matter in suspension, was also most marked. Believing as he did that mineral matter in suspension was the cause of goitre, he was of opinion that the best way of preventing the occurrence of the disease was in the formation, whenever practicable, of subsidence tanks or reservoirs. He cited an instance where this had been done on a large scale by Nature herself, namely in the Lake of Geneva. The turbulent goitre-producing waters of the upper Rhone Valley discharged themselves into the upper end of the lake. The same water, having deposited practically all its suspended matter in the lake, issued at the lower end as a beautiful clear stream, which had been shown to have lost its goitre-producing properties. He was glad to be able to inform the Society that Captain McCarrison was continuing his investigations at Gilgit, and that he had recently written to him (the speaker) to say that he had obtained some fresh evidence which he thought tended to confirm the organic theory of the disease. He hoped that further information on the subject would be laid before the Society in the near future.

Dr. Louis E. Stevenson remarked on the difficulty of the

investigation of endemic goitre, evidenced by the large number of theories of its causation advanced from time to time, upwards of forty of which could be enumerated. He had no doubt whatever that the poison, whatever its nature, resided in the drinking water, the evidence for which was overwhelming. St. Lager related that the youths of a certain township in France, in order to escape military service, drank copiously for several months before the arrival of the recruiting authorities from a well whose waters were notoriously goitrigenous. Their thyroids rapidly enlarged, and by this means they escaped service. Other instances were mentioned by the speaker. One fact that was indisputable in the etiology of the disease was that the poison was absent from rain water. In Constantinople and Venice, where rain water was used, there was no goitre. The same fact obtained in Holland and the lower parts of Belgium. Cardinal Billiet had put on record a remarkable instance of goitre-incidence occurring in the village of Puiset, in Planaise. Here he found seventeen families more or less afflicted with goitre and cretinism from using the spring water of the country; one family was absolutely healthy, and used rain water only. Moreover, it was a well-known fact that a recent goitre would generally quickly subside if the patient drank rain water only. Many instances of this had occurred in the speaker's practice. The goitre poison accordingly was due to some deleterious substance formed in, or produced by, contact with the soil, and Dr. Stevenson wished that evening to speak briefly on two theories, both of which he considered important: (1) the bacillary, (2) the metallic salts theory. With regard to (1), which was originally advanced by the two Italian physicians Lustig and Carle, as the result of their work in the Vale of Aosta, these observers found a bacillus which they called the *Bacillus liquefaciens* in all the goitrigenous waters examined by them, but they did not prove that the elimination of the microbes took away from the waters their poisonous action, and all their experiments on animals by inoculation of or feeding with cultures of the bacilli were negative. The principal facts in favour of the bacillary theory were: (*a*) That filtration diminished and boiling actually destroyed the goitrigenous principle in water; (*b*) that the further a goitrigenous water flowed from its source the less dangerous did it become, eventually losing all poisonous action, exposure to oxygen and sunlight gradually killing the bacilli. This fact seemed to Dr. Stevenson to explain the greater frequency of goitre in mountainous regions. (*c*) That epidemics of goitre had occurred in the world's history. (*d*) That goitre occurred principally in rural districts, where little care was exercised in choosing a water supply; where, in many instances, surface water was used, or subsoil water which had merely percolated through a porous superficial stratum, and was recovered for domestic

use by the agency of the village pump. (Dr. Stevenson gave instances.) (*e*) The frequency of goitre on the limestones of the carboniferous series, because these rocks were freely jointed, and it might be that water from the surface percolated rapidly along these joints, carrying bacteria in its train. (*f*) The goitrigenous action of many river waters, a great part of whose volume was derived from surface drainage. Against the bacillary theory might be mentioned the fact that constitutional disturbance—*e. g.* fever, etc.—never seemed to have been recorded in epidemics of the disease, and also the negative results of inoculation, etc., with bacilli. In the speaker's opinion these bacilli existed in the water only in consequence of some chemical environment, and were probably a species of soil bacteria. With regard to (2) the metallic salts theory, with special reference to the action of iron-pyrites (FeS_2) and the results of its decomposition, one curious fact was that St. Lager found iron-pyrites in some of the Vale of Aosta waters examined by Lustig and Carle. Dr. Stevenson proposed to take a series of geological formation on which goitre was found, and see what evidence they afforded in favour of this theory. (*a*) *Ordovician shales:* Goitre was prevalent on this series in Cumberland, in the counties of Roxburgh, Selkirk, and Dumfries, also in Westmoreland. Examination of these shales showed abundance of iron-pyrites, occurring in its usual cubical form, and also in the rhombic form, as Marcasite. Instances were mentioned of goitre on these rocks from personal observation of the speaker. (*b*) *Marls:* Dr. Stevenson accounted for goitre on the Permian and Triassic series of rocks by the fact that in many instances he could mention the water came in contact with marls, many of which he had examined. He found them variegated, consisting of bands of various hues—yellow, blue, and black—besides the ordinary red variety. The yellow bands were due to limonite produced by the decomposition of iron-pyrites, while the blue and black bands owed their colour to the presence of iron-pyrites in dissemination. A very striking instance of a blue marl which produced goitre was given as occurring in the department of the Isère in the so-called region of the Molasse. The stratum marked A was one of these blue marls containing iron-pyrites in dissemination. In every village in this department where the drinking water came in contact with this marl goitre was endemic. In some localities where the superimposed sandy layer B was rendered hard and compact by calcareous cement, and where the water was held up at a higher level, there was no goitre. In England the blue marls of the Gault and Wealden series were goitrigenous—*e. g.* at Horsham, where goitre existed, and where these blue marls abounded. In France the marls corresponding to the above—the *marnes aptiennes* and the *marnes néocomiennes inférieures*—were found by St. Lager to be eminently goitrigenous, and both these



formations contained a superabundance of iron bisulphide. Other instances could be mentioned. (*c*) *Carboniferous limestones:* Lime itself was not a cause of goitre, as large tracts of country in many lands, situated on the jurassic limestones, for instance, were free from goitre. Dr. Stevenson had carefully examined the lower strata of the carboniferous series and found a large amount of iron-pyrites in the limestones, sandstones, and shales of this geological horizon. (*d*) *Chalk and chalk-marl:* Goitre on these formations was not frequent, but according to Mr. James Berry was found fairly uniformly. So far as the speaker was aware the only accidental mineral on these formations, with the exception of glauconite and disseminated lime phosphate, was iron-pyrites occurring as marcasite, which was a very readily decomposable form of iron-pyrites. Dr. Stevenson concluded by reading a paragraph from a book entitled 'Among the Himalayas,' by Surgeon-Major Waddell, I.M.S., in which the author stated his belief that the goitre he saw in a locality near the Jelep Pass was due to iron contained in the drinking water.

Captain J. H. Hugo, I.M.S., said that in Nepaul goitre was present in goats, horses, and pigs, and among the poor inhabitants, but not among the rich. The poor obtained their water from the rivers, but mostly from shallow wells, whilst the rich obtained their water from the hills, the water being stored in a reservoir outside the residential parts and brought in pipes to the city; the Nepal Resident's escort (who were composed of Hindus specially enlisted in India) drank the pipe water and did not suffer from goitre. No sediment was, as a rule, perceptible

in the surface water drunk by the poorer people. Many Tibetans came for treatment, and they considered themselves benefited by biniodide of mercury ointment. In Bakloh, a hill station where Gurkha troops were stationed, goitre was prevalent in the rainy season when surface turbid water was drunk, and disappeared afterwards. In Central India goitre was very rare. He had only seen two cases, in two women, both of whom came from the mountains. If goitre were due to a micro-organism, it would have been expected to follow the trade routes, which it did not. It was probably due to some suspended matter in the water. Mica suspended in the water was often met with in goitrous districts.

Mr. W. W. CLARIDGE said that goitre was practically unknown in West Africa except at one place called Mampon, in Ashanti, and at this point there was an outcrop of limestone. The water which supplied this district came out of the limestone. Ironstone was also present, but in much less amount than in other districts which were not goitrous. About 10 per cent. of the inhabitants of Mampon were affected with goitre. It seemed certain that the disease did not follow trade routes, for, although Mampon was on the direct trade route, goitre never occurred at other places on the route. He agreed with the former speakers that goitre never occurred when rain water was used.