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PREVALENCE AND GEOGRAPHICAL DISTRIBUTION OF ENDEMIC GOITRE

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Goitre, as this survey shows in detail, occurs with varying intensity in almost every country; few countries appear to be entirely free from it. The disease has been observed in the far north, in the tropics, and in the far south; it occurs quite independently of climate, season or weather. Moreover, in its incidence goitre makes no distinction of race, nationality, colour, creed or class; the North American, the European, the Chinese, the Himalayan Indian, the Turkoman, and the peoples of Central and South America all suffer from it under certain conditions—some severely, some moderately, some but mildly.

Without doubt the most notorious goitre centres of the world are located in high mountain regions—in Alpine valleys, in the Pyrenees, on the slopes of the Himalayas, and along the Cordillera of the Andes. But goitre is also known to occur with considerable intensity in comparatively low-lying areas and even at sea level; for example, it is seen around the Great Lakes basin between Canada and the USA, in the plains of Lombardy, in the ice-excoriated parts of Finland, and in the low-lying Netherlands.

Students of iodine geochemistry have a ready explanation for these diverse phenomena. They say that the types of terrain in which goitre is for the most part found, be they at high altitude or low, are just those which have been subjected either to flooding or to intense glaciation and from which most of the soil iodine has been washed out and carried through the rivers to the sea. During the last Ice Age, earlier soils were swept away and new soil-making materials were generated by the grinding-up of virgin crystalline rock containing one-tenth, or even less, the average iodine content of mature agricultural soils. As the ice cover receded, replenishment of the iodine in glacial and postglacial soil materials began—a process which is still in progress. The time since the start of this replenishment, that is, the time since the disappearance of the great inland ice-sheets, is estimated to be 10 000 to 20 000 years for the central and northern parts of Scandinavia and the northernmost part of North America, and correspondingly longer for the southern parts of the glaciated areas of Europe and North America. This accords with the fact that the frequency distribution of goitre in North America and in a number of countries in Europe,

Asia and Australasia shows a close correlation with the areas and extent of quaternary glaciation where soils have not yet been sufficiently saturated with postglacial air-borne oceanic iodine (see *Geochemistry of Iodine* [215]).

The number of goitrous people in the world is not known; but if the statistics available for some countries may be taken as a guide, the total is probably not far short of 200 million. Although the geographical distribution of goitre has not apparently altered in the last hundred years, the intensity of the disease has substantially declined in certain countries—particularly those which have enjoyed rising standards of living and an enlightened outlook on public health. The endemics in Switzerland, the USA and New Zealand, for example, have been largely eliminated within the past thirty years through the prophylactic use of iodized salt.

Nevertheless, there are many countries where the incidence of goitre is still exceedingly high and a matter of serious public concern, and many others where the people live so near the critical level of iodine intake that whenever the slender resources of the thyroid gland are abnormally taxed, as, for example, during the nutritional privations of war, epidemic outbreaks of goitre result. Statistics for the year 1952 show that in eight states of Mexico there were over 2 million goitrous people out of a total population of about 10 million; in El Salvador, 329 000 people out of 1 856 000 are affected; in Finland, 2000 operative cases annually out of a population of 3.5 million account for 30 000 days of hospital attendance; in Sweden there are said to be 300 000 people with goitre in a total population of 7 million; Matovinović [276] estimates that some 1 400 000 persons suffer from the disease in Yugoslavia; and in Italy, Cerletti [455] reckons that no less than 5 million individuals are affected, that is, rather more than 10% of the total population. In England and Wales, in 1944, there were estimated to be some 500 000 cases of thyroid enlargement in schoolchildren and young adults; and in the USA the number of men rejected for military service on account of goitre was no less in the Second World War than in the First—namely, five in every thousand examined.

These and other similar facts are marshalled country by country in the following pages. The survey is divided into two parts, the first covering the Americas and Europe, and the second, Africa, Asia and Oceania.

THE AMERICAS

North America

Canada; United States of America; Mexico

Central America

Guatemala; Honduras; El Salvador; Nicaragua; Costa Rica; Panama; Dominican Republic

South America

Colombia; Venezuela; Ecuador; Peru; Bolivia; Chile; Argentina; Paraguay; Uruguay; Brazil

EUROPE

Northern Europe

Iceland; Finland; Sweden; Norway; Denmark; Estonian SSR, Latvian SSR and Lithuanian SSR; Netherlands

Eastern Europe

Poland; USSR (excluding Estonian SSR, Latvian SSR and Lithuanian SSR); Romania; Bulgaria; Yugoslavia; Greece and Albania

Central and southern Europe

Austria; Hungary; Czechoslovakia; Germany; Switzerland; Italy, Sicily and Sardinia; Malta; Spain; Portugal

Western Europe

Belgium; England and Wales; Scotland; Northern Ireland; Ireland; France

AFRICA

North-west and West Africa

Algeria; Morocco; Madeira and Canary Islands; French West Africa; Gambia; Sierra Leone; Liberia; Ghana; Nigeria; Cameroons; French Equatorial Africa; Angola

North-east and East Africa

Egypt; Sudan; Ethiopia and Eritrea; Somaliland Protectorate; Uganda; Tanganyika

Central and South Africa

Belgian Congo and Ruanda-Urundi; The Rhodesias; Union of South Africa; Caprivi Strip; South-West Africa; Bechuanaland; Swaziland; Basutoland; Seychelles and Madagascar

ASIA

Middle East

Turkey; Lebanon; Israel; Iran; Saudi Arabia; Yemen

Central Asia

Afghanistan; Pakistan; Kashmir; Nepal; India; Assam; Ceylon

Far East

Burma; Thailand; Indo-China (Cambodia, Laos and Viet Nam); Malaya; Indonesia; Sarawak; North Borneo; China; Korea; Taiwan; Japan; Philippine Islands

OCEANIA

Australasia

New Guinea; Australia and Tasmania; New Zealand

Pacific Ocean

Fiji Islands; Tonga (Friendly Islands); Cook Islands; Hawaiian Islands

The occurrence of endemic goitre has been recorded in all the above countries. So far as can be ascertained there is no published information relating to countries not named above.

Among those who have previously dealt comprehensively with the geographical distribution and prevalence of endemic goitre on a continental or world scale are: Hirsch,[8] Saint-Lager,[12] Bircher,[1] Clemow,[4] McCarrison,[9] Eggenberger,[6] De Quervain & Wegelin,[5] Pflüger,[11] McClendon,[10] Greenwald,[7] the Chilean Iodine Educational Bureau, London,[3] and the Oficina Educacional del Yodo, Santiago, Chile.[2]

PART I—THE AMERICAS AND EUROPE

North America

Canada

Proceeding through Canada from west to east we first meet with centres of goitre in British Columbia. Some 50 or 60 miles[a] from Vancouver, as one goes inland from the head of Howe Sound, the disease is found in the Pemberton valley and in the area watered by the Lillooet and Birkenhead rivers. An interesting account of this district has been given by Keith,[20] who relates that fifty years ago European settlers in Pemberton Meadows suffered so severely from goitre, both in themselves and among their cattle, pigs and horses, that they almost decided to leave the valley. Writing in 1949, MacDermot [21] records that owing to the administration of supplementary iodine in food and drinking-water, Pemberton Meadows is now a healthy and thriving community.

The coastal valley of Bella Coola, 270 miles north-west of Vancouver, is also peculiarly sensitive to the disease. Other areas of considerable prevalence in British Columbia lie to the east and north-east of Vancouver. These are the valley of the Lower Fraser river, the town of Kamloops, around Lake Okanagan at Keremeos, Penticton and Vernon, and from thence northwards including such places as Armstrong, Enderby and Salmon Arm. Farther east, it occurs in the neighbourhood of the Arrow Lakes and in the valleys towards the Selkirk Mountains. To the north there are centres in the Cariboo Mountains, at the town of Prince George, and all along the Grand Trunk Pacific Railway as far as Edmonton in Alberta.

In Alberta, Walker [24] has seen a great deal of goitre in a strip of territory running from Edmonton south to Calgary, especially at Leduc, Lacombe, Red Deer and Didsbury. It is also prevalent in the southern districts irrigated by the South Saskatchewan river between Lethbridge and Medicine Hat; but it does not seem to occur on the immediate southern boundary of the province.

Another part of Alberta where goitre is fairly common is 200 miles north-west of Edmonton in the area drained by the upper waters of the Peace river and Athabaska river. An early account of goitre in this area is given by Dr John Richardson,[22] surgeon and scientist on Franklin's famous expedition to the polar seas in the north-west of Canada between 1819 and 1822. " At Edmonton ", he writes, " the disorder attacks those only who drink the water of the river."

In Saskatchewan there are accounts of goitre at Saskatoon. According to Binning,[15, 16] a prevalence among schoolchildren of 12.3% in 1934 has

[a] 1 mile = 1.6 km.

been greatly reduced by the administration of iodine in various forms. Goitre is also found farther south, in the country immediately surrounding the town of Regina. Other centres are at Qu'Appelle, between Regina and Indian Head; at Bethune, Govan, Raymore, Cupar and Ituna, north of Regina; and in a strip of country running from Shaunavon eastward to Weyburn (Jackes [19]).

Goitre studies of schoolchildren have been made at widely separated places in Manitoba. At Dauphine, in the west of the province, 74% of the children were affected. In the south, 21% of children at Morden had goitre. At Winnipeg the goitre rate was 50%, and in the towns of Birds Hill and Stonewall, both in the Winnipeg area, 85% of the children were sufferers. The Indian School at Waugh, in the extreme east of the province, was free from goitre. These particulars are taken from the publications of Hamilton & McRae [18] and of Abbott.[13]

Evidence of iodine deficiency among people in Winnipeg and in a Japanese prison camp at Angler, Ontario, has been noted by Edward.[17] Information on the endemic occurrence of goitre in Ontario and Quebec is less precise than that for the other provinces, but the neighbourhood of the Great Lakes has long been recognized as notoriously goitrous. In a nutrition survey of the Indian people inhabiting the townships surrounding James Bay—the southern extension of Hudson Bay—undertaken by the National Committee on Community Health, small goitres were found in 5.3% of 728 subjects examined. The majority were in young women (Vivian et al.[23]). Since 1945 all salt sold through the Hudson's Bay Posts has been iodized.

In the Province of Newfoundland, goitre was observed but once only among 868 unselected people from St. John's and five outports, who were examined for clinical biochemical evidence of abnormalities due to defective nutrition (Adamson et al.[14]). The fact that consumption of fish is high no doubt accounts for iodine sufficiency in Newfoundland.

United States of America

Goitre has long been recognized as a serious regional health problem in the USA. Considered in broad outline, and geographically from east to west, the goitre centres of the USA are found throughout the whole length of the Appalachian range, in all states bordering on the Great Lakes, westward through North Dakota, and into the far western states of Montana, Idaho, Utah, Oregon and Washington where the incidence is particularly heavy. Except for isolated pockets of high incidence in Kansas—especially where it borders on Missouri—and in the New Orleans district of Louisiana, the great central plains are comparatively goitre-free, as also are the states on the Atlantic seaboard and the southern states of Mississippi, Alabama, Georgia and Florida.

The first reliable index of the over-all prevalence of goitre in the USA resulted from the examination of 2 510 701 men drafted for military service during the First World War. Nearly 12 000 men had simple goitre and 31% of these were rejected because their necks were so large that the collar of the military tunic could not be buttoned around them. The frequency of the disease was greatest among recruits from the States of Washington, Oregon, Montana and Idaho in the north-west and from the region of the Great Lakes. It was least in men drafted from the southern and Atlantic coast states.

Later, between the years 1923 and 1929, systematic goitre surveys of elementary schoolchildren were made in various states by the US Public Health Service. The results revealed a general distribution very much the same as that shown by the earlier military survey, except that whereas the examination of drafted men disclosed the highest incidence in the states of the Pacific North-West, the surveys of the Public Health Service indicated the greatest incidence to be in certain areas of the Middle West, that is, in Ohio, Indiana, Illinois, Michigan, Iowa, Wisconsin and Minnesota—states grouped around the Great Lakes.

Goitre rates in these areas were found to be high. For example, in the town of Cincinnati (Ohio), 26% of the boys and 40% of the girls were classed as having simple thyroid enlargement. In the State of Minnesota the endemic was even more severe, 41% of boys and 70% of girls from 13 different localities showing evidence of thyroid enlargement. Conditions in Michigan and Wisconsin were no better; rates of 40%, 60%, 70% and even 100% were reported among boys and girls from certain localities in these states.

Throughout the eastern states, although some moderately high percentages are recorded by the Public Health Service, there is on the whole much less goitre than there is around the Great Lakes and in the Far West. The State of Connecticut gave rates of 7% in boys and 29% in girls, and Massachusetts 9% in boys and 22% in girls. There is almost no goitre in territory east of the Blue Ridge Mountains. Indeed, South Carolina is famed for the fact that her fruits and vegetables have a high iodine content and that, in consequence, goitre incidence there is negligible.

As regards the Far West, the statistics collected by the Public Health Service in the State of Colorado revealed thyroid enlargement in 25% of the boys and 30% of the girls. Utah is a notoriously goitrous state, very high rates being found in the locality of Salt Lake City. In Oregon, thyroid enlargement prevailed in 22% of the boys and 38% of the girls. Goitre is endemic to a considerable extent in the coast towns of Oregon, exemplifying the fact that proximity to the sea does not necessarily guarantee freedom from the disease.

The goitre situation in the Middle West—particularly in Ohio and Michigan—has greatly improved in recent years owing to the introduction

of iodized salt and the official encouragement given to its use. Brush & Altland [26] have recently reviewed the results of thirty years of goitre prevention with iodized salt in this area. A survey carried out in four Michigan counties in 1951 showed a goitre rate of 1.4% in 53 785 students compared with a rate of 38.6% in 65 537 students from the same counties examined in 1924. Some idea of the present significance of goitre in the USA may also be gained from the medical examination records of registrants for military service during the Second World War. Referring to the occurrence of thyroid disease among 13 million men examined up to January 1944, Rowntree [43] says that during peacetime all doubtful cases were considered significant, with the result that the rate was 5 per 1000, but, as manpower for the fighting forces became scarcer, only the more outstanding clinical pictures were labelled actual disease—a fact which resulted in a recorded rate of 0.6 per 1000. Hyperthyroidism, in both war and peace, was more frequent than hypothyroidism, he adds.

Details of the US Public Health Service investigations quoted above are taken from Olesen.[38] Other authorities consulted are Adolph & Prochaska (Nebraska),[25] Johnson (Kentucky),[32] Richards (Utah),[42] Phillips (Texas),[40] Pennington (Kentucky),[39] Grollman & Gryte (western North Carolina),[29] Mahorner (southern states),[36] Jordan & Canuteson (Kansas),[33] Greenwald (West Virginia),[27] Kimball (Ohio and Michigan),[35] Phillips (south-western Virginia),[41] Kenyon, Kelly & Macy (Great Lakes),[34] Marine,[37] Greenwald (Ohio and West Virginia),[28] Hull (Colorado),[31] and Hamwi et al. (Ohio).[30]

Mexico

In the upper basin of the Rio Grande del Norte begins a great Central and South American zone of goitre comparable with the vast endemics of the Alps and Himalayas. It extends through Mexico and the Central American Republics into Colombia and Venezuela, along the Cordillera of the Andes through Ecuador and Peru as far as Chile and western Argentina.

According to Stacpoole,[44] the greatest goitre authority in Mexico, endemic centres are found in all Mexican states bordering the Pacific except lower California. Goitre also affects the mid-central and southern parts of the country. The north-central gulf-coast of Tamaulipas and the Caribbean regions of Campeche, Yucatan and Quintana Roo are practically exempt. Most of the goitre centres are situated in the mountains, but there are stretches along the Pacific coast where the disease is also to be found.

Up to the end of 1952, Stacpoole and two colleagues had examined more than one million children and adults in eight mid-central states, with a total population of over 10 million. The results of the survey (see Table I)

TABLE I. PREVALENCE OF GOITRE IN EIGHT STATES OF MEXICO

State	Total population	Cases of goitre	Prevalence (%)
Distrito Federal	3 309 367	165 468	5
Puebla	1 691 950	406 066	24
Michoacán	1 470 837	385 359	26
México	1 443 681	425 886	30
Guerrero	952 037	261 811	27
Hidalgo	861 521	303 282	35
Morelos	291 119	135 661	46
Tlaxcala	290 592	108 972	37
Total	10 311 104	2 192 505	20

indicate that in these eight states there are more than two million people afflicted with goitre, that is, a rate of about 20% for the whole area.

The survey covered 3756 towns and villages within 858 townships. Rates of more than 80% were common in many places and in some communities upwards of 90% of the population were found to be goitrous.

According to law, all municipalities in which more than 20% of the population are affected by goitre are obliged to use iodized salt exclusively, and energetic measures are being taken to overcome the administrative difficulties that prevent enforcement of the law. Since 1950 prophylaxis by means of iodized sweets has been carried out among 50 000 children in 45 schools in the Federal District and in 80 schools in the State of Morelos. The result is an average drop of 16% in goitre prevalence among children in these schools. Recent experiments in Mexico have proved the reliability of salt iodized with iodate in place of iodide.

Central America

Since the establishment of the Institute of Nutrition of Central America and Panama (INCAP) in 1949, extensive surveys have been made to determine the prevalence of endemic goitre in Central America. As a result, it has been shown that the disease is a serious public health problem in Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica and Panama.[45, 46, 47]

Guatemala

A survey made in 1938 by Herrera[48] confirmed earlier findings by Guerrero (1908) and by Díaz (1918) that goitre is a serious condition in

Guatemala, affecting 50% of the people in some localities. Dr Herrera established seven goitrous zones involving 16 departments: (1) Chimaltenango, Sacatepéquez, Sololá, the northern part of Escuintla and Suchitepéquez, and the southern part of Quiché as far as Totonicapán and Quezaltenango; (2) El Progreso and the south-west part of Zacapa; (3) the north-west part of Jutiapa and part of Jalapa; (4) the north-west of Quezaltenango and San Marcos; (5) the south of Huehuetenango; (6) the north-west of Huehuetenango; (7) the north-west of Santa Rosa. The Department of El Progreso showed the highest incidence.

The most modern statistics are those compiled by Scrimshaw and his co-workers in INCAP.[49, 52, 53] They have found an over-all prevalence of 38.5% in the Departments of Guatemala, Escuintla, Chimaltenango and Sacatepéquez, some regions of which showed rates varying between 60% and 74%.

Nodular goitres are common in the highlands of Guatemala; by contrast, nodular goitres are uncommon in El Salvador. Deaf-mutism and idiocy are frequently found in association with iodine deficiency in the highly endemic areas of Guatemala. These sequelae were not observed in El Salvador. Writing of conditions in Guatemala as he encountered them in 1950, Kimball[50] says: "I have never seen such degeneration; feeblemindedness and deafmutism were very frequent."

Energetic official action is being taken to combat goitre in Guatemala by means of iodized salt. Both iodate and iodide in doses of equivalent iodine content have been tested and found equally effective. Experiments on Guatemalan children reported by Scrimshaw and his colleagues[51, 54] show that after 32 weeks of treatment an original goitre rate of 51% was reduced to 16% with iodate, and from 60% to 23% with iodide.

Honduras

In common with most other Central American countries the over-all prevalence of goitre in Honduras is high. As part of the INCAP goitre survey, Borjas and Scrimshaw[55, 56] examined a total of 12 292 schoolchildren and 352 adults, comprising nearly 1% of the population in all 15 departments, and found that nearly one-fourth (22.6%) of these people had pathologically enlarged thyroid glands. Slightly less than 14% of the goitres were readily visible with the head in normal position and fewer than 1% had discrete nodules. The highest rates occur in the Ajuterique and Lejamani districts of the Department of Comayagua (73% and 74% respectively) and in the La Venta area of Morazán Department (64%).[49]

El Salvador

Goitre is endemic in all 14 departments of El Salvador.[58] During 1952 nearly 35 000 schoolchildren of all ages from public and private schools

in urban and rural areas were examined by a goitre survey team under the auspices of INCAP. Glands were not considered enlarged unless they were definitely four to five times the " normal " size.[45, 57, 59]

Of 8000 children examined in the capital (San Salvador) only 1.1% were found to have thyroids more than four to five times the normal size. Among the 26 400 children examined in the remainder of the country the average rate was 22.8%, with variations between 8.5% and 38.7%, depending on the department. Deaf-mutism, idiocy and cretinism were not observed. The worst affected department was Ahuachapán.

On the basis of these studies, it is calculated that 119 000 children in El Salvador out of a total school population of 673 000 are affected with goitre. If these average figures for schoolchildren can be taken as reasonably representative of the population as a whole, El Salvador would have 329 000 goitrous people out of a total population of 1 856 000 (Cabezas, Pineda & Scrimshaw [45]).

Nicaragua

An examination of 2427 children recently (1954) carried out under the auspices of INCAP gave the results shown in Table II (N. S. Scrimshaw —personal communication, 1954):

TABLE II. CASES OF GOITRE AMONG CHILDREN IN NICARAGUA

Department	District	Number of children examined	Number with goitre	Percentage with goitre
Carazo	Santa Teresa	157	85	54.1
,,	Diriamba	223	44	19.7
,,	Jinotepe	438	57	13.0
Masaya	Nindiri	90	20	22.2
,,	Masaya	224	32	14.3
Managua	San Rafael del Sur	117	62	53.0
,,	El Salto	51	23	45.1
,,	Las Maderas	72	28	38.9
,,	Montelimar	47	12	25.5
,,	Managua	457	98	21.4
,,	Tipitapa	35	1	2.9
Matagalpa	Matagalpa	355	81	22.8
,,	C. Darío	161	7	4.4
	Total . . .	2 427	550	22.6

These statistics indicate an average goitre rate of 22.6%. In the districts of Santa Teresa (Carazo) and San Rafael del Sur (Managua) the rate exceeds 50%.

Costa Rica

Goitre statistics for Costa Rica are few, but they are sufficiently disquieting to justify the official introduction of preventive measures. García [62] found a rate of 10.6% among male patients in a mental hospital. He also refers to a series of 1000 autopsies in which 45 goitres were noted. Investigations in the canton of Puriscal by Urcuyo [64] revealed 27 cases of thyroid abnormality among 1000 people examined; 6 of these cases were men and 21 were women.

More recent surveys by INCAP (N. S. Scrimshaw—personal communication, 1954) reveal an average rate of 12% among 24 000 children examined. The following are the figures for five of the seven provinces: Alajuela, 17%; Cartago, 12%; Heredia, 15%; Limón, 6%; San José, 8%.

Lack of iodine in drinking-water, monotonous diet, and hardness of water are considered by De Girolami & Fallas Díaz [61] to be the causes of the Costa Rican endemic. Cases of cretinism and deaf-mutism are of sporadic occurrence.

Panama

The Peruvian expert, Dr Arce Larreta, examined a total of 3540 persons in the Province of Chiriquí as part of the INCAP survey.[49] He found goitre rates as follows: 2.5% in children up to 6 years of age (808 examined); 50% in children of school age (1682 examined); and 75% in adults of 18 years or over (1050 examined).

More recently Reverte Coma [65-68] carried out studies in Herrera and Chame and found the following percentage prevalence:

	Pre-school children	*Schoolchildren*	*Adults*
Herrera	6.80	60.81	46.85
Chame	1.05	21.18	17.81

Many cases of cretinism and deaf-mutism were found.

Dominican Republic

According to Purcell [70] numerous cases of simple goitre are found in Santo Domingo. He mentioned El Cerado, El Pinar, Los Arroyos, El Coco and Los Naranjos as the districts most affected.

De León [69] refers to the frequency of goitre among the country people in the mountainous zone of Jarabacoa. Women, and children between the ages of 10 and 14 years, are especially prone to the disease. The condition

is accompanied by under-development, sexual immaturity, idiocy and cretinism. Sterility and other manifestations of reproductive failure are common among women. The goitre seen in these areas is characteristically benign; toxic phenomena are never seen. La Pelada, El Salto, Manabao, Pinarquemado, Boma, La Peña and Vera Bellica are the most affected sections in this area. If iodine treatment is applied in childhood excellent results are obtained. Nothing can be done medically to alleviate goitres in patients over the age of 20 years.

South America

From earliest times the continent of South America has presented a fruitful field of study for the goitre investigator. Crotti [71] recounts how the first explorers of New Grenada (now Colombia) were astonished to find the banks of the Rio Magdalena inhabited by a race of " heavy and stupid savages of sluggish habit who passed their days in sleep." Among the goitrous Indians of the Peruvian plateau, cretinism had reached such a degree in those days that it required nothing less than a papal bull from Paul III (*d.* 1549) to convince the missionaries that these were indeed men with souls to be evangelized.

Similar conditions still persist and goitre may be found today in almost every country of South America. Summaries of the history, prevalence and geographical distribution of goitre in South American countries up to the year 1950 have been made by the Chilean Iodine Educational Bureaux of London and Santiago.[2, 3] Orr [72] and Kimball [50] are two other authorities who have written interesting general accounts of goitre in South America.

Colombia

Endemic goitre in Colombia is a problem of long standing. Francisco José de Caldas, noted Colombian naturalist and patriot, repeatedly mentions goitre in his writings (1808). Apparently he was the first to attribute the disease to the quality of the local drinking-waters—some excessively charged with lime and others with calcium sulfate, iron, and decaying vegetation. About the same time (1810) Camacho studied the distribution and extent of the Colombian endemic and observed that the disease was frequent in the convents of Bogotá, where well water of exceptional hardness was used for drinking and cooking purposes (Socarrás [82]).

A special interest attaches to the story of goitre in Colombia because it was there that the famous French scientist, J. B. Boussingault,[73, 74] put forward for the first time (1831) the recommendation that domestic salt supplies should be iodized to prevent goitre. The circumstances are these. In 1824 von Humboldt [78] described the occurrence of goitre in the Andean plateau and referred to the striking fact that the inhabitants of goitrous localities recognized that salt from certain natural deposits was more

beneficial than that from others. The following year, a young doctor named Roulin,[81] who had recently come to Colombia from Paris full of information and ideas about Coindet's new iodine treatment of goitre,[3] noted this and was instrumental in having samples of the salts analysed by Boussingault. On analysis Boussingault made the significant discovery that those salts instinctively preferred by the goitrous peoples contained most iodine. This prompted his recommendation.

Although more than 120 years have passed since Boussingault's advice was given, it is only recently that active steps have been taken to stamp out, by means of iodized salt, the serious degree of goitre which is still found throughout almost the whole length of the valleys of the Magdalena and Cauca rivers. The decision to introduce iodized salt has been taken as a result of several new and detailed goitre surveys.

The first of these inquiries, published by Socarrás [82] in 1942, showed that 10% of 153 000 prospective recruits for military service examined over a period of five years were rejected because of simple goitre. In January 1945, the Department of Nutrition of the Co-operative Health Service (Servicio Cooperativo Interamericano de Salud Pública) began a four-year survey of the geographical distribution and frequency of simple goitre among schoolchildren from 7 to 14 years of age throughout the entire country. Few, if any, more complete surveys of this kind have ever been made anywhere in the world. The results, published in summary form by Parra [79, 80] and in great detail by Góngora y López, Young & Iregui,[77] are shown in Table III. They cover 183 243 children in 14 departments and show an average goitre rate of 52.62%, the highest figure being 81.14% for the Department of Caldas.

Commenting on this survey Parra [79, 80] mentions that the departments with the lowest goitre rates (Atlántico, Bolívar and Magdalena) border on the sea coast, where there is a higher consumption of foods of marine origin. He also refers to the fact that during the last thirty years simple goitre has been invading areas formerly untouched by it, e.g., the Departments of Caldas and Antioquia. This is because the regional supply of salt from iodized sources has gradually been almost completely replaced by cheaper salt of extremely low iodine content from large mines near Bogotá. Another interesting conclusion drawn from the survey is that in places with soft or semi-hard water the goitre incidence is less than in localities where the water is hard or very hard.

Where the endemic has been of long duration—100 years or more—the physique of the people is substandard and there are evidences of retarded mental development and of cretinism.

Goitre preventive measures involving the iodization of the salt supply for the entire country have been given official sanction. The average daily intake of salt per head is said to be 15 g, and the level of iodization adopted is 1 part of iodine in 25 000 parts of salt. That iodized salt is effective in

TABLE III. PREVALENCE OF SIMPLE GOITRE AMONG COLOMBIAN SCHOOLCHILDREN, 1945-48

Department	Children examined	Positive cases	Percentage
1. Antioquia	20 058	9 374	46.73
2. Atlántico	4 425	1 012	22.84
3. Bolívar	8 097	2 333	28.81
4. Boyacá	8 025	4 691	58.45
5. Caldas	25 280	20 511	81.14
6. Cauca	6 234	4 960	79.56
7. Cundinamarca	34 665	15 909	45.89
8. Magdalena	5 572	1 364	24.47
9. Huila	6 137	4 246	69.18
10. Nariño	12 892	4 844	37.57
11. Norte de Santander	4 130	1 684	40.77
12. Santander	10 523	4 993	47.45
13. Tolima	10 941	6 635	60.64
14. Valle del Cauca	26 264	13 879	52.84
Total	183 243	96 435	52.62

reducing the degree of goitre in young Colombian children is already evident from the results of a two-year trial recorded by Góngora y López & Mejia.[76] Beginning in May 1950, a total of 8062 children from seven different localities in the Department of Caldas were given iodized salt regularly. As controls, 797 children from two other zones in Caldas and 1648 children from the city of Bogotá were given no iodized salt. At a resurvey in April 1952 the number of cases of goitre in the iodized salt group had diminished by 57.6% compared with the rates obtaining in 1945-48. The goitre rate among the children not getting iodized salt was the same in 1952 as was found in the 1945-48 survey.

Venezuela

From the Rio Magdalena in Colombia the goitre belt extends eastwards into Venezuela through the basins of the Meta and Apure rivers, and more particularly along the Cordillera of Mérida, affecting such places as Pamplona, La Grita, Tovar, Mérida, Trujillo and Barquisimeto, and continuing as far as Valencia and Caracas.

The most authoritative account of endemic goitre in Venezuela is contained in the comprehensive health survey of that country by Bengoa.[83]

He is of the opinion that goitre did not exist in Venezuela prior to the colonization, owing to the typical nomadic tendencies of the indigenous tribes of the Caribbean countries. When the people began to live in settled communities, however, goitre began to develop. Indeed, Bengoa refers to the tradition that from the time of colonization practically everybody in Trujillo was goitrous, a fact which in those days marked out foreigners and people without goitre as rare individuals.

The intensity of the goitre endemic in several towns of the Republic is seen in the following tabulation, which shows the percentage rates among students examined in the year 1941.

Locality	*Goitre rate (%)*	*Locality*	*Goitre rate (%)*
La Grita	47	Pregonero	12
Guarico	28	Cuicas	11
Monte Carmelo	25	Tovar	5
Chejendé	18	Carvajal	2
Mérida	13	Campo Elías	2
Biscucuy	12	Mucuchies	1

These rates are for cases of *obvious* goitre. Bengoa,[83] from whose book the data are taken, says that only isolated cases of cretinism and deaf-mutism are encountered, and that the goitre problem in Venezuela as a whole does not have the same serious social significance as in some other South American countries. Nevertheless, he commends it to the notice of official public health authorities, with the recommendation that iodized salt should be introduced to diminish the present intensity of the condition.

A survey by the Instituto Nacional de Nutrición in 1951 revealed an average goitre rate of 10.46% among 71 796 schoolchildren examined (unpublished data). Radioiodine clearance studies have recently been carried out by Roche and his colleagues in two goitrous regions (Bailadores and Tabay) lying within the Venezuelan Andes.[84, 85]

Ecuador

From Colombia, the South American goitre zone passes southwards along the Cordillera into Ecuador, touching such centres as Quito, Cuenca and Loja.

More than 120 years ago, von Humboldt (1824) [78] and Boussingault (1833) [74] mention goitre as being endemic in Ecuador. In Llano Anciso a case was seen in which the swelling was 14 inches (36 cm) long and 8 inches (20 cm) across. Although this is exceptional, conditions predispose to the appearance of such phenomena. There are one or two areas, however, where goitre does not occur because the local sources of food salt are sufficiently rich in iodine.

In recent years the Ecuadorean goitre problem has been carefully studied by Sánchez & Paredes [88] and by Arcos.[87] The two former state that

most goitre is found in the central Andean spine running lengthwise through the middle of the country. The littoral zone to the west and the upper Amazonian area on the east side—both of which are comparatively low-lying—are less affected. They say that the native Indians and half-castes are most vulnerable to the disease because of their extreme poverty and poor nutritional status.

This coincides with the opinion of Arcos, who maintains that goitre persists in the rural areas of Ecuador, particularly in the narrow Andean valleys, owing to low standards of living and the lack of adequate medical and social services. Arcos confirms that the disease is very extensive in the Province of Cotopaxi (formerly called Léon), especially among Indian races. He thinks, too, that thyroid deficiency is the greatest single cause of decadence among these peoples.

Precise statistics are not available in respect of the Ecuadorean population; but it is believed that goitre affects both sexes equally. It is particularly evident at puberty and adolescence. Thyroid enlargement is also known to occur among domestic animals in Ecuador (Sánchez & Paredes [88]). Horses, pigs and lambs are affected.

Peru

Although goitre, cretinism and deaf-mutism have long been a burden on public health in Peru, only very recently have medical officials been able to convince the Government of the preventive possibilities in iodized salt and the need to make its use compulsory. The Ministry of Public Health in Peru has now organized a campaign for the prophylaxis of endemic goitre by means of salt iodized at the rate of 1 part of iodine in 10 000 parts of salt.

The location and intensity of the present-day endemic in Peru has been clearly defined by Salazar [95] in a series of maps, on which occurrence is plotted department by department. Most affected are those departments covering the central higher parts of the country. Moving from north to south, the following are the ten departments with the highest rates: Amazonas (28.79%), Cajamarca (3.63%), Libertad (6.38%), Ancash (14.36%), Huánuco (19.96%), Junin (5.09%), Huancavelica (8.77%), Ayacucho (4.28%), Apurímac (9.88%) and Cuzco (4.92%). Cases of goitre in the remaining 13 departments of the country occur in 2% of the population or less.

Burga,[90, 91] who is in charge of the Peruvian goitre campaign, has drawn special attention to the differences between goitre conditions in different parts of the Department of Amazonas. There, the goitre rate in low-lying areas—namely, 90%—is much greater than in the higher parts of the Department, and cretinism, mental deficiency and deaf-mutism are correspondingly serious. The drinking-water is from streams. In the highlands, on the other hand, Burga found a rate of 30%, mostly among adolescents.

Here the water-supply comes from wells. Goitre in newborn babies is common, and the disease is also seen in domestic animals, particularly dogs.

A feature mentioned by Monge [94] is the unusually large size of the goitres found in Urubamba Province near the town of Cuzco in the southern part of Peru. It appears, too, that toxic goitre (Basedow's syndrome) is not uncommon in this area.

Bolivia

Our knowledge of the distribution of goitre in Bolivia is due, in the main, to the modern investigations of Balcazar,[97] Fernández,[98] and Ibáñez.[99]

As with other South American republics, records of the Bolivian endemic are several centuries old. Following the Spanish conquest of the Incas early in the sixteenth century and the reorganization of the country as a dependency of the Viceroyalty of Peru, known politically as the Audiencia of Charcas, Viceroy Francisco de Toledo (1569-1581) sent a commission of " empiricists" from his seat of government at Sucre to Zudáñez, capital of the province of the same name in the Department of Chuquisaca, to cure the goitre there, so serious had it become.

Significant, too, is the fact that the Bolivian word for goitre, " coto ", has given rise to the place-name Cotoca, a township in Cercado Province, Department of Santa Cruz, in the east of the country. Similarly, in Tacuaremboti and in Tarija, where goitres are very abundant, the words " cotudos" and " cotos " are in common use to describe the peoples there.

Worthy perhaps of passing mention is the local belief in certain places in Bolivia that goitre co-exists with an abundance of alder trees which, so it is conjectured, absorb all iodine from the soil and render it iodine-deficient.

Exact numerical statistics are not available but, from his personal observations, Balcazar has assigned the following degrees of prevalence to eight of the nine departments of the country, arranged in order as nearly as possible from north to south. He says that over-all rates of 40% or more are not uncommon in some provinces.

Beni. Very abundant, especially in the Provinces of Cercado and Vaca Díez, and in parts of Itéñez.

Santa Cruz. Abundant. A rate of 17% among schoolchildren in the capital city. Many cases in the Provinces of Valle Grande, Chiquitos and Cordillera.

La Paz. Low incidence in the Yungas Provinces, but very prevalent in practically all the others. Very common in the peninsula of Copacabana (Lake Titicaca).

Cochabamba. Frequent in many provinces. Abundant in Independencia, the capital of Ayopaya Province. Grave foci in Pasorapa, Toyota and Emereque.

Oruro. Sporadic cases in several cantons.

Potosí. An extraordinary number in Millares. Many cases in Tacobamba, Ancoma and Potobanba. Grave foci in Condes and frequent cases in many other places.

Chuquisaca. Zudáñez Province is wholly goitrous. Many other places affected.

Tarija. Very prevalent. Main foci are in the capital and in the Provinces of Cercado, Méndez, Avilés, Arce and O'Connor.

The goitre problem in Bolivia is bound up with lack of education, poor housing, deficient nutrition, generally low standards of living and the prevalence of venereal disease, alcoholism and indulgence in coca.

The Bolivian Government plan to iodize all food salt used throughout the country and to ensure this end propose to create a salt monopoly.

Chile

Compared with other South American republics Chile is not a goitrous country, and, for this reason, studies on the problem are comparatively few. The most recent and most comprehensive surveys are those carried out by Donoso and his colleagues [103, 104] on 39 433 schoolchildren distributed over 287 schools in the six departments of the Province of Santiago. The over-all goitre rate was 11%; but, as Table IV shows, rates of 20%, 25% and 35% were the rule in some districts.

It seems that the disease prevailed to a considerable extent in the colonial era, but has largely declined with improved conditions and the advance of time. Romero [107] says that in Santiago during the sixteenth century a connexion existed between the prevalence of goitre among the aristocracy and the fact that they had their own private sources of highly purified drinking-water, whereas the poorer people obtained water from relatively impure public supplies. Fashionable painters of the time performed marvels in disguising the goitres of ladies who commissioned them to paint their portraits; elegance decreed the use of ribbons of black velvet around the neck and other aids to concealment. Some men, less concerned perhaps, allowed an unaesthetic and considerable tumour to show above the neckerchief.

Places considered to be mildly goitrous today lie in the area watered by the Aconcagua river, particularly around Los Andes and San Felipe. P. Martini (cited by Romero [107]) of Los Andes mentions having seen goitre on the mountain road through the Cordillera to Juncal in Argentina. Feferholtz & Ortiz [105] say that goitre is specially prevalent in Boco near Quillota, which is to the north-east of Valparaiso.

Farther south, cases are occasionally found along the valleys of the Maipo and Cachapoal rivers, and at La Punta, a settlement just north of

TABLE IV. PERCENTAGE OF THYROID ENLARGEMENT AMONG SCHOOLCHILDREN IN THE VARIOUS DISTRICTS OF THE SIX DEPARTMENTS OF THE PROVINCE OF SANTIAGO, CHILE

Department and district	Percentage with enlarged thyroid	Department and district	Percentage with enlarged thyroid
Santiago		**Talagante**	
Lampa	22	Isla de Maipo	15
Til-Til	25	Talagante	13
Quilicura	13	Peñaflor	5
Curacavi	36	**Maipo**	
Maipú	5	Paine	25
Florida	3	Buin	27
Renca	7	**San Antonio**	
Colina	25	Cartagena	0
Puente Alto	19	San Antonio	1
La Granja	23	Santo Domingo	13
Pirque	32	Navidad	11
San J. de Maipo	37	**San Bernardo**	
Conchali	10	Calera de Tango	21
San Miguel	4	San Bernardo	15
Cisterna	5	**Melipilla**	
Las Condes	10	El Monte	8
Quinta Normal	5	Melipilla	14
Nuñoa	0	Alhué	36
Providencia	6	Maria Pinto	13
Barrancas	12	San Pedro	3
Santiago	6		

Rancagua in O'Higgins Province (Cabello & Zúñiga; [101] Zúñiga [109]). In this neighbourhood, also, goitre has been noted at Doñihue. At Teno near Curico, Alvarez [100] records a series of 111 cases, of which only 2 were men. He also observed a number of cretins and dwarfs. There are no established foci of endemic goitre in the Concepción area. Suazo Figueroa [108] examined the reports of nearly 2500 biopsies and autopsies and found indications of the disease in only 45 persons (i.e., 1.8%), of whom 8 were men.

Other interesting Chilean contributions to goitre knowledge are those by Covarrubias,[102] who writes on the relation between the thyroid gland and pregnancy, and by Krebs,[106] who has studied the iodine content of soils and waters in relation to goitre prevalence in the Province of Santiago.

Argentina

Nowhere in the west of South America is goitre more widely diffused than in those provinces and territories of the Argentine Republic bordering the eastern slope of the Cordillera—namely, (from north to south) Jujuy, Salta, Tucumán, Catamarca, La Rioja, San Juan, Mendoza, Neuquén, Rio Negro, and Chubut. In this great 1500-mile strip of territory goitre has been known since the Spanish conquest and, according to the analytical researches of Mazzocco and Arias Aranda,[118, 119] and of De Salas & Amato,[113] is definitely traceable to iodine deficiency in the waters, soils and foods of the affected districts.

Towards the centre of the country goitre is endemic in the Provinces of San Luis and Córdoba; and a very high prevalence is found in the Territory of Formosa and the Provinces of Corrientes and Misiones, all of which are eastern areas adjoining Paraguay, Brazil and/or Uruguay.

The precise incidence in the various provinces and territories is not known; but some idea of the intensity may be gathered from surveys which have been carried out from time to time, particularly on schoolchildren. Thus, in some departments of Jujuy a goitre rate of 100% was observed by E. Sola (cited by De Salas & Amato [113]) in 1931. Later (1938), Lobo et al.[116] encountered 77 goitres in every 100 schoolchildren in the area of San Pedrito. Salta is no less goitrous. An examination of 1278 schoolchildren by Lewis [115] in 1924 revealed 87% in boys and 88% in girls. Lobo et al. found from 15% to 45% in Salta schools examined in 1938. In Tucumán rates of 65% in boys and 60% in girls have been recorded by Lewis, and the 1938 survey (Lobo et al.[116]) disclosed an average rate of 23% for the whole province, with a maximum figure of 33.5% in Chicligasta. Recent statistics (1939-45) [114] for Catamarca record a rate of 100% in a school at Andalgalá; and Lobo and his colleagues found 32.68% of goitre in 1500 children examined in La Rioja schools.

According to a 1937 census of schools in 16 different places in Mendoza,[113] goitre rates varied from 28% to 88% among young children, the average rate being 43.5%. In subsequent studies (1940), Perinetti and collaborators[123] found 24150 cases of thyroid enlargement among 52548 children examined (i.e., 46%). Of these, 60% were palpable goitres, 36% visible, and 4% nodular. Data of a similar kind are available for the Territory of Formosa and the Provinces of Corrientes and Misiones, in all of which goitre frequencies of the order of 50% and above are found among children of school age.[110, 120, 121, 125]

An iodine therapy campaign was launched in the northern provinces of Argentina in 1924 and again in 1938, control being exercised through physicians and teachers. Tablets containing 5 mg of iodine were distributed by the Public Health Service and iodized sweets were also used. Excellent results were obtained, but on the basis of this experience it was decided that

if tablets are adopted as the prophylactic iodine vehicle, it is preferable to issue them in 10-mg iodine strength. These may be given with safety even to quite small children. No cases of intolerance were encountered.

The Argentine Government is now tackling the goitre problem on a broader basis, and strong moves are being made towards the general introduction of iodized salt in all the seriously affected zones. Indeed, a law has already been passed making this practice compulsory in the Province of Mendoza.

Official concern is also reflected in the recent foundation of a Goitre Institute in the Faculty of Medicine at the University of Cuyo, Mendoza, under the direction of Dr H. Perinetti. Here, important field and laboratory studies of iodine-deficiency goitre have been carried out by Argentinian scientists, in collaboration with a team of experts from the famous Boston school of thyroidologists. The expedition, led by J. B. Stanbury of the thyroid clinic of the Massachusetts General Hospital, demonstrated by means of radioactive iodine the great avidity of the thyroid of goitrous Argentinian patients for artificially administered iodide.[126-128] This uptake is related to the degree of iodine deficiency and is inversely proportional to the amount of iodine excreted in the urine. Attention was focused mainly on people below the age of 35 years, all of whom had goitres; usually these were diffuse, but a few were multinodular and of great size.

Goitre literature pertaining to Argentina is extensive. In addition to the sources already cited, papers by the following authors have been consulted in preparing the foregoing summary: De La Barrera,[112] Bustos,[111] Maccarini,[117] Romero,[124] and Perinetti.[122]

Paraguay

Goitre is extensive in the mountainous districts of Paraguay and has been a public health problem for many years. It is recorded by Burton [129] that at one time there was goitre in almost every home in Asunción.

Under the auspices of the Servicio Cooperativo Interamericano de Salud Pública, the present frequency of goitre in Paraguay has been determined from a study of recent hospital statistics and by the clinical examination of more than 44 000 children between the ages of 6 and 16 years in towns covering the most densely populated areas of the country.[130, 132, 133]

Peña [132] and Isasi Fleitas,[130] the two doctors chiefly responsible, found an average rate of 23.5% among children, the frequency in girls being four times that in boys. Children of families in comfortable circumstances were less affected than those from working-class homes. The hospital records show that the great majority of persons admitted for operative treatment were between the ages of 16 and 45 years.

In view of the prevalence of goitre more or less throughout the whole country, and the frequency of complications such as myxoedema and

cretinism, iodized salt is officially recommended not only for children and pregnant women, but also for domestic animals in the endemic zone. During the three years 1946-48 tablets of Oridine, each containing 10 mg of iodine, were administered to children in four schools at the rate of one tablet per head weekly for about 20 weeks in each year. Before treatment the goitre rate was 26.1%; at the end of the first year's treatment it was 16.7%; by the end of the second year it had fallen to 8.2%, and at the end of the third year it was down to 4.8%.[130]

Uruguay

A searching inquiry in 1935 led Pérez Fontana, Bennati & Volonterio [136] to conclude that goitre is not seriously endemic in Uruguay. Subsequent studies by Proto [137] and by Bauza [134] and Bauza, Cerviño & Salveraglio [135] suggest, however, that certain areas are suspect and that the existence of a mildly goitrous zone must be acknowledged in the Departments of Salto, Tacuarembó and Rivera towards the north of the country.

Elsewhere, sporadic occurrences have been noted in various places; for example, in the Departments of Lavalleja, Rocha and Cerro Largo to the east and north-east of the country, and in the Department of Colonia on the west side.

Thyroid enlargement accompanied by mental retardation among children in certain schools in the Department of Rivera (e.g., at Sauzal) has obliged the local education authorities to prolong the period of a child's attendance at school.

There does not appear to be any absolute deficiency of iodine in the soils and waters of Uruguay. Likewise, the thyroid glands of human subjects, cattle and dogs, examined *post mortem*, show a normal iodine content. It seems, therefore, that the cause of goitre in Uruguay must be sought in some goitrogenic factor in food which is responsible for creating a relative deficiency of iodine.

Determinations of the calcium content of normal and pathological human thyroid glands by Pérez Fontana and his colleagues [136] showed that hyperthyroid glands had a low calcium content, whereas the calcium in hypothyroid glands was considerably augmented. There were insufficient data to establish a correlation between the amount of calcium in drinking-water and foods and the content of calcium in the thyroid.

Brazil

Endemic goitre is a problem of considerable magnitude in parts of Brazil. The areas more especially affected are the southern States of Rio Grande, Santa Catarina, Paraná and São Paulo, the south-eastern States of Rio de Janeiro and Minas Gerais, and the great central and western

States of Goiás and Mato Grosso. As the north-eastern part of the country—the States of Pernambuco and Maranhão and the regions around the mouths of the Amazon—does not feature in the goitre literature of Brazil, we may assume that the disease is non-existent there or is of little significance.

Rio de Janeiro

So great is the intensity of the endemic in the interior of the State of Rio de Janeiro that nearly all the inhabitants are affected and any person without goitre is regarded as abnormal. In 1944, out of every 1000 persons examined and treated by the Serviço de Endocrinología e Policlinica General, there were 387 with disorders of the thyroid gland (Peregrino [156]).

Minas Gerais

The goitrous districts of Minas Gerais lie from 100 to 200 miles due north of Rio de Janeiro at Barbacena, Ouro Prêto, Sabará, Congonhas and Conselheiro Lafaiete. The endemic presents a complex of symptoms similar to that described in other grossly affected areas—goitre, cretinism, deaf-mutism and mental debility. Chemical examination of the local water-supply and vegetable foods clearly proves that the country is deficient in iodine.

Dr Lobo Leite,[150-153] who is the recognized goitre authority in this area, found an average rate of 44% in the town of Lafaiete (Queluz) and surrounding rural districts. With the co-operation of school officials he established a prophylactic centre for the purpose of distributing iodized chocolate to the schoolchildren twice a week. A rate of 44% at the beginning of the scheme in 1940 had by 1942 declined to 27%. These two years of iodine prophylaxis also had the effect of greatly improving the mental alertness of the children. Many obtained higher marks and a larger number were promoted than before the iodine treatment was introduced. The preventive dose was ten times greater than the calculated need, but there were no harmful results.

Additional evidence of the goitre rate among the general population in Minas Gerais is provided by De Paula [147] and also by Pinto Viegas,[157] who found 252 records of thyroid disease among the case-sheets of 2500 miscellaneous patients in a doctor's private practice—a rate of 10%.

São Paulo

An extensive study of endemic goitre among infants, schoolchildren and college students in different parts of the State of São Paulo has been made by Dr Arruda Sampaio.[138-142] Between 1940 and 1947 he examined more than 22 000 individuals and found rates of from 5% to 10% in littoral districts gradually increasing as he passed up through the valley of the Parahíba river into the highlands of the interior, where rates of 60%, 70% and even 90% were encountered along the Serra da Mantiqueira,

which dominates the hinterland between the towns of São Paulo and Rio de Janeiro.

Goitre here is of the simple type. Its prevalence increases with age in zones which have an average or low proportion, being about 20% higher in children between the ages of 12 and 15 years than in those between 8 and 10 years. In heavily affected zones the goitre rate reaches a maximum even at pre-school age. Arruda Sampaio [142] mentions foci of endemic cretinism in the areas of his study and also refers to a case of almost total colour-blindness in a goitrous patient which successfully responded to iodine treatment.

Another considerable goitre centre in São Paulo lies 50 to 100 miles north-west of the capital and comprises the inland towns of Campinas, Botucatú, Pirambóia and Anhembí. Here, a goitre inquiry has been made by Dr A. Lyra and Dr A. De Melo e Albuquerque [154] on behalf of the Diretoria do Serviço do Interior. They examined 850 boys and 712 girls from 5 schools in this region and found an average rate of 38.58% among boys and 44.80% among girls. In a later publication, De Melo e Albuquerque [146] refers to a rate of 70.6% among 3030 children examined by him at Campinas.

Goiás and Mato Grosso.

Towns especially affected with goitre in the interior of these states are Natividade, Conceicão, Arrayas, Goiás, Goiânia, and Cuiabá in the far west. Silva & Borges [158] examined about half the children and young students regularly attending public and private educational establishments in the urban and rural zones of Cuiabá, Goiânia and Goiás—in all, 6803 persons of ages ranging from 7 to 21 years. The prevalence was very high in all three zones, being 72% in Cuiabá, 66.6% in Goiânia and 81% in Goiás. The rates were higher among coloured than among white children, in girls than in boys, in the country than in the towns, in public than in private schools, and in lower than in upper economic groups.

Paraná, Santa Catarina and Rio Grande do Sul

Nearly twenty years ago Duarte Nunes [148] reported that physical incapacity due to thyroid insufficiency was of frequent occurrence among army recruits examined by him in the military hospital at Curitiba. Men with goitres were indolent, lazy and easily tired. After physical effort, tremor of the limbs was a marked feature. For these reasons Duarte Nunes recommended that anyone suffering from goitre be excluded from the Brazilian army.

This matter has recently (1955) been re-examined in great detail by Paes de Oliveira et al.[155] Inspection of more than 120 000 young men of military age (19-20 years) drawn from nearly 200 municipalities in the States of Paraná, Santa Catarina and Rio Grande do Sul revealed that from

50% to 80% of recruits were rejected for service on account of ill-health and physical disability. Among the causes of rejection goitre stands high, rates of 25% being common in the upland areas of southern Brazil.

Northern Europe

Iceland

Endemic goitre does not occur in any part of Iceland, nor has it ever been known to have occurred there; goitre in schoolchildren has never been detected and even sporadic cases of simple goitre are rare. But hyperthyroidism, including exophthalmic goitre, appears to be relatively frequent (Sigurjónsson [159-161]). In short, whenever diffuse goitrous enlargement of the thyroid does occur in Iceland it is almost always accompanied by thyrotoxicosis. Thus, of 50 diffuse goitres examined by Sigurjónsson, 38 were associated with Graves'-Basedow's disease, 10 were cases of simple hyperthroidism, and only 2 were considered to be without definite symptoms of thyrotoxicosis.

The absence of simple iodine-deficiency goitre in Iceland is undoubtedly due to the fact that the iodine intake of the population is high because of the large consumption of fish and fish products. This leads to an unusually high concentration of iodine in the thyroid and is the reason why in Iceland the human thyroid is exceptionally small.

In the adult Icelandic male the average thyroid weight is about 14 g and in the female, 11.6 g. This is about half the accepted normal weight (25 g) of the non-goitrous thyroid in other countries. Correspondingly, the average iodine content per gram of dry substance is 4.01 mg in glands from males and 3.43 mg in those from females. This is double the average iodine content (2 mg per gram of dry substance) of normal glands from other non-goitrous countries. It is clear, therefore, that the *total* amount of iodine in Icelandic thyroids is more or less the same as that found in normal thyroid glands elsewhere, namely, from 8 mg to 12 mg.

Finland

Wahlberg [173-175] distinguishes four goitre belts in Finland extending northwards from the coast of the Gulf of Finland into the central part of the country which has the most lakes. The most easterly of these belts starts in the neighbourhood of Viipuri and continues north-eastwards around Lake Ladoga and across the Karelian Isthmus. Farther west, the second belt runs northwards from Miehikkälä (St.-Michel) towards Jäppilä. The third region lies immediately east of Lake Päijänne and the fourth west of it, Lake Päijänne thus intervening between these two goitrous areas. Only the coast of the Gulf of Bothnia and the south-western part of the country lie outside the endemic zone.

On the basis of statistics obtained from the medical examination of military conscripts over a period of ten years, Wahlberg concludes that incidence depends on geological conditions. The above-mentioned four belts of high frequency are in that part of the country which was not submerged at the end of the Ice Age—areas which, compared with others, have a higher calcium and lower iodine content of soils and waters.

The prevalence of goitre in Finland in relation to environmental iodine supply has been investigated by Adlercreutz,[162, 163] by Virtanen & Virtanen,[172] and by Vilkki.[171] Adlercreutz analysed a total of 74 samples of water from 60 different places in Finland and reached the conclusion that, generally speaking, there is a positive correlation between the occurrence of goitre and a low iodine content of water. He found several exceptions, however, notably at Veteli, a town in the Department of Vaasa, where a water supply containing little iodine serves both a definite goitre area and its non-goitrous surroundings, and at Värtsila, where goitre is associated with a water of high iodine content.

The daily iodine intake from food and the urinary iodine excretion of men, women and girls from goitrous and non-goitrous rural areas have been compared by A. I. Virtanen and E. Virtanen, thus:

	Goitrous area			*Non-goitrous area*		
	men	*women*	*girls*	*men*	*women*	*girls*
Total iodine in daily diet (μg) . .	53	56	52	68	62	70
Urinary iodine (μg per litre) . . .	20.3	21.7	20.0	26.3	24.0	27.0

The recent study by Vilkki [171] deals with the iodine content of foods generally consumed in Finland and, in particular, with the iodine content of milk from two contrasted areas—namely, Turku, where the goitre rate is comparatively low, and Kuopio, where the rate is distinctly above the average for the country. Milk consumed in the Kuopio area, where goitre is prevalent, contains approximately 40% less iodine than milk from Turku, where the prevalence is low. The average iodine intake per person per day from all food sources is about 50 μg in the high goitre area and about 70μg in the area of low prevalence. Thus, the mean iodine supply in Finland is considerably below the minimum level of 100 μg per head per day recommended by the World Health Organization.

On the question of the actual incidence of goitre in Finland, Wahlberg records that the endemic is responsible for 2000 operative cases annually out of a population of 3½ million. These account for 30 000 days of hospital attendance and give rise to numerous cases of chronic heart disease. For the purpose of assessing the goitre situation in Finland, 1000 consecutive parturients and their 1015 children (15 twin pregnancies) were examined by Hiilesmaa [164] in the First and Second Women's Clinics at the University of Helsinki. Enlarged thyroids were found in 141 of these 1000 women; but if one includes the cases in which nodules (adenomata) were detected

in non-enlarged thyroids, then the percentage of abnormal thyroids in this series of mothers rises from 14.1 to 28.4, as the following tabulation shows:

	Number of cases	*Number with nodules*	*Number without nodules*
With goitre . . .	141	91	50
Without goitre . .	859	143	716
Total examined .	1000	234	766

The high incidence of thyroid nodules is considered one of the chief characteristics of endemic goitre in Finland. Of the 1015 infants born to these 1000 women, 139 were found to have goitre.

Iodine deficiency in animals is frequently encountered in Finland. R. Moberg (personal communication, 1949) says that the deficiency is so acute in the Karkkila district that saucers containing alcoholic tincture of iodine are customarily placed under the rafters of stables and cow-houses—a practice which is claimed to yield especially good results in overcoming reproductive failures.

Goitre prevention by means of iodized salt is strongly advocated throughout the whole of Finland by Wahlberg, Uotila & Turpeinen;[176] but if this is not immediately practicable it should certainly be applied at once in the most seriously affected areas—namely, Tavastehus, Viborg, St.-Michel and Kuopio.

Sweden

The distribution of goitre in Sweden has been clearly defined by the exhaustive studies of Dr J. A. Höjer.[177-181] From Västernorrland and the northern and eastern parts of Jämtland the goitre belt extends southwards through practically the whole of Gävleborg and all Kopparberg, except the north-western tip, into Värmland, Västmanland and the northern part of Östergötland. The southern goitre area extends from the Östergötland plain into the Counties of Jönköping, Kalmar and part of Kronoberg.

Goitre-free or almost goitre-free areas are the plains of Skåne, Halland and Västergotland, the district of Bohuslän and the plain of Dal, as well as the slopes of the tableland lying south-west of the city of Jönköping. The most northerly part of Norrland and the islands of Öland and Gotland in the Baltic are also goitre-free.

Höjer and his survey team examined 29 000 people in 180 different places and found that, in the most severely goitrous areas, the goitre rate averages about 25%; but that there are many places where 15% of the population are affected. They concluded that in all Sweden there must be not less than 300 000 people with goitre.

An interesting feature of Höjer's investigation is the way in which he has been able to correlate goitre occurrence with the topographical lie of

the land. His fullest account [179] contains many explanatory sketches and diagrams showing the kind of terrain in which goitre is most likely to be found. Deep valleys with overhanging mountains, and areas at the foot of large slopes, are notorious goitre grounds. Plains and high plateaux are less affected.

In so far as Norrland rivers are concerned, Höjer confirms McCarrison's thesis that goitre frequency gradually increases along a river valley as one passes from the source of the river to its mouth. These north Swedish rivers rise in goitre-free regions, pass through areas of sporadic occurrence and eventually flow into lands of considerable goitre intensity. In south Sweden, however, matters are quite the reverse. It is true that the Emån river runs from end to end entirely through endemic goitre areas, but, in the case of the Svartån and Stångån rivers, goitre is more prevalent in the upper reaches than in the lower. Similarly, rivers in the County of Blekinge, and those of Halland, flow from goitre areas into districts almost goitre-free.

According to Höjer's observations, wherever the prevalence of human goitre in Sweden is high, say, from 15% to 30%, one may almost certainly expect to find goitre among domestic animals—horses, cows, sheep, dogs, and cats. Where goitre is of sporadic occurrence Höjer occasionally saw domestic animals affected, but in goitre-free districts he never found any goitrous animals.

Toxic goitre is not unknown in Sweden. As might be expected, its distribution closely corresponds to that of simple endemic goitre (Sällström [182]). This is in accord with experience in many other countries. As regards cretinism, Höjer found about one case among every hundred persons in districts where goitre is endemic. A special study carried out in southern Sweden on the extent of mental deficiency in districts with varying degrees of goitre shows that mental deficiency increases with increasing prevalence of goitre.

Prevention of goitre by iodized salt is officially recommended in Sweden and instructions on how to obtain and use the salt have been circulated by the Royal Medical Department to all public health administrations and municipal medical officers.

Norway

The most goitrous districts of Norway are found in a belt extending from the interior of Telemark County north-eastward for about 120 miles into Hedmark County where the country around Lake Mjösa is particularly affected.

Kjløstad,[185] in a survey carried out in 1921, found a great deal of goitre among schoolchildren in towns in central Telemark. In some places the rate was 80%, 90% or even 100%. Typical percentages, for girls and boys

respectively, were: Bø, 45 and 55; Sanda, 74 and 96; Brunkeberg, 38 and 25; Flatdal, 55 and 44; Krokan, 29 and 80; Sandnes, 56 and 42; Utbøen, 45 and 57. It is interesting that in several of these places the goitre rate was higher in boys than in girls; but the over-all figures for 537 girls and 510 boys in the Holla, Lunde, Bø, Seljord and Kviteseid areas were 57.5% in girls and 55.8% in boys.

Studies by Nicolaysen [189, 190] and by Lunde [186-188] refer to goitre among schoolchildren in towns bordering the Oslo Fjord and in the neighbouring area of Sandsvaer just south of Kongsberg. At Vittingfoss, for example, the rate was 55%, at Berg 38%, and at Komnes 40%. Considerably farther north, Nicolaysen found goitre in isolated districts throughout Gudbrandsdal in Opland and Österdal in Hedmark.

On the west coast of Norway cretinism occurs in the area immediately north of Bergen and south of the Sogn Fjord (Skaar [192]). North of the Sogn Fjord the prevalence in relation to environmental iodine supply has been studied by Iversen, Lunde & Wülfert.[184] At the isolated village of Veitestranden in Sogn 70% of the 500 inhabitants were found to be goitrous. Not far distant, the district of Vik in Sogn is goitre-free.

More recently, Devold & Closs [183] carried out a goitre survey in the district of Forsand near Stavanger. In this area goitre prevalence and thyroid size increased with distance from the sea, from 19.8% in men and 29.9% in women in the group nearest the sea to 35.9% in men and 62.8% in women in the group farthest up the valley. Noteworthy was the finding that consumption of fish by the people decreased as distance from the sea increased.

Denmark

The older literature repeatedly states that Denmark is free from endemic goitre. More recently, however, it has been shown that certain parts of the country have localized accumulations of goitre cases, not severe perhaps, but sufficiently noticeable to warrant medical attention and the need for preventive action. Thus, in 1933 Dalsgaard-Nielsen [194] discovered a comparatively large number of goitres in Bedsted-Lø a small parish in South Jutland lying between Aabenraa and Løgum Kloster. On more closely examining 40 unselected goitres in this area he found [195] that 23 were hyperthyroid, 6 were hypothyroid and 11 did not show any special characteristics.

The goitre problem in Denmark was subsequently elucidated more thoroughly in a comprehensive monograph by Rosenquist.[199] who investigated the endemic area along the river Gudenaa between Silkeborg and Randers, particularly the district at Gern and Svostrup. He compared the prevalence at these places with that in the goitre-free district of Snejbjerg some 30 miles farther west. The percentage prevalence was as follows:

	Males	*Females*
Snejbjerg (goitre-free) . . .	0.8	5.5
Gern (goitrous)	5.7	18.4
Svostrup (goitrous)	12.2	30.2

In the two goitre districts (Gern and Svostrup) a total of 2433 persons were examined of whom 363, or 14.9%, were goitrous. Forty-six, or 12.7%, of these 363 goitrous people showed symptoms suggestive of toxic goitre.

Meulengracht [198] and Iversen [196, 197] have shown that thyrotoxicosis increased noticeably in Denmark during the Second World War. Meulengracht's evidence, derived from records of hospital admissions, shows that a gradual rise in the number of cases of thyrotoxicosis during the period 1933-41 was followed by a sudden upward jump in 1942. The number of cases seen in his own clinic rose from 34 in 1941 to 118 in 1942. Meulengracht considered possible statistical fallacies in the returns, but concluded that both the steady rise between 1933 and 1941 and the abrupt increase in 1942 were real phenomena, though probably independent. He could not find any explanation for the rise; the 1942 " epidemic " could not be ascribed to the emotional disturbances of war, because in the histories of his patients he could find no abnormal occurrence of mental crises. Furthermore, there was apparently no corresponding increase in thyrotoxicosis in neighbouring countries involved in the war.

Iversen,[196, 197] who greatly amplified and extended Meulengracht's original observations and brought the matter up to 1947, confirms that the wartime increase in thyrotoxicosis in Denmark was a real one and not simply the result of better diagnosis. His figures relating to the city of Copenhagen are given in the tabulation below. They reveal a slow increase in incidence from 1938 to 1941, a sharp rise beginning in 1942 and reaching a peak in 1943-44, and a falling-off to 1947, when the rate was practically the same as in 1939-40.

Year	*Cases per 100 000 of population*
1938	19
1939	23
1940	23
1941	34
1942	77
1943	84
1944	83
1945	52
1946	31
1947	21

The psychological effects of the German occupation are not held responsible for the sudden change in prevalence because the behaviour of the invaders during 1941, when the rise in thyrotoxicosis began, was comparatively

mild and there was no further rise in 1944, when conditions became much more exacting. Moreover, during the same period, the incidence and severity of toxic goitre tended to decrease in Belgium and the Netherlands, while in Norway a small increase in incidence during the early stages of the German occupation was followed by a fall.

Iversen points out that wartime changes in diet may have played some part and in this connexion puts forward the following interesting theory, although without proof. Before the war large quantities of soya-bean-oil meal were imported into Denmark for feeding cattle. These imports were greatly reduced in 1940 and ceased entirely in 1941 and subsequent years. Soya bean is well known to contain an anti-thyroid factor which, when soya is normally used as cattle-feed, might find its way into cow's milk and thus supply the human population with sufficient anti-thyroid factor to keep down the incidence of thyrotoxicosis. If this is true, cases of thyrotoxicosis would tend to increase in number when, as in wartime, the supply of soya bean with its content of anti-thyroid factor was cut off.

These speculations find some support from what in fact were the very opposite experiences of Belgium during the war. Here, not only was there no increase in the absolute number of cases of toxic goitre, but the severity of existing cases appeared to decline. Side by side with this was an increase in the incidence of simple goitre. In explanation of these phenomena, Bastenie,[193] who made the observations, points out that during the war the Belgian people tended to eat more and more vegetables of the *Brassica* genus—cabbage, kale and the like—which contain anti-thyroid substances. If the increased simple goitre in Belgium was in fact of the " cabbage " goitre type, then a reduction in severity might be expected in cases of toxic goitre on the same diet. The opposite effects might therefore be expected if anti-thyroid compounds were withdrawn from the diet. Such, it is postulated, was the case in Denmark during the war.

Estonian SSR, Latvian SSR and Lithuanian SSR

There does not appear to be much goitre in the former Baltic States. Adelheim's data for Estonian schoolchildren are quoted by McClendon [202] and show a goitre rate of less than 0.5% in the four districts Hapsalu, Tallinn, Rakwere (Wesenberg) and Paide (Weissenstein). A later survey by Ucke [203] confirmed that there is little goitre in Estonia.

Goitre occurs in some districts of Latvia. The iodine content of Latvian waters in relation to the distribution of goitre has been studied by Kupzis.[200, 201] In general, where the disease is known to be absent or infrequent, as at Kemeri, Mitau, Silupe, Riga and the surrounding coastal districts, Liepaja in the west, and Wolmar in the north, waters contain between 2 μg and 15 μg of iodine per litre. In contrast, iodine contents of 0.1 μg to 2 μg are found in areas farther inland where goitre is of common occur-

rence—namely, Zesvaine, Madona and Priekule. There do not appear to be any goitre data referring to Lithuania.

Netherlands

The first reliable goitre statistics from the Netherlands were those of Brand,[206] for whom the war of 1914-18 provided an opportunity to examine 46 975 mobilized servicemen from all parts of the country. He found that 10% of men from the Rhine-Maas area in the centre of the country had goitre, whereas only 1.4% of those from the Province of Groningen in the north were affected.

Subsequently (1924), the Central Board of Health of the Netherlands Government set up a special commission to study the goitre problem in greater detail and to advise on appropriate measures to remedy a situation which had apparently been getting gradually worse during the previous 25 years. This commission—composed of clinical men, chemists, pathologists, bacteriologists and other experts—reported in 1932 on the examination of 34 000 children and adults in schools and factories.[209]

These new statistics for the most part confirmed Brand's distribution data of 15 years earlier and, as a result, a very detailed goitre map of the Netherlands has been made. Broadly speaking, the eastern, central and southern parts of the country are prone to be goitrous, whereas the western and northern regions are almost free from the disease.

Immediately to the east of the Zuider Zee a considerable incidence has been found in such places as Wolvega, Steenwijk, Hoogeveen, Meppel and Kampen. At the south end of the Zee goitre occurs among the people of Harderwijk, Hilversum, Bussum, Naarden and Weesp. Towards the eastern frontier the incidence is liable to be high in Emmen, Koevorden, Almelo, Enschede, Diepenheim, Boekelo, Winterswijk, Aalten and Doetinchem. Centrally, high figures were found among schoolchildren in the Betuwe (" river " area) at Tiel, Wamel and Leeuwen, and at Hoven, Arnhem, Ede, Renkum and, particularly, Kuilenburg, Gorinchem, the Krimpen area and Breda. In the extreme south and south-east of the country the survey revealed goitre in Roermond, Eindhoven, Roosendaal and Bergen op Zoom; and on the western seaboard it has been found at Hillegom, Lisse, Sassenheim, Noordwijk and Warmond.

Places which are goitre-free, or have a negligible prevalence, are Assen and Groningen in the north, Zutphen in Gelderland, and Gouda and Barendrecht in the western part of the country. In a recent nutrition survey of Ijsselmonde, goitre was encountered occasionally by Kaayk.[210]

An interesting study of goitre in the south-east corner of Friesland has been made by Pasma.[211-213] He refers particularly to the municipality of Oststellingwerf, where 40% of the children were found to have thyroid enlargement. In the same area goitre is common at Weststellingwerf and among

very young children at Wolvega. Pasma observed that the intellectual level of the affected children was much below those who were goitre-free. Conditions in south-east Friesland are in marked contrast to those in north-west Friesland, which is entirely non-goitrous.

As part of the work of the Goitre Commission, Dr J. F. Reith, of the State Institute of Public Health at Utrecht, carried out a large number of analytical studies which prove conclusively that deficiency of iodine in the drinking-water is the cause of goitre in the Netherlands.[209, 214] The inverse relationship between the goitre rate and the iodine content of drinking-water is clearly seen in the tabulation below, which shows the percentage of goitre found among schoolchildren in various towns and the content of iodine in the water.[209]

	Goitre rate (%)	*Iodine in water (μg per litre)*		*Goitre rate (%)*	*Iodine in water (μg per litre)*
Hoogeveen	66	3.6	Harderwijk	45	2.3
Renkum	58	1.3	Doetinchem	44	2.4
Roosendaal	55	1.5	Kampen	41	0.9
Alemlo	53	3.0	Steenwijk	36	1.1
Gorinchem	52	3.0	Bergen op Zoom	31	1.1
Arnhem	50	1.0	Meppel	27	1.1
Kuilenburg	50	1.6	Zutphen	9	36.3
Ede	48	2.5	Gouda	6	69.8
Breda	47	1.7	Barendrecht	0	89.2

On the basis of their investigations the Goitre Commission reached the conclusion that, on an average, the daily intake of iodine from food and water was deficient by 80 μg per head of population. Accordingly they recommended that drinking-water in goitre regions should be fortified with potassium iodide so that each individual would receive approximately 80 μg of additional iodine per day. The *per caput* consumption of tap-water in prepared food and for drinking purposes was estimated to be 1.5 litres daily. It was therefore decided to raise the iodine content of tap-water by 50 μg per litre.

The iodizing installation used by the municipal water departments consisted of a glazed-stone mixing-vessel in which 100 litres of a 0.5% or 1% solution of potassium iodide was prepared. The addition of this stock solution to the main reservoir was achieved by means of a regulated dropping-needle, and the raised iodine content was checked by periodical analyses.

The Netherlands is the only country where goitre prophylaxis by iodized water has been successfully applied for any length of time on a large scale. In the hands of the Netherlands authorities the method has yielded results which compare favourably with those achieved in other countries by iodized salt. For example, at Kuilenburg a rate of 40% among children in 1931 had declined to 18% by 1937, to 14% by 1939 and to 4% by 1941.

Unhappily, plans to set up additional installations to supply iodine-rich tap-water throughout the country had to be abandoned on account of the 1939-45 war. Indeed, the Germans stopped this form of prophylaxis entirely and it has never been re-introduced. As an alternative, the public health authorities advocated that all salt used for making bread be iodized in those municipalities which had previously applied the iodized-water method of prophylaxis. Accordingly, a decree came into force in 1942 making it compulsory for bakers in those particular munipalities to use only iodized salt—the so-called " Jobrozo ". Writing in 1952, De Josselin de Jong [207] states that Jobrozo (which contains 1 part of iodine in 33 000 parts) is now used compulsorily for bread-making in 260 communities. Originally Jobrozo was somewhat more expensive than common salt; but the Royal Netherlands Salt Industry now produces it at the same cost. The results of this method of preventing goitre in the Netherlands have recently been described by Hipsley,[208] who has introduced the method in Australia.

While officially controlled prophylaxis, first with iodized tap-water and later with bread salt, was gradually being applied town by town, a lively public awareness of the goitre problem became evident, and places not at once covered by the official measures began to introduce various uncontrolled prophylactic procedures of their own. To regularize these independent activities the Royal Netherlands Salt Industry put on the market an iodized salt, called " Jozo ", for general use. This contains 1 part of potassium iodide in 200 000 parts of salt, and between 1932 and 1951 its production rose from 520 000 kg to 10 million kg.

The Netherlands goitre campaign is a model of what can be done with determination and efficient management to rid a country of this disease. Within 20 years the youngest generation—children below 5 years of age—has been freed from the menace of goitre; serious cases are no longer observed among adults; the prevalence of moderate thyroid enlargement is decreasing steadily; and no harmful consequences of iodine prophylaxis have been reported (De Josselin de Jong [207]).

This account of goitre in the Netherlands would be incomplete without mention of the recent investigations of Binnerts,[204, 205] who, building upon the earlier studies of Brouwer and Wiertz, has clearly shown that as one passes from severely goitrous areas through mildly goitrous areas to regions where there is no goitre, there is a corresponding rise in the iodine content of the cow's milk collected.

Eastern Europe

Poland

Practically the whole of the south of Poland is goitrous. The disease occurs with high intensity in the Voivodship of Kraków, in Lower Silesia,

and all along the northern slopes of the Carpathian Mountains westward into Sudetenland. In these parts the goitre rate is always about 10% and in some localities—notably in the Myślenice and Nowy Sacz districts of Kraków Voivodship—rises to 40% or even 60% (Tubiasz;[222-224] Nowakowski [221]).

Goitre is also endemic in central and eastern Poland, in such places as Poznań, Zielona Góra, Krotoszyn, Leszno, Kalisz, Łódź, Warsaw, Kielce and Lublin. Here, the prevalence, although significant, is somewhat lower than in the south, being 13% in districts around Poznań and 21% to 28% at Krotoszyn (Czyżewski & Falkiewicz [216]).

There are no published data from the north of the country, but surveys are now in progress at Gdańsk, Sopot and Gdynia on the Gulf of Danzig and at Koszalin in the north-west.

Before the 1939-45 war a National Goitre Committee was established to collect statistical data and to apply prevention by iodized salt—a measure introduced in the Voivodship of Kraków on 1 January 1935. The results of this committee's work, available in papers by Tubiasz [224] and Heller,[219] show that an average rate of 17.6% of goitre among military recruits in Kraków Voivodship over the five years prior to salt iodization was reduced to 2% by 1938, that is, after three years of iodized-salt prophylaxis. This rapid and marked decrease in the goitre rate occurred with a salt iodized at a level of 1 in 200 000 and only in districts where the salt was employed. It was not observed elsewhere.

Post-war investigations have established that the distribution of goitre in Poland corresponds in general with that prevailing before the war, but the degree of intensity of the disease has worsened. The endemic is severest in the south, and individuals who have left goitre-free districts to come to live in Lower Silesia are known to develop goitre there. It appears, too, that a hitherto unknown endemic focus of considerable intensity exists in the region of Poznań. According to Heller,[220] the rise in goitre incidence in Central Europe (a similar increase has been found in Germany) was to be expected owing to quantitative and qualitative defects of diet during the war. He also attributes the rise to changes in fertilizer practice. In former times Chilean nitrate of soda, which contains a significant proportion of iodine, was extensively used in Poland; it has now been superseded by synthetic nitrogen fertilizers containing no iodine. Another contributory factor is said to be the cessation of kelp-burning for iodine on the coast of Brittany. Considerable volumes of iodine vapour from this source were carried inland by the prevailing winds, and Heller estimates that at one time about 14 tons of atmospheric iodine annually fell in rain on to Central European soils. The validity of this supposition is fully discussed in the *Geochemistry of Iodine*.[215]

The increased post-war severity of the disease has prompted the Ministry of Health to institute a preventive campaign on a national scale, and

provincial goitre committees have been set up in Kraków, Lublin, Poznań, Warsaw, Katowice, Rzeszówa and Kielce, with the duty of mapping the extent of goitre in Poland and organizing the distribution of iodized salt. Iodized salt was re-instituted in the Voivodship of Kraków in 1946 and was introduced for the first time in that of Wrocław in 1949.

To make it possible for just comparisons to be made of results from different districts, the Ministry of Health have recommended the adoption throughout Poland of a uniform scale for measuring the degrees of goitre. A modification of the classification of Nowakowski is favoured—namely, group 1, in which the enlargement is less than half the size of the fist of the person examined; group 2, visible thyroid enlargement equal to half the size of the individual's fist; group 3, enlargement equal to the size of the individual's fist; group 4, enlargement greater than the size of the individual's fist.

A unique feature of the Polish preventive campaign is the proposal to transfer for a time all pregnant women and small children from endemic valleys to higher localities where goitre is non-existent. This " settlement operation ", as it is called, is based on experience in Switzerland, where as long ago as 1849 it was found that children transferred in this manner did not develop goitre to such an extent as those who had not changed their habitation.

USSR (excluding Estonian SSR, Latvian SSR and Lithuanian SSR)

In point of goitre distribution, the vast territories comprising the Union of Soviet Socialist Republics may conveniently be divided into three sections—European, Caucasian, and Asiatic.

European section

In the European section eastwards as far as the Ural Mountains, which form the natural physical boundary of Europe, goitre occurs endemically in several places. To the north-west numerous cases are found on the eastern shores of Lake Ladoga and in the area between Lake Ladoga and Lake Onega, particularly in the valley of the river Oyat and throughout the district of Olonetz. This focus may be regarded as an extension of the Finnish endemic.

In Byelorussia goitre occurs in and around Minsk, and, farther south, in the marshy low-lying country drained by the Pripet and the Beresina rivers where about 20% of the schoolchildren are sufferers, but there is no cretinism. The Ukraine has several goitrous localities, notably at Chernigov in the north-west and at Sumi and Kharkov nearer the centre. An extension of the Polish endemic is found at Lvov and in the Region of Volhynia, where the disease is reported to be mainly of the hyperthyroid and large colloid type and is accompanied by considerable dental caries and severe

disturbances of the circulatory and digestive systems. Goitre occurs also in northern Bukovina, in Moldavia, and in Bessarabia towards the frontier of Romania.

Another goitrous region is found in the centre of the European section relatively close to Moscow. The areas affected are to the north-east of Moscow at Yaroslavl, Kostroma and Ivanovo, and to the south at Serpukhov, Ryazan, and along the river Oka, which drains part of the Central Russian Uplands.

Proceeding eastwards towards the Ural Mountains we cross a belt stretching from Kirov in the north to Saratov in the south. In the northern part of this belt, goitre is found on the Vyatka river near Kirov and in Mari Region between Gorki, Chuvash and Kazan. At the Kazan Medical Institute it has been found that in ordinary foods a high manganese and a low ascorbic acid content goes hand in hand with a high incidence of endemic goitre. Farther down the Volga basin goitre occurs in the regions of Alatyr, Ulvanovsk, Penza, Kuznetsk, Syzra and the lower Volga town of Saratov. The valley of the river Sok and the neighbouring area of Kuibyshev (Samara) east of Syzra are also reported to be goitrous.

In the main chain of the Urals goitre is found at various places, but particularly in the centre, on both the western and eastern slopes. The valley of the river Sylva and the nearby towns of Perm (Molotov), Debessy, Kungur, Krasnofimsk and Birsk are the chief seats of the disease on the western slopes. On the Siberian side, the town of Sverdlovsk is the principal goitre focus of the central Urals.

Caucasian section

In the Caucasus, centres of goitre and cretinism are found all along the southern declivities of the mountains. In the north-west, the valley of the Kuban river, which flows westward through the Territory of Krasnodar to enter the Black Sea just south of the Sea of Azov, is stated to have a goitre rate of 40% among the female population. High rates are also found in the adjoining areas of Karachaevsk and Kabardino-Balkarsk, especially around the Elbrus group of mountains.

In Gruzia (Georgia) the valleys of the rivers Ingur, Adzharis-Tskhali and Rion, which flow near Kutaisi into the eastern end of the Black Sea north of Batum, are well-known goitre areas, and in the neighbourhood of Batum itself there is an intense endemic in the mountainous districts of Adzharistan.

In 1938, Gelovani [232] reported what was then a new endemic locality in Letshkhoom, an upland area of Georgia bordering on the lower part of Svanetia. Here, 52% of the people suffer from goitre and there is much cretinism. The water-supply of Letshkhoom villages is derived from shallow wells, to which the larger domestic animals also have access, and which have been proved by chemical analysis to contain little or no iodine.

In the centre of the Caucasian section there is a goitre focus in the valley of the river Aragwa in east Georgia north of Tiflis. At the east end of the range, in the vicinity of the Caspian Sea, there are less important centres in Daghestan and near Shemakha in the Republic of Azerbaidzhan west of Baku.

Asiatic section

Eastward beyond the Caspian Sea, over the great Kara Kum desert and through Turkmen, there lie the Republics of Uzbek, Tadzhik and Kirghiz, which together encompass one of the most notorious goitre areas of the world. In Tadzhikistan an inverse relationship has been found between the prevalence of goitre in certain districts and the amount of iodine present in local foods and water. Experiments to control goitre by the iodization of bread have been undertaken in these localities.

The central Asiatic endemic begins at Bukhara and Samarkand and reaches its greatest intensity in the Region of Ferghana (Kirghiz), especially in the Chatkal Mountains, around the town of Tashkent and at Kokand.[a] To the south of this area, abutting on the extreme north of Pakistan, lies the Pamir plateau, where in some valleys—notably that of the river Wanj which flows into the head-waters of the great river Oxus (Amu-Darya) — the entire population without exception is said to suffer from goitre. The goitre endemic of Ferghana and the Pamir plateau is continuous with that extending south-eastwards through Kashmir and the Himalayas.

Grouped with the Ferghana focus is the endemic found throughout the mountains of Semirechensk in " The Land of the Seven Rivers " between Lake Issyk-Kul in the north of Kirghiz and Lake Balkhash in Kazakh (formerly Turkestan). It was in this part of the world that Marco Polo saw goitres when on his famous travels from Venice to the court of the Grand Khan in China about the year 1275. After passing through the high Pamirs he came to the Chinese provinces of Kashgar and Yarkand at the extreme western end of the Takla Makan desert in Sinkiang (Chinese Turkestan). Writing of the people in Yarkand, Marco Polo [244] says: " They are in general afflicted with swellings in the legs, and tumours in the throat, occasioned by the quality of the water they drink." The leg swellings were due to elephantiasis.

Elsewhere in the Asiatic section there are three major goitre areas. These lie in the south of central Siberia, one at the head-waters of each of the three great parallel northward-flowing Siberian rivers—the Ob (or Obi), the Yenisei, and the Lena.

Proceeding from west to east, the first of these three districts extends from the Altai Mountains, at the north-west corner of the Mongolian plateau, northwards to the town of Tomsk. The endemic is especially severe

[a] Kokand has been described as " a city of cretins " (*Brit. med. J.*, 1905, 1, 34).

in the middle and west Altai, that is, in Ojratsk, and covers the area of the sources of the rivers Ob, Bija, and Katun in the east Altai district of Kusnetz.

The second focus lies in the upper basin of the Yenisei and centres round Tulunsk, a town on the trans-Siberian railroad midway between Krasnoyarsk and Irkutsk. The river Uda flows northwards through goitrous regions at this point. Finally, there is the considerable endemic around Lake Baikal and the head-waters of the river Lena. Here, in the neighbourhood of Irkutsk, about half the population are goitre sufferers. In the middle reaches of the Lena a goitre belt stretches for more than 600 miles from Kirensk to Yakutsk.

East of Lake Baikal, in Buryat-Mongol and Chita (formerly Trans-Baikalia), goitre is found in two more or less circumscribed areas—one in the district watered by the river Chilok, which flows into the south-east end of Lake Baikal, and the other on the eastern slopes of the Yablonoi Mountains, particularly at the town of Nertchinsk and at the confluence of the Shilka and Argun with the Amur, rivers which form the boundary between this part of Soviet territory and the north of Manchuria. Here, the goitre rate may reach 74%. Arndt [226] records that goitre is often found in association with local endemics of osteo-arthritis. Domestic animals are also affected with goitre in this area.

The foregoing review of goitre distribution throughout the USSR is based on information taken from the comprehensive treatise on the subject by Arndt [226] and from papers by the following authors. Localities with which particular authors are specially concerned are given within brackets.

European section: Schermann (Mari); [252] Kutsherenko, Judina & Rimak (Volhynia); [240] Kutsherenko, Judina & Kutsherenko (Chernigov); [239] Kutsherenko (Ukraine); [238] Kutsherenko (Ukraine); [237] Tabakov (Birsk); [258] Lyapustin (Urals); [242] Chekalov (Kostroma and Ivanovo); [229] Primak (Ukraine); [249] Rybalkin (north Bukovina); [250] Kamchatnov (Kazan); [234] Florinskii (Yaroslavl).[231]

Caucasian section: Slavin (Kabardino-Balkarsk); [256] Valedinskaya (Kabardino-Balkarsk); [259] Nikolaev (Kabardino-Balkarsk); [247] Alfeev (Karachaevsk); [225] Strunnokov (Karachaevsk); [257] Kuznetsov (Karachaevsk); [241] Zhukovski (Karachaevsk); [260] Nizhibitski (Karachaevsk); [248] Mamedov (Azerbaidzhan); [243] Egorov & Orudzhiev (Azerbaidzhan); [230] Aslanishvili (Svanetia); [227] and Gelovani.[232]

Asiatic section: Shkarenko (Uzbek); [254] Masumov (Ferghana); [245] Kolomiitseva (Tadzhikistan); [236] Khazan (Tadzhikistan).[235]

Romania

The most highly goitrous regions of Romania lie along the Carpathian Mountains running from north to south of the country, and along the

Transylvanian Alps from west to east. Studies by Câmpeanu [263] and by Danielopolu and co-workers [264-269] contain a wealth of information, with numerous distribution maps and illustrations showing what must be among the saddest and most distressing cases of goitre and cretinism ever photographed.

Two areas in which Danielopolu and his associates made a detailed investigation are Bukovina in the north (now part of the Ukraine) and the District of Sibiu, which lies in the centre of the country on the northern slopes of the Transylvanian Alps. In Bukovina, the Czeremosz valley, which traverses the Romanian-Ukrainian frontier, is highly goitrous, as also is the valley of the Moldavitza in the District of Câmpalung-Moldavia. Here, 46% of the inhabitants examined by Danielopolu had goitre. At Ispas in the Bukovinian district of Storojinet (now in the Ukraine) 465 cases were seen in seven small hamlets. Although simple goitre was commonest, there were many cases of cretinism, myxoedema, deaf-mutism and imbecility.

Among the communes investigated in the Transylvanian district of Sibiu were Tălmacuil with a goitre rate of 21.5%, Sibiel with a rate of 50%, and Cisnădie with a rate of 25.4%. At Ighisul-Nou, in the valley of the Târnava Mare immediately north of Sibiu, Danielopolu found 31.7% of goitre. Zlatna in the District of Alba Iulia to the north-west of Sibiu is also very goitrous.

Goitre is prevalent in certain parts of Moldavia, on the east side of Romania. Andronovici [261] examined the schoolchildren of thirteen Moldavian towns and found rates of 20.2% at Fălticeni, 24.1% at Jassy, 24.5% at Roman, 34.1% at Piatra Neamt and 13.5% at Bacău.

In Romania, goitre is notoriously a disease of poverty. The inhabitants of all the small goitrous villages surveyed by Danielopolu were very poor and lived under exceedingly primitive housing conditions—very often a whole family in one badly ventilated and ill-lit shack together with their domestic animals. There is least goitre among the men who pass a large part of their time in the mountains as shepherds, woodmen and charcoal burners. Social environment in relation to unfitness in military recruits in Romania during the years 1941-46 has been the subject of study by Banu & Dinu,[262] who mention goitre as one of the causes of rejection for service.

Iodine prophylactic measures have been successfully applied in several places in Romania; an iodized salt (1 in 10 000 strength) is being used with great benefit and no harmful results whatsoever.

Bulgaria

Goitre is markedly prevalent along the banks and tributaries of the west Bulgarian river Struma, which rises in the Vitosha Planina south-west of Sofia and has a general north to south direction, eventually flowing through

Greek Macedonia and entering the Aegean at the Gulf of Strimon on the east of Thessalonika. In Greece the spelling of the name changes to Stroûma, and in classical times the river was known as Strymon.

The word " Struma " is often used, especially in German literature, as a synonym for goitre—the adjectives " scrofulous ", " strumous " and " goitrous " being nearly interchangeable. Some say that the river was named after the disease. It seems much more likely that the disease took the name of the river in whose valley it abounds.

The goitre rate among adults and schoolchildren in the town of Teteven, about 50 miles north-east of Sofia, was investigated by Ticholov [270] in 1926 and again in 1947. In the former year about 10% of the total population were affected; by 1947 this over-all figure had risen to 20%, and the rate among schoolchildren was as high as 80%. In the village of Ribaritza, a strong focus of endemic goitre situated about 12 km from Teteven, no less than 81% of boys and 89% of girls were found to be goitrous in Ticholov's 1947 investigation. Teteven was originally supplied with water from local springs and wells; in 1939 the source of supply was changed to water carried by aqueduct from the neighbouring river Beli-Vit. It has not been possible to determine the iodine content of both well and river supplies, but Ticholov assumes that alteration in the chemical quality of the drinking-water is the cause of the increased incidence of goitre in Teteven.

Yugoslavia

Endemic goitre is a serious public health problem in Yugoslavia, contributing much to chronic ill-health and lowered output; it adds significantly to the cost of State medical care. The general distribution of the disease has been described by Simitch,[281] by Miholić,[277] by Ramzin, Bučić & Lukić,[279] and by Matovinović;[276] detailed surveys of particular areas have been made by Schneider & Ganss [280] and by Arko; [271] the occurrence of thyroid enlargement in domestic animals is discussed by Jovanović, Pantić & Marković; [274] and the problem of goitre in the army has been the concern of Ceramilac.[273]

The goitrous area extends continuously for more than 500 miles from Slovenia in the north-west to the extreme south-western corner of the country in the neighbourhood of Bitolj (Monastir) and the lakes Presba and Okrida in Macedonia. The only goitre-free areas lie along the Adriatic coast and throughout Vojvodina in the north-east. The intensity of the endemic varies. It is highest on the banks of the river Ibar and in certain valleys of the Zlatar Planina in the *sandjak* of Novi Pazar, i.e., in the south-western part of Serbia. Slovenia, too, has high rates; but the intensity is somewhat lower in Croatia, in Bosnia and Hercegovina, and in Montenegro. Goitre in Yugoslavia is mostly located in high mountain districts and tablelands, but is also found in river valleys and in the plains.

In the north-west of the country (Slovenia) there is considerable goitre throughout the head-waters of the rivers Sava and Drava (Danube) between the towns of Ljubljana and Maribor (Marburg). This centre, which is an extension of the Klagenfurt-Graz goitre area in southern Austria, has been specially studied by Arko,[271] who mentions the following places as goitrous: the mountains of Kozjak, Pohorje and Haloze, and the low-lying area of the Pannonian plain in the vicinity of Beltinci. Arko very carefully examined 257 children (up to 14 years of age) in the village of Zetale near Rogašk Statina and found goitre in 60% of them.

An investigation of the Croatian villages of Rude and Braslovje undertaken jointly by the Institute of Hygiene and the Clinic of Internal Medicine, Zagreb, showed that of 863 people examined, 716 (or 82.97%) had enlarged thyroids. Among these 716, there were 58.38% with severe goitres of the first degree (Matovinović [276]).

Much has been written about the severe south Serbian focus, which includes the valleys of the Lim, Uvac, and other rivers flowing from the Zlatar Planina, the towns of Nova Varos, Prijepolje, and Novi Pazar, and extends eastwards over the river Ibar to the Kopaonik and Jastrebac Mountains in Moravia, with a southwards branch into the Kosovo-Polje plains and the valley of the river Vardar at Skoplje. Olive Lodge [275] in her book *Peasant Life in Yugoslavia* writes that 80% to 85% of the population of the *sandjak* suffer from enlarged thyroids.

The detailed survey made by Schneider & Ganss [280] in the villages and valleys surrounding the Zlatar Planina offers good examples of the variations in prevalence which may occur within a comparatively small area. At Hisardžik, a small mountain village of 250 people situated on the southern slope of the deep valley of the river Miloševo, 60 out of 80 persons examined had pathologically enlarged thyroids. Further up the same valley, at Karaula, there was no goitre at all; nor could any cases be found at Kačevo, a settlement close to Hisardžik. Similarly, in the not-far-distant Kosatica valley the upper reaches are goitre-free while the lower part is distinctly goitrous. High up on the top of the Zlatar Plateau itself, goitre is completely unknown, but in the northern declivities at Nova Varos and lower down the Bistrica valley " lovely " goitres are seen.

Schneider & Ganss [280] attribute these variations to sharp distinctions in local geology and topography. Goitre occurs only in valleys, not on plateaux. Valleys in which the slopes are chiefly covered with soft rich soils are not goitrous; those with steep wall-like sides scantily covered with poor soil favour the disease. The incidence is higher where faults and folds predominate, and at the intersection of strata of different ages.

Jovanović, Pantić & Marković [274] describe hypothyroidism occurring among domestic animals in areas where the human population suffers from goitre. Goats showed most thyroid enlargement but no signs of dwarfism, sterility or low vitality. In sheep, the thyroid enlargement was not so

pronounced but poor lactation, poor wool production, and a high mortality rate among lambs were noteworthy. Sterility, low milk yield, short lactation, too frequent silent heat, and poor condition of young stock are the symptoms of hypothyroidism reported in cattle. Little abnormality was seen in pigs. Horses also suffer from goitre, the incidence being higher in primitive than in imported breeds. Affected animals were less able to work, and stallions had decreased sexual impulse. Foals do not develop normally and are often stunted.

Owing to the seriousness of the goitre endemic in Yugoslavia, the Government is giving every support to control programmes, and, in keeping with recommendations made by the World Health Organization, has passed a law requiring the iodization of salt at a level of 10 mg of potassium iodide per kg of salt, effective from 1 July 1954. Salt-iodization plant has been installed on a pilot scale and will be increased until all salt distributed for human consumption is iodized in conformity with this regulation (Matovinović; [276] Brožek & Ferber [272]).

Greece and Albania

Goitre is reported to be endemic in and around Poroy, Djuma and Sérrai, three towns situated on the edge of the lowland slopes where the Struma valley broadens into the plains of Greek Macedonia. Further west, goitre is also seen at Karadjova in the area of Vodená and Yiannitza.

In Albania thyroid disease is known at Berat towards the south of the country. There is no published literature on goitre in Greece and Albania. The foregoing information was communicated privately by C. Evelpidi (1948).

Central and Southern Europe

Austria

Goitre has long been a concern of Austrian preventive medicine. With the exception of a few districts in the Danube valley and in the direction of the Hungarian plain to the east, practically the whole country is goitrous. From west to east the most notorious localities are:

(1) The Province of Vorarlberg, which is bounded by the Swiss Alps, Lake Constance and the Algauer Alps to the south of Bavaria. Here, the district of Montafon south of Bludenz is specially affected.

(2) The Tirol, especially in the neighbourhood of Telfs and Innsbruck.

(3) The Province of Salzburg, particularly along the river Salzach at Zell-am-See and Taxenbach. The city of Salzburg itself has a high goitre rate.

(4) The Province of Kärnten (Carinthia), especially the area around Klagenfurt. This includes the valley of the river Drau (Drava) and the towns of Friesach, Wolfsberg and St. Paul.

(5) The Province of Steiermark (Styria) where the areas around Murau and Judenburg have a high incidence. The town of Graz on the eastern edge of the Styrian Mountains and many other places along the valley of the river Mur are mildly goitrous.

(6) Upper Austria in the vicinity of Vöcklabruck, Bad Hall, Steyr, and Rohrbach north-west of Linz.

(7) The extreme east of the country is the least affected. Nevertheless, many cases are found in Burgenland Province on the borders of Hungary, and in Vienna, the capital city (Schroetter;[294] Burtscher & Sprenger;[285] Wagner-Jauregg;[296, 297] Bauhofer;[283] Kopf;[287] Kutschera-Aichbergen[290]).

The prevalence throughout Austria is high. Taking the country as a whole, 44.2% of boys and 48.1% of girls were found to be goitrous in the 1923-24 survey of 686 000 schoolchildren organized by Wagner-Jauregg.[296, 297] The highest regional rates were in Vorarlberg Province, with percentages of 58.9 in boys and 63.6 in girls. The lowest rates were in Burgenland Province, with 15.9% in boys and 19.5% in girls. The city of Vienna showed percentages of 41.1 in boys and 46.2 in girls.

The situation in more recent times is scarcely less acute. A survey of five groups of Viennese civilians under United States occupation in 1945 revealed non-toxic diffuse goitre in from 21% to 42% of the individuals examined, the rate in children under 14 years being 38% in boys and 35% in girls (Davidson et al.[286]). In the Upper Austrian town of Rohrbach, notorious for its high goitre rate, the percentage with thyroid enlargement was 31 in 1952 compared with 66 in 1946. The drop is due to the adoption of iodine preventive treatment. At Bad Hall, an Upper Austrian watering-place well known for its high-iodine drinking-water, about 11% of school-children are affected. In contrast, the rate among children living outside the town in nearby districts is 35% or even higher. In Steyr, for instance, the rate for children is 49%. The fact that 11% of Bad Hall children have goitre in spite of a high iodine intake from water is evidence that iodine deficiency is not the whole etiological explanation; goitrogens in food, bad hygiene, or other factors may also be involved (Kopf[288]).

Studies of the occurrence of endemic goitre among people who have moved from goitre-free areas into affected areas have been made by Schreckels.[293] He examined 2220 such people in and around Salzburg and found that within a year of coming to live in the goitre area 40% of them developed thyroid enlargement. The longer the people had been settled in the area, the higher was the prevalence of goitre among them.

A feature of the goitre endemic in Austria stressed by Kriebernig[289] is the increase in prevalence which has taken place in post-war years, especially in the newborn. This happened both after the First World War (Abels[282]) and after the Second. Sollgruber[295] gives the following figures: among 4800 newborn infants examined in the ten years 1944-53 in the maternity ward of Dornbirn hospital in Vorarlberg, the average goitre rate was 7%;

in the two years 1952 and 1953 the rate was 11% and in the first quarter of 1954, 20%. Sollgruber treats these infants from the third day of life with large doses of iodine spread over several days. He strongly recommends the general use of iodized salt and considers it should be the standard salt on sale everywhere, untreated salt being obtainable only by special prescription. Kopf [288] records that, in Vöcklabruck, administration of potassium iodide to pregnant women, preferably from the fourth month, reduced the goitre rate in the newborn from 47% to about 5% in the space of two years.

Hungary

Broadly speaking, goitre is confined to three main parts of Hungary—the northern frontier, the west-centre and south-west, and the neighbourhood of Debrecen in the north-east. The Great Hungarian Plain in the centre and east of the country is goitre-free.

Upper Hungarian localities affected are: Magyaróvár, on the river Leitha in the extreme north-west, where a percentage prevalence in schoolchildren of 33.3 has been recorded; Komárom, with a rate of 35%; and Tatabánya, with a rate of 59.3% among children. Farther east, children in the northern towns of Vac, Salgótarján and Miskolc in Upper Hungary near the Czechoslovakian border showed rates of 9.3%, 17.5% and 14.5%, respectively. In Budapest and surrounding districts, from 5% to 12% of children are said to be goitrous (Gortvay; [299] Bodnár & Straub; [298] Straub; [311, 313] Sós, Fekete & Molnár [308]).

In the west-central part of the country near Lake Balaton, children in the towns of Sümeg and Tapolca showed rates of 11% and 10.1%, respectively; but at Tihany, which lies immediately on the lake shore, there is no goitre (Straub [311]). According to Véli, [318] schoolchildren are considerably affected in the town of Kaposvár, which lies between Lake Balaton and Pécs. In this general area, too, a goitre endemic among the children of Komló has been reported by Várbiró, Száva & Koch. [317] In Pécs itself, thyroid enlargement is commonly seen in newborn infants, among schoolchildren—the rate being 10% to 13%—and in older people (Hal & Horváth; [300] Horváth and co-workers [302, 303]). The iodine content of food and water in relation to goitre in Pécs was determined in 1933 by Scheffer [305] and again in 1949 by Horváth, Nógrádi & Dános. [302] The latter study showed that one part of the city supply contained 4.5 μg of iodine per litre and another part 1.5-2.0 μg per litre. Goitre was commoner in that part of the city supplied exclusively with water of the lower iodine content.

In the extreme east of Hungary, little goitre is seen; but there are exceptions—notably in the neighbourhood of Debrecen, where the following goitre rates have been recorded by Straub & Török: [315] Hajduhadház (11.7%), Vámospércs (22.6%), Ujhuta (40-50%), Ohuta (50-60%), Bodahe-

gyközség (82.2%) and Ómassa (83.3%). In 1947 Kiss[304] drew attention to the increasing prevalence of goitre in Nádudvár, a town in the Debrecen area.

A feature of the goitre literature of Hungary is the several attempts that have been made to find out whether the radioactivity of soils, and their fluorine content, are factors implicated in the causation of goitre. No causal connexion has been found.

Iodized salt (10 mg of KI per 1000 g of salt) was officially introduced into certain parts of Hungary in 1948, and the results of five years' prophylaxis by this means have been summarized by Sós & Szabó.[309] The most marked improvement has occurred in the west and north of the country, particularly among children. No very significant reduction in prevalence has been noticed in the south trans-Danubian region.

Czechoslovakia

Maps prepared by Feix, Rezler & Šilink,[320, 321] on the basis of the examination of 44 262 men and women and 85 060 children from all districts of Bohemia and Moravia in 1947-48, show that thyroid enlargement of every type is prevalent to a considerable degree throughout the whole of these regions of Czechoslovakia. In some communities the frequency may be as high as 100% among women.

Data on the distribution of goitre in army recruits collected by Klíma [325] in 1933 reveal a marked focus along the Erzgebirge on the Saxony border to the west of Bohemia, especially in the neighbourhood of Karlovy Vary (Karlsbad) and Pilsen. This western belt extends round the northern Sudetenland frontier, through such places as Usti and Liberec, and links up with the Silesian goitre districts of south-west Poland.

Determinations of the urinary output of iodine by individuals in 29 west Bohemian communities situated in the neighbourhood of Liberec, Usti, Prague, Pilsen and Karlsbad have been made by Vohnout & Pihar.[335] On the assumption that the minimum iodine requirement is 100 μg per head daily, the results show that people in these regions have an intake of iodine deficient by 30-80 μg per day.

During the years 1949 to 1954, Hostomská et al.[324] treated 1931 Prague children in age-groups from 3 to 15 years with thyroglobulin plus iodized salt in strengths of 1 in 100 000 to 1 in 40 000. A considerable decrease in the size of both medium and small goitres resulted. In the Prague area, goitre is also reported from the towns of Dobříš, Roudnice and Sušice (Fleischhans; [322] Šilink & Maršíková [331]). In Sušice and neighbourhood, all schoolchildren and most workers in the Union of Agricultural Co-operatives were examined by Horáčková & Pokorný,[323] who found hyperthyroidism to be the most common type of thyroid disturbance even where cretinism is traditional. The intensity of the endemic in this district has decreased since the removal of people from the most seriously affected

areas; nevertheless, incidence remains high and presents a grave health problem especially among children in upland areas. The systematic use of iodized salt is strongly urged by the authorities.

Moravia, the central part of Czechoslovakia, is heavily goitrous, particularly in the north. Local goitrogenic factors have been investigated by Šilink & Maršíková,[331] who determined thiocyanate values in the blood of volunteers from Šumperk in northern Moravia and Roudnice in Bohemia, two districts where goitre is rife. These values are higher in autumn, when the consumption of fruit and vegetables is greatest, than in the spring, and there is a direct relationship between the amount of thiocyanate in the blood and the degree of thyroid hyperplasia.

This does not mean, however, that thiocyanate itself is the goitrogenic factor, because the serum thiocyanate values in the goitre subjects from Šumperk and Roudnice are no higher than those found in subjects who had been given less than 0.1 g of potassium thiocyanate by mouth for long periods without the thiocyanate having any goitre-producing effect whatever. Šilink & Maršíková argue, therefore, that the foods consumed by the inhabitants of these districts contain not only a substance capable of raising the blood thiocyanate level, but also a specific goitrogen which they have not been able to identify.

Vomela [336] has studied the Holešov and Fryštát areas of eastern Moravia in great detail. In the mountains, extreme forms of goitre and cretinism are common; 80% to 90% of the inhabitants are affected in some villages. Here, the general picture is definitely one of hypothyroidism. On the Moravian plains, on the other hand, goitre also occurs but is accompanied by tachycardia, exophthalmos and other symptoms of hyperthyroidism. Zones of intermediate altitude show goitres of both types, even within one family.

During his surveys in the district surrounding Ostrava in the extreme north of Moravia, Doleček [319] found a relatively large number of goitres associated with hypertension and other related disturbances. Doleček is among those who stress the importance of goitrogenic factors in the local foods and the need to employ rational prophylaxis.

Farther east, in Slovakia proper, goitre has been the subject of special study in Banska Bystrica [332] and in the Zitný Ostrov area immediately south-east of Bratislava where Slovakia abuts on Austria and Hungary between Vienna and Budapest. This focus is noteworthy inasmuch as the disease is more prevalent in the lowlands than in the surrounding mountains (Tománek; [334] Podoba, Németh & Grmelová; [330] Németh & Podoba [327]).

Following an extensive survey of the Zitný Ostrov area by the Bratislava Institute of Endocrinology in 1949, iodized salt was introduced in October 1950, first at a level of 1 in 200 000 and later at a level of 1 in 100 000. A resurvey carried out in 1954 on 17 750 persons of both sexes, ranging in age from 6 to 20 years, showed that there had been a distinct recession of the

endemic, a decrease in the number of nodular cases, and a striking diminution in the size of local goitres (Németh & Podoba [327]).

Finally, in the extreme east of Czechoslovakia there lies Carpathian Ruthenia—now part of the Ukraine—where, in the vivid description of Suk,[333] goitre and its consequences (cretinism and myxoedema) may be seen at their worst. Here, the most wretched centres are the poor villages, in which, during the unfavourable winter months, the people live an unhealthy life in dark and cold unventilated huts. They consume large quantities of cabbage—raw cabbage, pickled cabbage, boiled cabbage and cabbage water. Indeed, cabbage is the staple diet. The goitrogenic effect of cabbage is revealed in the data collected by Suk in a number of out of the way villages in the Carpathian highlands (see Table V).

TABLE V. GOITRE PREVALENCE IN CHILDREN AGED 6 TO 14 YEARS IN SOME VILLAGES IN THE CARPATHIAN HIGHLANDS

Results of examination	All villages taken together			Three villages with excessive cabbage diet		
	number	percentage		number	percentage	
Without goitre	136	25.2		25	9.1	
Slight goitre	262	48.6		151	54.9	
Medium goitre	100	18.5	74.7	67	24.4	90.9
Large goitre	41	7.6		32	11.6	
Total examined	539			275		

It is seen that the percentage of cases without goitre, taking all villages together, is much higher than that in the three villages where the consumption of cabbage is excessive.

Germany

Proceeding from the south to the north of Germany, it is possible to distinguish five main goitre zones: one extending from Baden-Baden and the mountains of Breisgau and the Black Forest eastwards through Württemberg and southern Bavaria to the Austrian border; one in the Vogtland and Erzgebirge on the north-western frontier of Czechoslovakia; one stretching from the borders of Luxembourg north-eastwards along the Hunsrück and Taunus ridges through Hesse and Lower Franconia into Thuringia; one comprising Münsterland, parts of Westphalia, and the Bergische Land near Düsseldorf; and one in Brandenburg, extending from the region of Cottbus south-eastwards into Polish Silesia.

The first of these zones includes the Kaiserstuhl area, the valley of the river Kinzig and the towns of Wolfach and Freudenstadt in the Black Forest, the towns of Hechingen and Geislingen in Württemberg, and a large number of places along the Austrian frontier between Lake Constance and Salzburg. Among these southern Bavarian centres are Lindau, the Algauer Alps, Kempten, Landsberg, Schongau, Weilheim, Garmisch, Wolfratshausen, Tölz, Ebersberg, Miesbach, Traunstein, Pfarrkirchen and Berchtesgaden. Goitre is also said to occur in the Bayrischer Wald along the north bank of the Danube between Regensburg and Passau.

The second important zone lies between Plauen and Dresden. It covers the Vogtland and the north side of the Erzgebirge and takes in Auerbach, Freiberg, Chemnitz, Oelsnitz, Schneeberg, Marienberg, Zwönitz and Annaberg.

In the third distinctive area, incidence is not excessively high but there are, nevertheless, some well-marked goitre centres. Between Luxembourg and Koblenz the disease occurs in the Eifel district north of the Moselle river—notably, at Prüm, Bitburg and Wittlich. On the south of the Moselle, the town of Bernkastel and the neighbouring ridge of the Hunsrück are affected. Across the Rhine to the east of Koblenz there is goitre within a circle drawn through Siegen, Giessen, Wiesbaden and St. Goarshausen. This includes the Westerwald and the Taunus country immediately north of Wiesbaden where Königstein is a known focus. A traveller proceeding north-eastward from Siegen to Kassel would find goitre cases at Wittgenstein, Biedenkopf, Frankenberg, Fritzlar, Rotenburg and Melsungen. In the Mannheim-Frankfurt area there is goitre on the Odenwald and in the Spessart country, the town of Heppenheim to the north of Mannheim deserving special mention. Farther east, one finds the disease on the upper Tauber river, at Rothenburg in Middle Franconia, along the Steiger Wald, where Iphofen is a well-known centre, and at Gersfeld in the Rhöngebirge west of Meiningen. In Thuringia, the towns of Weissensee and Schmalkalden are said to be affected.

Fourthly, there is an area of slight endemicity in the Duisburg—Dortmund—Düsseldorf triangle and in the Bergische Land, a region which rises in plateau-like terraces from the Rhine near Düsseldorf. The nature of thyroid disorder here has been described by Leicher.[372] During their post-war investigation of the nutritional status of children in the British Zone of Germany, Widdowson & McCance [389] found cases of thyroid enlargement in the municipal orphanages at Duisburg and Wuppertal-Vohwinkel.

The fifth zone is found in the far east of Germany. It begins at Guben and Cottbus and extends south-eastwards to join the goitre belts of south-west Poland and northern Czechoslovakia. Goitrous localities of special note in this region are Spremberg and Hoyerswerda.

Throughout the past hundred years the geographical distribution of goitre in Germany has remained fairly constant, but the intensity of the disease has been subject to marked fluctuation. After the First World War, German physicians reported an increase in prevalence all over the country, even in areas normally goitre-free, like Nuremberg, the Ruhr district and the North German Plain. By the end of the 1920's this outbreak had subsided. The same happened after the Second World War. An upward trend in the frequency of thyroid disease became noticeable around 1942. Between the end of the war and the close of 1950 this had developed into an extensive epidemic, much more widespread and severe than that which occurred after the 1914-18 war. The following figures given by Ligdas [373] are typical of many reports. They relate to schoolchildren in Dresden and other towns in that area of Saxony.

	Goitre rate (%)		
	1948-49	*1949-50*	*1950-51*
School beginners	9.1	11.9	14.4
Fourth-year scholars . . .	8.7	19.1	19.8
" Confirmands "	11.6	19.0	22.6
Trades School	13.0	18.0	23.6
High School	12.2	16.2	22.8
Trades High School . . .	16.2	20.4	37.7

These post-war goitre waves are due, as is apparent from many reports, to dietary deficiency during the war period. Proof of this is found in the fact that certain well-fed groups of people—for example, cooks, interpreters and occupying troops—escaped the goitre wave. This is also borne out by Haubold's investigation of schoolchildren in Bavaria, where the goitre rate rose to 42%, while only 9% of children in occupying American families were affected.

Arguments have been advanced by Haubold [362-365] that the specific dietary deficiency responsible for the post-war goitre wave is a decreased intake of vitamin A and carotene. His goitre surveys in the Weilheim district of Upper Bavaria show that in villages where the vitamin-A and carotene contents of butter and herbage are exceedingly low, the goitre rate is more than double that in villages where these dietary factors are substantially more plentiful. The goitres occurring under circumstances of vitamin-A deficiency are of the hyperthyroid type, and it has been shown by Bukatsch, Haubold & Lackner [346] that treatment with vitamin A or carotene causes regression of the goitre and amelioration of the signs of hyperthyroidism.

On the other hand, Ligdas [373] maintains that, in spite of the interesting observations by Haubold, deficiency of iodine in natural form remains the factor chiefly responsible for the post-war goitre waves. At the beginning of the Second World War the German people were consuming an average of 12 kg of sea-fish per head per annum. During the first five years following

the end of the war the people hardly ever saw sea-fish at all, according to Ligdas.

In the years between the two wars, prophylaxis by iodized salt, " Vollsalz " as it is called in Germany, had been tried in many areas; but owing to the fear of possible harmful effects (now known to be without foundation) more propaganda against the use of iodized salt has been advanced in Germany than in any other country in the world. Gloel,[357] Medical Officer of Health at Landsberg in Bavaria, reported in 1934 that as a result of the almost exclusive use of iodized salt a strong, healthy, non-goitrous generation was growing up in the goitrous districts of Bavaria, notably at Kempten. He deplored the fact that in his own district the practice had been abandoned for fear of iodine poisoning. Where iodized salt had been in general use since 1924, Gloel did not find a single case of thyroid enlargement among pupils of a school he inspected in 1930. Four years later, however, owing to the withdrawal of iodized salt, 75% of the children in the same school were suffering from thyroid enlargement. He also records that provincial teachers had noticed a corresponding decline in the average intellectual capacity of children beginning school life.

Today the situation in southern Bavaria is little better than in 1934, and a strong plea for the re-introduction of iodized salt has recently been made by Bauer.[340] In co-operation with five medical colleagues he examined a total of 45 818 schoolchildren in the localities of Miesbach, Chiemgau, Traunstein, Berchtesgaden, Pfarrkirchen and Donauwörth, and was " shocked " to find goitre rates of 80% and even more in some places. In the Donauwörth area, for example, 93% of young people in Egelstetten had goitre, 61% in Ellgau, and 77% in Genderkingen, while Donauwörth itself, with 23%, is relatively immune.

Hundreds of papers have been written about goitre in Germany. Entries 337 to 390 in the accompanying bibliography are selected as dealing more especially with distribution and incidence.

Switzerland

Endemic goitre has long been a serious health problem in Switzerland. Practically all parts of the country are prone to the disease, and in many localities it is markedly associated with mental deficiency, deaf-mutism and other disorders. Indeed, the burden of cretinism has been a heavy charge on public funds. In 1923 the Canton of Bern alone, with a population of little more than 700 000, had to hospitalize 700 cretins incapable of any social life.

Cantons where the incidence has always been high are Aargau, Zürich, Schaffhausen and Thurgau in the north; Appenzell, St. Gallen and Graubünden in the east; Bern, Luzern and Uri in the centre; and Fribourg and Valais in the south-west. There is less goitre in the north-western cantons, Basel, Solothurn and Neuchâtel.

Thanks, however, to the official encouragement given to the general use of iodized salt the situation has greatly improved in recent years. Goitre rates have fallen steeply and deaf-and-dumb institutions have been closed or diverted to other purposes (Wespi [435]). Recruitment statistics provide unmistakable evidence of this downward trend. Table VI (Schaub [426]) shows that in the last 25 years the number of exemptions from military service on account of goitre has fallen from a previous average of 30 per thousand to 1 per thousand. The recession began with the introduction of iodized salt in the early 1920's and has been maintained ever since.

TABLE VI. INCIDENCE OF GOITRE AMONG ARMY RECRUITS IN SWITZERLAND

Year	Number of men examined	Number of men exempt on account of goitre	Number of goitres per 1000
1900	26 285	2 451	93.2
1905	26 448	3 093	116.9
1914-18	151 106	3 403	22.5
1921	32 838	1 817	55.3
1925	39 681	1 229	30.9
1935	29 627	338	11.4
1939-45	228 101	340	1.5
1945	31 654	21	0.6
1947	31 366	23	0.7

The same decline is seen in the goitre statistics relating to young people. For example, an examination in 1937 of schoolchildren in the Canton of Valais—a region particularly affected—gave the results shown in Table VII (Bayard [391]).

TABLE VII. INCIDENCE OF GOITRE AMONG SCHOOLCHILDREN IN THE CANTON OF VALAIS

Period	Normal thyroids (%)	Palpable thyroids (%)	Enlarged neck (%)	Pronounced goitres (%)
1920 (Before introduction of iodized salt)	28.8	54.3	14.9	2.0
1934 (Ten years after introduction of iodized salt in 1924)	70.5	27.3	2.1	0.15

At three towns in the valley of the Broye, a singularly goitrous area of the Canton of Vaud, where 20% to 40% of conscripts were usually rejected, Messerli [415] has shown that between 1921 and 1951 thyroid enlargement in children has very greatly decreased. The statistics are as follows; they should be considered in the light of the fact that since 1924 100% of all salt consumed by the people throughout the Canton of Vaud has been iodized.

Locality	*1921*	*1937*	*1951*
Avenches . .	78.9	24.1	7.1
Payerne . . .	78.0	22.4	4.0
Moudon . .	73.5	18.3	4.9

Similar results have been obtained from many different parts of Switzerland, and all responsible investigators agree that the descending curve of incidence can be correlated with the period over which supplementary iodine has been introduced into the diet of the population. The sale of salt is not a federal but a cantonal matter, in accordance with the salt laws of individual cantons. Accordingly, the introduction of iodized salt has differed markedly from canton to canton, both in point of time and in regard to the quantity sold. Goitre statistics coincide precisely with these facts. Thus, the reduction in the number of conscripts rejected on account of goitre begins much earlier in those cantons which introduced prophylaxis in the years 1922, 1923 or 1924 than in those which did not introduce it until 1929 or 1930. Furthermore, as is evident from the statistics shown in Table VIII (Schaub [426]), the magnitude of the reduction directly parallels the absolute amount of iodized salt consumed.

In his assessment of the results of goitre prophylaxis in Switzerland published by the World Health Organization in 1953, Nicod [419] remarks

TABLE VIII. RELATION BETWEEN CONSUMPTION OF IODIZED SALT AND REJECTION OF ARMY RECRUITS ON ACCOUNT OF GOITRE

Cantons*	Average consumption of iodized salt per canton, expressed as a percentage of total salt consumed				Average number of rejections on account of goitre, per 1000 recruits called up			
	1910-22	1923-32	1933-42	1943-47	1910-22	1923-32	1933-42	1943-47
1 to 9	Nil **	75.3	96.5	96.0	36.3	16.7	1.8	0.3
10 to 17	Nil	30.0	68.1	86.8	30.1	21.2	6.0	0.7
18 to 25	Nil	8.5	25.1	53.5	35.2	22.2	8.7	1.5

* 1 to 9 : Nidwalden, Vaud, Zug, Schaffhausen, Schwyz, Obwalden, Valais, Neuchâtel, and Appenzell Ausser-Rhoden.
10 to 17 : Ticino, Glarus, Uri, Appenzell Inner-Rhoden, St. Gallen, Geneva, Graubunden, and Thurgau
18 to 25 : Zürich, Bern, Luzern, Fribourg, Solothurn, Basel-Stadt, Basel-Land, and Aargau

** The single exception is the Canton of Appenzell Ausser-Rhoden, where iodized salt was introduced in 1922.

that the only canton which has almost entirely resisted the use of iodized salt, that of Aargau, is the one which still rejects the largest number of young people on account of goitre.

The literature on Swiss goitre is extensive; the accompanying bibliography cites only a few of the more important epidemiological studies.[391-438]

Italy, Sicily and Sardinia

The many descriptions of goitre and cretinism to be found in the classics and in Italian literature of the Middle Ages show that thyroid disease has been a problem in Italy from earliest times. Indeed, its seriousness and persistence into the nineteenth century prompted one of the first and most competent goitre surveys ever made under government auspices. This was the Commission of nineteen members appointed in 1845 by King Carlo Alberto of Sardinia to investigate the extent, nature and causes of the disease throughout his Kingdom, which in those days comprised the provinces of Savoy, Nice, Piedmont, Genoa and the island of Sardinia.[487] Cerletti [455] is convinced that even today five million people in Italy (i.e., 10% of the population) are affected by thyroid disease. The literature of Italian goitre, of which we cite 54 papers,[439-492] is certainly the most extensive of any country in the world.

Geographically, the endemic occurs to a varying degree throughout the whole of the Alpine region in the north of the country, in a semi-circular belt extending from the Ligurian Alps through Piedmonte, Lombardia and Trentino to Venezia in the east. The disease is found not only in the upland valleys, but also in the plains north and south of the river Po, although to a much lesser extent.

Moving from west to east, the places particularly affected are the Region of Piedmonte, intensively studied by Cerruti,[456] and the towns of Cuneo and Saluzzo, where outbreaks of acute goitre occurred among troops in 1940-41 (Anglesio [441]). Next we come to the district of Aosta and the valley of the Dora Baltea at the foot of Mont Blanc, long a noted centre, surveyed fully by Trikurakis,[489, 490] and recently the focus of an outbreak described by Vogliazzo & Forni.[492] Nearby is the Canavese region, the chief centre of which is Ivrea, where acute forms of goitre in adults have been noted by Maggiorotti.[471]

In this same general area goitre is seen at Vercelli and in the valleys of the Sesia and Ticino rivers. Also affected are the Province of Varese between Lakes Maggiore and Como; the town of Como itself; the valley of the river Adda and the mountains of Valtellina and Sondrio in the extreme north; the alpine hinterland of Bergamo and Brescia, including Breno and the valley of the Chiese; the Region of Trentino-Alto Adige (which includes the Dolomites); Valsugana; the neighbourhood of Belluno; the Carnic Alps and the district around Udine in Venezia-Giulia. Authori-

ties who have written especially about these regions are Pighini,[483] Muggia,[478-480] Fiorio,[466] Cancellara,[452] and Paccagnella.[482] Their investigations indicate that in the area between the Alps and the river Po thyroid enlargement is found in 20-30% of schoolchildren. In high mountain districts these figures may rise to 50-60% and in certain communities may reach even 70-80%. Indeed, rates of 100% are not unknown (Ambrosi [440]).

In the great north-central plains thyroid disease is much less severe, but acute episodes do arise from time to time as, for instance, that recently described by Denes & Andreotti [462] at Carmignano di Brenta, a municipality in the grape and cereal-growing country 9 miles north-east of Vicenza in Padua Province. Here, signs of thyroid enlargement were first noticed in 1947, attained their greatest severity by 1950, and then disappeared.

Apart from the main Alpine belt and the sporadic outbreaks in the northern plains, goitre also occurs in the Ligurian Apennines immediately north of Genoa (Bagnasco [442]). A large number of places in the Etruscan Apennines due south of Modena are also affected. For instance, Mucci [476] records rates of between 10% and 60% among boys and girls at Montese, Magreta, Guiglia, Mirandola and Riolunato. The etiology of acute goitre in the valleys of the Secchia and Dolo rivers has been investigated by Pighini & Gualdi; [484] and Businco [449] has described at length all the circumstances surrounding a goitre focus of unusual severity in the district of Sestola near Monte Cimone. Somewhat further south is the Province of Pistoia, where an epidemic of goitre took place among young people in the war years 1941 to 1946 (Bizzarri [447]). All sorts of theories have been advanced to account for this outbreak—nitrites and sulfur compounds in the water-supply, emotional factors due to war stress, and so on—but it seems that food deficiency during the period of emergency is the most likely cause.

In Tuscany, also, epidemic goitre has been noted by Nassi & Calamari [481] in the region of Montespertoli, an upland village about 16 miles south-west of Florence. Clinical examination of the children led to the conclusion that an infection acting on a population in a state of nutritional deficiency and border-line thyroid adequacy was the cause. The most recent account (1955) of goitre in the Province of Florence is that by Magherini & Zecchi.[472]

Due east of Florence towards the Adriatic coast, a centre of severe endemic goitre lying in the upper valley of the river Conca on the eastern slopes of Monte Carpegna has been minutely described by D'Alo.[460] The affected horseshoe-shaped area is bounded by the Faggiola and San Paolo on the east, by Monteboaggine and the Carpegna massif on the south, and by Monte Palazzuolo and Costagrande on the west. The most important inhabited centre in the locality is Montecerignone. Extreme poverty, malnutrition, wretched living conditions, and unhygienic ill-lit and badly ventilated houses are the unhappy lot of the people in this area.

Goitre is endemic in Umbria and throughout the Marches in central Italy, especially along the river Tenna in the Montegallo area and in other parts of the province of Ascoli Piceno (Scoccianti;[488] Balice;[443, 444] Pitzurra[485]). On the west, the disease is known in the Latium uplands in the Viterbo area (but not in Viterbo itself) to the north of Rome (Cerletti[455]) and at Giulianello in the parish of Cori to the south of Rome. This latter focus has been carefully studied by Di Porto & Antoniotti,[464] who point out that the district is extremely volcanic and suggest that the prevalence of goitre may be due to an excess of silica in the local foods and waters, a theory in agreement with that of Trikurakis.[490]

Very high goitre rates (40-80%) are reported by D'Amora[461] from villages in the Sorrento peninsula. At Lauro, a village in the uplands about 30 miles east of Naples, 9% of boys and girls between the ages of 5 and 14 years were found by Sainsbury[486] to have goitre. The main formation in the area is limestone and the water is deep spring with the low iodine content of 2.1-2.2 μg per litre. The dietary standards are poor and the consumption of fish negligible. On the opposite side of the country, goitre centres are found both on the sea-shore and in the hills of the Gargano peninsula (Cerletti[455]). In Lucania thyroid enlargement is noticeable at several places, particularly in Potenza Province (Ambrosi;[439] Calbi[450]). Throat measurement of elementary schoolchildren at Palazzo San Gervasio, a town lying between Canosa and Potenza, has enabled Cancellara[451] to calculate an index of thyroid enlargement which he finds useful for determining the incidence of thyroid disease in a given section of the population.

In the extreme south of Italy a little-known area of endemic goitre has been described by Criscenti.[459] This affects the districts of Savuci, Taverna and Maranise, in the Province of Catanzaro, where the people live very largely on chestnuts and rye, and where the soils are derived from granitic rocks and archaean crystalline schists. At Taverna 93% of schoolchildren were found to be sufferers; at Savuci the rate was 77%.

Foci of endemic goitre and cretinism in Sicily have been described by Coppola.[457] Nicosia in the Province of Enna is a noted centre. In Sardinia the prevalence of the disease among schoolchildren has been studied by Corda[458] and by Desogus.[463] It occurs chiefly in the Province of Cagliari.

At Sondrio and in the Valtellina goitre prophylaxis by iodized salt (1 : 50 000) had, by 1938, been in vogue for about fourteen years with good results (Lutrario;[469] Ambrosi;[440] Cerruti.[456]). In that time the number of cases showing obvious enlargement fell from 57% to 1.4%. Besides the general decrease in thyroid size there was a lowering of the infant-mortality rate and improved mental alertness among children. Iodine preventive measures have also been applied in the Valle d'Aosta by a committee set up by the public health authorities of the Region. Iodized chocolates, each containing 10 mg of potassium iodide, were distributed to schoolchildren at the rate of two per week, and in some schools open wide-mouthed bottles

of tincture of iodine were exposed. Good results were obtained from the chocolate tablets, but no benefit followed the exposure of iodine tincture.

Malta

D. C. Wilson (personal communication, 1955) says she has seen goitre in Maltese people who come from the north and west of the island where the water-supply is derived from wells. It is of interest that waters obtained from waterworks in and around the centre of the island have a high iodine content, ranging from 21 μg to 40 μg per litre. Unfortunately, no comparative analytical figures are available for well waters from the north.

Spain

There is a great deal of goitre in Spain. Almost all mountainous districts are affected, some to a serious degree. Particulars of the distribution are derived from four principal sources: (1) the 1927 report of the Commission of Inquiry on Goitre, set up by the Spanish Government in 1921 under the direction of Marañón; [497, 498] (2) the long and important series of investigations (1947-56) conducted under the leadership of Ortiz de Landázuri of the Faculty of Medicine, Granada, and the Department for Goitre Prophylaxis, Board of Health; [495, 499-512, 515-517] (3) the reports [494, 513] of the well-known Barcelona endocrinologist Cañadell, in collaboration with the Swiss investigators Eugster & Dieterle; and (4) the accounts of goitre in the Province of Sevilla by Rivero Fontán and co-workers.[493, 514]

From data acquired by provincial health inspectors, Ortiz de Landázuri and his colleagues have prepared a map showing, by a system of crosses, the comparative intensity of the endemic in those provinces in which the disease chiefly occurs.[495, 507] The indications are as follows; provinces not mentioned are those for which no data are given on the map.

Northern Provinces

Lugo	++	Navarra	++++
Oviedo	++++	Huesca	++
Santander	++	Lérida	+
Vizcaya	++	Barcelona	++
Pontevedra	+	Zaragoza	+
León	+++	Tarragona	+
Zamora	+		

Central Provinces

Ávila	++	Guadalajara	+++
Madrid	+	Teruel	+++
Cáceres	++++	Albacete	+
Cuenca	++	Castellon	+
Badajoz	++	Valencia	+++

Southern Provinces

Sevilla	++	Jaén	++
Córdoba	+	Granada	++++
Cádiz	+	Almería	+
Málaga	++		

In the north, a belt of very considerable intensity extends from Catalonia along the Pyrenees through the Cordillera Cantabrica and the Asturias to Galicia in the west. Tracing this in greater detail, we find goitre especially in the north-west of Gerona Province, where the regions of Ribas de Fresser and Camprodón provide many cases. In the neighbouring Province of Barcelona there is much goitre in the Montseny area, in the Llusanés valley and in the country to the north of Berga. Conditions here are described by Eugster & Dieterle [494] as exceedingly reminiscent of those in the foothills of the Swiss Alps; indeed, the people call the district "*pequeña Suiza*" (little Switzerland). Incidence is highest in the deep intersecting valleys of the region whereas the high tablelands are mostly free from the disease. Cañadell has published a detailed goitre map of this area.[513]

Moving westwards through Lérida Province, we find considerable goitre in the Valle d'Arán. In Huesca, the northern valleys of the river Cinca and its tributaries are well known to be goitrous. From thence the endemic extends through the Provinces of Navarra and Vizcaya into Santander, whence it spreads over the Asturias, Oviedo, León, and into the valleys of Galicia. In the extreme north-western section the endemic is less severe than in the high valleys of the Pyrenees between Spain and France where, in addition to simple goitre, there is a good deal of cretinism and deaf-mutism. Cretinism is also a strong feature in the Asturias—an area which, according to Marañón,[498] has been studied in great detail by Goyanes and Ceniga. Here, numerous cases of goitre and cretinism occur near the sea as well as at higher levels.

In central Spain goitre is found along the Sierra Gredos lying to the south of Ávila Province west of Madrid. In this area the valleys of the head-waters of the rivers Tormes and Alberche are particularly affected. West of this towards the Portuguese border, goitre is exceedingly prevalent in the Sierra de Gata. Here, indeed, we find one of the most notorious goitre centres in the world—the region of Las Hurdes, a section of the Sierra de Gata covering the extreme northern tip of the Province of Cáceres.

Las Hurdes constitutes an incomparable field for the study of goitre. It is the most important focus in all Spain. The area is composed of three long narrow valleys of unbelievably rough and inhospitable country. The geological formation is exclusively of slate and has a sparse and unproductive vegetation. The prevalence of goitre exceeds 25% and large numbers of the goitrous population are also cretinoid. Cases of idiotism, deaf-mutism, infantilism and dwarfism are many, and not a single man from

the district has been found fit for military service either because of low stature or marked feeble-mindedness. The whole region is one of tragic aspect and has given rise to numerous legends—often exaggerated no doubt—in the records of ancient and modern travellers and national writers (Legendre; [496] Marañón [497]). Other goitre areas in central Spain lie in the east towards the Mediterranean; they include the mountains of the Alto Maestrazgo in the Province of Castellon de la Plana and a large part of the Province of Valencia.

Southern Spain's most goitrous province is Granada, where the region of Las Alpujarras on the southward slopes of the Sierra Nevada is highly affected and has been studied in detail by the school of Ortiz de Landázuri.[495, 499-512, 515-517] Elsewhere in the south goitre is found in the north part of Sevilla in the neighbourhood of Constantina between the Guadalquivir and the Sierra Morena. Cases are also encountered in the Sierra de Algodonales between the Provinces of Sevilla and Cádiz, and in the Serranía de Ronda on the west border of Málaga Province.[493, 514]

The outcome of a great deal of experimental work in the University of Granada has convinced Ortiz de Landázuri and his colleagues that iodine deficiency is the main cause of goitre in the Granada area. This assumption is based on the extremely low iodine content of the drinking-waters from affected districts [500] and is confirmed by the fact that in the space of 16 months there was an over-all decrease in the goitre rate, from 60% to 33%, as a result of administering iodized salt (1 : 50 000) in an area of extreme endemicity.

Portugal

The distribution of goitre in Portugal is best seen on the map published in 1950 following the national inquiry on endemic goitre instituted by the Director-General of Health.[518] Although nowhere exceptionally severe, the disease is endemic or of frequent occurrence in the following districts:

Northern Portugal. Vinhais, Terras de Bouro, Mondim de Basto, Amarante, Penafiel, Baiao, Castro Daire, Sátão. Cretinism is seen in Vinhais and Amarante.

Central Portugal. To the east, the goitre belt of western Spain (Sierra de Gata) extends into the districts of Sabugal, Belmonte, Penamacor, Fundão, Castelo Branco, Oleiros, Proença-a-Nova, Mação and Crato. On lower ground to the west, nearer the sea, goitre occurs in Miranda do Corvo, Ancião and Castanheira de Pera.

Incidence is highest in the region of Castelo Branco; here goitres begin to develop in children of five or six years of age, whereas the great majority of cases in other parts of Portugal occur between puberty and the age of fifty.

South Portugal. Goitre is seen in the neighbourhood of Montemor-o-Novo east of Lisbon, and there is a belt of mild incidence in the extreme south, covering the districts of Odemira, Ourique, Almodovar, Loulé and Tavira.

In common with other countries the disease occurs much more frequently in females than in males; it often appears in various members of the same family; but in only four sufferers was it found to be associated with deaf-mutism. Goitre is known by several different words in Portugal. *Bócio* is the medical term, but ordinarily it is called *papeira* or *papo*; other familiar names are *garganta, lobo* and *papada.* Organic debility, emotional disturbances, prolonged anxiety, and peculiar qualities of soil and water are some of the factors to which goitre is attributed. There is a popular notion in Ourique that the disease is caused by drinking water that has passed over the roots of a fig-tree.

Western Europe

Belgium

It seems to be generally agreed that goitre is not an outstanding problem in Belgium today, although there are earlier reports of its endemic occurrence in some of the high-lying southern districts towards the Ardennes and Luxembourg. The comparative absence of goitre goes hand in hand with Clinquart's [529] observation that drinking-waters in Belgium contain more iodine than those in Switzerland.

During the 1939-45 war, however, Brull [521] first drew attention to a changing incidence of thyroid disease in Belgium. He found that the basic metabolic rate of all goitre cases seen at his clinic in Liège showed a steady decline from an average figure of +21.9% in 1939 to +6.6% in 1942. This was confirmed by Bastenie [520] who, in comparing the number and severity of cases of thyroid disease observed at the St. Pierre Hospital, Brussels, in the years before and during the German occupation, found that whereas the incidence and severity of hyperthyroidism did not increase and may probably have decreased, there was a significant increase in the incidence of simple goitre at all ages but particularly in the age-group 15-25 years.

The observed changes in incidence and severity are thought to be related to the quantity and quality of the diet, especially the wartime increase in the consumption of cabbage and related vegetables which contain substances of the thiourea group. In this connexion it has been pointed out that if the increase in simple goitre in Belgium during the war was in fact comparable to the " cabbage " or " rape-seed " goitre of animal experiments, a reduction in severity might be expected in cases of toxic goitre on the same diet. Such patients would, in effect, be treating themselves on the most modern lines. If this is the correct explanation it leaves open the possibility

that there was an actual increase in thyrotoxicosis in Belgium during the war, which was masked because the population was being simultaneously dosed with thiourea compounds taken in the diet.

England and Wales

In his *Treatise on English Bronchocele*, Inglis [554] says that at one time goitre was as common in the Yorkshire dales as in Geneva or any of the Alpine valleys. Children could be seen at play with precautionary pieces of black velvet around their necks—a superstition to ward off the goitre evil or charm it away.

Other records[a] in the early medical history of English counties show that goitre and cretinism were prevalent in Norfolk, in the Manchester area, in Monmouthshire, in Cornwall and elsewhere. There was a strong endemic centre in Weardale in the west of Durham, and cretins were notorious at Chiselborough in Somerset. A local predilection for oatmeal cakes was believed to be responsible for goitre in Matlock. And to this day the synonym " Derbyshire neck " brands that county as goitrous—albeit unfairly, for goitre has always been equally severe, if not more so, in Oxfordshire, Gloucestershire, Somerset and Dorset.

The first connected account of the geographical distribution of goitre in England is that by Berry,[537] who found thyroid enlargement moderately prevalent in the south-east of England, particularly in the Wealden area of Sussex and on the high ground around Horsham and towards Haslemere in Surrey. To the west and south-west the disease was conspicuous in Gloucestershire and in east and south Somerset. There was a distinct seat of occurrence in the Warwickshire villages south of Leamington. Farther east, a centre existed in Bedfordshire and there was evidence of goitre in Buckinghamshire and Hertfordshire. In the midlands a considerable number of goitrous people were noticed in Staffordshire, Lancashire and Derbyshire. From thence Berry traced the goitre belt northwards through Yorkshire to the junction of west Durham, Northumberland and Cumberland where there was a well-known endemic focus at the lead-mine district of Alston and the adjoining area of Weardale.

A comprehensive all-England examination of 375 000 schoolchildren undertaken by the medical department of the Board of Education in 1924 [540] not only confirmed the goitrous areas delineated by Berry a quarter of a century earlier, but disclosed a trend of goitre incidence sufficiently disquieting to prompt the first official recommendation that " prophylactic administration of iodine to girls in some endemic areas of England and Wales might be desirable ".[582] The over-all goitre rate revealed by the 1924 survey among schoolchildren of 12 years of age was 5.26% in boys and

[a] See references 533, 535, 536, 538, 539, 544, 546, 548-551, 553-555, 557, 558, 560-563, 567, 571, 572, 574-579, 581, 586-588, and 591 in the bibliography.

13.33% in girls in areas of high prevalence, and 1.49% in boys and 4.41% in girls in the areas of low prevalence. But some places—notably, in Devon, Somerset, Oxfordshire, Northumberland and Durham—had goitre rates of 10% to 20% among boys and more than 30% among girls.

The prophylactic administration of iodine recommended by the 1924 survey was never given general effect; but during the inter-war years some attempt was made to introduce iodized chocolate and sweets in a few affected localities. These measures, however, depended too much on the unaided efforts and enthusiasm of individual public health officials and consequently lacked the continuity which support from a central authority alone can ensure.

Without doubt the incidence of goitre in England has considerably diminished over the past hundred years in consequence of rising standards of public hygiene, better food and improved water-supplies; but the disease has never been entirely extinguished and has always continued to disturb the minds of research groups and organizations anxious to improve the physique and health of the people. In the year 1936, in the County of Somerset, goitre rates of 36% were still the rule among schoolgirls living in the neighbourhood of Taunton, Yeovil and Wells; [592] and in 1940 urgent attention was being drawn in the medical press to the high incidence of goitre persisting throughout South Wales.[545]

The war of 1939-45 brought the subject into a new prominence because of reports that thyroid enlargement was increasing in areas cut off from supplies of sea-fish. It was also noticed that the condition was unusually common among young women drafted into factories for war work. The Medical Research Council thereupon appointed a committee to consider these observations and to carry out special surveys of certain sections of the population in several counties of England and in two in Scotland. Among the committee's findings were: established goitre in 50% of adult women at Hook Norton, Oxfordshire; thyroid enlargement in 43% of girls at Sherborne in Dorset; in 26% of boys and girls at Okehampton in Devonshire; and in 21% of girls at St. Albans, Hertfordshire. By contrast, only 2% of children showed thyroid enlargement at Maldon in Essex where the drinking-water is rich in iodine.[570]

In short, the areas in which official surveys have located evidence of iodine deficiency in England are the same today as they were 50 or 100 years ago. At the time of their investigation (1944) the Goitre Subcommittee of the Medical Research Council estimated that in England and Wales there were some 500 000 cases of thyroid enlargement in persons of ages 5 to 20 years inclusive.[565] There is no reason to suppose that this figure is any less today, 12 years later; indeed, the following comparatively recent reports suggest the very opposite. Lisney,[559] County Medical Officer of Health, Dorset, refers to a surprising increase in thyroid enlargement coupled with increased lassitude and anaemia among women seen at the Dorchester

ante-natal clinic in 1949 compared with previous years. Similarly, Simpson [580] reports thyroid enlargement linked with real ill-health, lassitude and catarrh among expectant mothers attending her ante-natal clinics in the Isle of Wight during 1951. Cooke [542] also describes a symptom-complex among women in West Hartlepool which responds to thyroid medication and is believed to be analogous to, if not identical with, the Roberton syndrome commonly met with in Christchurch, New Zealand. This involves lassitude, coldness and hair changes following pregnancy and is regarded as a condition of hypothyroidism associated with endemic goitre. Finally, Hoey [552] reports a high incidence of goitre in the Bedwellty area of Monmouthshire particularly in Aberbargoed and New Tredegar. He recommends the compulsory use of iodized salt and suggests that it would possibly be helpful to make thyroid disease notifiable. The prevalence of goitre in two contrasted South Wales communities (Rhondda Fach and the Vale of Glamorgan) is at present (1956) under active study by Cochrane & Miall,[541] with the assistance of W. R. Trotter.

In 1944 [565] and again in 1948 [570] the Goitre Subcommittee of the Medical Research Council urged the general adoption of iodized salt throughout the United Kingdom as a means of preventing goitre. The level recommended is 1 part of potassium iodide in 100 000 parts of all salt, or 1 part in 40 000 parts if only packeted table salt is to be iodized. In 1950 the Government of the day seemed disposed to fulfil this recommendation; but no action followed. All that has been sanctioned and carried into effect is the addition of potassium iodide to the vitamin tablets issued by the Ministry of Food to expectant and nursing mothers.

Scotland

The survey by the Medical Research Council [570] mentioned in the section on England and Wales confirmed the well-known fact that the content of iodine in drinking-water is a determining factor in the distribution of endemic goitre. Even more important, however, was the finding that an iodine level which in a soft water may be adequate to prevent goitre may be insufficient where the water is hard. This explains why in Scotland, where the waters are mainly soft, goitre appears at a lower level of iodine intake and is much less prevalent than in England, where the waters are mainly hard.

Although goitre is not a common disease in Scotland there are nevertheless some areas where it is prone to occur, namely, in the Southern Uplands and in parts of Inverness-shire. At one time the affected region in the south extended over the greater part of Roxburghshire, the west of Berwickshire, the upper parts of Selkirk and Peebles, the northern districts of Lanarkshire, the eastern side of Ayrshire, the whole of Dumfriesshire and Kirkcudbrightshire, and the eastern parishes of Wigtownshire.[598] Today,

goitre has largely disappeared from these counties with the exception perhaps of Dumfriesshire, where the valleys of the rivers Esk, Annan and Nith remain distinctly suspect areas. The rates of thyroid enlargement found among boys and girls in the 1948 survey of the Medical Research Council were: 19% at Kirkconnel in upper Nithsdale,[a] 20% at Langholm, 23% in the Burgh of Lockerbie, and 17% in the Burgh of Dumfries.

In Inverness-shire a considerable amount of thyroid enlargement has been found among schoolchildren at Fort William, at Kingussie, in the Burgh of Inverness itself, and in Glen Urquhart, where the rates were particularly high, 35% in boys and 47% in girls.[570]

Elsewhere in Scotland goitre is of little account nowadays, but to complete the record it should be mentioned that in earlier times there were goitre centres in Perthshire,[594, 596, 597] in the Isle of Arran,[594] around Wishaw,[601] in the valleys of the western tributaries of the Clyde, especially in the coal-mining district of Larkhall,[596] and in and near Fauldhouse midway between Edinburgh and Glasgow on the east side of the Forth-Clyde watershed.[599] Goitre is also said to have occurred at one time on the east coast of Fife-shire.[596]

A fairly recent study has been made by Keddie [593] of the distribution of congenital deaf-mutism in Scotland. He states that 928 congenital deaf-mutes attended schools for the deaf in Scotland during the 20 years 1924-44, but the records of the districts from which these children came reveal nothing to suggest that deaf-mutism is invariably confined to the goitre areas.

Northern Ireland

During the course of routine medical examination of people from Northern Ireland applying for visas to enter the USA in 1929-30, Olesen & Neal [604] found a surprising amount of simple goitre among individuals coming from all parts of the six counties of Ulster.

In all, they examined 4648 males and 3992 females ranging in age from a few weeks to more than 80 years. The rate of indisputable thyroid enlargement among the males was 11.8% and among the females 27.4%. In both sexes the greatest amount of goitre was found between the ages of 15 and 24 years, the percentage being highest (33.1) in girls of 15 to 19 years.

More recent investigations have been made by Erskine,[602, 603] who determined the goitre rate in children attending public elementary schools in the south of County Antrim. Here, the goitre areas are typical rural districts with some small towns and villages situated on the main roads and near the sea coast. They extend from Waterfoot near Cushendall in the north, to Derryclone in the extreme south of the County and are bounded

[a] Long ago Mitchell [598] gave the disease the local name of " Nithsdale neck ".

on the north by the Atlantic Ocean and the North Channel, on the east by Belfast Lough, on the south by the city of Belfast and the river Laggan, on the west by Lough Neagh, and on the north-west by the Ballymena region of the County. The type of country varies considerably. On the north-east is a coastline of steep escarpments rising from the sea; inland a great plateau slopes down to a low-lying area on the west covered by flat bog or deposits of glacial clays and gravels.

Compared with other countries, the average goitre rate in Northern Ireland is not high. In every 1000 children examined, Erskine found 39 cases, of which 26 were in girls and 13 in boys. She saw more thyroid enlargement in rural than in urban schools and seldom found a case among sea-coast communities. Although the over-all rate averaged only 3.9%, there were some individual schools on the west plateau and in the valleys sloping towards Lough Neagh where the rate reached anything from 9% to 25%.

Faulty diet, iodine deficiency, bad hygiene and poor housing are the causes of goitre in County Antrim, according to Erskine. Focal and general infections are commoner in goitrous than in normal children; and the adverse effect which the condition has on the health of women during pregnancy and at childbirth is particularly noticeable.

Ireland

The general impressions of those competent to judge are that goitre is obviously much commoner in Ireland than in England. The area of highest endemicity is the South Riding of County Tipperary, but the disease is also known in County Dublin, County Wicklow, County Meath, and in Kilkenny[608] (also I. Brady and T. Stallard—personal communications, 1955). Cases have been recorded in an orphanage in Sligo (M. Kirby—personal communication, 1950) and there is a slight incidence in Counties Leix and Mayo. Goitre is said to be unknown in Galway and Kerry.[609]

The high prevalence in South Tipperary has been the subject of study by the Medical Research Council of Ireland over a period of years, and the results of their investigations are to be found in papers by O'Shea,[609] Naughten,[606] and O'Donovan.[608] Data (see Table IX) were accumulated from clinical examination of schoolchildren and chemical determination of the iodine content of the local dietary, soils and waters not only in South Tipperary but, by contrast, in the non-goitrous sea-coast village of Spiddal in Galway, and in Port Laoighise (Maryborough) and Claremorris, two localities of intermediate goitre incidence.

These data show clearly how goitre is most prevalent where there is least iodine in the locally produced foods, milk, soda-bread and potatoes. The outstandingly high iodine content of soil and water in the coastal district of Spiddal corresponds with high iodine in the local foods, and entire absence of goitre.

TABLE IX. RELATION BETWEEN OCCURRENCE OF GOITRE IN SCHOOLCHILDREN AND IODINE CONTENT OF SOILS, FOODS, AND WATER

Place	County	Goitre in children (%)	Iodine content (μg per 100 g) of				
			soils	waters	milk	soda-bread	potatoes
Cloran	Tipperary	65	3 721	1.9	1.0	1.6	0.5
Kilsheelan	,,	70	3 809	0.9	0.9	0.9	0.6
Tipperary town	,,	65	3 071	0.5	1.5	4.7	0.6
Maryborough	Leix	40	3 010	1.7	3.5	12.6	11.7
Claremorris	Mayo	10	5 050	0.4	3.6	10.7	7.0
Spiddal	Galway	0	14 390	20.1	55.6	18.3	5.6

There is no law compelling people to use iodized salt in Ireland, but the public health authorities encourage its use throughout the whole country and particularly in the areas where goitre is known to be prevalent.

France

The geographical distribution of goitre in France is the same today as it has been throughout the past century, although during that time the intensity of the disease has much decreased (Mayet; [620-623] Rochaix [626]).

The principal zones are: an eastern belt extending along the entire German-Swiss-Italian frontier from northern Alsace to the Alpes-Maritimes on the Mediterranean coast; a south-central zone covering the Auvergne and Massif Central; and a strong but smaller belt along the Pyrenees and Spanish frontier. Isolated from these three main areas are foci in the Departments of Aisne and Orne in the north-west. Excluding the two last-named, the districts of greatest incidence may be conveniently listed thus:

North-eastern Zone

Moselle	Bas-Rhin
Vosges	Haut-Rhin
Haute-Saône	Doubs

South-eastern Zone

Jura	Haute-Savoie
Ain	Savoie
Isère	Hautes-Alpes
Drôme	Basses-Alpes
Vaucluse	Alpes-Maritimes

South-Central Zone

Puy-de-Dôme	Saône-et-Loire
Corrèze	Loire
Cantal	Rhône
Lot	Haute-Loire
Aveyron	Ardèche
Lozère	Gard

Pyrenees Zone

Landes	Haute-Garonne
Basses-Pyrénées	Ariège
Hautes-Pyrénées	Pyrénées-orientales

In the eastern zone the heaviest intensity lies in Savoy, where the Tarentaise and Maurienne ranges are intersected by many goitrous valleys. Bérard & Dunet [613] regard water as the essential etiological agency in this area and they point to the existence of " conscripts' springs ", where recruits used to go to drink the water in order to develop neck swelling and so escape military service. They recall, too, the boarding-school at St. Jean-de-Maurienne where the pupils developed goitres during term but lost them when on holiday out of this area, only to develop them again on returning to school. " Holiday goitre " also develops rapidly in individuals from other parts of the country who choose to spend their vacation in these goitrogenic districts.

North of the Savoy mountains the endemic stream follows a course along the Jura and Vosges whence it swings to the north-west over the Moselle country and through the Ardennes into the northern Paris plain. In Alsace the high ground on either side of the Rhine is affected; but the valley between, especially in the neighbourhood of Strasbourg, is goitre-free (Rhein [625]).

Of the south-central area covering the Auvergne mountains and extending eastward to the Cevennes and westward to the plain of Aquitaine, there is little to be said except that compared with former times the intensity of the endemic here has greatly decreased in recent years (Bérard & Dunet [613]). A series of fairly recent papers by Faugère, Vichnevsky, Laroche, Trémolières and Derache define the present goitre position in the Departments of Corrèze and Lot, which lie in this general area.[616, 618, 619, 627, 628] In both these departments goitre rates of 40% to 50% are to be found among schoolchildren of ages between 7 and 18 years.

In the Pyrenees, also, goitre is on the wane according to Rochaix.[626] It has not, however, completely disappeared and what seem to be almost permanent foci still exist in the canton of Luz-Saint-Sauver, in the valley of the Ardour south of Bagnères-de-Bigorre, and in the valleys of the Neste and the Aure.

Since the intensity of goitre is automatically diminishing with improved conditions of sanitation, and especially of water-supply and nutrition,

preventive measures as practised in other countries have never been considered necessary by public health authorities in France.

PART II—AFRICA, ASIA AND OCEANIA

Africa

Isador Greenwald,[629] the well-known goitre historian, has accumulated what he regards as compelling evidence that goitre, now endemic throughout most of Africa, was unknown in ancient Egypt or in Roman North Africa and, indeed, did not originate anywhere on the African continent until the nineteenth or even the twentieth century.

Nevertheless, there are several early accounts of its existence. Johannes Leo [636] (*c.* 1494-1552), usually known as Leo Africanus, an Italian of noble Moorish stock and long ranked as the best authority on Mohammedan Africa, records in his *Descrittione dell'Affrica* having seen goitre during his travels (1513-15) through Morocco and the Sahara. This account has been supplemented by a number of later observations which confirm that in North Africa goitre has long been endemic on the slopes and in the valleys of the Atlas Mountains, in Spanish Morocco, and in the Kabylia Mountains in Algeria.

When making his way from the Gambia to the upper waters of the Niger in 1795-96, Mungo Park [649] saw goitre among the native peoples in the Bambuk country and at Segu-Sikoro in the direction of Timbuktu. The first European to reach Timbuktu from Tripoli, A. G. Laing,[655] also mentions goitre in the narrative of his West African journeys (1822) when endeavouring to reach the source of the Niger through the interior of Sierra Leone.

The histological and other characteristics of goitres found among North African immigrants in the Lyons region of France are described in detail by Guinet & Berger.[630]

Algeria

Some of the goitrous localities in eastern Algeria are mapped in a short paper by Sergent [632] published in 1912. He refers to the calcareous nature of the terrain and mentions the regional names given to the disease—namely, *Handjoura* (Arabic); *Hazzouza* at Thaourirth-naith-gana; *Aghbal* at El-Kseur; *Arkoum* at Tizi-Ouzou; and *Akerkour* at Lafayette.

The fullest and most recent study (1955) is that by Vergoz, Boulard & Bernard,[634] who found that the endemic zone is much more extensive than that traced by Sergent in 1912. It seems that the most seriously affected area is the Department of Constantine on the eastern side of the country

where the disease is found throughout practically the whole of Little Kabylia from the interior to the sea coast. Goitre centres particularly noticeable in this zone are Collo, Philippeville, El Milia, Taher, Djidjelli, Akbou, La Soummam, Bougie, Guergour, Takitount and Oued Amizour.

The goitre belt continues westwards into Grand Kabylia in the Department of Algiers where comparatively high rates are seen at Tigzirt, Tizi-Ouzou, Michelet, Boghni, Dra-el-Mizan, Palestro, Ménerville, le Fondouk, Rovigo, and Souma. This section of the endemic terminates at Blida, just south of Algiers. The city of Algiers itself is immune. Farther to the west there are one or two places on the coast, notably Gouraya and Montenotte, where the prevalence, although lower than in Kabylia, is still disquietingly high.

Oran, to the west of the country, is the least goitrous of the three main northern divisions of Algeria. The only place where the disease has been noted up to the present is the neighbourhood of Nedroma, which lies near the Moroccan border just south of Nemours.

The inquiry by Vergoz, Boulard & Bernard took account of about 40 000 persons—schoolchildren, military recruits, hospital patients and others—of whom 4500 had goitres. This over-all rate of approximately 10% rose markedly in certain groups and in certain places. Thus, at Takitount in the Department of Constantine, 189 children out of 200 (94.5%) were found to be goitrous; at Souma 65% and at Cap Aokas 61% of children were victims. Women were more intensely affected than men; in an area of high endemicity the figures were 71% for women and 23% for men. Cretinism appears to be rare in Algeria, and among the 40 000 people examined there was not a single case of deaf-mutism.

Vergoz and his colleagues make a strong plea for the introduction of iodized salt in Algeria. They do this from general economic and humanitarian considerations rather than because they think the goitre scourge in Algeria is exceptionally severe. In fact, goitre is much less intense there than in many other countries. They remind us that although goitre may not kill and although its lighter incidences may not seriously affect the behaviour of the subjects (mildly goitrous children are able to pursue their studies and adults are able to marry and have children) it is nevertheless a degenerative social malady from which greater evils may develop and involve unnecessary charges on the medical services of the state. These facts should be faced and preventive measures applied.

The iodine contents of drinking-waters from a non-goitrous locality and from two widely separated goitrous localities in Algeria are compared by Vergoz, Boulard & Bernard.[634] The figures have an obvious significance:

	μg of iodine per litre
Algiers (no goitre)	2.0
Souma (goitrous)	0.7
Cap Aokas (goitrous)	0.2

These authors also state that salt supplied for domestic consumption in Algeria, of whatever origin, has a very low iodine content.

Morocco

In former Spanish Morocco goitre is called " *Hansla* " by the local people, and endemic centres are to be found scattered here and there along the Rif mountain chain. Two of these have been studied in some detail—the kabila of Beni Jaled by Manuel Amaro [637] and the *kabila* of Beni Ahamed by Alonso Romeo.[635]

The *kabila* of Beni Jaled consists of 72 hamlets with a total of 14 200 inhabitants. The district lies in the mountains almost at the centre of the country and through it runs the main highroad connecting the towns of Melilla in the east and Tetuan in the west. Goitre occurs in only four of the 72 hamlets in the *kabila*—namely, Achedad, Ifartan, Takasbut and Taska. Out of a total of 300 persons in these four centres taken together, Manuel Amaro found 18 cases of simple goitre, 2 cretins, 2 deaf-mutes, and 1 case of Graves' disease. In each village the affected persons were near relatives all deriving their supplies of drinking-water from the same springs. Large quantities of turnips are eaten by these people; indeed, turnips constitute a staple food. Manuel Amaro believes this to be a causal factor but thinks also that the district is poor in iodine owing to its altitude and the mountain barriers which shelter it from the sea. The prevailing wind is from the desert south.

Beni Ahamed, the second district in which a goitre survey has been made, adjoins Beni Jaled on the west. Maximum intensity in the zone occurs in the townships of Dar Gaba, Tafsa, Bazet and Kelala. Alonso Romeo [635] made a careful clinical examination of 91 cases drawn from 19 townships, and among these he diagnosed hypothyroidism, hyperthyroidism and one case of cretinism.

The endemic area covering the centre of former Spanish Morocco extends southwards into the north of former French Morocco, where, according to Alonso Romeo, the *kabila* of Beni Zerual is greatly affected. There do not appear to be, however, any precise accounts of the nature and distribution of goitre in former French Morocco. During their investigation of endemic fluorosis in the phosphate-mining community at Khouribya, which lies inland about 60 miles south-east of Casablanca in the direction of the Atlas Mountains, Murray & Wilson [638] found no evidence or record of goitre in this area. The mean iodine content of four samples of water from the supplies used by the Khouribya settlement was 10 μg per litre, a relatively high amount which would probably account for the absence of thyroid disease in this area of endemic fluorosis.

Madeira and Canary Islands

With regard to the islands lying off the north-west African mainland, goitre is said to be rare on Madeira [8] but there is a considerable amount of it on Santa Cruz de la Palma, one of the most westerly islands of the Canary group.

Hernández Feliciano [639] examined 274 cases (13 men and 261 women, the great majority of whom were in middle adult life) from 14 localities and found that the dominant clinical characteristic was one of hyperthyroidism. A map giving the distribution of the 274 cases shows that the disease is not localized but may be found all round the island at widely separated places:

Santa Cruz	86	Tazacorte	30
Breña Alta	8	Tijarafe	2
Breña Baja	4	Puntagorda	5
Mazo	32	Garafia	8
Fuencaliente	1	Barlovento	2
El Paso	13	Puntallana	7
Los Llanos	54	San Andrés	22

La Palma is a mountainous island of underlying basaltic structure covered by a thick cap of porous volcanic rock and profusely encrusted with lava, tuff, and banks of sand. The iodine content of the drinking-water, which is derived chiefly from springs, is exceedingly low; values for samples drawn from nine different localities ranged from 0.11 μg to 0.87μg per litre, with an average of 0.27 μg per litre. Hernández Feliciano stresses the need for prophylaxis by means of iodized salt.

French West Africa

Of all national goitre surveys none has been bolder in conception, vaster in area, more exacting for the surveyors, and in its results more satisfying for its promoters and for the reviewer than that conducted by the medical officers of the Government Public Health Service in French West Africa under the impetus and direction of Dr Léon Pales.[641-647]

The Federation of French West Africa embraces the following eight separate territories: Mauritania, French Sudan, Upper Volta, Niger, Senegal, French Guinea, Ivory Coast and Dahomey; it covers an area of more than 1 800 000 square miles (4 600 000 km^2), nearly nine times that of continental France, and has a population of about 16 000 000. During the year 1948 the medical administration examined 3 162 039 people, of whom 153 591 were found to be goitrous, that is, 4.86%. At that time Pales [641, 644] concluded from these statistics that there were probably not less than 700 000 sufferers from goitre in all French West Africa.

A further investigation was made in 1950 to fill gaps left in the 1948 inquiry and to complete as far as possible the detailed map of distribution.

The number of Africans examined has now risen to 4 449 040, of whom 371 205, or 8.3%, were found to be suffering from endemic goitre. If this new knowledge be accepted as the basis of a general estimate, it will be seen that rather more than 1 300 000 people are afflicted with goitre in French West Africa and that Pales' earlier figure of 700 000 was an underestimate.[646]

Excellent maps prepared by Pales & Tassin de Saint Péreuse on a scale of 1:2 000 000 and printed in five colour gradations from yellow to dark-brown show the distribution and varying intensity of the endemic in French West Africa and also the names of the tribal races occupying the affected locations.[642, 645, 646] Looking across the map from west to east and south-east, the following areas stand out as the most goitrous:

Senegal

Rates of 14% to 40% are common in the cantons in low-lying east Casamance on the banks of the Songrougrou and Casamance rivers just south of the Gambia. High rates are also found around Dialakoto on the upper waters of the Gambia river.

French Guinea

There are centres of high prevalence (from 12% to 30%) throughout the Fouta Djallon mountain region, which covers practically the whole of the central part of the territory. Farther east, rates of 20%, 40% and 50% occur in some of the cantons around the town of Siguiri. To the south of French Guinea, where it borders on Liberia and the Ivory Coast, the endemic is severe around Macenta, Beyla and N'Zérékoré.

French Sudan and Upper Volta

The goitre area at Siguiri continues eastwards without interruption through the southern part of French Sudan and into the territory of Upper Volta. Among strongly affected areas are those adjoining the towns of Bougouni, Ségou and Koutiala in the Sudan, and an extensive region encircling the town of Dedougou north of Bobo Dioulasso in Upper Volta. The most northerly focus in this general area, and indeed one of the most severe in all French West Africa, lies near Bandiagara about 200 miles due south of Timbuktu. Here, eight communities register rates of 40% to 73%.

Ivory Coast

The principal goitre centre in this territory lies in the mountainous region of Man. It forms part of the Beyla and N'Zérékoré belt in southern French Guinea and shows rates of anything from 10% to more than 40%. Another

prominent focus lies to the east-centre of the country immediately north of Katiola 200 miles from the sea where rates of 31% and 42% have been recorded in the cantons of Fondébougou and Kembigué, respectively.

Dahomey

This narrow strip of territory in the south-east of French West Africa is not so seriously affected as some of the other territories that make up the Federation. Nevertheless, there are centres of goitre in the north around Natitiagou and Kandi, and also on the right bank of the Niger opposite the Canton of Gaya.

Viewing French West Africa as a whole, there would appear to be more goitre in mountainous regions than on the plains. But prevalence has not necessarily any connexion with altitude; thoroughly investigated villages, in which a very high proportion of the inhabitants were examined, have shown rates of 30%, 40%, 50% or even more, whether situated in mountainous country or on the plains, in savanna or in the forest. Two facts, however, may be regarded as axiomatic: goitre is extremely rare on the Atlantic sea-coast and is likewise extremely rare in the regions of the Sahara. Indeed, in French West Africa goitre is practically non-existent north of the 14th parallel, a line which constitutes an almost rigid east-west barrier between the goitrous and non-goitrous zones. The territories of both Mauritania and Niger lie north of this parallel; almost no goitre is found in either.

An arresting explanation is advanced by Pales [641, 644] for this remarkable phenomenon of disease-geography. For the most part, the highly endemic zones are sited upon soil foundations of granito-gneiss—a fact confirmed by Wilson in her later survey of Sierra Leone.[657] Pales, however, does not pay so much regard to this immutable geological consideration as to the fact that the goitrous terrain in French West Africa, the great weight of which hangs below the 14th parallel, is precisely the area in which the native peoples are dependent for their supplies of cooking and seasoning salt on " pot-ash " derived from the incineration of local plant foods, and are by reason of economic and transportation difficulties precluded from access to natural sodium chloride derived from sea-water by solar evaporation at coastal centres or from the rich salt-producing areas in the south Sahara.[641, 644]

There is little need, Pales says, to suppose a one-time sea in the Sahara to explain the possible presence of iodine in the Sahara salts which would confer goitre immunity on the peoples inhabiting that particular zone or any zone to which Sahara-produced mineral salt becomes available in the natural course of trade. The fact is, however, that the Sahara salt trade-routes have never penetrated much below the 14th parallel.[643] Peoples long established south of that line have for the most part been dependent

on vegetable salts rich in potassium which may contain little iodine, or indeed, as Pales postulates, may possess a subtle goitrogenic agent as yet unidentified. Inquiries to settle these unanswered questions are proceeding.

In French West African territories goitre is about twice as prevalent in women as in men; it is more frequent in adults than in children. According to Denoix,[640] whose investigations apply principally to the Upper Volta, the age of greatest frequency extends from 10 to 30 years, with a maximum towards the 15th year, that is to say, about the period of puberty. The largest goitres are seen in old women. It cannot be stated with certainty whether diffuse parenchymatous goitres or nodular goitres are the more prevalent, but it is probable that the diffuse type is the commoner. Cases of hyperthyroidism are exceptional, and in the statistics cancer of the thyroid is very rarely noted.

Goitrogenic cruciferous plants, more particularly the genus *Brassica* (cabbages, turnips, kale, etc.), do not figure in the native dietary. Indeed, the soils of this region of Africa are of a type far from being favoured by the Cruciferae. Consequently, these are few in number and variety, and oddly enough the ones that do occur are found mostly in zones free from goitre.

Prophylactic trials with iodized salt are in active progress and have already given highly promising results, especially at Macenta in French Guinea just north of the Liberian border.[647] Pales hopes that these first demonstrations of the efficacy of iodine as a goitre preventive are but the prelude to the systematic iodination and distribution of commercial marine salt extracted in the salt works of the Sine Saloum at Koalack, in Senegal, where the present annual production amounts to 50 000 tons and could be increased without any difficulty.

Besides spreading over extensive tracts of country in French West Africa, the goitre belt in this part of Africa also extends into the territories of Gambia, Sierra Leone, Ghana (formerly the Gold Coast) and Nigeria; it continues southwards through French Equatorial Africa into the hilly districts of northern Angola. A map showing the distribution of endemic goitre in relation to the geological occurrence of pre-Cambrian rocks throughout the whole of West Africa is given by Wilson et al.[657]

Gambia

Writers on goitre in this part of the world are wont to say that the explorer Mungo Park [649] saw goitrous people in Gambia when making his way to the upper waters of the Niger in 1795-96. He mentions having seen cases in the Bambuk country and in the neighbourhood of Segu; but these places lie in French West Africa hundreds of miles beyond Gambia to the east, and it is not certain that Park saw goitre actually in Gambia itself.

That the disease does occur there, however, has been recorded by Todd [667] and more recently by M. P. Hutchinson (personal communication to D. C. Wilson,[657] 1952). The affected area lies in the upper river district to the east where the pre-Cambrian granite formations begin, and is obviously linked up with the Senegal endemic in the same region. It would not be surprising, either, if goitre were found in the centre of the country in the neighbourhood of Georgetown because, in Senegal, both north and south of the Gambia at this point goitre is known to occur (see page 76).

Sierra Leone

" Ballansama is a man of the middle size, of a jolly appearance, both in person and expression, though a little disfigured by a large wen on his throat, which appears a disease very common to the Kooranko." That is how Laing [655] described the King of Northern Koranko whom he met in 1822 when travelling through the interior of Sierra Leone to explore the sources of the Niger. The Koranko country is goitrous today. In fact, Sierra Leone provides an excellent example of how in spite of energetic studies at widely separated intervals of time, and strong recommendations for iodine prophylaxis having been put forward on more than one occasion, only desultory efforts to remedy the situation have as yet been made and goitre still persists.

During December 1923 and the early part of 1924, Blacklock [650, 651] and his wife made a strenuous three-month tour into the hilly regions of the east and north through the tribal country of the Kono and Koranko, where they found goitrous people in considerable numbers. Their findings were fully discussed at a meeting of the Royal Society of Tropical Medicine in 1925, when Blacklock concluded his address with these words: " I am particularly anxious to ascertain what is the experience of members of this Society in regard to the administration of iodine to populations, because if the risks are indeed negligible, it is our duty to take steps to deal with the problem of goitre in our tropical possessions as soon as possible."

Almost exactly thirty years later, Wilson [657] traversed more or less the same route, found high percentages of goitre where Blacklock found them, showed that the affected areas coincide with the distribution of granitic rocks of pre-Cambrian geological age, and correlated the prevalence of the malady with low iodine content of drinking-water. In her paper to the same Society, she makes the following comments: " There is thus a belt of endemic goitre from Senegal to Angola which deserves the attention of administrators and clinicians in order that appropriate remedial measures may be instituted. The time [in Sierra Leone] is very favourable for the introduction of iodized salt which is the easiest method of dealing with goitre prophylaxis."

Blacklock's observations, and those by Wilson a generation later, agree that goitre is absent in the low-lying western parts of Sierra Leone towards the coast; these goitre-free areas are situated on comparatively modern geological formations overlying earlier rocks. In the upland eastern section of the country the endemic affects the Mende, Kissi and Kono peoples dwelling in the Kenema, Kailahun and Kono districts of the South-Eastern Province. Among Kono men and women a rate of 56% was noted by Wilson; the thyroid gland was frequently much enlarged, multinodular and cystic, and obvious goitre was sometimes present in young children, but no case of congenital goitre was seen. Farther north, the disease occurs among the Koranko living at the base of the Loma Mountains and in the Koinadugu district of the Northern Province where a rate of 71% has been recorded by McIntyre [656] in Bendugu village.

On a route from the south to the north of the goitre areas a traveller would pass through the following places of high incidence—Jiama, Paya, Kaiyima and Yaiya in the Kono country, and Saywaia, Kruto, Bandakarafaia, Kimadugu, Bendugu, Kaballa and Dankiwalli in the Koranko country. These villages all lie at the head-waters of the Sewa, Bagwe and Rokel rivers on the watershed between Sierra Leone and the sources of the Niger in French Guinea.

As already mentioned, the areas of endemic goitre in Sierra Leone are associated with pre-Cambrian granite rocks which have become altered by intensive weathering under tropical conditions. It would appear that the chief factor influencing goitre distribution is that these rocks have gradually been deprived of iodine by leaching and that, in consequence, the waters issuing therefrom have an exceedingly low iodine content. Wilson and her colleagues [657] give the following figures:

	Goitre rate (%)	*Iodine content of water (μg per litre)*
Highlands (to the east):		
Koinadugu (Koranko)	42.9-71.0	< 1.0
Kono	55.9	< 1.0
Kenema and Kailahun	19.0-24.7	< 1.0
Lowlands (to the west):		
Kambia—Port Loko area	no goitre	1.0-2.8
Moyamba—Bo area	no goitre	4.3

Goitre was found to be endemic where the waters contained less than 1.0 μg of iodine per litre, but was not recorded where the iodine content was 2.4 μg per litre or above. Sea-fish, the other important source of dietary iodine, is obtainable by most people near the coast but is rarely eaten in the more distant inland areas where goitre occurs. Another factor which, according to Wilson, may contribute to the causation of goitre in Sierra Leone concerns the intake of vitamin A from red-palm oil. It will

be recalled that Haubold [365] found a high prevalence of goitre in mountain villages in Bavaria associated with a low intake of vitamin A and carotene. In Sierra Leone the intake of fats is generally speaking adequate and that of vitamin A from red-palm oil is high. But the availability of red-palm oil depends on oil-palm density, which in the goitre areas of Kono and the adjacent Koinadugu country is not nearly so high as elsewhere, and supplies suffice only for a short season. It is possible that this seasonal scarcity may help to precipitate goitre in places where the iodine content of the diet is already precariously balanced on the borderline between sufficiency and insufficiency.

Ghana

In the extreme north of the Northern Territories of Ghana goitre has been noted by F. C. Rodger (personal communication to D. C. Wilson,[657] 1953) on the banks of the Red Volta and also for 50 miles along the Sissili river, a northern tributary of the Volta. He describes the goitres as " colloid-looking " and, in one place, as being associated with fluorosis. In this same general area goitre has also been observed by B. B. Waddy (personal communication to D. C. Wilson,[657] 1954) near the junction of the Red and White Volta rivers and in the Navrongo and Bawku districts close to the boundary between Ghana and the Upper Volta Territory of French West Africa.

Nigeria and British Cameroons

When journeying through Nigeria in the early years of this century, Tonkin [663] came across goitre in Gitata, a small pagan village perched high on a rocky ridge, almost exactly in the centre of the country immediately north of Keffi on the trade route between Loko on the river Benue and Zaria some 200 miles northwards. Tonkin estimated that 20% of the village inhabitants were affected, some with very large goitres. He saw no sign of the disease in the valleys on either side of Gitata.

Several later, and more or less casual, observations have been made from time to time—notably by Denfield,[659] who has vividly portrayed the goitres seen in the Bauchi Plateau in a series of remarkable photographs—but it was not until 1951-53 that Wilson and her colleagues [658, 664-666] correlated the various scattered pieces of information, added to them, and presented a picture of the Nigerian endemic as a whole.

Broadly speaking, the geological layout of Nigeria consists of three upland areas of pre-Cambrian granite—one in the north, one in the south-west, and one in the south-east—separated from each other by a belt of marine sediment lying roughly in the form of an open letter Y across and down the middle of the country in the great valleys of the rivers Niger and Benue, the one flowing from the north-west and the other from the north-east

along the converging arms of the Y to meet at Lokoja and thence sweep southwards to the sea as one.

The goitrous areas invariably lie on the granites of the pre-Cambrian complex, or in districts dependent on waters derived from these rocks. Goitre is absent on the marine sediments of the Niger-Benue river basins. The central plateau in the cup of the Y, an area studied by Wilson more intensively than any other, is of special interest inasmuch as basaltic and lava flows of Tertiary and Recent Age cover part of the granite. Here, families living or farming on the basalt are free from signs of goitre; they obtain much larger yields of crops. For example, the Vom section of the Berom tribe live on granite but farm on basalt and are mostly non-goitrous; but another section of the Beroms, not far away at Forum, live and farm on granite and have many goitrous women among them. Similarly, on the escarpment between Pankshin and Shendam towards the south of Plateau Province, and in the adjoining parts of Bauchi Province, goitre is common among tribes using waters that drain off the granite formations of the Naragota, Shere, Jarowa and Jere hills.

Wilson lists the goitre districts of Nigeria as follows:

Northern Region

North-west and south of Sokoto	East of Niger
North of Niger	South and east of Zaria
East of Katsina	West and south-east of Bauchi
West of Kano	North and east of Benue
South of Bornu	Many parts of Plateau Province
North-east of Ilorin	East and west of Kabba

Western Region

North of Oyo	North and west of Ondo

Eastern Region and British Cameroons

North of Ogoja	Bamenda District and south of Yola
Western part of Mamfe Division	

All these areas of endemic goitre lie on granites of the pre-Cambrian basement complex, or are associated with waters which drain off these rocks. The only exception, as explained above, is on the central plateau, where an obvious difference in prevalence and degree of thyroid enlargement (much less, if any at all) was found amongst aboriginal peoples living in granite districts overlain by basaltic lava flows of more recent origin.

The prevalence in relation to the iodine content of the water-supplies in these districts of differing geology is brought out in Table X (Wilson [666]).

The exact incidence of goitre throughout Nigeria is unknown. Among Rukabi families in Zagun village, Wilson found an average rate of 46%, the distribution being 32% in adult men, 72% in adult women, 23% in

TABLE X. RELATION BETWEEN PREVALENCE OF GOITRE AND IODINE CONTENT OF WATER-SUPPLY IN SOME PLACES IN NIGERIA

Place	Source of water	Number of subjects examined	Percentage with goitre	Iodine content of water (μg per litre)
Zagun	Older granite of pre-Cambrian basement complex	162	46	0.6 0.7
Miango	Basaltic lava flows of Tertiary and Recent Age	150	Nil	5.0
Vom	Pre-Cambrian granite, but people farming mainly on basalt	250	3	0.6
Abakaliki	From deep water shaft. Marine sediments. Niger river basin	301	Nil	92 *

* On lead-zinc mine ; probably exceptional

boys and 25% in girls under 16 years of age. Hyperthyroidism is rare, but cretinism and deaf-mutism are frequently seen. In Nigeria livestock are moved about over wide areas, and the only recorded occurrence of goitre among animals concerns a herd of pigs belonging to a bacon factory situated in a district where human goitre is prevalent; the condition cleared up following the administration of an iodine supplement.

There is no evidence that goitrogenic factors other than iodine-deficient waters are operative in Nigeria. The endemic is not confined to regions where vegetable ashes are used as salt, as is the case in French West Africa (see Pales [641, 643, 644]). Local sources of salt are insufficient for the country's needs; accordingly, imported salt is sold in Nigerian markets. The question of making iodized salt the only type imported into Nigeria is being considered by the Federal Medical Department.[662] Already, regulations prohibiting the use of non-iodized salt have been made by Tiv, Nasarawa, Zaria, Idoma, Igala, Donga and Takum Native Authorities in the Northern Region. Iodized salt means salt to which has been added potassium iodide in a proportion of not less than one part in fifty thousand.

French Equatorial Africa and French Cameroon

Two highly interesting zones of endemic goitre in French Equatorial Africa have been the subject of study by doctors of the French Colonial Service—one in the Lom-Kadei area to the east of French Cameroon and the other at Koumra, which lies between the rivers Chari and Logone-Pendé about 60 miles west of Fort Archambault.

French Cameroon

There is goitre in the Bamum country in the west of French Cameroon and also in the mountainous region occupied by the Wandala tribe in the north; but the most seriously affected area lies between the rivers Lom and Kadei in the east of the country. This was surveyed in detail by Masseyeff [669, 670] in 1953.

The area is formed entirely of primary granitic material of pre-Cambrian age, with the exception of the semi-metamorphic series of schists and quartzites in the valley of the Lom. The south is a region of forest, very dense in some places, and the north is to a great extent covered by a savanna of *Imperata cylindrica*. The soil is poor and the area is sparsely populated with a total of about 100 000 inhabitants in a density of the order of 1.85 persons to the square kilometre. This section of French Cameroon is crossed by two great intercolonial travel routes, one running from west to east through Bertoua and Batouri, and the other from Bertoua to the north through Bétaré-Oya and Garoua-Boulaye. It is in these places and in other villages and settlements along the two thoroughfares that goitre occurs.

Masseyeff investigated five localities: the villages of Garoua-Boulaye and Bétaré-Oya in the savanna region of the north; certain villages, also in the savanna, situated on or near the north-south route from Bétaré-Oya to Bertoua; the villages of Yanda, Kanda and Mbeth in the forest region immediately to the west of Bertoua; the western environs of Batouri where the villages of Bakombo and Ndimbo lie in open forest near the savanna; and some forest villages situated in clearings in the region of Ngélébok. A total of 4397 men, women and children were examined; the results are shown in Table XI.

TABLE XI. PREVALENCE OF GOITRE IN SOME LOCALITIES OF FRENCH CAMEROON

Locality	Males		Females	
	number examined	percentage with goitre	number examined	percentage with goitre
Savanna region (north)				
Garoua-Boulaye and Bétaré-Oya	451	29.9	135	50.4
On route from Bétaré-Oya to Bertoua	501	59.3	408	76.0
Forest region (south)				
Environs of Bertoua (to west)	745	54.9	933	72.9
Environs of Batouri (to west)	341	51.9	273	82.4
Region of Ngélébok	382	37.7	228	50.0
Total	2420	48.0	1977	70.7

These figures show that the disease is extremely prevalent, especially in women. It appears, too, that severity is greatest at the boundary between savanna and forest and tends to avoid true savanna and deep forest. All the very dense goitre zones are on granite soils; the endemic diminishes in areas where the soils are derived from gneiss, schists and other metamorphic rocks.

Nodular goitres are much less common than diffuse goitres, some of which are of enormous size, " greater in volume than the heads of the individuals bearing them ". Consequently, deaths due to tracheal compression are frequent. Hyperthyroidism is rarely, if ever, seen. Those who know the country well say that the people are particularly lethargic and indolent wherever goitre is most in evidence. Every small village has one or two goitrous cretins. These pathetic creatures live an almost purely vegetative existence, insensible of their surroundings and unable to do more than eat and sleep. In this region, too, goitre is of common occurrence among goats, and hunters report having killed goitrous rabbits.

Masseyeff could prove no definite relationship between the occurrence of goitre and the consumption of any particular food such as ground-nuts or maize, although it seemed to him that the zones in which maize is grown and consumed coincide very well with those of high goitre rates. The young shoots of the alimentary herb " sissongho " (*Pennisetum purpureum*) are much appreciated by both man and beast in this district and it would be interesting to inquire by laboratory experiment whether this food has any goitrogenic properties.

At one time salt made from incinerated vegetable material was extensively used, but it has long been abandoned in favour of imported salt. The prevalence of goitre has not thereby diminished; consequently, the hypothesis advanced by Pales [641, 643, 644] that vegetable salt contains a goitrogenic principle does not appear to Masseyeff to be applicable in French Cameroon. He advocates the introduction of iodized salt, with potassium iodate as the iodizing agent.

Koumra

On a journey from Algiers across the Sahara and down through French Equatorial Africa by way of Tamanrasset, Agadès, Zinder and Fort Lamy as far as Bengui on the border of the Belgian Congo, Dupont [668] saw goitres in many places; but nowhere were they so numerous or so massive as in the neighbourhood of Koumra, which lies at the centre of a subdivision of the Region of Moyen-Chari between the rivers Chari and Logone-Pendé not far west of Fort Archambault.

Here, in the heart of the country of the Saras, a beautiful, well-built, easy-going, brave and devoted people, goitre (called locally " *Kâa* " or " *Kanreu* ") has long been notorious. Bouilliez, director of trypanosomiasis investigations at Fort Archambault, described and mapped the

endemic area in 1916, noting that about 80% of the population were affected.[667] His successor, Muraz,[671-673] confirmed Bouilliez's observations in 1922, added to them, and published his most recent comments on the goitres of this area in 1943.

Dupont found it exceedingly difficult to establish the exact over-all percentage prevalence of goitre among the Koumra people, but could fix it definitely at 75% among men presenting themselves for medical examination prior to military service. Since, as elsewhere, goitre in Koumra is found more frequently in women than in men and also occurs in children of quite tender age, Dupont concluded that practically the entire Koumra population suffers from the disease. This is in marked contrast to the estimated rate of 2.5% in the Region of Moyen-Chari as a whole and less than 1% in the Region of Ombella-M'Poko, about 300 miles farther south, where a general survey of 51 villages in the Bangui area was carried out by Nimier at Dupont's request.

Although the Koumra goitres are seen more often in women than in men, Dupont found goitre more prevalent in boys than in girls. The goitres in females do not make their first appearance at the time of puberty; they are either earlier or later. During pregnancy the swelling markedly increases in volume but diminishes after the accouchement. Some goitres reach an enormous size. The average neck circumference of a well-built non-goitrous adult Sara is 14-15 inches (36-38 cm) in a man and rather less in a woman. In goitred people Dupont found circumferences of nearly 23 inches (58 cm) in a woman of 20, and 22.5 inches (57 cm) in a man of 25 years of age. Goitrous children had neck circumferences of 14.5-16.5 inches (37-42 cm) and an infant of 18 months with thyroid enlargement had a neck measurement of 11 inches (28 cm).

Cases of goitre in children under 5 or 6 years of age are exceptional; most frequently the goitre becomes manifest about the age of 20 years and in some instances its development may be very slow, extending over 20, 30 or even 35 years. These slowly evolving tumours are a common cause of sudden death due to asphyxia; the unfortunate sufferer, apparently in good health, on falling asleep will without warning be seized by suffocation during the night and die rapidly. The other usual complications of goitre—hyperthyroidism, myxoedema, cancer of the thyroid—are rare in Koumra.

Bouilliez considered that the origin of goitre in Koumra lay in the parasitic infection very prevalent in that area.[667] Muraz[671-673] also held the same view, but observed a definite ethnical predisposition inasmuch as the Baguirmian-Hausa colony, who had at that time been living alongside the Sara people for 20 years and had been using the same drinking-water from deep wells, did not present a single case of thyroid enlargement. They were entirely free from the disease. Dupont,[668] on the other hand, regards causation as wholly a matter of water-supply. He was struck by the fact that there is very little goitre in towns or villages situated directly on the banks

of rivers in the neighbourhood of Koumra. There is none at Goundéré on the river Mandoul only a few miles away. There is practically none at Fort Archambault on the river Chari; all the goitrous persons seen there came from the region of Koumra.

The drinking-water of Koumra is obtained solely from a group of 11 deep wells. One of them, no longer yielding much water but once the main source of the community, has a depth of more than 120 feet (38 m); another, now supplying most of the people, is 92 feet (28 m) deep. Dupont inclines to the theory that goitre is infectious in origin; rivers are pure and undefiled, being sterilized by the intense tropical sun, whereas waters from deep wells, being deprived of the sun's beneficent action, retain all sorts of impurities caused by the infiltration of infected products cast out by the inhabitants, even into the wells, in spite of notices that this is prohibited.

Muraz [672, 673] first proposed prophylaxis by iodized salt in 1926, but the scheme broke down through lack of co-operation. Dupont,[668] writing 15 years later, believes that, for the time being at any rate, the goitre problem in this part of the world can only be attacked by surgery or by the individual administration of tincture of iodine or potassium iodide. The general iodization of the sun-dried salt which comes in slab form into this area, especially from Lake Chad, is, he thinks, impracticable. Worthy of mention in this context—simply to emphasize local ignorance and futility in these matters—is the native remedy of tying a piece of twine or a thong of antelope skin tightly around the goitre in the hope of limiting its growth. A similar Nigerian custom is described by Denfield.[659]

Angola

The West African goitre belt, which as we have seen begins in Senegal and extends southwards along the pre-Cambrian foundations of the Gambia, French West Africa, Sierra Leone, Ghana, Nigeria and French Equatorial Africa, eventually reaches Angola, where the disease has been noted near the diamond mines in the north-eastern parts of the country by A. Warwick (personal communication to D. C. Wilson,[657] 1954).

Goitre is also found in the elevated plains of Benguela which rise eastwards towards Huambo in the west-centre of Angola. Here, Leitch [674] mentions especially one hilly district which is named " Goitre Mountain " owing to the fact that practically all its inhabitants are affected.

Just outside the extreme south-east border of Angola runs the narrow Caprivi Strip connecting South West Africa with Rhodesia and separating Angola from Bechuanaland. B. T. Squires (personal communication, 1955) reports a high prevalence in the strip and has seen cretinism there. Since goitre knows no political boundaries it may be taken for granted that the endemic spills over into Angola at this point (see also page 100, Steyn et al.[725]).

Egypt

More than thirty years ago Dolbey & Omar [675] drew attention to the fact that up and down the valley of the Nile simple parenchymatous or colloid goitre is extremely common among the fellaheen—the farmers or field labourers of Egypt—who make up about 80% of the total population. At that time hyperthyroidism was scarcely ever seen among the fellaheen, but there were increasing and disquieting signs of it among the cosmopolitan inhabitants of the towns and among Egyptians of wealth and leisure who, from considerations of taste or of employment, live in the larger cities and have adopted European habits and diet.

Recent research by Ghalioungui [676] entirely confirms the frequency of thyroid disease in Egypt. In a series of 892 patients seeking treatment for endocrine disorders of various kinds he found 643 " thyroid cases " (72%) and of these more than half were hyperthyroid. In Ghalioungui's view the general prevalence of thyroid disease in Egypt must be higher than these figures indicate because most people suffering from simple uncomplicated goitre do not come for consultation; only those who experience toxic symptoms present themselves.

Goitre is said by Dolbey & Omar [675] to have been known to the ancient Egyptians and to have been depicted on their monuments, reliefs and drawings; but Ghalioungui can find no confirmatory evidence of this in the works of archaeologists and authors who have studied ancient Egyptian civilization from a medical standpoint.[678] The picture of Cleopatra in Ruffer's *Studies in the Palaeopathology of Egypt* (1921) cannot be considered a portrait, and the slight bulge in the neck region is possibly an exaggeration due to the high-relief technique practised by Egyptian carvers of that epoch. Nor, in a fairly wide experience of old Egyptian monuments and their reproductions does Ghalioungui remember having seen a cretin, a hypothyroid, myxoedematous, or goitrous person represented. However, there is no reason to believe, he says, that goitre did not exist among ancient Egyptians, since the conditions of soil, food and water that prevailed forty centuries ago must have been very much the same as those existing today.

First to mention the endemic as distinct from the sporadic occurrence of goitre in Egypt was Ibrahim,[679] who found it in the villages of the Dakhla Oasis, which lies 200 miles west of Luxor and 350 miles south of Alexandria. The village with the highest goitre rate was El Qalamun, where 18% of the men had goitre and 3 children out of 35 examined were definite cretins. Other villages were less seriously affected, but there was a rate of 6% among adult males at Mut and cases were also seen at El Gedida, and at El Khârga in The Great Oasis to the east of Dakhla. It was not possible to examine any women.

Further and more up-to-date information about the goitre endemic in the Dakhla Oasis is available in two surveys made by Ghalioungui, the

first in 1951 and the second in 1955.[677, 678] The results of the second survey are summarized in Table XII:

TABLE XII. PREVALENCE OF GOITRE IN THE DAKHLA OASIS, 1955

Age-group	Mut			El Qalamun			El Rashda			El Gedida			El Moushia		
Under 10 years	34	Nil	Nil	73	18	25%	90	14	15%	45	17	38%	66	9	14%
10-15 ,,	6	2	33%	15	8	53%	23	11	48%	7	4	57%	1	Nil	Nil
15-20 ,,	7	5	71%	1	Nil	Nil	—	—	—	—	—	—	1	Nil	Nil
Above 20 ,,	20	2	10%	38	10	26%	17	1	6%	86	39	45%	13	1	8%
Total . . .	67	9	13%	127	36	28%	130	26	20%	138	60	43%	81	10	12%

Note. **Column 1 under each village gives the number of people examined ; column 2 and column 3 give, respectively, the number and percentage of those with thyroid enlargement.**

Goitre is common in all parts of the oasis. The highest over-all rate (43%) is seen in El Gedida and the two lowest in Mut (13%) and El Moushia (12%). The condition most frequently occurs between the ages of 10 and 15 years, and the age-group that seems to suffer least is that over 20 years; this, however, may be partly accounted for by the fact that the young men regularly migrate to the Nile Valley towns when they come of age. The general level of intelligence, initiative and activity is very low; defectives were found in greatest number in El Gedida, the village with the highest goitre rate. Obvious cretinism and myxoedema are rare.

Regarding causation, Ibrahim[679] says that, so far as the Dakhla Oasis is concerned, contaminated drinking-water is out of the question; the water comes from artesian wells at a great depth and is comparatively pure. However, it contains large amounts of calcium and magnesium sulfate and Ibrahim regards this as the chief causative factor. Ghalioungui[678] also agrees that in the oasis polluted water can be excluded from consideration. On the basis of iodine analytical studies he holds that the cause of the Dakhla endemic is, quite simply, the lack of sufficient iodine in the soil, water, local salt and agricultural products. This situation is aggravated by hard water; the varying calcium, magnesium, manganese and chlorine content of the different wells probably accounts for the different incidences at different parts of the oasis. Fish are unknown and are regarded as legendary animals. Goitrogenic foods, such as cabbage, do not form part of the diet of the oasis dwellers.

In the Nile Valley, on the other hand, polluted water is without doubt the primary goitre-producing agency, in the opinion of Dolbey & Omar.[675] People living in villages situated immediately on the banks of the Nile drink the river water; it is comparatively clean and these riparian villagers

do not develop goitre as a rule. Thyroid enlargement occurs almost exclusively among people living in villages away from the Nile where the wells and irrigation channels are incredibly polluted. Similarly, Dolbey & Omar found no goitre among the Bedouin Arabs who drink from remote desert wells yielding water which is purity itself compared with that from the grossly polluted pools, wells and canals in the villages of the fellaheen.

Sudan

At least five centres of endemic goitre have been located in the Sudan: (1) on the Nile around Ed Damer in the Northern Province; (2) at Halfayet el Melouk, a small village about 20 miles north of Khartoum; (3) in the Upper Nile Province among the Neur and Shilluk tribes south-west of Malakal; (4) in the mountains of Darfur Province to the extreme west of the country; and (5) in a narrow strip of territory inhabited by the Azande in the south-west.

The first and fourth of these endemic areas are of comparatively minor importance. The second and third have recently (1956) been studied in some detail by Ghalioungui et al.[680] They examined a total of 809 people, ranging in age from infancy to more than 60 years, and found that 402 of them, or 49.6%, had definitely enlarged thyroid glands. Sixty-five of these subjects (16 goitrous) were seen at Halfayet el Melouk; the remainder were located either in Malakal itself or in villages situated along the Bahr el Zaraf (Giraffe river), Bahr el Jebel (White Nile), and Bahr el Ghazal (Gazelle river) to the west and south-west of Malakal. The particulars are shown in Table XIII.

TABLE XIII. PREVALENCE OF GOITRE IN TWO ENDEMIC AREAS IN THE SUDAN, 1956

Village	Number of people examined	Number of goitrous people	Percentage with goitre	Iodine content of water (μg per litre)
Halfayet el Melouk	65	16	24	—
Malakal	86	30	34	—
Bantiu	242	149	62	—
Leer	79	27	34	5.7
Fangak	102	34	33	2.4
Wankai	181	116	64	—
Tarnob	45	25	55	0.7
Miscellaneous	9	5	55	—
Total	809	402	49.6	

The highest rate (64%) was seen in adolescents between 10 and 19 years of age, but there was also a 60% rate among children below 5 years. Water from three localities was examined for iodine content; samples from Tarnob, where the goitre rate is high, had a very low content.

The fifth endemic area in the Sudan covers a tract of country approximately 200 miles long and 60 miles wide, lying roughly on a SE-NW axis just where the Sudan borders on French Equatorial Africa and the Belgian Congo. It includes such places as Yambio, Naandi and Tambura, and is a region that presents features of unusual interest to the student of goitre. These have been fully described by Woodman.[681] Throughout the area are found the sources and head-waters of innumerable small streams flowing northward towards the Nile. The soil is predominantly ironstone laterite with acid clay catenas. Limestone is conspicuous by its absence. Sun-eroded areas are liable to become sandy and to have much of the nutritive content of the thin soil layer leached out and carried away by percolating water. Nevertheless, this narrow strip is known as the "green-belt" because it contains the most fertile soil of the region.

The most striking, and most puzzling, characteristic of the endemic is the apparently strict territorial limits within which it is confined. On the east the disease virtually disappears at longitude 29°; proceeding 60 miles to the north where rainfall is slightly less, where the streams increase in size but diminish in number, and where the soil gets poorer, goitre becomes less and less common and soon disappears; the western margin of the endemic ends abruptly on the borders of French Equatorial Africa where the streams run south-westward from the divide to join the M'Bomou river and eventually the Congo; the same applies to the south, where the streams run towards the Uele and the Congo.

Restriction of the endemic to this relatively small strip of 200 miles by 60 miles is hard to explain on ecological grounds. As Woodman [681] points out, the same kind of terrain, the same tribe and the same conditions of diet exist to the east of longitude 29°, where the endemic stops, as pertain in the heart of the endemic area. Similarly, why is it that only occasional goitres are seen immediately south and west of the watershed where the laterite soils are identical with those of the endemic strip?

On an average about 3% of the population have goitre and nearly 85% of cases are in women. The condition is commonest between the ages of 13 and 35 years, although there are many cases in girls of ten years and younger; in one instance an infant in arms and a child of three and a half were affected. Parenchymatous colloid goitre is the usual type but adenomatous goitres are also seen. Hard nodular thyroids are occasionally met with in patients between 40 and 60 years and are usually becoming malignant. Many of the goitres seen in young women involute to comparative normality but a large proportion attain a weight of 4-6 ounces (110-170g); sometimes tumours of 16-20 ounces (450-570 g) are seen. The almost

complete absence of true Graves' disease is a feature; in fact, the type of goitre seen in this area is described by Woodman as the least toxic of all known varieties. Cretinism and myxoedema are non-existent.

A presumption that within the endemic area the soils and waters lack sufficient iodine to prevent goitre cannot, in Woodman's view, readily account for all aspects of the endemic in this district. Altitude, climate, soil (as far as it has been investigated by chemists), flora, tribal inhabitants, diet, and incidence of parasitic infection and other diseases continue to be the same outside the affected strip; yet there is no goitre. Can it be, he asks, that the virgin streams after flowing for 50-60 miles through a leached and sandy terrain begin to derive iodine from rotting vegetation or other source? Chemical determinations of iodine can alone answer this, and it would seem of the greatest importance to have these carried out on samples of water and soil from both inside and outside the goitrous area before indulging in further speculation.

Woodman concludes: " It is hoped to make iodized salt available in all the shops of the endemic area. It would be ideal if this could be the only salt on sale."

Ethiopia and Eritrea

The high plateau of Ethiopia figures prominently as a focus of endemic goitre in north-east Africa. In 1904 Singer [686] made a journey from Khartoum up the White Nile and along the Sobat and Baro rivers into Ethiopia, whence he ascended the plateau and traversed the whole country from west to east as far as Djibouti in French Somaliland.

People with goitre were met with throughout the entire plateau, more commonly on the west side than on the east, but none was seen at the point of entry into Ethiopia, namely, in the flat country below the plateau where the Sobat and Baro debouch from Ethiopia into the Sudan. This confirms the observations of Balfour (see Blacklock [651]), who saw no goitre when travelling on the Pibor river, a tributary of the Sobat, in 1903.

Singer's cases were usually enormous goitres of the parenchymatous type, but adenomatous and other forms were encountered, and Graves' disease was far from rare. Indeed, the fact that he more or less accidentally came across six cases of typical Graves' disease—four in one family—in a brief journey through the country gave the impression that many more would be found on systematic inquiry. Singer's description of the enlarged blood-vessels coursing and throbbing over the surface of an enormous trilobed growth pulling at the neck of an exhausted man of 27, seen at Goré in the west of the country, is especially vivid.

Other earlier writers on goitre in Ethiopia include Mérab,[684] who saw much of the disease at Tegoulet, Ankober and Djimema. He mentions

that a local method of treatment practised by the Gallas is to catch a live porcupine and apply it to the goitre in the manner of a leech; its sharp-pointed teeth puncture the gland in many places, drawing off great quantities of blood and a considerable amount of colloid fluid. In contrast to Singer's observations, Mérab regards exophthalmic goitre as exceedingly rare in Ethiopia.

The most recent accounts of the Ethiopian plateau endemic are by Angelini & Scaffidi [682] and by Gasperini.[683] The two former became acquainted with the disease during service in the Italo-Abyssinian campaign of 1936, when they were struck by the number of goitrous women who came for treatment to their field hospital at Enda Atzalà Chercòs.

Enda Chercòs, or Christ's House, lies in the Atzalà valley, one of many goitrous localities found throughout the region of Enda Meconni in southern Tigrai. The Enda Meconni endemic extends along the Alagi mountain range from the plains of Mai Mescic in the north to the depression of Mai Ceu in the south. Beyond this area to the south, Angelini & Scaffidi saw goitre in the Provinces of Wollo and Shoa where it was particularly evident at Debra Birhan and Ankober in the orbit of Addis Ababa. They also refer to its prevalence in Wollega and Gojjam Provinces in the west of the country.

These two authors emphasize that it is almost solely the female sex that is affected; they saw scarcely any goitre among men and regard the predominance of cases in women as an indication of the mildness of the endemic, arguing that in regions where the disease is exceedingly severe the two sexes are affected almost to the same extent and, in addition, cretinism and deaf-mutism are always very pronounced. They did not come across any cretins or deaf-mutes.

On being asked their opinion as to the cause of the disease and the reasons for its widespread occurrence among women, some of the Atzalà valley people insisted on stressing the particular importance of family mourning, which, in women, determines the cut of the hair; very often the commencement of a goitre is attributed to the shaving of the head at the time of the death of this or that relative. Others blamed the drinking-water, so often fouled by the decaying bodies of land animals and birds. Mention was also made of a stream in the vicinity of Mai Mescic north of the Alagi range which bears the name Mai Gurgurì (i.e., goitre water) because those who habitually drink from it invariably contract goitre.

Initial attempts by Angelini & Scaffidi to introduce iodine preventive measures were succeeded some years later by the more precise and systematic efforts of Gasperini.[683] He was especially concerned with goitre along the Eritrean border, where the chief endemic centres are a few small villages in the districts of Makale and Uagh, and in the neighbourhood of Adigrat. Supplies of salt for this region are obtained in blocks from Massawa and other places on the Red Sea coastal area of Dancalia.

Gasperini describes in detail the method by which this salt from the Eritrean salars was iodized and explains how he overcame certain difficulties connected with the process and with the subsequent distribution of the salt.

Somaliland Protectorate

Reporting in 1936 to the Economic Advisory Council's Committee on Nutrition in the Colonial Empire, the medical authorities in British Somaliland mention that they found some clinical evidence pointing to a possible deficiency of iodine in the diet of the Somalis; but it would appear that this cannot be very serious because the report specially stresses the distinctive stature and physique of the nomad Somalis and the absence of any widespread nutritional disorders.[687]

Uganda

Goitre does not appear to be a pressing problem in Uganda. Nevertheless, nearly every Baganda child examined by Dean [688] at a primary school in Kampala was found to have an enlarged thyroid. According to Dean no one has yet seen a Baganda cretin.

In his paper on goitre in the Belgian Congo, van Campenhout [691] refers to occurrences of the disease on the spurs of the Ruwenzori Mountains and in the basin of the Semliki river between Lake Albert and Lake Edward. As the Ruwenzori range and the river Semliki form part of the western boundary of Uganda, this endemic area deserves mention here.

Tanganyika

There is little information about goitre in Tanganyika, but Trolli mentions its occurrence " in the mountainous regions ".[692] Since the context in which he was writing concerned the Belgian Congo and, in particular, the uplands around Lake Kivu and in the Ruanda-Urundi territory, it is possible that he was referring to the mountains of north-west Tanganyika immediately adjoining this area.

More recently, C. D. Williams (personal communication, 1954) has recorded the presence of goitre specifically in the southern highlands.

Belgian Congo and Ruanda-Urundi

Four distinct and well-documented regions of endemic goitre exist in the Belgian Congo. These cover: (1) an upland area in the north and north-east; (2) the high mountain barrier separating the Belgian Congo from Uganda and Tanganyika in the east; (3) the mountainous parts of Katanga Province in the south and south-east; and (4) a smaller area in the far west situated just south-east of Léopoldville. No goitre is reported

from the vast low-lying parts of the Congo river basin in the centre of the country.

North and north-east

The first of these endemic regions extends throughout practically the whole of the area bounded by the Ubangi-Uele rivers in the north and the most northern stretch of the main Congo river. It thus occupies a strip of territory about 600 miles in length, from Bangui and Zongo in the west to Niapu and Panga in the east, and about 150 miles in depth from north to south. Although the entire area is continuous so far as goitre occurrence is concerned, it may conveniently be considered in three main sections—west, centre, and east—by reason of the fact that the published literature on the subject naturally divides itself in this tripartite way.

The western section, described more especially by Schotte,[702, 703] Daloze,[692] van Campenhout,[691] and Baudart,[689] covers the area watered by the rivers Ebola, Dua and Mongala. It includes the districts of Banzyville and Yakoma on the river Ubangi, and its most heavily affected focus is Abumombazi, which is situated at the head-waters of the Ebola.

The central section, referred to particularly by Rodhain,[701] Trolli,[692] and van Campenhout,[691] covers the area watered by the rivers Uele, Likati, Rubi and Itimbiri. It includes the districts of Bondo on the river Uele, and Aketi and Buta on the river Rubi.

The most easterly section of the endemic has been studied intensively by De Smet [695, 696] but has also been visited by Rodhain.[701] It covers the region watered by the rivers Lulu and Aruwimi, especially the triangle in the neighbourhood of Yangambi formed by the Aruwimi and the right bank of the upper Congo with apex at Basoko. Eastward extensions of this goitrous area are found as far as Niapu near the source of the Rubi and at Panga on the river Ituri north-east of Stanleyville.

According to natives of this northern Congo area goitre is of fairly recent origin there, and is said to date back only to about 1895. Van Campenhout,[691] who spent much time in the Ebola-Likati area south and west of Bondo during the years 1894-97, was never particularly struck by the existence of the disease at that time; and Rodhain,[701] who had lived in the Ubangi region since about 1900, only mentions his first cases in 1912-15. Following these early observations, reports of goitre occurrences mount up rapidly and the survey-map of the Ebola-Dua-Likati area made by van Campenhout in 1934 shows goitre rates of 20%, 30%, 50% and 60%. Confirmatory data were given by Baudart [689] in 1939, thus:

	Number of people examined	*Number goitrous*	*Percentage goitrous*
North of the Ebola	4226	1649	39.02
South of the Ebola	4682	2442	52.16
Banks of the Uele	5661	345	6.09

In the Ebola region Baudart observed goitre quite frequently among infants at birth; but it is of course more prevalent in adults, especially women. To the east of this northern zone De Smet [695] noticed an increasing prevalence (from about 1.5% to 80%) as he moved from Yangambi on the right bank of the upper Congo northwards towards the Aruwimi river. On the left (south) bank of the Congo at this point the people are reported to be less afflicted by the disorder. The explanation given is that centuries of rain have washed out all iodine from the soils on the northern bank whereas the alluvial soil of the south bank is being constantly reinforced with minerals from the river. Among dwellers immediately on the river banks on either side, where much fish is consumed, there is no goitre. Toxic goitre occurs in this area; and cases of goitrous fibroma in women are not uncommonly accompanied by sterility, a condition considered to be associated with hypersecretion of the sex hormone, folliculin (see also Velghe [705]).

East Congo and Ruanda-Urundi

Goitre centres have been found in various parts of the north-east and east of the Belgian Congo, particularly on the spurs of the Ruwenzori Mountains between Lakes Albert and Edward (van Campenhout [691]), around Lake Kivu and in the Territory of Ruanda-Urundi at the head of Lake Tanganyika (Demaeyer & Vanderborght [694]), and in the districts of Lokandu and Kasongo (Kadaner [699] and Velghe [705]) which lie on the river Lualaba, respectively 200 and 350 miles south of Stanleyville.

Ruanda, with a population of approximately two million, was made the subject of special study by Demaeyer & Vanderborght,[694] who examined a total of 22 801 people of the Bahutu and Batutsi tribes—about a thousand from each of 22 different places. The goitre rate varied from 1.83% to 28.37% according to locality; it was higher among women than among men and most goitres were of the parenchymatous type. Nodular goitre was not observed in individuals under the age of 30, and no cretinism, deaf-mutism or Graves' disease was seen.

The higher rates were usually found in places with a high rainfall and situated on lava and basaltic rocks rich in magnesium, calcium and potassium. Dry regions on schists and quartzites had a low incidence. The data for the 22 localities studied bring out this relationship (see Table XIV).

It will at once be seen that in a general way the percentages of goitre increase from top to bottom and from left to right of the table, that is, they increase with the degree of rainfall and, for the same level of rainfall, with the proportion of potassium, magnesium and calcium salts in the rocks.

In Ruanda, " vegetable " salt used to be eaten but has been completely replaced by ordinary salt and cannot therefore be associated with the presence of goitre. Among the different vegetables eaten by the Bahutu and Batutsi only one has any relationship with the *Brassica* genus; this is " isogo "

TABLE XIV. PERCENTAGE PREVALENCE OF GOITRE IN RELATION TO RAINFALL AND NATURE OF ROCKS

Rainfall (mm)	Schists and quartzites	Granito-Gneiss and micaschists	Lavas and basalts
Below 800	4.66	—	—
800-900	2.04, 2.09, 2.92	1.83, 3.68	—
1000-1100	3.74	4.04	—
1100-1200	7.30, 14.73	17.62	—
1200-1300	11.19	17.57, 23.25	14.60, 25.24
1300-1400	6.25, 12.40	19.31	23.00
1500-1600	—	22.00	—
1700-1800	—	28.37	—

(*Erucastrum Arabicum*), but as it is in almost general use both in areas of high and in those of low incidence, it does not seem that it can be incriminated as goitrogenic.

The goitres mentioned by Kadaner [699] at Lokandu in the Maniema region occur predominantly in women and are not regarded as very serious; those seen by Velghe [705] among the Matapa at Kasongo were also mostly in women, but apparently in this district sterility and goitre go hand in hand. Lack of iodine in the soil and water is not considered to be primarily responsible for the frequency of goitre here, since the disease is much less prevalent in neighbouring communities living in an identical environment. It is believed that the sterility among women is due to a conditioned deficiency of iodine produced by an excessive secretion of the sex hormone, folliculin, acting as a goitrogenic agent. Men are less affected with thyroid trouble because their testosterone secretion is generally normal in amount (see also De Smet [695]).

South and south-east

The southern endemic covers the greater part of the highlands of Katanga Province. With its centre at Sampwe in the Kundelungu Mountains, where incidence is highest, it extends to Mwanza in the north, almost to Elisabethville in the south, as far east as Pweto on Lake Mweru, and westward through Bukama, Kalule, Kamina and the Lomami country to the river Lulua and the Dilolo area on the borders of Angola (Schotte; [702, 703] Trolli; [692] van Campenhout; [691] Calonne [690]).

The Sampwe district, examined closely by Calonne, [690] is situated in the valley of the river Lufira, a tributary of the Lualaba. It is surrounded by mountain masses yielding a multitude of small streams near to which are established native settlements consisting chiefly of the Basela and Balomotwa

tribes. These people live a hard and frugal life, as a general rule sowing only one crop on a poor impoverished soil, possessing few if any livestock, and all obtaining their drinking-water from the same mountain sources.

The disease is seen only at lower levels along the margins of the rivers feeding the Lufira, not on the high plateaux. The over-all rate of established goitre among 1118 natives examined by Calonne was 24.5%. If 71 cases of diffuse hypertrophy seen in young people about the age of puberty are included in addition, the over-all rate increases to 30.8%. Men were less affected than women; out of 395 males of all ages there were 34 with goitre (8.6%) compared with 240 cases among 723 females examined (33.2%). Certain districts were intensely affected, with rates among women of 50%; nevertheless, as is not unusual in goitre country, some villages situated in the very heart of the affected area were, inexplicably, entirely free from the disease.

Toxic goitres develop in about 25% of cases, and an interesting observation is that clinical signs of hyperthyroidism, especially in girls, are quickly brought on by any unusual physical exertion—running a race, for example. Congenital goitrous defects—idiocy, deaf-mutism and cretinism—are very frequent in the Sampwe area.

Western Belgian Congo

Medical census of the population of the Province of Kasai towards the west-centre of the Belgian Congo, and of the Lower Congo District in the extreme west, reveals only isolated occurrences of goitre (Trolli [692]). There is, however, a mildly endemic centre in the Foréami *cercle* of Popokabaka, an area occupied by the Bayaka tribe about 150 miles south-east of Léopoldville. It covers the region watered by the rivers Kwango, Twana and Wamba, and it extends to the Mosamba country east of the Wamba. Himpe & Pierquin [697] and Vande Voorde [704] are the authorities on this endemic.

The staple diet of the natives is " monwa " (cassava) and is the same for all regions of the *cercle*. The yam is in fairly widespread use, and to a lesser extent rice and maize. By way of condiments there are gourds, peanuts, grasshoppers, caterpillars, a few cooked vegetables and pimento. The survey by Himpe & Pierquin [697] relates to a total of 36 316 persons in the administrative sectors of Ngowa, Munene and Kabula among whom they found only 303 goitres. The prevalence is therefore slight, being on an average 0.83% and nowhere higher than 4.25%. Goitre runs very distinctly in families, starting at an early age and developing slowly to maturity in adult life. In regard to size, the 303 enlargements varied considerably and are classified thus:

Pigeon's egg	78	Fist size	71
Hen's egg	90	Baby's head	16
Duck's egg	45	Football	3

There are few complications; goitre does not apparently influence fertility, and hyperthyroidism if it occurs at all is not acute.

Finally, so far as the goitre geography of the Belgian Congo is concerned, Perin [700] has noted that the disease is frequent in the Kimvula area of the Lower Congo to the west of Popokabaka. Here, the people are of poor physique, anaemia is common, and there is marked lumbar curvature and a high proportion of pelvic malformations in women, leading to difficulties at childbirth.

The Rhodesias

The Districts of Serenje and Mkushi in the Central Province of Northern Rhodesia are areas of endemic goitre. The region, occupied for the most part by the Lala, a Bantu tribe, consists of a wooded highland plateau and a valley area. The majority of the Lala dwell in the highlands; the rest live in the lowland valleys through which run the Lukusashi, Luangwa and Lunsemfwa rivers, which receive the streams and tributaries arising on the Zambesi side of the Congo-Zambesi watershed.

Beet [706] made an exhaustive nutritional survey of 660 Lala children at 17 schools in both plateau and valley areas. He found 38% of children with enlarged thyroids. The rate was higher in girls but the difference was not marked. To the north-east of Serenje and Mkushi, but in the same general area, lies Chitambo, where D. Mackay (personal communication, 1946) has reported the prevalence of goitre.

There is very little published information about goitre in Southern Rhodesia but, according to W. R. Carr (personal communication, 1954), the disease is endemic in many parts. This is confirmed by the recent (1954) decision of the Government to consider the iodization of all crude salt, of which about 10 000 tons are consumed annually in Southern Rhodesia. As this supply comes from a number of different local sources, the iodization of all consignments presents an administrative problem.

Union of South Africa and neighbouring territories

Following the general west-east north-south pattern of our world survey, it is convenient to treat the southern section of the African continent as a whole. Accordingly, the Union of South Africa is considered together with its neighbouring territories, more or less in the following order: the Caprivi Strip, South-West Africa, Bechuanaland, Swaziland, and Basutoland. The main centres, features, and causes of endemic goitre in this vast area are fully documented and described by Steyn and his colleagues in the 1955 report of the South African Goitre Research Committee.[725] Among others who have made notable contributions to knowledge of goitre in South Africa are: Frack [712] (Transvaal); Blom,[707] Buttner [708] and Schur Brown [721]

(Langkloof Valley); Dormer [710] (Natal); Le Riche [715] (Johannesburg); Kark & Le Riche [713] (Orange Free State and Natal); and Steyn's collaborators, Malherbe & Osburn.[716-718]

Eastern Caprivi Strip

As mentioned on page 87, goitre is prevalent in the narrow strip of territory running between the south of Angola and the north of Bechuanaland to connect South-West Africa with the Rhodesias. The Caprivi Strip is some 200 miles long and 20-30 miles wide, with a total area of approximately 4500 square miles (about 11 500 km^2) and a population of about 15 000. The country is flat and very sandy, except in the most low-lying areas which grow luxuriant crops. During the rainy season large tracts are inundated. The nutritional state of the people appears satisfactory but their standard of hygiene is low, and, owing to the marshy nature of much of the country, malaria is rife.

In 1942, Annecke (see Steyn et al.[725]) made a goitre survey of the Eastern Caprivi Strip and reported that " anything above 70 per cent of men, women and children show a simple enlargement which in older age may become nodular (probably adenomatous)". He found the disease predominantly in females and suggested a relationship between its occurrence and the distribution of the manketti- or mungongo-nut tree. It was subsequently proved, however, that the manketti nut has no goitrogenic properties. B. T. Squires (personal communication, 1955) visited the south-eastern portion of the Eastern Caprivi Strip in 1949 and reported a 50% goitre rate there; enlarged thryoid glands in breast-fed babies were no exception. In this area manketti-nut trees are extremely rare.

The more recent observations by the South African Goitre Research Committee (Steyn et al.[725]) confirm the high prevalence in the Eastern Caprivi Strip, even among breast-fed infants and toddlers. The mean goitre rate throughout the area is 50%, but at Linyanti village it rises to 70%. From the results of their investigations the Committee conclude that the major cause of the endemic is a primary iodine deficiency in soil, water and food, aggravated no doubt by the contamination of drinking-water and general unhygienic conditions.

Western Caprivi Strip and South-West Africa

A goitre survey of the western portion of the Caprivi Strip, which for administrative purposes falls under the jurisdiction of South-West Africa, has been made on behalf of the South African Goitre Research Committee by Kuschke.[725] He found that the endemic of the eastern strip extends westward and affects the tribes inhabiting the western end of the strip and the adjoining areas of South-West Africa and Bechuanaland. Among the

Barakwengo, the goitre rate was almost 70%; among the Okavango, 62.6%.

Of all the enlarged thyroids examined by Kuschke only a few were nodular and one definitely in an early carcinomatous stage. He attributes the disease to iodine deficiency in the food, water and soil of the area and recommends that iodized salt be supplied not only throughout the whole of the Caprivi Strip but also to the tribes of the neighbouring Okavango Native Territory.

For the rest of South-West Africa there are no definite facts, but Steyn et al.[725] suggest that as the subterranean waters in the southern semi-arid regions of the country contain fluorine, there is every likelihood that fluorine-induced goitre occurs there just as it does in the adjoining areas of north-western Cape Province, also known to be fluorine-rich.

Bechuanaland Protectorate

Goitre is seen in Bechuanaland only in the far north, where the country marches the whole length of the Caprivi Strip. As already mentioned, there is a high prevalence in this area, especially along the Linyanti river to the east and along the Okavango river in the extreme north-west of the Protectorate. Elsewhere in the country only occasional cases of goitre are met with (B. T. Squires—personal communication, 1955).

Union of South Africa, Swaziland and Basutoland

Taking the Union, Swaziland and Basutoland as a whole, goitre is found in the following five main areas:

1. *Transvaal.* A narrow belt stretching for 300 miles across Transvaal from Zeerust in the west through Witwatersrand as far as Nelspruit in the east. Places affected in this endemic area (from west to east) are: Zeerust, Groot Marico, Kuilfontein, Koster, Rustenburg, Brits, Bronkhorstspruits (just east of Pretoria), Belfast, Machadodorp, Waterval Boven, Elandshoek Valley, Nelspruit and Barberton.

2. *Swaziland.* From the Nelspruit and Barberton area of eastern Transvaal the goitre belt curves southward and occupies practically the whole of Swaziland.

3. *Basutoland and the Drakensberg range.* The entire Drakensberg area, including Basutoland, is potentially goitrous. On the northern slopes of the range the disease occurs at Witzieshoek in the Orange Free State. On the eastern side it is found along Bushman's river and also in the Estcourt and Helpmakaar areas of Natal. Somewhat farther south on the eastern Drakensberg there are occurrences at Impendhle, Polela and Underberg. Goitre has also been noted in and around Blikana and Herschel

which lie at the foot of the Witteberg range in Cape Province just beyond the southern border of Basutoland. Qumbu on the south-eastern edge of the Drakensberg is another goitre centre falling within this geographical group.

4. *Southern Cape Province.* In the south-east of Cape Province goitre occurs in the Winterberg area and in places along the river Kei, which rises in these mountains. Fort Beaufort, to the south of the Winterberg, is a goitre centre.

In the extreme south of the Province the whole of the region from Prince Albert and the Groot Zwartberg eastward to Humansdorp and Port Elizabeth is a well-known goitre area. It includes (from west to east) Schoemanshoek; the Outeniquas Mountains and the neighbourhood of George and Knysna; Uniondale, Krakeelrivier, the Hoeree valley, Kleinrivier, Joubertina, and other places in the Kouga Mountains and Langkloof-Kouga river valleys.

In the south-west of Cape Province goitre has been noted at Villiersdorp, Greyton and Caledon to the south-east of Cape Town; and also at Ceres and Prince Alfred's Hamlet in the Hexrivierberg region to the north-east of Cape Town.

5. *North-western Cape Province.* Goitre occurs throughout the entire area from the coast at Port Nolloth eastwards for 300 miles to Kenhardt. This belt includes: Springbok, Nababeep and Ookiep; Poffadder; and Kakamas and Upington on the Orange river. Another 200-300 miles to the north and east of Kenhardt, the disease is found at such places as Kuruman and Vryburg.

Chemical analysis of water in these regions led Steyn et al.[725] to conclude that endemic goitre in the north-western Cape Province is chiefly due to the general presence of goitrogenic quantities of fluorine and calcium in the drinking-water and not to an inherent primary iodine deficiency. There are, of course, exceptions. Areas exist in the north and north-western parts of Cape Province where goitre is due, in a measure at least, to an absolute iodine deficiency; this is the cause, for example, at Upington and Kuruman. And there is the fact, as yet unexplained, that the prevalence among scholars at Port Nolloth and Vryburg is fairly high in spite of a very satisfactory concentration of iodine and a minimal amount of fluorine in the municipal water-supplies.

The prevalence of goitre throughout the Union and neighbouring territories of South Africa varies considerably. Malherbe found that 26.6% of children at Kuilfontein School (Oberholzerskloof) in the south-western Transvaal were affected, but at one place in the Nelspruit-Barberton area on the east side of the Transvaal no less than 290 Bantu women out of 300 examined had goitre. In Swaziland the rates among school-children are generally high, varying from 4% at Goedgegun European

School to 71% at Imbuluzi Native Mission School 11 miles north of Mbabane.

Among Natal schoolchildren the incidence is apparently considerably lower than in the Transvaal. Strydom (see Steyn et al.[725]) carried out a thyroid survey at 14 European, 9 Coloured and 6 Native Schools in Natal and found rates ranging from zero in the European Schools to 4% in the Native Schools.

Thirty years ago (1927) approximately 65% of the inhabitants in the Krakeel, Hoeree and Klein river valleys (Langkloof-Kouga region) showed simple thyroid enlargement. More recent statistics from this area are 23% of slightly enlarged glands in Coloured children at a school in Knysna, and rates varying from 3% in primary and secondary schools at Joubertina to 22% at Opkoms School. Rates of 7% to 25% are recorded by the South African Goitre Research Committee among children in the endemic fluorosis areas of north-western Cape Province.

During the course of their investigations the Goitre Research Committee encountered many cases of simple goitre which were intermittently toxic. By far the highest prevalence of thyrotoxicosis, including exophthalmic goitre, was seen in north-western Cape Province. Steyn and his colleagues believe that the fairly general use of large amounts of iodine in the form of Lugol's solution for the treatment of simple goitre is in some measure responsible for the high prevalence of thyrotoxicosis here. This raises once more the evergreen problem of Jod-Basedow or iodine-induced hyperthyroidism.

On the question of causation, all the information collected in the course of the exhaustive analytical investigations conducted by the South African Goitre Research Committee has amply confirmed the view that iodine deficiency is the primary cause of endemic goitre in the Union and neighbouring countries. Contributory factors in certain areas already mentioned are excessive quantities of fluorine in the drinking-water. Soils, waters and vegetation extremely rich in available calcium are also incriminated in some localities as, for instance, the Langkloof Valley region. It has also been suggested, by Buttner,[708] that the occurrence of the element tellurium in the Knysna area may be a contributory etiological factor, but there is no confirmation of this.

The Goitre Research Committee, headed by Steyn, strongly recommend the non-compulsory introduction of iodized salt in all the endemic goitre areas where the disease is due to a primary iodine deficiency, i.e., in every goitre area throughout the Union except in those parts of the north-western Cape Province where goitre is fluorine-induced.[725]

Thyroid disease is surprisingly uncommon among farm animals in the endemic goitre areas of South Africa, but occasional cases are seen. When investigating stock diseases all over the Union and in South-West Africa, the Eastern Caprivi Strip and Swaziland, Steyn & Sunkel[723] only twice

saw evidence of iodine deficiency in animals. The first was in a small area in the Orange Free State where merino ewes gave birth to a high percentage of lambs with enlarged thyroids and a number of stillborn lambs. The second occasion was an outbreak of goitre among newborn Afrikander calves on a farm situated on the south bank of the Black Kei river in the Cathcart district of Cape Province. The only other recorded occurrence of goitre in Afrikander calves is that cited by Matthew & Thomas [719] on a farm in the eastern Cape Province. According to a recent report (1956) there is no iodine deficiency among animals in the Highveld region around Potchefstroom west and south-west of Johannesburg.[711]

Seychelles and Madagascar

Minor occurrences of goitre have been noted in urban and rural areas of the Seychelles by M. Dick (personal communication, 1952), and in the mountainous interior of Madagascar by Cloitre [729] and by Nimier (see Dupont [668]).

Cases seen in Madagascar are mostly of sporadic and unrelated occurrence among Betsiléo and Hovas women who come from such districts on the high plateaux as Ambositra, Ambohimahasoa, Fianarantsoa and Alakamisy-Itenina. The disease is unknown among the Tanalas, Baras and other peoples of the eastern coast region and extreme south of the island.

Nimier (see Dupont [668]) found no more than 50 goitres in 60 000 inhabitants of the Ambositra district, and Cloitre [729] emphasizes that there are no grounds for regarding the disease as seriously endemic in Madagascar. Of 32 cases seen by him, 31 were in women over 25 and mostly between 35 and 50 years of age. Visible thyroid swelling in adolescent girls was not uncommon.

Asia

The headquarters of goitre and cretinism on the continent of Asia are the northern and southern slopes of the Himalaya Mountains. This classic endemic focus extends eastwards almost without interruption through Burma into China and neighbouring countries. The adjacent endemic areas of southern Asiatic Russia have already been noted (see pages 42-43). In the western regions of Asia goitre occurs endemically only here and there; a few places in Turkey are mildly goitrous, and there are centres in Lebanon and in Iran.

With the exception of Lebanon, the countries along the Levantine coast—Syria, Israel and Jordan—are apparently goitre-free, as also are Iraq and Arabia, although it is said that goitre has been seen on the Yemen-Aden border.

Turkey

Speaking generally, goitre is not a serious problem in Turkey. Nevertheless, the fact emerged during discussions at the Tenth National Medical Congress, held at Ankara in 1948, that one or two areas may be regarded as endemic.[731] One of these covers the northern bulge of Turkey where steep valleys from the spurs of the Kastamonu-Ilkaz mountains slope sharply to the southern shores of the Black Sea. This general area includes Adapazari, Düzce and Bolu; the environs of Bartin, Kastamonu, Taşköprü, Gerze, and the peninsula at Sinop. Somewhat farther east, goitre has been found in the district of Amasya.

Another endemic region lies to the west and south-west of the country; here the principal centres are Afyon, Aydin and the neighbourhood of the Menderes Chai river south-east of Smyrna, and Isparta, which is recognized as an area of pronounced goitre. In the southern bulge of the Turkish mainland opposite Cyprus, goitre is found in the Bozkir and Ermenek Districts of Konya Province and in the Taurus Mountains. In the eastern part of Turkey there are centres of the disease at Erzincan and Erzurum relatively near the endemic areas of Armenia and the Caucasus.

According to Saka,[732] the city of Istanbul and the country surrounding the Sea of Marmara, as well as the regions westward into Thrace, are practically goitre-free, although cases of thyrotoxic disease appear to be frequent. Saka examined the thyroids of 71 persons from all parts of Turkey who had died from a wide variety of diseases. He found the average weight of the normal gland to be 26.6-28.0 g. Weights above average were noted in persons who came exclusively from districts of high elevation where goitre is of frequent occurrence, e.g., from Bartin (42.5 g and 80 g), Djerkesch (44 g), Erzincan (49 g) and Erzurum (43 g and 55 g).

Animal goitre is not uncommon in Turkey, particularly in the northern Kastamonu-Ilkaz region. Akçay [730] examined the thyroid glands of 177 cattle *post mortem*; of these, 125 were affected with simple hyperplastic goitre, 9 had colloid goitres and 8 were exophthalmic.

Since about 1945 the inhabitants of goitre regions in Turkey have been supplied with iodized salt, and goitre posters and pamphlets have been distributed.[731]

Lebanon

Physiographically the Lebanon consists of two parallel mountain chains running the length of the country in a NE-SW direction—the Lebanon range proper to the west, and the Anti-Lebanon to the east. Between these two ridges is a high plateau, the Bekaa.

Goitre is endemic at several places on the slopes and in the valleys of these mountains, particularly those on the inner sides facing the Bekaa

plain in the central section of the country. Ciaudo et al.[736] give the following origin of 100 cases they had occasion to observe:

Kab-Elias	18
Zahlé	15
Deir El Harf	14
Hamana	13
Beskinta	6
Hasroun	4
Broumana	3
Salima	3
Miscellaneous	24
Total	100

Kab-Elias is situated on the eastern slope of the main Lebanon chain, and overlooks the Bekaa. Zahlé is similarly placed, deeply recessed between two mountains. It is impossible to walk along the streets of these two villages without noticing goitrous people.

In the narrow coastal strip between the Mediterranean Sea and the western Lebanon foothills the disease is practically non-existent. Among the 24 miscellaneous cases listed above, only four came from the seaboard: one from Gebeil (Byblos), one from Chekka, one from Jounieh and the fourth from Chiah. All these subjects, although born by the sea, were descended from goitrous parents of mountain stock. It is exceptional if not impossible to find a Beirut native with goitre; any cases that may be seen there have originated elsewhere.

The goitres seen in the Lebanese mountains are of the diffuse parenchymatous type and often of considerable size; toxic symptoms are not uncommon, and malignancy is occasionally met with. Chaia [733] has made the interesting observation—reminiscent of that by Calonne [690] in the Belgian Congo (see page 98)—that excessive or unusual physical effort may induce thyroid enlargement. He noticed that goitre developed in a number of young soldiers under hard training within six months of enlistment.

The social implications of goitre in the mountain areas of Lebanon, and the need to institute preventive measures, have been emphasized by Refet.[737] He proposes the following régime for eventually ridding the country of goitre.

(1) Examination by the district doctor of all primary schoolchildren between the ages of 7 and 14 years, to eliminate if possible those who might be sensitive to iodine medication.

(2) First year of prophylaxis: give each child one tablet of Iodostarin (diiodotariric acid) or one tablet containing 0.001 g of sodium or potassium iodide, regularly every Monday morning for 40 weeks. Stop during the holidays.

(3) Second year of prophylaxis: one Iodostarin or iodide tablet per child once a week for four weeks during each half-year.

(4) Third and fourth years of prophylaxis: continue the tablets weekly for one month every half-year, as in the second year of prophylaxis, in cases where the goitre has not disappeared.

Israel

Recent mass immigrations into Israel of Jews from all over the world—people with different cultural, nutritional and climatic backgrounds which they have tended to preserve in the new environment—provided Feldman [738] with an opportunity to examine whether these differences are reflected in the incidence and type of thyroid disease in Israel. His study relates to Jewish people in three groups of origin: European-American, African-Asian, and native-born Israelis.

Thyroid glands taken at consecutive autopsies from 72 unselected Jewish children under 15 years of age were of normal weight and showed no pathological lesions. Of a total of 323 patients treated either surgically or medically for thyroid disease during life in the five years from 1948 to 1953, only five were infants or children under 15 years.

From these facts Feldman concludes that Israel is not a country where goitre is endemic.

As for the adult population, Feldman found that 42 thyroids out of 110 taken at consecutive autopsies from individuals over 15 years old showed pathological change—a rate of 38% in random adult *post mortem* examinations. The rate of thyroid disease among all adults clinically examined by him during life for any reason whatsoever was 7 per 1000, or approximately fifty times less than that disclosed after death. The reason for this Feldman finds in comparing *post mortem* and clinical findings; the *post mortem* examinations reveal that thyroid lesions are fairly common but rarely become clinically manifest.

The type of pathological change seen after death was more or less the same for all adults irrespective of birthplace. In the clinical material, thyroid disease was observed more frequently in patients of European-American origin. Feldman concludes from this that Jews born in Europe and America either acquire more severe thyroid disease than the other two groups or are more prone to seek medical aid.

Iran

Two centres of goitre occurrence have been noted in Iran. These are the villages of Alischavaze and Kereshtek about 25 miles from Teheran. The possibility of introducing iodized salt in this locality is being explored by

M. B. Mashayekhi (personal communication, 1953). Gaguik of the medical school at Teheran University is testing the iodine content of different waters in Iran in relation to goitre occurrences there.

The Indian peninsula [a]

The severe manifestations of goitre in the south-eastern Soviet Republics of Uzbek, Tadzhik and Kirgiz, on the Pamir plateau, and in other remote centres on the northern slopes of the central Asiatic massif (see page 42) are repeated with equal intensity on the Indian side of this great mountain barrier. In fact, the northern frontiers of the Indian peninsula extending from Afghanistan through Kashmir and Jammu eastwards for more than 1500 miles along the southern valleys and foothills of the Himalayas into Assam and Burma have a goitre reputation more formidable perhaps than that of any other part of the world. The intensity of the disease is so great in some places as to merit the term hyper- or super-endemic (Stott & Gupta [772]). The goitre literature of the various countries that make up the Indian peninsula is intermingled to such a degree that it is dealt with here as a whole, and not necessarily with reference to political boundaries.

Geographical distribution

Descending into the north of West Pakistan from the mountain passes of Afghanistan and Badakhshan—areas themselves not immune [235]—one enters the western end of the goitre zone at Chitral, a wild and desolate region mountain-girt and mountain-intersected by the precipitous spurs and slopes of the Hindu Kush. Immediately to the east, in the north of Kashmir at the head-waters of the Indus, lies the district of Gilgit which, together with Chitral, is famed in the annals of goitre and cretinism by the researches of McCarrison.[751, 752, 770] In the North-West Frontier Province of Pakistan, on the edge of Kashmir, a considerable amount of goitre has been observed by H. W. Waite (personal communication, 1954) in the Kagan valley and hills of Hazara. From Gilgit the goitre belt extends south-eastwards through Kashmir along the Karakoram range and over the districts of Baltistan and Ladakh into the north-west of India proper.[739, 768]

Here, the endemic pervades the sub-Himalayan regions of Himachal Pradesh (Kangra, Hamirpur, Kyelang, Kulu and the Spiti river [740]); the Shiwalak Hills and the districts of Tehri, Kasauli,[757] Ambala [746] and Dehra Dun; the former Province of Kumaun [763] (Almora and Naini Tal [773]); the almost inaccessible Himalayan habitations in the State of Nepal;[741, 743] and the low-lying plains of Uttar Pradesh including the Districts of Pilibhit, Bareilly,[750] Bahraich, Gonda, Basti, and Gorakhpur, where Padrauna is

[a] Includes Afghanistan, Pakistan, Kashmir, India, Nepal and Assam.

especially noteworthy as a goitre centre.[772, 773] These latter regions form an almost continuous stretch of goitrous country filling the whole area between the Gogra river and the southern border of Nepal.

Still farther east the endemic continues across the river Gandak through Champaran and Purnea; it touches Darjeeling [769] (also S. R. Sen Gupta—personal communication, 1953) and the States of Sikkim and Bhutan.[743] Due south of this area, goitre has been recorded in East Pakistan at Dinajpur and Rangpur;[8] and in Assam the disorder occurs with some intensity at Goalpara [748] and throughout the Lushai and Naga Hills at places such as Tripura, Aijal, Imphal (Manipur) and Sibsagar [744, 768] (also A. K. Mitra—personal communication, 1948).

Apart from this great northern endemic, goitre is by comparison not excessively acute elsewhere in India or Pakistan. Nevertheless, in Pakistan the disease is a distinct problem in the Multan and Montgomery areas of the west Punjab [742, 766] (also D. C. Wilson—personal communication, 1957). It has also been noted by McCarrison at Larkana on the lower Indus and it occurs sparingly on the Pakistan seaboard of Kutch.[754]

In the State of Rajasthan (formerly Rajputana) goitre is practically non-existent except in the Aravalli range and in the neighbourhood of the tributaries of the river Luni near Ajmer.[754] South of the Luni and Aravalli area by about 300 miles, goitre is fairly common along the banks of the Narbada river, which flows westward to the gulf of Cambay between the Vindhya range on the north and the Satpura range on the south; in both these hilly regions the disease is not unknown.[754]

The central Indian plateau of Madhya Pradesh is not conspicuously goitrous, but the malady is usually to be found in the neighbourhood of the southern tributaries of the Jumna and in the Jhansi and Lalitpur uplands where these rivers originate.[754] On their goitre map of India, Megaw & Gupta [767] mark endemic centres between the Kaimur range and Jubbulpore; and there are reports of the disorder in the high country east of Jubbulpore affecting the Surguja and Ranchi districts of Chota Nagpur, and Sambalpur in Orissa (C. Thomson—personal communications, 1951-52).

Throughout southern India goitre is found but sparingly. It has, however, been noted by McCarrison at Bijapur and on the slopes and submontane tracts of the Western Ghats, particularly at Coimbatore and in the Nilgiri Hills. The Madras side and the Eastern Ghats are practically goitre-free with the exception perhaps of Arcot, where McCarrison records occurrences along the banks of the Cheyyar river in the vicinity of Arni.[754]

Thus, in summary, a competent cartoonist charged with the task of brushing-in the goitre areas on a map of the Indian peninsula would heavily underline the hollows under the entire length of the Himalayan " eyebrow ", lightly cover an irregular and fragmented area of secondary importance across the central plateau from West to East Pakistan, and merely touch some minor grey-spots in the Deccan and extreme south.

Degree of prevalence

In 1917, McCarrison [755] estimated that the whole of India probably contained about five million goitrous people. He records that in some Himalayan villages 60% of infants still at breast were sufferers, and it was difficult to find a man, woman or child free from the disease. Thirty-five years later, Ramalingaswami,[768] after reviewing all the statistical evidence available in the intervening period, reached the conclusion that the prevalence of endemic goitre in India had not changed appreciably in recent years and that McCarrison's estimate of five million affected persons is probably valid today.

Hospital and dispensary returns [748, 768] give an idea of the relative severity of the disease in different parts of the Indian peninsula. The greatest number of cases coming for treatment is encountered in the Dehra Dun, Gonda and Gorakhpur Districts of Uttar Pradesh (formerly the United Provinces) where an average of 100 000 persons presented themselves in 1940 and almost half that number in 1949. In Bihar, incidence is about the same as in Uttar Pradesh, the most grossly affected district being Champaran. The Punjab (particularly Kangra District), Bengal, and Assam (particularly Goalpara District) each yielded about 30 000 cases in 1940. In Assam some 34 000 cases reported for treatment in 1949. The figures are as follows:

	1940	*1949*
Punjab (All) . .	30 000	—
Punjab (East) . .	—	10 508
Uttar Pradesh .	100 000	44 723
Bihar	100 000	—
Bengal (All) . .	30 000	—
Bengal (West) .	—	8 295
Assam	30 000	33 999
Madras	—	8 258
Bombay	—	926

Considering that only a small proportion of sufferers seek hospital treatment, the actual number of affected persons must be several times greater than the hospital returns. The results of some recent goitre surveys confirm this belief (see Table XV).

The annual report of the Public Health Commissioner with the Government of India for the year 1945 records a 70% goitre rate among schoolchildren in Ambala, East Punjab.[746] During her recent (1956) survey of 319 schoolchildren in Multan District, West Pakistan, D. C. Wilson (personal communication, 1957) found visible thyroid enlargement in 41.3% of boys and 72.3% of girls.

TABLE XV. PREVALENCE OF GOITRE IN VARIOUS PARTS OF INDIA IN RECENT YEARS

Region	Prevalence of goitre (%)	Number of persons surveyed	Year of survey	Authority
Kashmir, Karakoram Mountains	90	—	1945	Allen-Mersh [739]
Uttar Pradesh, Dehra Dun	32	554	1945	Ramalingaswami [768]
Uttar Pradesh, Bareilly	26	133	1947	Lyall [750]
East Punjab, Shiwalak Hills	32	5042	1952	Ramalingaswami [768]
East Punjab, Shiwalak Hills	37	1337	1952	Ramalingaswami [768]
Bihar, Purnea District	50	(3 villages)	1952	Ramalingaswami [768]
Bihar, Ranchi District	70	563	1952	C. Thomson (personal communication, 1952)
West Bengal, Darjeeling	67	8204	1953	Sen Gupta & Swarup [769]

Cretinism and deaf-mutism

Be they old or new, all descriptions of the goitre endemic in the heavily affected areas of northern India refer especially to the prevalence of cretinism, deaf-mutism and idiocy; these most tragic of the sequelae of goitre are as much a part of the endemic as the goitre itself. According to Stott et al.,[773] affected villages in the Himalayan tract have an average goitre rate of about 40%, with some 4% of deaf-mutes. Stott and his colleagues have delved deeply into the incidence and distribution of deaf-mutism in the United Provinces (now Uttar Pradesh); nothing so good has been published since. From various data they calculated that in 1921 there were 25 000 congenital deaf-mutes in the United Provinces alone, a figure substantially the same as that in 1911. In Stott's opinion the number of congenital deaf-mutes in the age-group 0-5 years is vastly underestimated because the parents of these unfortunate creatures hesitate to report their children as defective until all hope is lost, clinging as long as possible to the belief that speech and hearing are merely delayed.

Etiological factors

(1) *Pollution.* McCarrison [751, 752] made a notable contribution to knowledge of the factors that influence thyroid enlargement when investigating the circumstances surrounding the occurrence of goitre in the nine neighbouring Himalayan villages collectively known as Gilgit. Eight of these were situated one above the other on the same water-supply, which

in its downward passage in surface channels to and through the successive villages became increasingly polluted by human and animal excreta. The ninth village—Barmis—was located some distance apart and had its own water-supply, a spring of exceptional purity not subject to pollution. This village was free from goitre; but the disease prevailed in the other eight, with a rate which was least in the village at the highest level (11.8%) and gradually increased until it became 45.6% among the general population in Kashrote, the village at the foot.

From these observations McCarrison concluded that the increasing intensity of goitre as one came down stream might be due to the obviously increasing impurity of the water-supply. To prove the point he administered to 35 volunteers, and to himself, a twice-daily drink containing a large quantity of the suspended matter filtered from the grossly polluted goitre-producing water issuing from Kashrote, the most severely affected Gilgit village. In about a fortnight 10 of the 36 volunteers, one of them being McCarrison himself, developed noticeable thyroid enlargement; 5 had transitory swellings and 21 were unaffected. Coincidently, 31 other young men consumed, in the same circumstances, the same suspended matter after it had been boiled. None developed goitre.

These early experiments are mentioned here because they offer the first experimental proof of an assertion constantly recurring throughout the goitre literature of primitive countries—namely, that excessive amounts of organic material in water, whether the actual bacteria themselves or some toxin produced by them, can exercise a goitrogenic effect and thus raise the bodily demand for iodine in the same way as can the excessive concentration in drinking-water of an inorganic chemical constituent such as calcium.

Confirmation of this point of view is afforded by McCarrison's later experience in a boarding-school at Sanawar, not far from Kasauli in the outer Himalayas.[757] Here, goitre had persisted for many years and at the time of McCarrison's inquiry was affecting no less than 66% of girls over 15 years of age. Investigation showed that the school water-supply—a spring—was subject to bacterial pollution from human and animal excreta. A new and clean supply was introduced; within a few years goitre had entirely disappeared from the school.

In this connexion one recalls the modern thesis of Hettche,[747] who concludes from his epidemiological and etiological study of goitre as revealed in one hundred years of research, that the disease is caused by an injurious substance of the urochrome group occurring in contaminated water-supplies. The toxic agent is said to bind copper in the serum, and can be used to produce goitre experimentally in animals which may be prevented by simultaneous administration of iodine. McCarrison also found that goitres developing spontaneously in well-fed experimental animals confined in dirty cages could be prevented by increasing the con-

sumption of iodine proportionately to the unhygienic conditions under which the animals were living.

(2) *Lime-rich waters and soils.* The frequent association of goitre with limestone rocks and with drinking-water rich in lime has been noted from earliest times. McClelland's [764] extensive medico-topographical studies in places as far apart as Bengal and the North-West Provinces led him to the conclusion, published in 1835, that magnesian limestone formations were primarily responsible for the propagation of goitre in India. There is little new under the sun, for, one hundred years later, Stott and his colleagues [773] advanced very much the same view and pointed to a direct correspondence between the distribution of goitre in the United Provinces and drinking-waters and soils of high calcium content. Moreover, many villagers in this area know that it is a " chuna " water containing a large excess of lime and coming from limestone rocks that is the peculiar cause of goitre. They recognize it by its hardness, heavy consistency, astringent taste, limy smell, and above all by the fact that it remains warm in all seasons whereas good (non-goitre) water invariably keeps cool.

(3) *Poverty and faulty diet.* Others among the many who have observed goitre in India point to poverty and insufficient and imperfect dietary as the main conditions in which the disease originates. Bramley [741] noticed this in Nepal and Tibet in 1833; Macnamara [766] refers to it; and so do McCarrison & Madhava,[759] who in discussing the genesis of goitre in India attribute much to faulty and unbalanced diets. C. Thomson (personal communications, 1951-52) links poverty with the goitres seen in villages below the Ranchi plateau in Bihar where a cheap dietary composed largely of sweet potatoes is used extensively instead of cereals. Stott & Gupta [772] correlate the distribution of goitre in the Padrauna *tehsil* of Gorakhpur with the distribution of *bhat* and *bangar* soils. Broadly speaking, the super-endemic areas are confined to the sandy *bhat* soils, which yield food produce of low quality. Villages on *bangar* soil, which yields high quality food, are generally goitre-free.

(4) *Iodine deficiency.* Early chemical investigations by McCarrison et al.[762] provide no evidence that in Himalayan India the incidence of endemic goitre is in inverse ratio to the iodine content of soil and water. In the heart of the endemic zone, as well as in the Himalayan foothills, two places adjacent to one another may have approximately the same amount of iodine in their soils yet goitre may be prevalent in one and not in the other. Similarly, the water-supply of a given locality may contain an appreciable amount of iodine and yet goitre may be endemic therein, while the water-supply of another locality may contain less iodine than the first and yet goitre may not be endemic therein. This is because the iodine level in Himalayan soils and waters is not the determining factor in goitre causation

here. As has already been mentioned, bacteriological impurity in water is the essential goitrogenic agent, although it is true that this effect may be mitigated and controlled in proportion to the quantity of iodine present in the water.

On the other hand, D. C. Wilson (personal communication, 1957) finds that the chief factor determining the occurrence of goitre in the Multan area of West Pakistan is the iodine content of the local drinking-water. Eight representative samples used by goitrous people in this region were compared in respect of iodine content with control samples from Kasur, about 200 miles distant, where goitre is unknown. The eight Multan waters had an average iodine content of 3.6 μg per litre usually associated with a high degree of hardness. By contrast, water from the non-goitre district of Kasur had an iodine content of 10.8 μg per litre.

Goitre has long been known in the Multan region of West Pakistan. Macnamara [766] described it there in 1880; Chaudhri [742] noted a rate of 60% in the villages of the Kabirwala *tehsil* in 1929; and Wilson [774] referred to it in 1941 in connexion with her fluorosis investigations in that area. According to recent reports (D. C. Wilson—personal communication, 1957), medical observers are convinced that goitre has greatly increased in the Multan area and in West Pakistan generally since 1947 when, owing to the partition of Pakistan and India, unusual movements of populations have taken place and additional water-pumps have had to be installed on old sites to cope with the increased requirements. Apparently the new water-supplies do not always have an adequate iodine content.

Animal goitre in India

Bramley [741] records that during his sojourn in Nepal, where goitre is notorious among men, women and children of all ages, it was by no means uncommon to find animals such as the buffalo, goat, sheep, and dog similarly affected. On one occasion he saw a goat bring forth a kid with a goitre as large as its head. Animal goitre is also specifically mentioned as occurring among dogs, cats and birds in the super-endemic areas of Gonda and Gorakhpur in Uttar Pradesh. A. K. Mitra (personal communication, 1948) gives an interesting account of goitre among calves in the Subsagar district of Assam, an area where human goitre also prevails.

McCarrison,[9] on the other hand, rarely came across goitre in animals. In the course of ten years' residence in the Chitral and Gilgit districts he saw only two cases in dogs, one in a horse, and one in a goat. Altogether McCarrison examined 116 mules, 101 dogs, 150 cows, 100 sheep and goats and 101 ponies belonging to the villagers of Gilgit, but did not encounter a single case among these 568 animals. No history of goitre in domestic animals was obtained by D. C. Wilson (personal communication, 1957) during her recent survey in the Multan region of West Pakistan.

Preventive measures

Despite the etiological complexity of the Indian goitre endemic it is not denied, even by those who show that the cause of goitre in India is impure water or excessive calcium intake rather than a primary iodine deficiency, that the easiest and cheapest way of preventing the disease is to provide the necessary supplementary requirement of iodine in iodized salt. Here, as Ramalingaswami points out, India is confronted with a difficult problem.

Except for a small quantity of rock salt mined at Mandi in Himachal Pradesh, the bulk of the salt produced in India is a coarse crystalline product obtained by solar evaporation of brine. About three-quarters of this is made up of sea salt and the remainder is obtained from inland salt lakes. Efforts are being made by the Salt Expert Committee of the Government of India to improve permanently the quality of Indian salt, but in the meantime ways are being explored of iodizing the currently used crude salt as uniformly as possible. This is important not only because of the imperative need to begin fighting endemic goitre at once, but also because it is not easy to persuade people in the endemic areas, who have been accustomed to crude crystalline salt for centuries, to change over suddenly to refined salt.

To obviate the losses of iodine from salt iodized with iodides which can occur in the humid atmosphere and strong sunlight of India, iodization of salt with iodate is preferred. Experiments have already been carried out by C. Thomson (personal communications, 1951-52) in the Ranchi goitre district which prove that this method of iodization is effective and harmless.

Ceylon

Pendant on the Indian subcontinent hangs the pear-shaped island of Ceylon, approximately the size of Holland and Belgium combined, and inhabited by about seven million people. The south-west-central area, where population density is greatest, is mountainous, wet, and goitrous; the rest of the country to the east and north is flat, dry, and comparatively goitre-free. Heavy rainfall and high temperatures in the south-west region where goitre chiefly occurs have led to intense weathering and chemical leaching of the ancient crystalline rocks of which Ceylon is mainly composed, giving rise to laterite or lateritic soils according to the degree of leaching. Waters throughout the island are soft; and those from the highly leached goitrous areas in the south-west have a low iodine content. These are the essentials.

Greenwald,[661, 775] who has probed into the history of goitre in many countries, finds only three original mentions of the disease in Ceylon prior to Wilson's [776, 777] survey of 1950, one in 1843, one in 1849 and one in 1894 and all relating merely to occasional occurrences in the Galle district of

the extreme south-west. From this he concludes that goitre was not common in Ceylon until quite recent times.

In the course of nutrition surveys carried out by workers of the Medical Research Institute at Colombo during the years 1947-49 it was reported that goitre was endemic in certain rural parts of the island. Early in 1950, Wilson,[776, 777] was asked by the World Health Organization on behalf of the Ceylon Government to ascertain whether the amount of goitre reported in these surveys constituted a serious public health menace. She examined 722 Ceylonese children and adolescents—317 boys and 405 girls—attending rural schools in ten different parts of the island, six in the wet region of the south-west and four in the dry region of the north. The results are shown in Table XVI.

TABLE XVI. PREVALENCE OF GOITRE AMONG CEYLONESE CHILDREN AND ADOLESCENTS IN TEN DIFFERENT PARTS OF CEYLON

Situation of villages	Boys		Girls		Iodine content of water (μg per litre)
	number examined	percentage with goitre	number examined	percentage with goitre	
Wet region					
1. On coastal strip, inland	20	15.0	50	38.0	2.2
2. On sea coast	50	18.0	50	40.0	5.3
3. On coastal strip, inland	—	—	50	22.0	—
4. On foothills, inland	45	13.3	26	23.1	—
5. On hills, inland	50	6.0	50	56.0	2.7
6. At 5000 feet, inland	27	11.1	30	40.0	1.4
Total	192	12.5	256	37.5	
Dry region					
7. On sea coast	—	—	50	6.0	—
8. On coastal lagoon	50	Nil	30	6.7	—
9. On Jaffna peninsula	50	Nil	50	12.0	6.6
10. On plateau, inland	25	Nil	19	5.3	61.0
Total	125	Nil	149	8.0	

In general, incidence is highest in the section of the country where rainfall is highest. This covers the Central, Western, and Sabaragamuwa Provinces, which include the coastal strip between Colombo and Galle. The drier eastern and northern provinces of the island are not seriously affected, although a rate of 12% was found by Wilson among girls in a school on the Jaffna peninsula in the extreme north.

As is usual, girls and women of child-bearing age are the chief victims. Among boys incidence is only moderate and few goitres are seen in men. Toxic symptoms are rare in Ceylon and no cases of cretinism or deaf-mutism are recorded. Animal goitre is also unknown.

Drinking-waters are generally soft and therefore the hard-water factor cannot be incriminated; but some waters, notably in the coastal villages numbered 1 and 2 in Table XVI gave evidence of faecal and bacterial contamination which could decrease the amount of available iodine. It is evident that waters from the wet goitrous regions are much less rich in iodine than those from the dry non-goitrous localities.

Adverse economic circumstances and shortage of rice owing to imported supplies from Burma having been cut off during the 1939-45 war have in recent years obliged many Ceylonese communities, particularly in the south, to subsist on restricted dietaries inadequate in protein and supplemented with local vegetable foods not largely consumed in normal times. Wilson conceives it possible [777] that insufficient intake of the right kind of protein, and an increased intake of anti-thyroid material ingested from the unusual foods consumed during the war might be sufficient to interfere with iodine metabolism and hormone synthesis and so cause thyroid enlargement. There is, however, no proof of this.

As a goitre-preventive measure, potassium iodide tablets were distributed in some areas as a result of Wilson's survey and recommendations, but there is little sign that the preventive programme continues to be pursued with vigour and determination.

Burma

Goitre is prevalent in the mountainous parts of Burma, particularly throughout the Chin Hills in the west of the country, the Kachin Hills in the north, and the Shan States on the east. The western and northern goitre areas are contiguous with the endemics covering the Lushai and Naga Hills of eastern Assam.

Statistics gathered by Raymond [779] from groups of villages in the Chin country show that the disease is commoner among children than among adults; but the adult goitres are much larger and frequently give rise to serious pressure symptoms. Incidence is higher in females than in males and is always greatest at puberty and pregnancy. Water-supplies are singularly pure and free from faecal contamination, and therefore are not incriminated; but dietary deficiency of vitamin A is notorious, and Raymond regards this as the most important single goitrogenic factor operating among the Chin Hills people.

On the north and east, where Burma abuts on China, goitre rates are exceedingly high in the Myitkyina area; also around Bhamo, Namkham and Shwegu in the Northern Shan States; and on the Burma-China road in

the neighbourhood of Lashio and eastwards towards the Salween river.[773] Secluded valleys in the Shan States are particularly affected, according to Robertson,[837-839] and the disease seems often to be confined to certain tribes. Seagrave [780] mentions that in the limestone hills of the Namkham area at least half the population suffer from goitre.

An exceptionally large number of cretins and deaf-mutes are seen in the Burmese goitre areas.[773, 778] Among the Kachins who inhabit the valleys and steep hill-sides along the north and north-east frontiers the enormous rate of 10 per 1000 is recorded by Stott et al.[773] The Kachin people drink water from hill streams impregnated with lime and customarily eat large quantities of lime in powdered form. Stott and his colleagues believe that this peculiar habit is in large measure responsible for causing goitre among these northern Burmese peoples.

Indo-China (Cambodia, Laos and Viet Nam)

Reports of goitre come from three parts of Indo-China: (1) the mountainous region extending northwards from Vientiane through Luangprabang into the Yunnan Province of China; (2) the upland area of North Viet Nam (formerly Tonking) lying to the north of Tuyenquang; and (3) the Mekong delta of South Viet Nam (formerly Cochin-China) with Cantho as its centre. Apparently goitre does not occur—or only sparingly—in the great Annam mountain chain curving in a half-circle through Viet Nam from Kamkeut in the north to Saigon in the south. Lower and middle Laos, and the plains of Cambodia (with the exception of Cochin-China in the very south), are goitre-free. It may also be mentioned here that goitre is known to occur in the Kingdom of Thailand on the west of Indo-China, for the most part a low-lying country,[870] but there are no recent accounts readily available.

The authority on the first of these Indo-Chinese goitre areas is Jeanselme [782] who, when journeying up the Mekong river from the south, first saw " neang " (the name by which goitre is known among the people of northern Laos) in the country beyond Vientiane. As he penetrated further into this calcareous mountain region, Jeanselme observed that the disease became more and more pronounced. At Luangprabang, a sizeable town situated on the confluence of the Mekong and its tributary the Nam Khan, he saw some enormous tumours, mostly among women.

Somewhat to the east, goitre is prevalent along the Tranninh river and in the region between Borikan and Xiengkhouang where about half the population is affected. North of Luangprabang, up the river Nam Hu, the disease is of common occurrence on both banks as far as the village of Moungngoi; but beyond this point in the direction of Laichau along the valley of the Nam Ngoua, a tributary of the Nam Hu, incidence appears to

diminish, and in the riparian villages of the Black River (Song Bo), on which Laichau is situated, goitres are neither frequent nor voluminous, even among women.

The second goitre region in Indo-China lies across the Red River (Song Koi) to the north-east of the first in the northern part of Tonking (upper North Viet Nam). It comprises the area between Tuyenquang and Kaobang, including Chem Hoa Chow and the steep escarpments and gorges through which the Song Gam and the river Claire flow south to join the Red River near Tuyenquang. Its northern edge touches the Chinese Province of Kwangsi.

Various writers have called attention to goitre in this section of Indo-China—notably, Clavel in 1890 (Tuyenquang), Sadoul in 1890 (upper Black River), Billet[781] in 1896 (Upper Kaobang), Jeanselme[782] in 1910, Le Roy des Barres in 1923, Cloitre[729] in 1930, and Tran Kiem Phan in 1937 (see Leuret[783]). Only the northern hilly parts of the area beyond Tuyenquang are affected; goitre does not exist on the low-lying swampy delta around Hanoi where rice is grown. Jeanselme examined 377 prisoners (283 men and 94 women) from delta provinces and did not find a single case. Upstream on the Red River, however, from Ta Than as far as Man Hao goitre is endemic on both banks. It is here that the upper Viet Nam endemic passes from Indo-China into Yunnan (see page 129).

The third, less well recognized, zone of goitre in Indo-China is the Bassac strip of Cochin-China in the extreme south which has recently been stigmatized as goitrous for the first time by Leuret.[783] It consists of the seven Trans-Bassac Provinces of Hatien and Rachgia on the Gulf of Siam, Chaudoc, Longxuyen, Cantho and Soctrang along the Bassac, and Baclieu on the shores of the China Sea, and the two Cis-Bassac Provinces of Sadec and Vinhlongh.

This vast region is entirely alluvial, semi-liquid, semi-solid, traversed by thousands of canals and small channels. Hot and humid, it lies practically at sea level with no irregularities other than the low dykes and road bridges of the rice fields. Springs and wells are unknown; drinking-water is provided by the rains of the winter and summer monsoon seasons, and by the canals at all seasons. No systematic goitre survey has been carried out in the area, but Leuret[783] considers it significant that he was called upon to operate on 29 goitres in a continuous period of 22 months, especially in a region where the people do not characteristically appeal to western medicine until they have exhausted the resources of the witch-doctor. Moreover, even when patients must eventually have recourse to the modern medical and surgical clinics of the west, they display a maximum of resistance in regard to surgery. This is more particularly true of goitre, which is regarded at most as a disfigurement to be borne without complaint. Under these circumstances, 29 goitres operated upon by one surgeon within 22 months in a region not ordinarily deserving the appellation " endemic " must denote a relatively

high general incidence. Confirmation of this belief was forthcoming from Leuret's second series of surgical cases in which there were 12 goitres out of 93 operations of all kinds.

Malaya

Polunin [786] has gathered together all the available information on goitre in Malaya and has himself considerably added to it. His maps are models of what goitre maps should be. Visible thyroid glands are common in most of the undeveloped mountainous inland areas, the over-all rate being about 40%. By comparison, the rate among communities near the sea is only between 1% and 2%.

In the northern third of the country, the areas chiefly affected are the hills and valleys of Kedah and Upper Perak. A health survey of the State of Kedah in 1935-36 revealed 131 cases of goitre in the districts of Sok and Jeneri. On the banks of the Chapar, a tributary of the Sok river, there were two *kampongs* (Banggol Batu and Banggol Berangan) where all the inhabitants were goitrous and the children had a cretinous appearance.

In Perak goitre is a serious problem in the remote district of Belum at the head-waters of the Perak river. Polunin examined 102 people in Belum over 14 years of age and found 48 with visible thyroid enlargement. Three other districts in Upper Perak—the *kampongs* of Ulu Kendrong, Klian Malau, and Ulu Jepai—also show high rates, especially among women.

Goitre is extremely common in the central states of the country—notably, in and around Kuala Betis and along the Nenggiri river in Kelantan; in the basins of the rivers Aring, Trengganu and Tembeling in Trengganu; and especially in the Ulu Jelai area of Pahang extending from the Cameron Highlands south-eastwards across the Telom Jelai-Kechil watershed as far as Kuala Lipis. Goitres among trout introduced into mountain streams in the Cameron Highlands have been reported by Le Mare,[784] who also mentions the prevalence of the disease among the human population in that locality.

Other goitre centres in Malaya are found along the western slopes of the main mountain chain—for example, at Ulu Luit and Ulu Langat in Selangor, and at Ulu Beranang in Negri Sembilan. In the *kampongs* situated near Alor Gajah some 10 to 20 miles from the Malaccan coast, incidence is much less than in central Malaya, and on the extreme south coast of Johore and in Singapore goitre is practically non-existent.

Polunin's data are summarized in Table XVII. In a total of 1328 people —618 Malays and 710 aborigines—dwelling in the inland parts of Pahang and Upper Perak, and on the western slopes of the central mountain chain, the goitre rate was 39.5% for the Malays and 40.8% for the aborigines. The disease is not confined to any particular geological formation; indeed, the only goitre-free area is one where limestone predominates.

TABLE XVII. PREVALENCE OF GOITRE IN RELATION TO GEOLOGICAL FORMATION IN MALAYA

Locality and race	Geology	Number of people examined			Percentage with goitre		
		males	females	total	males	females	total
Pahang, Ulu Jelai							
Aborigines	granite	185	161	346	39	67	52
Malays	limestone	230	190	420	22	52	36
Upper Perak							
Aborigines	quartz porphyry, limestone, granite	87	76	163	6	43	23
Malays		53	50	103	21	74	48
Western slopes of main mountain chain *							
Aborigines	quartz porphyry and granite	117	84	201	21	55	35
Malays		50	45	95	38	58	47
Total . . .		722	606	1328	25	57	40
Coastal regions of Johore							
Aborigines	alluvium on granite	46	22	68	2.1	Nil	1.4
Malays		76	40	116	Nil	2.5	0.8
Total . . .		122	62	184	0.8	1.6	1.1
Alor Gajah district, Negri Sembilan							
—	limestone	31	42	73	6	17	12

* From Kuala Chenka in Perak through Selangor and Negri Sembilan to Lenek in Johore

Malayan waters are usually soft and their iodine content is exceedingly low. Seven samples drawn from rivers draining inland areas where goitre incidence is high gave values from 0.2 μg to 0.6 μg of iodine per litre. Iodine deficiency is therefore considered to be the primary cause of goitre in Malaya; calcium excess does not enter into the problem.

Indonesia

Centres of endemic goitre are found throughout the whole length of the Indonesian archipelago, from Sumatra in the west to Timor in the east. The following summary of affected localities is compiled from the papers of Pfister,[799-803] Donath,[790] van Bommel,[787] Eerland,[791-793] Eerland, Noosten & Vos,[794] Noosten,[798] Elsbach,[795] van Gulik,[796] Simons,[806] and others (see bibliography).

Sumatra

The northern and central volcanic regions inhabited by the Batak people, including the high plains of Groot-Atjeh; the plateau of Gajo-Loeös; the Lököp valley; the Alas valley; the east coastal plains of Bindjai and Deli in the *dusun* of Upper Langkat; the Siantar Uluan country; the mountain region of Sinaboeng and Sibajak; the whole area around Lake Toba, including the peninsula of Samosir; Mandailing; the slopes of Mount Ophir; the country surrounding Lake Koto as far as Padang-Pandjang on the west, and Solok and Padang on the south. At the southern end of Sumatra, goitre is prevalent along the Barisan mountains, particularly in the sub-department of Lebong in the area of the river Ketuan; also at Moeara-Aman and Benkoelan; and in the valleys of the rivers Batang Hari and Komering.

As far back as 1883, Marsden [797] wrote in his history of Sumatra that " the natives of the hills through the whole extent of the island, are subject to those monstrous wens from the throat, which have been observed of the Vallais, and the inhabitants of other mountainous districts in Europe". Today, incidence is still exceedingly high, amounting in some places to more than 80% in women and 60% in men. Cretinism and deaf-mutism are common.

Particularly goitrous are the inaccessible mountain tracts occupied by the Batak peoples in the north—Gajo-Loeös (Atjeh), the Alas valley, and all the country surrounding Lake Toba southwards to Padang and Solok. The whole region has a volcanic geology and parts of it are almost entirely covered with vast layers of light tuffaceous rocks and soils. According to Elsbach [795] the population of the Gajo-Loeös live in a perpetual state of iodine deficiency. Drinking-waters contain only between 0.6 μg and 2.8 μg of iodine per litre, and Alasland agricultural soils analysed by von Fellenberg for van Bommel [787] showed an iodine content no higher than the lowest values recorded for soils from European goitrous areas.

Java

The chief endemic foci in Java are the Residency of Kedoe; the Dieng plateau; the villages around Wonosobo, Garoeng and Magelang; the Tengger mountains; and, above all, Kediri a district in the centre of the country south-west of Soerabaja dominated by the two volcanoes Wilis and Keloet. South-east of the Residency of Kediri, near Blitar, is Penataran, where goitre is said to be endemic; the disease also occurs in the remote limestone wilderness of Lodojo, and in a narrow strip to the south of the Brantas river.

The prevalence of " gondok ", as goitre is called in Java, is normally about 60% among schoolchildren in Kediri, but may often be 80% and in some villages has been known to reach even 100%. Eerland,[792] who

has studied this area closely, recorded 126 cretins, a much larger number of cretinoids, and nearly 2000 deaf-mutes. He says that the normal thyroid gland of Javanese peoples living in non-goitrous areas is smaller than that of the European and averages 11.9 g. The so-called " normal " gland in the goitrous Kediri district has an average weight of 52 g in males and 57 g in females. In a random sample of 249 goitrous subjects from Kediri, 67 had goitres weighing over 500 g (1 lb). The two largest weighed respectively 2850 and 2930 g, or between 6 and 6.5 lb. Toxic goitre is rare in Java.

Superstitions regarding the cause of goitre include belief in " goitre images ". Near Penataran close to the source of the Soemberdandang stands a Hindu goitre image with the head of an elephant. People believe that at certain times this image pours water from its trunk into the nearby wells and streams, and that if one drinks this water goitre will inevitably result.

Bali

Expert studies of ancient Javanese medical texts written on copper and on lontar leaf indicate that goitre has afflicted the island of Bali for perhaps ten centuries. With certainty the disease has been known there for a hundred years; it is mentioned by almost every writer on goitre in the Dutch East Indies since 1856.

The plateau of Tjatoer in the north-east section of the island is the major seat of the endemic. Anyone who has witnessed market-day at Kintamani when people come together from the whole plateau will be convinced of this at a glance. Moreover the area provides another striking example of the extraordinary selectivity of the goitre noxa. At the end of a path leading off the main road between Singaradja and Kintamani lie two villages—Lampoe and Tjatoer—quite different in character although only a few hundred yards apart. Lampoe is the home of about 100 Chinese traders, established there for three generations and much intermingled by marriage with the native Balinese. Food is varied; water is boiled before use; there is not a single case of goitre. Tjatoer, on the other hand, contains some 700 pure Balinese belonging exclusively to the Bali Aga race, the original inhabitants of the island. These people lead quite different lives from their immigrant Chinese neighbours. Poverty-stricken, unwashed, and commercially undeveloped, they subsist on a monotonous diet of maize and rice; water is drunk unboiled from a goitrogenic spring cursed by Dewa Belanga (see below). Goitre is very prevalent in Tjatoer.

Noosten,[798] to whose exhaustive description of goitre in Bali we are indebted for the foregoing, also gives an intensely interesting account of the traditional beliefs concerning the infliction of thyroid disease by the goitre goddesses Dewa Ajoe Bengkala and Dewa Belanga, and of the lengthy and involved festivals (*slametans*) celebrated, often at great cost,

to placate these ill-disposed deities and exorcize their evil spirits. Noosten also details some of the complex mediaeval concoctions prescribed as remedies for goitre in Bali, and gives examples of the secret incantations, or *mantras*, recited when these medicines are administered. He illustrates, too, some of the magic figures and devices scratched or engraved on the cooking vessels in which the recipes are prepared. These primitive signs are supposed to enhance the magic power of the drug.

From all his patient collection of facts and folklore about goitre in Bali, Noosten concludes that preoccupation with the disease, and in fact the whole goitre concept, is deeply rooted in the Balinese people. No better evidence of this can be found than in the words uttered when a Balinese wishes emphatically to protest his innocence: " *Apang gondong tiang toesing nawang* ", which means " May I get goitre if I know anything about it.".

Celebes and Timor

Goitre occurs at Madjene and at Maros on the west coast of Celebes (Donath [790] and Noosten [798]). Two other centres are marked on Noosten's map of this oddly shaped island, one almost at the tip of the northern arm in the neighbourhood of Kotamobagoe and the other near Masamba in central Celebes due north of the Gulf of Bone.

In Portuguese Timor, goitre is known throughout the north-east of the island between Manatuto and Kailaco (Noosten [798]).

Indonesian Borneo

In central and south-eastern Borneo goitre is reported [798] to occur at the following places: (1) along the Melawi valley, in the neighbourhood of Sekajam, and in the Sipoeak river area; (2) on the Apo-Kajan plateau and in the Kotei or Mahakam river basin to the north-centre of the country; (3) on the banks of the Barito river, and at Meratoes and Martapoera in the south-east of the country. Details of incidence and other features of the endemic in central Borneo are lacking.

Goitre prophylaxis in Indonesia

Preventive measures were first introduced in 1927, when iodized salt (1 : 200 000) was distributed throughout the Dieng plateau and Tengger area of Java. By 1930 prophylaxis had been extended to the Gajo and Alas regions of Sumatra, and in 1933 the Kediri Residency of Java followed suit.[790, 798, 805] Writing in 1939, Simons [806] pronounces the step justified by the favourable results and makes a plea for its extension. He affirms that iodized salt is completely harmless.

At the time these preventive measures were introduced, salt was manufactured under monopoly and in block form only at the salt works on the island of Madoera off the north-east of Java. The method of iodization is unique. In view of the high temperature to which the salt is exposed in the brick-making machine, it is essential to avoid incorporating iodine in the salt before it passes into the machine, otherwise iodine will be lost in the process. Instead, each salt brick destined for prophylactic use is soaked after it has been made with 1 ml of a solution of potassium iodide and sodium thiosulfate in water. The liquid, containing 3.3 mg of potassium iodide per ml, is poured from a small spoon into a hollow on the top of each brick, and by capillary action spreads evenly throughout the entire brick. In this way 3.3 mg of iodide is absorbed by each 600-g brick, giving an iodization level of 1 in 200 000 (Donath [790]).

Around the year 1939 or 1940, the level of iodization was raised from 1 in 200 000 to 1 in 100 000, and experiments were made by Van Veen [808] (also personal communication, 1950) in the goitrous Kintamani plateau of Bali to see whether the crude sea salt used by the Balinese population could be iodized in granulated instead of brick form without loss of the added iodine. It was proved that if the loose salt were stored dry in bamboo containers near the fire according to local custom, no loss of iodine occurred.

North Borneo

Goitre is endemic over a large area of North Borneo; it is regarded with much aversion by all natives and is responsible for a great deal of the inbreeding and degeneration which has occurred there (Clarke;[811] F. Heim—personal communication, 1953). In the country of the Muruts, a primitive aboriginal people living in the southern part of the Colony roughly south of a line joining the northern shores of Brunei Bay on the west coast with Mount Trusmadi in the interior, the principal endemic areas are: the Bokan country, Ulu Kinabatangan, Tomani area, Bole district and Ulu Mengalong.

The disease also occurs sporadically in the hills to the west of the Keningau plain, in the Dalit, and between Melalap, Tenom and Kamabong. Other goitre centres that have been named are the Pansia district of Sipitang; Bundu Tuhan in Ranau; the Tambunan hills, especially Monsak village; the Lanas district of Tulid; and the hill regions of Kudat.

Systematic clinical surveys have not been made, but reports from medical officers fix the goitre rate at anything between 1% and 25%. F. Heim (personal communication, 1953) describes the prevalence at three Minokok villages in Upper Kinabatangan as " rather high ", and a rate of 33.6% has been recorded among 1014 natives examined in the Bokan country.[812] The disease is between two and three times more frequent in

females than in males. Usually the thyroid swelling becomes apparent about puberty and may reach a very large size in adult life. Thyrotoxicosis is rare.

The goitre centres are mostly situated in jungle-clad hilly country of sand and limestone through which the streams and rivers run rapidly over stones and boulders. Clarke [811] found it an unusually interesting experience to conduct clinics in areas where cretinism is endemic. The hill Kwijaus and the Muruts living in the secluded goitre-bearing hills of the middle Padas between Kamabong and Bole are particularly affected. Briefly, outstanding features are reduction in height, often with disproportionate shortening of the limbs, a general physical podginess with thick dry skin, short thick fingers, protuberant abdomen, perhaps umbilical hernia, dull expressionless faces, noses with widely patent nostrils and depressed bridges, thick lips, exaggerated bossing of the skull, and various degrees of mental retardation. Many of the good-natured dwarfs show a specious giggling brightness; not a few are deaf or dumb, or both. The worst cases, sub-human in appearance, are seldom seen, as they are hidden in the jungle at the approach of strangers.

Some half-hearted attempts have been made to supply the natives with iodized salt in certain areas of the interior by means of air-drops or by overland routes. In Heim's experience (personal communication, 1953) the natives would readily take to iodized salt and in some instances have themselves requested the Government to arrange for its purchase.

Sarawak

T. Harrisson, (personal communication to I. Polunin,[786] 1951) who has made a special study of goitre in Sarawak, states that the disease is common in certain inland areas, sometimes to a serious extent, whereas other inland areas not far distant are completely non-goitrous. This immunity applies particularly to the Kelabit country, which covers the upper Baram river district in the interior of the 4th and 5th Divisions of Sarawak. Here the people are goitre-free because they use an iodine-rich salt derived from local salt springs, of which there are about twenty or thirty in the neighbourhood. By contrast, in the areas of the interior where goitre occurs, Kelabit salt is unobtainable and people rely solely on imported salt.

Samples of Kelabit salt have been chemically examined by B. W. Simpson (personal communication to I. Polunin,[786] 1951), who found an iodine content of 10.5 mg per kg (i.e., 1 in 95 240), and later by M. M. Murray (personal communication, 1955) who found 65.2 mg per kg (i e. 1 in 15 330). Even the lower of these levels would be quite sufficient to prevent goitre in a community regularly using this salt.

W. G. Evans (personal communication, 1955) writes that some of these protective salt springs in the Kelabit country are no more than a wet seepage

out of the ground into which the local people, having first prepared the ground, insert a hollow tree-trunk deep into the origins of the water to make what is in effect a narrow well. The saline water is then siphoned out and subjected to a lengthy evaporation process by vigorous boiling over a wood fire. The salt thus produced is a very valuable commodity in the Kelabit outlands and although it is not possible to place a monetary value on it because cash is so little used in these parts, it can be said that a few ounces is sufficient payment for a hard day's work.

The natives fully appreciate that their freedom from goitre is due to their use of this salt, and for this reason Kelabit salt is not only esteemed for its protective virtues but also has a reputation as a curative for existing goitre.

China (mainland)

Endemic goitre is of ancient lineage in China. From time immemorial travellers penetrating into the fastnesses of its northern, western and south-western provinces have been struck by the evidences of human misery and degradation due to goitre and cretinism; their diaries and journals are full of vivid impressions which these scenes have made.

The Chinese term for goitre is *Ying*, meaning a tassel hanging from the neck. Lee [827] cites references showing that the disease was known in China in the third century B.C. and that its treatment by alcoholic infusion of seaweed was practised at that time. Marco Polo [244] saw goitres in the Chinese Turkestan provinces of Kashgar and Yarkand when on his famous travels from Venice to the court of the Grand Khan about the year 1275. Six centuries later, Hosie [820, 821] speaks of the " enormous and unsightly " goitres he encountered when journeying through the Provinces of Szechwan, Kweichow and Yunnan in western China; and Warwick [848] makes similar references to the prevalence of the malady in many sections of the Great Wall, along which he explored for a thousand miles in the early 1920's.

Other Western writers who recount like experiences in different parts of China are Hewett,[819] Lewis,[828] Bolt,[816] King,[824] Rock,[840] Miller,[833-835] Maxwell,[832] McClendon,[831] and Robertson.[837-839] In recent years Oriental medical scientists have themselves added greatly to the documentation.[814, 817, 822, 823, 825-827, 830, 836, 841-846]

The main goitre belt begins in the north-east of the country in the neighbourhood of Shanhaikwan on the southern border of Manchuria (now the North-East Administrative Area of China); it follows a westward semicircular route across the mountainous watershed north of Peking into Chahar and Suiyuan, and then turns south through the Province of Kansu as far as Chinghai. From thence it extends through Sikang and the western regions of Szechwan and Kweichow into Yunnan, the most goitrous province in all China. With the possible exception of Tsungming Island in

the mouth of the Yangtse where goitre has been noted by Maxwell,[832] all the coastal provinces, including those of the great plain in the east-centre of the country, are virtually goitre-free, at least so far as the simple endemic variety is concerned; but everywhere in these provinces cases of Graves' disease are frequent. Indeed, of all goitre cases brought to Miller's [835] attention in these areas about 60% were toxic. A good goitre map of China is given by Liu & Chu.[830]

Northern China

On a journey from Peking northward to Jehol *via* the plain of Chihli, Tungchow, Yenchiao, San-Hohsien and Chichou, Bolt [816] found well-marked endemic goitre nests in the mountainous country extending up into the Feng Shui Ti district. Throughout the fertile plain of Chihli to the east of Peking drinking-water is hard, but only occasional thyroid enlargement was seen; in the mountainous region farther north, however, the water is obtained largely from shallow surface wells and is undoubtedly soft. It is almost always boiled before use. Here, by a rough and ready method, Bolt estimated the goitre rate to be 40% in men and 60% in women. When questioned about their neck growths the people affirmed that they were due to a *lack* of something in the water and even claimed that they arose because the water was soft. This recalls conditions in Malaya (see page 121) and suggests an absolute deficiency of iodine as the cause, and not pollution or the presence in water of any other goitrogenic factor. Bolt also noticed the peculiar fact, which may or may not have a bearing, that the shells of hens' eggs in this vicinity are much thinner than usual and that many of them are so deficient in lime salts as to leave the egg membranous in places.

Writing of this area, Adolph & Ch'en [813] mention especially the intensity of the disease near the Western Tombs and Eastern Tombs (Imperial Burial Grounds) situated respectively to the south-west and north-east of Peking in the Province of Hopeh. Entire villages in these regions are reported to be almost 100% goitrous. Analyses by Adolph & Ch'en show that the iodine content of water and foodstuffs from the environs of these mausolea is generally speaking less than that of foods and water collected in non-goitrous parts of Hopeh and in the neighbouring Provinces of Shantung and Shansi which are goitre-free. Adolph & Whang [815] also found adequate amounts of iodine in vegetable foods from the Soochow-Shanghai area, where simple goitre is extremely rare or non-existent.

The goitres of North China—and this is particularly true of the Peking district—are of the non-toxic type; the swellings vary in size from that of a hen's egg to that of a melon (Bolt [816]).

Western China

During his several expeditions through the Provinces of Kansu, Szechwan, Kweichow and Yunnan in western China, Hosie [820, 821] saw

goitre at many points, in both sexes and at all ages. King [824] confirms that parts of Kansu, particularly the high plateau south of the Mongolian border watered by the upper reaches of the Yellow River (Hwang Ho), are very goitrous. Spring water or the water of mountain streams in which the roots of willows or other trees are exposed is the native explanation of the cause. The disease is also prevalent in the Gold River district on the China-Tibetan border where a survey has been carried out by Liljestrand.[829] It is frequent, too, in the Sungpan region to the north-west of Szechwan. Here, the people eat Ching salt and Tsou salt, both of which contain barely sufficient iodine (1:111 000 and 1:170 000, respectively) to protect against the action of any strong local goitrogenic agency. It is believed by Cheng & Ku [817] that the customary high cabbage dietary of the Sungpan people is responsible for tipping the scales to the side of iodine insufficiency.

But, of all goitrous Chinese provinces, the one about which most has been written is Yunnan on the borders of Burma in the south-west. Writing of Kakatang, a village on the Weisi—a tributary of the Mekong river—in northern Yunnan west of Likiang, Rock [840] says: " What sights one can behold in such a place as Kakatang! Nowhere have I seen goiter so prevalent as here. The people carried regular pouches in their throats like certain monkeys when they fill up with peanuts. One man, half blind, was loaded down with a goiter so huge that the weight of it dragged down his lower jaw, making it difficult for him to keep his mouth closed."

The most impressive accounts of goitre in Yunnan are those by Jeanselme [782] and by Robertson.[837-839] The former entered Yunnan from the south after completing his goitre survey of Indo-China and saw many cases in the villages amd market-places frequented by the mountain-dwellers between Man Hao on the southern border and Kunming (Yunnanfu), the capital of the province. Jeanselme estimated the over-all rate in Kunming to be 20%, and he records that the disease is no less severe in the prefecture of Kai Hoa, lying farther to the east. At Tali, and all around the great lake on which Tali is situated, Jeanselme saw many myxoedematous cretins with wan and puffy faces and unsteady gait.

Conditions as revealed by Robertson's survey some thirty years later were no different. He was concerned chiefly with the health status of peoples living along the route of the great Burma-China highway and in the adjoining country. Inspection of the adult population of both sexes working in labour gangs during the construction of the road disclosed a goitre rate of 80% in some gangs, the average in all gangs being over 50%.

Robertson was much struck with the patchy distribution of the Yunnan endemic. In the north-west, the people all along the valleys of the Salween, Mekong and upper Yangtse rivers are very heavily affected, but the disease is not so evident west of Pao-shan. Similarly, on the road from Kunming to Hwei-tsheh in the north-east there are villages in which almost everybody has a goitre, whereas Hwei-tsheh itself is not markedly goitrous. Robertson

explains the patchy distribution on geological grounds. In the western part of the province, before one comes to the canyons of the Mekong and Salween, the country is composed of irregular ranges of upper grasslands and undulating plains where pastoral agriculture is intensively practised. Much of this country is on porous limestone soil and it is here, in remote villages, that goitre is evident both in man and in his flocks and herds. Throughout the lower-lying parts of the province where rice, potatoes, wheat, and fruits and vegetables of all sorts are cultivated, the disease is not so prominent.

Others who have commented on goitre occurrences in this general area are A. J. Broomhall (personal communication, 1950), who speaks of the frightful goitres seen in the Si-Chang district of Sikang, and Galt,[818] who describes the disease as fairly common among the Tai and almost universal among the mountain Kaws inhabiting the Kiulungkiang (Chili) region of southern Yunnan.

From his exhaustive studies, Robertson [837-839] concluded that extreme environmental iodine deficiency aggravated by an excessively hard water-supply is the cause of goitre in Yunnan. Proof of this is seen in the fact that the disease is not usually so severe, if it exists at all, among communities in West China who are accustomed to using local salts rich in iodine, for example, the salt mined at Nanlang in Szechwan. The salt derived from Yunnan mines is deficient in iodine and Robertson suggested that as a partial preventive measure it should be mixed with Szechwan salt in equal parts.

To arrange systematic goitre surveys in Yunnan and to organize preventive measures, an advisory committee entitled the Yunnan Anti-Goitre Association has been formed under the honorary presidency of the Governor of the Province.

Southern China

Jeanselme [782] refers to Simon's observation of goitre among mountain-dwellers in the environs of Lungchow, a town in the Province of Kwangsi close to the North Viet Nam border. Farther to the east, Lewis [828] unexpectedly came upon a strong focus of goitre in the Province of Hunan when journeying over the mountains between Lanshan and Lienchow. Nearly at the top of the ridge is a village where he saw greatly enlarged thyroids in large numbers. The villagers told him that the disease was of long standing and that practically the entire adult population were victims.

North-East China (formerly Manchuria)

Yamaguchi of the Manchuria Medical College, Mukden, was the first to take up the scientific study of goitre in former Manchuria. He published his results in the *Journal of the South Manchuria Medical Society* in 1921,

but in spite of much effort the present writers have not been able to see Yamaguchi's original accounts and it is believed that many who quote him can never have seen them either. Apparently the reports cover the incidence of the disease according to locality, sex and age, and call attention to the possibly decisive role that an excess of lime in drinking-water may play in causation. Yamaguchi's work was continued by his colleagues, and between 1935 and 1939 detailed studies of the Manchurian endemic and its relation to environmental iodine supply were published by Kodama, Suzuki & Masayama,[825] Takei and his colleagues,[844-846] Takamori,[842, 843] Noda,[836] and others. No recent accounts of goitre in former Manchuria appear to exist.

The principal focus lies in Jehol, the province in the south-west of North-East China (formerly Manchuria) adjoining Hopeh in North China. Here, the endemic may be regarded as continuous with that already described as occurring along the Great Wall north of Peking. It particularly affects the district of Ping-chuan and the north side of the Wall, but is also severe farther to the north and north-west at Lingyuan, Chengteh, Luanping, Lunghwa, Chihfeng and Weichang.

The goitre prevalent in Jehol is classified by Takei [845] and Takamori [842] as belonging to the Alpine type and is commonly associated with deaf-mutism, idiocy, cretinism and myxoedema. The goitre rate varies between 10% and 60% and may be as high as 85% in the Pingchuan area. Chinese and Mongolians are equally prone to the disease and immigrant Japanese rapidly become victims; a Japanese non-commissioned officer acquired a goitre four months after entering the country and a consular police official contracted a second-degree thyroid enlargement (Dieterle's scale) within nine months of being stationed at Pingchuan. As usual, incidence is higher in females than in males; infants are occasionally affected.

East of Jehol, goitre occurs in the basin of the river Liao and in the upland parts of the Liaotung peninsula, where Siuyen (west of Antung) and Huanjen are especially mentioned. Elsewhere in former Manchuria there are goitre pockets to be found throughout the eastern hills, for example at Tunghwa and Mishan which lie 300 and 600 miles north-east of Antung and Mukden, respectively. Other centres are found at Hulan and Suihwa immediately north of Pingkiang (Harbin), and throughout the Khingan Mountains in the extreme north at the head-waters of the Nonni river (McClendon; [831] Noda [836]).

The results of various analytical and biochemical investigations have been advanced by the Mukden medical school and their associates as evidence that the principal cause of goitre in former Manchuria is insufficiency of iodine in soils,[836] water [825, 841] and local foods.[845] By themselves, the data are not wholly convincing unless other factors are taken into account. For example, well-waters from Jehol, where goitre is rife, register from 4 μg to 14 μg of iodine per litre, a level at which goitre would not

normally be expected to arise. It must be remembered, however, that waters in the Jehol area are so excessively hard that an iodine level of even 14 μg per litre may fail to protect. At Talien (Dairen), on the goitre-free tip of the Liaotung peninsula, the water contains 24 μg of iodine per litre.

Studies by Noda [836] not only in Jehol but throughout the whole of former Manchuria show that the amount of iodine in soils where goitre prevails is distinctly less than that in soils from non-goitrous districts, thus:

Prevalence of goitre	*Soil iodine (μg per kg)*
Nil (peninsular Liaotung)	2 249
Nil (Upper Sungari)	1 567
Under 10%	1 397
10% to 50%	1 053
Over 50%	791

The highest rates are in areas underlain by pre-Cambrian and limestone formations.

There are no recent reports regarding preventive measures in former Manchuria, but twenty years ago treatment by means of iodine was carried out in parts of Lingyuan, one of the worst districts of Jehol, and marked improvement was noticed after about two months. Of 9 children treated under 10 years of age, 6 recovered; of 56 between 10 and 20 years, 12 recovered.

Animal goitre in China

Imperfect calcification of hens' eggs—a common occurrence in the mountain country north of Peking—has already been mentioned as possible evidence of iodine deficiency. From the same area comes Geil's observation (see Warwick [848]) that goitrous antelope are not unusual in the Imperial Forest Preserve at the Tung Ling or Eastern Tombs. Robertson [838, 839] suggests that iodine deficiency is the cause of abortion in cows in Yunnan Province, and preliminary observations led him to believe that many horses and cattle in West China suffer from lack of both salt and iodine.

Korea

Apparently the only part of Korea where goitre is endemic is the Kangai neighbourhood in the northern hilly section of the country. Here, according to Mills,[849, 850] simple goitre is quite common in various stages of development, and the Koreans have a saying that anyone who drinks the water that drains from the decaying roots of the edible pine will develop the disease.

Smith [851] suggests that in all probability the fact that no part of the Korean peninsula is far removed from the sea, and that sea foods are a large factor in the diet of the people, accounts for the comparative rarity

of endemic goitre in the country. On the other hand, at the time of writing (1928), he could discern that cases of hyperthyroidism were on the increase throughout Korea.

Taiwan

Goitre is exceedingly common in Taiwan. Maxwell [832] records that in certain mountain villages almost all the inhabitants have the disease. Affected areas include the Ōka area of Taipeh (Taihoku) District in the north, the Taiko neighbourhood in the west, and the regions of Pinan and Dainan in Taitung (Taitō) District in the south-east of the island. Surveys of prevalence have been made by Kawaishi,[855] Hashimoto & Kyo,[853] Hashimoto & Sha,[854] and Kawaishi & Hashimoto.[865] Some representative results are shown in Table XVIII.

TABLE XVIII. PREVALENCE OF GOITRE IN TAIWAN

Area	Number of people examined	Number of people with goitre	Percentage with goitre	Bibliographical reference no.
Entire island (over-all prevalence)	318 116	26 979	8.5	855
Ōka district of Taihoku	23 463	6 200	26.4	853
Pinan and Dainan districts of Taitō	4 060	745	18.3	854

The rate in the north and west was highest at Sekitokei in the Ōka area (45.4%) and lowest at Taiko (17.2%). Cases were especially numerous in the region of the Kanwen delta (40.7%) and in the basin of the Tansui river. Rates in the Pinan and Dainan regions of Taitung varied from 5% at Miwa to 26.7% at Rika. The highest rate (63.5%) was recorded by Kawaishi & Hashimoto [865] in the Shirakawa of Mizuho in the foothills on the mid-eastern side of the country.

Evidence points strongly to the fact that insufficient iodine intake is the main cause of goitre in Taiwan. Kawaishi [855] considers, however, that mere iodine deficiency is not entirely responsible and that geochemical and climatic factors which raise the demand for iodine must also be taken into account. Since hypercalcaemia is rather common among goitrous people in Taiwan, a deranged calcium metabolism is regarded by Kawaishi as possibly associated with goitre causation. Sai [857] examined this question but could find no statistically significant relationship between the blood-calcium level and the type and extent of thyroid enlargement in cases of endemic goitre in Taiwan. There was, however, a tendency for the urinary excretion of calcium and potassium to be greater than normal in both endemic goitre and Basedow's disease.

In regions where human goitre is endemic, thyroid enlargement also occurs among pigs. Kobayashi [856] examined the thyroids of 200 castrated male and female pigs and found no less than 81% of enlarged thyroids in those from Ōka village. One gland weighed 550 g. In Hwalien (Karenkō) District, where there is a 65-70% rate of human goitre, 48% of pigs were affected. Histological sections taken from thyroids which outwardly appear normal reveal cellular changes indicating that so-called " normal " glands from this area are already in a pre-goitrous state before visible enlargement begins. Castration has no influence on the development of goitre in pigs.

Japan

There is general agreement that, compared with other countries in the same geographical region, simple goitre is not a problem of any magnitude in the main islands which make up Japan—Honshu, Hokkaido, Kyushu, and Shikoku. On one occasion, McClendon went looking for goitres in likely places in the interior but could find no more than four cases among 20 000 inhabitants (McClendon,[867-871] Aschoff,[860] Papellier,[874] Kawaishi & Hashimoto [865]).

Freedom from the disease is ascribed to the widespread and regular habit of eating seaweed. In Japan seaweed is served in a variety of ways as a constant article of diet and an amount of 10 g (dry), or even more, is often the portion for one person at a meal. On average, 10 g of dry seaweed would contain about 5 mg of iodine.

Where seaweed is not eaten, however, as sometimes happens in mountainous localities inland, the simple thyroid enlargements of puberty are common; indeed, the goitre rate may be quite high. For example in Gifu Prefecture north of Nagoya in central Japan, Katsumata & Murakami [864] examined 2434 girls and young women, of ages 13 to 26 years, at 15 different girls' schools and silk mills in 13 different localities, and found undoubted thyroid enlargement in 1242 (50%) of these subjects. Rates varied from 5.4% in a school at Seki situated on the plains at the edge of the mountains to 61% in a school at Funatsui, a town high in the Japanese Alps.

It is true that the great majority of these enlargements (96%) were not visible to the naked eye and were only determinable on palpation. Nevertheless, the high prevalence of palpable thyroid enlargement among girls in the Gifu area indicates that the zone is potentially goitrous. Katsumata & Murakami [864] refer also to the occurrence of puberal goitre in Aichi Prefecture south-east of Nagoya and mention likewise that the Prefectures of Hyōgo and Okayama at the western end of Honshu are not immune. The prevalence, however, is slight; a survey by Morinaga [872] in 1950 showed only 4.6% of cases among 1480 children (6-14 years) at schools in the vicinity of Yakake in Okayama Prefecture, and 4.7% among 1516 out-patients attending Yakake hospital.

Other recent surveys resulting in the discovery of minor goitre foci in Japan are those undertaken in Hokkaido, the most northerly island of the country, by Hashiba, Ogawa & Otsuka [862] and by Okii [873] of Sapporo University of Medicine. In the Hidaka highlands in the south of Hokkaido a rate of 3.05% was recorded among a total of 4683 primary, junior and senior high-school minors of ages 6 to 18 years. The rate increases towards the east of the Hidaka district, reaching 7.3% to 12% at the villages of Erimo, Meguro and Shoya situated at the tip of the Erimo peninsula. Okii examined 2234 people in and around Esashi in the south-west of the island and found an over-all rate of 2.3%, the highest rate being in the area of Kamomejima.

In summary, therefore, Japan may be classed as a mainly non-goitrous country in which it is possible to pick out a few less favourable regions where a mild incidence prevails, especially among the adolescent. Although outside the scope of this review, it may be mentioned that one or two writers (Aschoff;[860] Kawaishi & Hashimoto [865]) draw attention to the fact that whereas simple endemic goitre is practically non-existent in Japan, toxic goitre (Basedow's disease) is seen approximately as often as in Western countries. In Japanese thyroid surgery, toxic goitres predominate. Studies on goitre of farm animals in Japan have been made by Takamori.[875]

Philippines

According to Miller, the Filipinos show the highest goitre frequency of any people residing in the Orient. The disease, he says, seems to be almost as prevalent in the Philippine Islands as in Switzerland.[834, 835]

Early records collected by Greenwald [879] prove that goitre was known in the Province of Batangas at the end of the eighteenth century, in the Province of Tayabas in 1845, and among the Bontoc Igorots in the highlands of northern Luzon at the beginning of the present century. In 1905, Duncan [876] reported its prevalence in a tribe living at Macabebe on the marshy northern shores of Manila Bay.

No systematic modern survey of prevalence has been made, but case-histories and hospital records relating to the number, type and provenance of thyroid patients operated upon in Philippine hospitals between 1909 and 1948 have been studied and analysed by various writers. These show that goitre is found in nearly all the 49 provinces composing the archipelago (Lopez-Rizal & Padua;[882] Reyes;[885] Erickson;[877] Estrada, Nery & De Vera;[878] Recio [884]).

The chief goitre region in the Philippines is the Province of Nueva Ecija in the central valley of Luzon where the twin municipalities of Peñaranda and Papaya are notorious as the home of goitre in the Islands. Other centres in Luzon are: Bangued and Manabo in Abra Province in the north-west; the Bontoc district; the Province of Isabela on the east side; the area

round Manila including Bulacan, Macabebe in Pampanga, and Cavite; the Bataan peninsula; and Tayabas and Batangas in the south of the island.

In the central islands of the archipelago there is goitre to be found on Panay at Capiz and Iloilo, and on Negros and Cebu. Nichols [883] noted the disease at Taytay, a town situated in the north of the island of Palawan; he remarks that as Taytay is on non-calcareous soil the goitre occurrence cannot be associated with excess of lime. Actually, the geological formation there consists of a water-laid volcanic tuff. In Mindanao, the southernmost part of the Philippines, goitre has been recorded at Lanao and in the valley of the river Sindangan.

On the basis of a comparison between the relevant hospital returns for the 15 years up to 1924 and those for the two-and-a-half years following the liberation of the country at the end of the 1939-45 war, Recio [884] concludes that thyroid disease has increased in the Philippines during recent years.

Oceania

Soils are much richer in iodine than the rocks from which they are derived. Eminent authorities who have critically examined the iodine cycle in nature believe that precipitation of iodine from the atmosphere is by far the most important agency through which soils are iodine-enriched. The explanation that iodine is mainly concentrated in soils as a residual component resulting from the weathering of underlying primary rocks is untenable, since such a process would call for the destruction and removal of incredible tonnages of other less-soluble rock or soil constituents.

Atmospheric iodine originates from the sea; it is liberated from sea-water by oxidation and is carried inland by winds either in a gaseous state or adsorbed on floating particles of dust. Air-borne iodine is brought down by rain or snow; the first rains of any rainy period contain more iodine than the later rains. Addition of air-borne oceanic iodine to soil through rain or snow is a slow process; hundreds of thousands of years are required to build up an iodine-rich soil in this way.

During the Ice Age the older iodine-rich soils were swept away and the whole course of soil evolution began afresh. New soil-making materials were generated by the grinding-up of virgin crystalline rocks containing one-tenth, or even less, the average iodine content of mature agricultural soils. As the ice cover receded, replenishment of the iodine in glacial and postglacial soil materials began—a process which is still in progress in some countries (see *Geochemistry of Iodine* [215]).

As an introduction to goitre in Australia, New Zealand and the islands of Melanesia, this digression into the geochemistry of iodine is excused on two grounds. First, Australia and New Zealand are among the countries in which the frequency distribution of goitre may be correlated with the areas and extent of quaternary glaciation where soils have not yet been

sufficiently saturated with postglacial air-borne oceanic iodine. As Hercus [887] himself remarks in reference to the distribution of simple goitre in New Zealand: "Speaking generally, our immature, recently deposited soils predispose to the development of goitre, and all parts of New Zealand can be said to be goitrous." Secondly, the digression affords an opportunity to put on record that due recognition has not apparently been given to the fact that it was an Australian medical officer, Harvey Sutton,[908] who in the course of goitre studies in New South Wales and Victoria was the first to notice and explain correctly the relationship between rainfall and goitre incidence, and to offer a reason why iodine is preferentially fixed in upper soil layers rather than in the deeper horizons of the same profile.

His accurate assessment of what happens during an important phase of the iodine cycle is characteristic of other similar investigations in Australasian countries. No peoples have faced the goitre menace with more efficiency and more energy, and none are nearer its final conquest. Thanks to Hercus and his school, New Zealand's contribution to local iodine knowledge is fuller than that of probably any other country; and it is not difficult to predict that the recent elucidation by Clements & Wishart [894] of the goitrogenic influences operative in parts of Tasmania will always rank among the classic researches in this field.

New Guinea

Politically, the island of New Guinea is divided into West New Guinea and the Territory of Papua and New Guinea, which is a United Nations Trust Territory administered by Australia. Running the whole length of the country from west to east is a central mountain backbone with peaks rising to between 12 000 and 16 000 feet (3500 and 5000 m). Lying off the east of New Guinea are the islands of New Britain and New Ireland, which form part of the Territory of Papua and New Guinea.

The distribution of goitre throughout the New Guinea islands is patchy. Noosten [798] mentions three affected localities in West New Guinea—namely, the region around Doreh Bay at the north-east corner of Vogelkop, the Timorini area, and the banks of the river Digoel in the south-east of the country. In the territories to the east under Australian mandate, known goitre centres are: a village close to Mount Toma about 30 miles from Rabaul in New Britain; a collection of villages in the Hydrographers' Range on the north-east coast of Papua near Buna; and a group of Papuan villages situated in the mountainous country at the head-waters of the Angabunga river about 40 miles inland from the coastal area west of Port Moresby.

The last-named focus was discovered by Clements [888] during a medical survey in the western portion of the Central Division of Papua undertaken for the Papuan Administration in 1935. Here, Clements saw no goitre among the Roro tribe on the coast, or among the subcoastal Mekeo tribe,

who inhabit a dozen or so villages scattered at irregular intervals inland along the banks of the Angabunga river. But, higher up, at an altitude of about 6000 feet (2000 m) under the shadow of Mount Edward Albert, the highest peak in the Owen Stanley Range, he found chronic parenchymatous goitre in four villages—Ikuwei, Maini, Kailape and Tura.

Distribution is highly localized. Other villages high on the mountain sides, in apparently similar positions to those affected, were found to be free from goitre; and within the goitrous villages themselves many people have continuously drunk water from the same source as the goitred people without contracting the disease. The malady is confined to adults, the great majority of sufferers being women. Onset is associated with first pregnancy and no woman becomes pregnant after having developed a thyroid enlargement—a feature, Clements remarks, unusual in a population with a high birth-rate. The natives believe that in women goitre is the result of eating pig during the period of pregnancy; many pigs are eaten in a feast which may last a month. Diets excessively rich in protein and fat are among the many that have been branded as goitrogenic; if this be true, a month's feast which includes a high proportion of pig fat might well impose an unaccustomed thyroid stress, especially during pregnancy.

Australia and Tasmania

Systematic goitre surveys in Australia are relatively few in number and in any case have been directed to areas already known to be or suspected of being goitrous. As more surveys are undertaken it is possible that other goitre regions will be uncovered. The disease has not been recorded among the aborigines, either formerly or at the present time. Soon after the arrival of the first white settlers, the aboriginal peoples moved out of districts now recognized as goitrous and are today living in apparently non-goitre areas, for the disease has not been observed among them (Clements [886]).

Queensland

Reports by school medical officers suggest that the town of Cairns in the north of Queensland, and parts of the Atherton Plateau, which lies directly to the south-west of the town, are mildly goitrous. The degree of incidence, however, is unknown (Sutton [908]). There are rumours of occurrence in the country between Toowoomba and Cunnamulla 200 to 300 miles west of Brisbane, but there is no official confirmation of this.

New South Wales

Examination of 75 000 children in rural districts and an additional 10 000 in towns (Sutton [907, 908]) revealed considerable areas of goitrous

country in the Great Dividing Range, which runs down the eastern part of New South Wales from the Queensland border in the north to the border of Victoria in the south. These areas lie in several large river valleys, particularly the populous Hunter river valley, and in fertile plateaux throughout the range. The percentage rates (given in parentheses for boys and girls respectively) were highest in such places as Grafton near the north-east coast (0.42, 4.35), Armidale in the New England Range (0.76, 3.57), Tamworth at the head of the river Namoi (6.33, 12.0) and Muswellbrook in the Hunter valley (5.5, 11.27).

Excluding the town of Grafton already mentioned, the incidence is less marked in the extreme north-east corner of the State, that is, in an area bounded by Wallangarra, Armidale, Coff's Harbour and Tweed Heads. To the south, in the area bounded by Bathurst, Albury, Eden and Wollongong—but excluding Canberra—incidence is comparatively slight. There is a small endemic area between Camden and Yerranderie, 50 miles to the west of Sydney. A map showing the relative prevalence of goitre in these different sections of New South Wales is given by Sutton.[907] Among children at two schools in the Sydney suburb of Bondi, Clements [890] found an over-all thyroid enlargement, palpable or visible, of 7.9% in boys and 17.3% in girls.

Canberra

In 1947, the city of Canberra was found to be in a goitrous area. A survey by Clements [890] revealed the rates shown in Table XIX among boys and girls in three age-groups between 6 and 14 years. It is seen that the prevalence is higher in girls than in boys, particularly in the 12-14 years' age-group.

Shortly after the foregoing facts came to light, an iodine prophylaxis project was started in Canberra under the sponsorship of the Australian

TABLE XIX. PREVALENCE OF THYROID ENLARGEMENT AMONG CHILDREN IN CANBERRA

Age-group	6-8 years				9-11 years				12-14 years			
Sex	boys		girls		boys		girls		boys		girls	
Number examined	177		186		198		160		177		164	
Thyroids:	number	%	number	%	number	%	number	%	number	%	number	%
palpable	22	12.4	41	22.0	49	24.7	59	36.9	50	28.2	61	37.2
visible	8	4.5	10	5.4	11	5.6	16	10.0	9	5.1	37	22.5
Total . . .	30	16.9	51	27.4	60	30.3	75	46.9	59	33.3	98	59.7

Department of Health. The scheme consisted of administering to pregnant and lactating women, infants, children and adolescents, once a week, a tablet containing 10 mg of potassium iodide. The tablets were distributed through infant welfare centres and schools. The results over five years have been reviewed by Clements [886, 891] in Table XX, which shows the percentage rate of visible goitre among Canberra children in the 9-11 age-group at each successive examination.

TABLE XX. PREVALENCE OF VISIBLE GOITRE AMONG CANBERRA CHILDREN IN 9-11 AGE-GROUP AFTER INTRODUCTION OF IODINE PROPHYLAXIS

Year	Boys		Girls	
	number examined	percentage with visible goitre	number examined	percentage with visible goitre
1947	198	5.6	160	10.0
1948	236	2.1	215	5.0
1951	140	0	124	0
1952	299	0	281	1.7

In 1951, results from one school were not available, and in 1952 the survey was limited to children who had resided in Canberra for the previous three years. Nevertheless, the incidence throughout shows a marked downward trend and the results clearly demonstrate the effectiveness of this method of goitre prevention and its suitability for infants and young children whose intake of iodized table-salt would at that age be negligible.

Regarding goitre prevention in Canberra, Hipsley [898] has drawn attention to the convenience of adding iodized salt to bread at the time of baking, as has been customary in the Netherlands since 1943. The method has recently been adopted in Canberra and now replaces the distribution of iodide tablets to schoolchildren and to expectant and nursing mothers.

Victoria

Gippsland, the wide littoral area lying between the mountains and the sea at the south-eastern end of Victoria, is the home of goitre in this State. Starting at Melbourne and moving eastwards through Gippsland for about 200 miles one would find goitre in the following succession of closely neighbouring towns and hamlets: Dandenong, Noojee, Warragul, Leongatha, Traralgon, Walhalla, Sale, Bairnsdale, Stratford, Bruthen in the Tambo valley, and Buchan and Orbost in the valley of the river Snowy. The districts of Dargo and Omeo in the Bowen Mountains to the north of Gippsland, where rainfall is heavy and frequent, are also affected.

Prevalence is comparatively heavy. In Bairnsdale, one of the chief towns of Gippsland, rates of 20% to 33% in boys and of 32% to 47% in girls were recorded by Summons [906] in 1927. Of 14 boys between the ages of 12 and 14 attending the junior technical school at Sale, 8 had goitre. Clements' more recent Gippsland figures (1948), given in Table XXI, show little, if any, improvement on their earlier counterparts.[890]

TABLE XXI. PREVALENCE OF THYROID ENLARGEMENT AMONG CHILDREN IN GIPPSLAND

Age-group	6-8 years				9-11 years				12-14 years			
Sex	boys		girls		boys		girls		boys		girls	
Number examined	172		147		120		119		61		72	
Thyroids:	number	%	number	%	number	%	number	%	number	%	number	%
palpable	40	23.2	45	30.6	35	29.2	34	28.6	17	27.9	17	23.6
visible	23	13.4	25	17.0	21	17.5	30	25.2	8	13.1	30	41.7
Total . . .	63	36.6	70	47.6	56	46.7	64	53.8	25	41.0	47	65.3

It will be noticed that the maximum rate in boys is in the 9-11 years' age-group, whilst in girls maximum intensity occurs between 12 and 14 years of age.

On the other side of Victoria to the west of Melbourne goitre is much less evident, but minor occurrences have been noted in scattered and localized areas around Ballarat, Geelong, Colac, Bendigo, Ararat, Hamilton and Warrnambool.

South Australia

The only endemic goitre area in the State of South Australia lies in the Adelaide Hills, part of the Mount Lofty Range to the east of Adelaide. This closely settled farming region extends to about half a million acres (200 000 ha) and has a population of approximately 20 000. Jungfer,[899] who supervised a child health survey in the area, found a general goitre rate in the " 10 years and over " age-group of 21.1% among girls and 4.1% among boys. The rates were somewhat higher (26.6% and 11.1%, respectively) in a selected group of " ten-plus " children who had been born in the Adelaide Hills and had been permanently resident there up to the time of Jungfer's survey.

Western Australia

" Goitre is not a problem of any importance in Western Australia. Hospital records show very few cases and no evidence of endemic areas in the State." This statement by the Commissioner of Public Health (1943) is confirmed by Clements,[886] who writes that despite a deliberate search for goitre in the south-western corner of the State where a number of trace-element deficiency diseases occur in animals, endemic goitre has not been recorded.

Northern Territories

There are no reports of goitre occurrence in the Northern Territories of Australia.

Tasmania

Practically the whole of Tasmania is goitrous. The disease has been known in the island since the last century, but the first serious study of the problem was not made until 1949, when Clements examined 8000 school-children and found visible goitres in approximately 6% of boys and 20% of girls in the age-group 12-14 years. He also noted that at least 20 in every 100 adult women had a goitre, and pointed out that the annual death-rate from thyrotoxicosis in Tasmania had been significantly higher than the Australian average for at least 70 years.[892, 894]

Accepting world experience that endemic goitre is due to inadequate dietary iodine intake, and following the Canberra precedent noted above, Clements succeeded in promoting a preventive scheme whereby tablets, each containing 10 mg of potassium iodide, were distributed by the health authorities to all children up to the school-leaving age of 16 years. In 1954, five years after the prophylactic procedure was introduced, a second survey was made to determine its effects. This involved the examination of some 20 300 children between the ages of 5 and 17 years. As may be seen from Tables XXII and XXIII, the results were almost entirely contrary to expectations.

In the first place, the 1954 survey showed a marked increase in goitre prevalence among both boys and girls in each age-group, with the exception of girls 12-14 and 15-17 years of age. Secondly, the goitre rates for each year of age in both boys and girls from 5 to 8 years in the 1954 survey (see Table XXIII) were similar; this is in marked contrast to the results obtained in the 1949 survey, when there was a substantial difference in prevalence between boys and girls, and steep increases from the youngest children to the older age-groups. The 1949 pattern of prevalence was similar to that observed in other Australian surveys.

To find an explanation for these unexpected rises in incidence during a five-year iodine régime, the reliability of the standards of diagnosis was

TABLE XXII. PREVALENCE OF VISIBLE GOITRE AMONG CHILDREN IN TASMANIA BEFORE AND AFTER IODINE PROPHYLAXIS

Age-group (years)	Sex	1949 survey		1954 survey	
		number examined	percentage with visible goitres	number examined	percentage with visible goitres
5	M	217	0	675	5.03
6-8	M	1218	1.39	3286	8.12
9-11	M	1376	3.71	2769	9.02
12-14	M	1180	6.44	2727	9.90
15-17	M	190	3.5	444	5.85
5	F	184	2.7	694	5.90
6-8	F	1259	3.1	3099	9.61
9-11	F	1364	8.51	2733	12.58
12-14	F	1675	20.8	3344	16.74
15-17	F	253	23.3	535	22.99

TABLE XXIII. PREVALENCE OF VISIBLE GOITRE AMONG CHILDREN IN TASMANIA, FOR EACH YEAR OF AGE FROM 5 TO 8, IN 1954 SURVEY

Age (years)	Boys		Girls	
	number examined	percentage with visible goitres	number examined	percentage with visible goitres
5	242	7.8	303	8.2
6	489	10.0	486	11.1
7	546	11.7	550	11.4
8	460	10.8	450	12.2

checked and confirmed, the efficiency of the system of tablet distribution was verified, and the over-all prevalence figures for 1949 and 1954 were subjected to mathematical analysis and re-study district by district.

When in this way the country was partitioned into six districts and data were related strictly to the districts in which they had been gathered, and not lumped with others for the island as a whole, it was found that in three districts there had been a general fall in incidence since 1949, proving that iodine had been effectively doing its work, but that in other two and possibly three areas there had been a steep rise. The over-all rise in prevalence seen in the figures as a whole was due to the sharp rises in these three individual areas. The district-by-district analysis of data also confirmed the

improved rates among older girls, and established that the higher rate among young children in 1954, as compared with 1949, was real and not due to some error of diagnosis or irregularity in the distribution or altered potency of the iodide tablets. This feature remained the most remarkable of the 1954 survey.

These findings led Clements & Wishart [894] to consider the possibility that there might be two causes of goitre in Tasmania—a straightforward iodine deficiency operative in some districts and a goitrogenic agency predominant in others. Strong support for the goitrogen hypothesis was found in two interrelated sets of circumstances. In 1950, just one year after prophylaxis by iodide tablets began in Tasmania, the Commonwealth Government introduced a free-milk scheme for schoolchildren to stimulate milk consumption throughout Australia for health reasons. To meet the increased demand for milk occasioned by this scheme, particularly in the autumn and winter months when cows are usually dried-off, farmers were obliged to keep their herds in production all the year round. Accordingly, they extended their plantings of chou-moellier (*Brassica oleracea* var. *acephala*, marrowstem kale), a crop available for direct grazing through the winter months when grass is burnt off by frost.

Between the years 1948 and 1953 the area in Tasmania sown to chou-moellier increased from 83 acres (34 ha) to 235 acres (95 ha) and the quantity of chou-moellier and kale seed sold in the country during these same six years increased from 23.7 to 214.9 hundredweights (from about 12 to 110 quintals). The districts where chou-moellier cultivation increased most were found to correspond exactly with those where goitre incidence had increased between the 1949 and 1954 surveys.

Chou-moellier belongs to the *Brassica* genus, members of which may contain the goitrogen L-5-vinyl-2-thio-oxazolidone. Since the goitrogenic activity of this substance is destroyed by heat and since all vegetables of the *Brassica* genus eaten directly by Tasmanians are cooked, Clements & Wishart reasoned that the goitrogenic effect might be transmitted indirectly to the human subject through milk from cows fed on chou-moellier. Patient research from several different angles yielded strong supportive evidence for their point of view. This included the fact that the rise in goitre rates among young children coincided with their increased consumption of milk under the free-milk scheme; the fact that regular weekly doses of 10 mg of potassium iodide failed to prevent the development of goitre in these children; the fact that milk from chou-moellier-fed cows administered experimentally to humans and to laboratory animals clearly interfered with their I-131 uptake; and the fact that marked thyroid hyperplasia developed in calves born of cows which had been fed on chou-moellier. Evidence was also forthcoming that milk containing a goitrogen could be produced by cows grazing on pastures heavily contaminated with certain cruciferous weeds.

Final proof of the hypothesis set up by Clements & Wishart [894] requires the actual isolation of the goitrogenic substance from milk and a demonstration of its anti-thyroid potency on human subjects. Nevertheless, their findings are more than indicative that much of the goitre in Tasmania is due to goitrogenic interference with a vital step in the synthesis of thyroxine which cannot be overcome by iodine administration. Clements & Wishart are careful to stress, however, that this does not affect the fact that a large amount of the goitre endemic in Tasmania and elsewhere in Australia is due to straightforward iodine deficiency and is therefore amenable to iodine preventive measures.

Animal goitre in Tasmania

An outbreak of congenital goitre in lambs on alluvial river flats in the Huon valley south of Hobart was reported by Southcott [903] in 1945. Since then occurrences have been noted in the Derwent valley and at several places in the southern midlands. Goitre also appears to be prevalent among farm horses in Tasmania, and occasional cases suggestive of iodine deficiency have been seen in calves in various districts (Green [895]).

New Zealand

Goitre is endemic in both the North and South Islands and affects Maoris and Europeans alike. There is a tradition that the malady was in evidence among the Maori peoples long before the beginnings of British settlement; their language has for many generations contained the word " tenga ", which means goitre. Among European colonists the disease was first mentioned in 1882 by Nedwill, who noticed its frequency in and around Christchurch; in 1888, Hacon recorded its widespread occurrence throughout the Provincial District of Canterbury; and from inquiries conducted in 1910 Colquhoun concluded that the whole country was goitrous.

Medical inspection of recruits during the 1914-1918 war, when 1680 men out of 135 000 examined were rejected for active service on account of goitre, brought the problem more directly to public attention and systematic surveys were thereupon undertaken. In 1920 Hercus & Baker [918] examined 15 000 schoolchildren in the age-group 5 to 12 years in Canterbury and Westland (South Island) to find 32% with markedly enlarged thyroid glands and a further 29% with glands sufficiently palpable and visible on deglutition to constitute pathological enlargement. This preliminary survey was later greatly extended to cover many thousands of children in both the North and South Islands and was coupled with chemical determinations of iodine in a large number of representative soils and waters collected throughout the entire Dominion (Hercus and co-workers; [915, 917, 919, 920, 923, 924] Shore & Andrew [929-932]).

By these surveys the southern section of the South Island (Otago and Southland) showed an average goitre rate of 26% rising to 30% and 40% in the Taieri and Clutha valleys west and south-west of Dunedin. In the central and northern portion of South Island (Canterbury, Nelson, Marlborough) the rate was much higher, exceeding 60% in South Canterbury and around Christchurch. Observations at the government maternity hospital in Christchurch revealed 60% of mothers with goitre and approximately 8% of babies born with thyroid enlargement, sometimes to a degree sufficient to interfere with normal flexion of the head at delivery.

The North Island Provincial Districts of Wellington, Taranaki and Hawke's Bay had an average goitre rate of 21%; there were black spots in the Hutt valley (41%) north-east of Wellington, and in the west coastal county of Wanganui, where the rate reached 46%. Other fairly goitrous districts of the North Island were found in the mountainous parts of Auckland where rates of 30% were recorded among schoolchildren in the Counties of Taupo and Rotorua, and in the Waikato and Piako valleys to the west of Rotorua. Shore & Andrew [929] record rates of 47% in boys and 56% in girls at Gisborne. Only New Plymouth in the west of Taranaki Provincial District, and the Thames and Coromandel peninsula in the north of Auckland, has rates under 10%.

The iodine analytical determinations yielded data which fully sustain the iodine-deficiency theory of causation. Though anomalies were encountered, the whole body of facts was too large and the inverse relationship between goitre prevalence and environmental iodine supply too consistent to be fortuitous. Broadly speaking, it was found that in New Zealand iodine is lowest and goitre highest on the recent alluvial soils of river valleys, on porous soils derived from siliceous volcanic rocks and on marine sandstones and greensands—indeed, on all clayless sandy soils and gravels from which iodine is easily leached out by weathering. By contrast, goitre is low and iodine high in regions underlain by igneous rocks (granite, basalt, andesite) yielding clayey soils and fertile brown or red loams rich in iodine.

As a result of these exhaustive investigations, iodized salt was officially introduced into New Zealand on a voluntary basis in June 1924. At first the salt was inadequately fortified at a level of 1 part of potassium or sodium iodide in 250 000 parts of salt. Three years later, wide and detailed inquiries in grocers' shops and in a representative sample of Canterbury homes revealed that of all salt bought for table and culinary purposes only 5% was of the iodized variety. By 1934, following a vigorous educational campaign by the Department of Health, the proportion had risen to 30%. In 1940, yielding to the pressure of enlightened medical opinion, the New Zealand Government raised the iodide standard to 1 part in 20 000 parts of salt, and the New Zealand Medical Research Council's Thyroid Research Committee recommended that salt iodized in this proportion should become

the standard domestic salt of the country and that non-iodized salt should be supplied only to people asking specifically for it. Although this policy has not yet been wholly adopted, approximately 80% of the population today use iodized salt of the 1 : 20 000 strength, at least at table.

Despite the fact that the more potent salt (1 : 20 000) was not introduced until 1942, a notable decline in the prevalence of thyroid enlargement among schoolchildren had already become apparent by that time. In 1951 Tolley [934] made a survey of the children living in the South Canterbury and North Otago school areas with the object of comparing the prevalence among them with that found by Hercus and others 25 years previously. She found the average rate for both these districts to be 25%, as compared with 62% in 1925. The almost complete disappearance of gross goitrous enlargements accounted for most of this fall. On the other hand, Tolley found that the number of " incipient " enlargements (i.e., palpable and small visible goitres) was still relatively high, indeed somewhat higher than the 1925 figure. From this she concludes that either the iodine intake is still too low, even with salt iodized at the 1 : 20 000 level, or that some unknown factor is responsible.

Reviewing Tolley's results in the light of their own experience, Clements & Wishart [894] suggest that the residues of incipient goitre may be due to the action of a goitrogenic substance of a character similar to that suspected to operate in Tasmania (see page 144). They recall that in New Plymouth, at one time regarded as virtually goitre-free, the rate of visible thyroid enlargement among children rose from less than 2% in 1927 to 53% in 1933 (Mecredy; [926] Shore & Andrew [931]). Chou-moellier, along with other species of *Brassica*, has been grown in and around New Plymouth for many years. It may well be that changes in the pattern and extent of *Brassica* cultivation, or of the cultivation of other possibly goitrogenic crops, have not been sufficiently investigated in relation to goitre occurrence in New Zealand.

Animal goitre in New Zealand

Domestic animals are not exempt from thyroid disease in New Zealand. Hercus [916, 919] has seen goitres, sometimes of large size, in sheep, cattle, pigs and dogs—especially fox-terriers. In racing stables cases have been known of horses developing goitre during training. Of particular interest has been the occurrence of epidemic thyroid enlargement in lambs.[911, 912, 925, 933] Symptoms suggesting acute iodine deficiency among sheep led to serious loss of lambs in the Wanaka district of South Island in 1929. The trouble was overcome by means of iodized licks.[925] More recently, a severe outbreak of goitre accompanied by heavy neo-natal mortality in lambs from kale-fed ewes has been described by Sinclair & Andrews.[933] A few moderate cases were also observed among lambs from

pasture-fed ewes, but these did not appear to be associated with unusual mortality. In both pasture-fed and kale-fed groups goitre was prevented and the iodine status of the lamb thyroids raised by dosing the ewes with potassium iodide during pregnancy.

South Pacific Islands

Absolute proof that goitre can be endemic in an extreme maritime environment is found in the South Pacific. Proximity to the sea does not necessarily protect all the peoples inhabiting the islands scattered throughout the 18 million square miles of ocean from the Marianas in the north to Norfolk Island and Pitcairn Island in the far south. The disease occurs in Fiji and cases have been reported from Tonga, Samoa and the Cook Islands.

Fiji Islands

A survey by members of the Otago Medical School, New Zealand, found goitre endemic in the valley of the Singatoka, the second largest river in the island of Viti Levu. Many villages containing both Fijians and Indians are dotted along its banks, and simple goitre is endemic in both races, except in the Fijian villages near the mouth of the river where much sea-food is eaten (Hercus [887]). L. Wills (personal communications, 1950 and 1951) also reports " plenty of goitre all round the Island in spite of fish and marine life in the menu." She saw many visibly enlarged thyroids among pregnant Fijian women.

Growing concern at the apparently increasing goitre incidence among the Indian population in western and northern districts of the Colony has prompted the South Pacific Health Service to make iodate-fortified salt available in Fiji.

Tonga or Friendly Islands

According to the Chief Medical Officer [935] and to Simmons,[939] Tongans exhibit a certain amount of goitre which points to iodine deficiency. Some fish is eaten but not a quantity large enough to supply the full iodine requirement.

Samoa and the Cook Islands

Occasional sporadic cases of simple goitre have been reported from Samoa and the Cook Islands, but the incidence is so low as to merit the term goitre-free being applied to these islands (Hercus [887]). In a thorough nutrition survey of 365 Cook Islanders of all ages chosen at random in 66 family groups from the village of Arorangi on the island of Rarotonga, Faine & Hercus [936] noted only one mild case of thyroid enlargement; the

large consumption of fish and sea-foods must provide a sufficiently high iodine intake.

Hawaiian Islands

Goitre is not endemic in the islands of the Hawaiian group; nevertheless, the non-toxic nodular variety is by no means rare. Examination of hospital records by Freeman [937] revealed this type of goitre in more than 25% of 423 patients who had undergone thyroid surgery at The Clinic, Honolulu, during the twenty years to 1950.

Several studies have shown that there is sufficient iodine in drinking-water and local foods in Hawaii to prevent thyroid disorders that might result from lack of iodine. A conjecture that the high frequency of cleft palate in Hawaiian children might be associated with low metabolic rate in their mothers was proved by Henderson & Krantz [938] to be unfounded.

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