on northern Long Island, hence no attempt has been made to discuss the literature bearing on the causes of the successions or the plant associations that have been distinguished on neighbouring coasts. He gives a diagram (Fig. 26) to show the relations of the various successions dealt with.

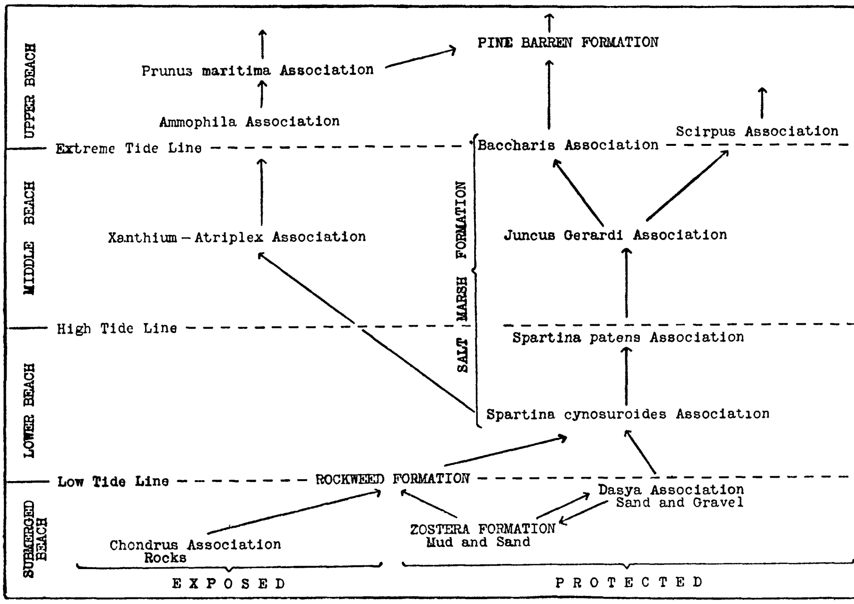


FIG. 26. Diagram to show the successional relationship of the plant associations in the Littoral Succession, Cold Spring Harbour, Long Island. (From Transeau.)

We have given a long summary of these two papers on the ground that the authors deal with plant communities which are so extensively developed in various parts of the world and, while differing in detailed floristic composition, present considerable resemblances as to general conditions, and also because their methods and results cannot fail to be of interest and value to workers in other parts of the world.

ANTARCTIC AND SUBANTARCTIC VEGETATION[1]

(I) "National Antarctic Expedition, 1901—4. Natural History. Vol. 6. Zoology and Botany." British Museum, London, 1912, price 16*s.*

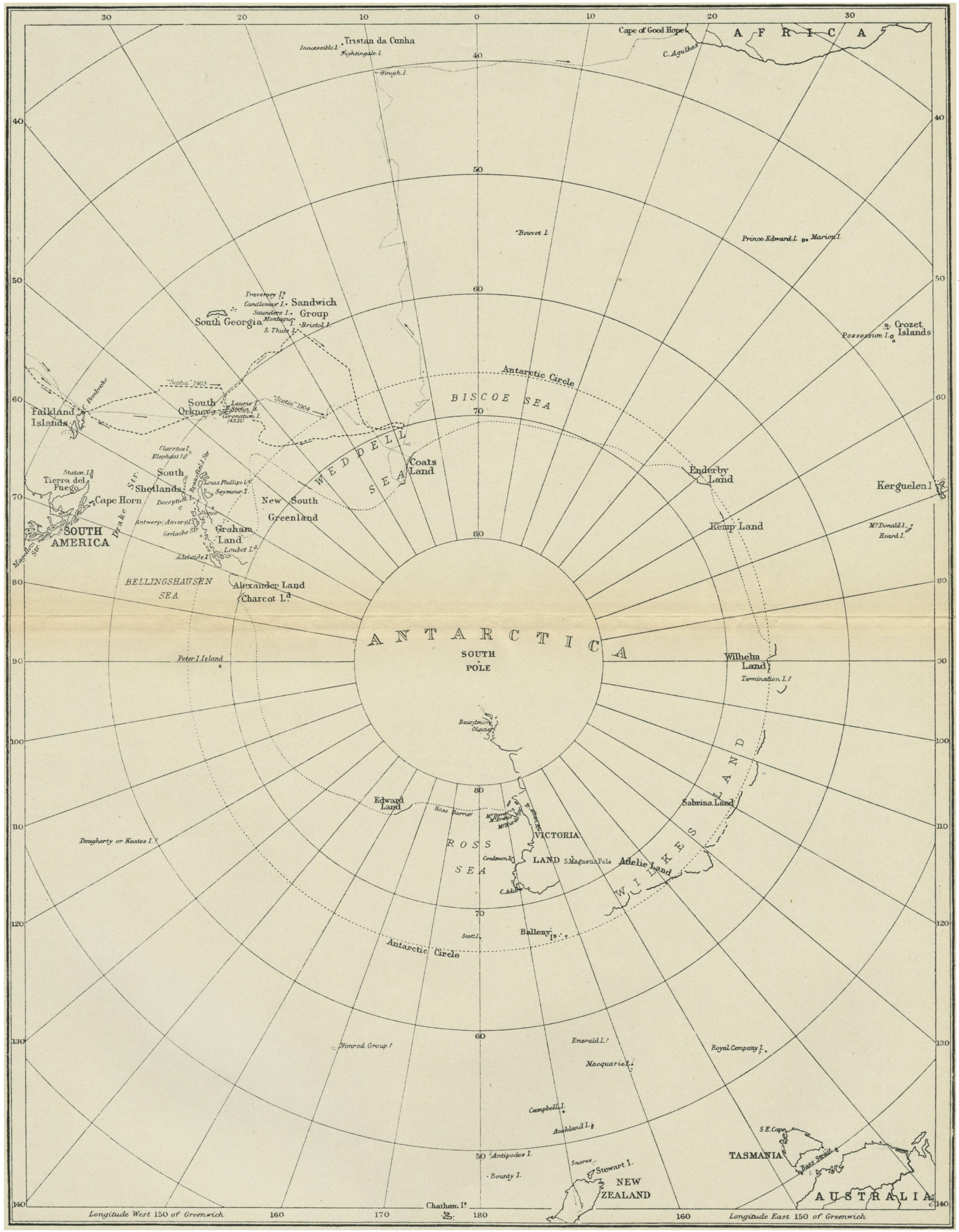
(II) "Scottish National Antarctic Expedition. Vol. 3. Botany." Scottish Oceanographical Laboratory, Edinburgh, 1912, price 23*s.* 6*d.*

(III) **Fritsch, F. E.** "Freshwater Algae collected in the South Orkneys by Dr R. N. Rudmose Brown of the Scottish National Antarctic Expedition." *Journ. Linn. Soc., Bot.*, **40**, 1912, pp. 293—338.

(IV) **Darbishire, O. V.** "The Lichens of the Swedish Antarctic Expedition." *Wiss. Ergebn. d. schwed. Südpolar Exp.* 1900—3, Band 4, Lief. 11, Stockholm, 1912, 73 pp.

(V) **Skottsberg, C.** "The vegetation in South Georgia." *Ibid.*, Band 4, Lief. 12, 1912, 36 pp.

[1] See Plate 13. For permission to reproduce this chart we are indebted to the kindness of R. N. Rudmose Brown and W. N. Bruce.



RUDMOSE BROWN—PROBLEMS OF ANTARCTIC BOTANY (see pp. 240—248).

(VI) **Skottsberg, C.** "Einige Bemerkungen über die Vegetationsverhältnisse des Graham Landes." *Ibid.*, Band 4, Lief. 13, 1912, 16 pp.

(I) This volume contains a report by Fritsch on the freshwater algae collected near Cape Adare (71° S.) and in the region around McMurdo Sound (nearly 78° S.). Of the 91 species observed, 52 were Cyanophyceae. Large sheets of *Phormidium* and *Lyngbya* were found flourishing in the ice or, during the milder months, in the waters of the ponds and lakes; these sheets formed a substratum for a rich growth of other Cyanophyceae and for species of *Pleurococcus*. The freshwater Diatom flora was rather uniform; the only genera were *Navicularia*, *Fragilaria*, and *Hantzschia*. One Desmid was observed, a species of *Penium*; this is the only Desmid as yet recorded for the Antarctic continent.

(II) Of the ten reports in this volume, including all the botanical results except the phytoplankton, several are republished from various journals. The one selected here for the following summary, as being of greatest general interest, is that by Rudmose Brown entitled "The problems of Antarctic botany."

The author remarks that the renewed interest in the Antarctic, as expressed in recent expeditions, by various collections and observations, has shown that the south polar flora, poor as it may be, is nevertheless in some respects richer than was supposed. The interest of these collections lies largely in the questions they raise as to problems of geographical distribution and the origin of the Antarctic flora. The study of the adaptations of the various species to their environments, especially important in the case of cosmopolitan species, promises valuable results, but is more likely to be undertaken seriously when the systematic and geographical interests of the flora have been more fully worked out; for a newer study usually must wait until the older aspects of the science have been satisfied, and it is moreover desirable that such physiological and morphological questions should be studied on the spot. At the present time there are several habitable dwellings within the regions of south polar ice that have been erected by one or other of the recent expeditions; of these the house at Scotia Bay, South Orkneys, is permanently inhabited as an Argentine Meteorological Observatory, while that at Wandel Island has been, or shortly will be, taken possession of for a similar purpose. Hence laboratory accommodation on a small scale in the Antarctic regions is practicable and need not be costly, and though most of these stations are not very far south this is an advantage, for while all are within the veritable polar regions and experience the real Antarctic climate, they escape in large measure the long night and its attendant drawbacks, besides being readily accessible so that a relieving ship could reach all or any of them every summer. The Danes have established in north polar regions, on Disco Island, West Greenland, a fully equipped biological laboratory, and the author points out the extreme desirability of a similar station in south polar regions.

The most striking feature of the Antarctic flora is its poverty compared with that of the Arctic; thus the Arctic regions support about 400 species of flowering plants, the Antarctic regions only two (*Deschampsia antarctica* and *Colobanthus crassifolius*). The amount of light available is the same in north and south at corresponding latitudes, yet the contrast between the two vegetations is even more marked when one remembers that in Spitzbergen, in 79° N., the ground is bright in summer with a hundred species of flowering plants, while at the South Orkneys, in only 61° S., there is not a single species. In Grant Land, 81—82° N., in three localities, Peary collected 57 mosses and 7 hepatics—a greater number of bryophytes than at present known from the whole of the Antarctic regions south of 60° S. Snow is probably not much more abundant in the south, and winter temperatures, at least in the outermost south polar regions, neglecting for the moment comparative latitudes, are not more severe than in the north.

The real explanation is probably to be found in the short and inadequate Antarctic summer with its remarkably low temperatures. At the South Orkneys, 60° 44′ S., the mean of the summer months (December, January, and February) is barely 32° F., and in no month does the mean rise to 33° F., while the mean of the warmest day in 1903—4 was only 37·7° F.; at Snow Hill Island (64° 24′ S.) the mean of the warmest month (January) was found to be only 30·38° F., while at Cape Adare, Victoria Land (71° 18′ S.) the summer mean is 30·4° F. At 77° 50′ S., in McMurdo Sound, the "Discovery" found that the mean summer temperature was 21·4° F., and the mean of the warmest month (December) was 24·6° F.

These temperatures may be compared with those of the Arctic regions. At Spitzbergen (79° 53′ N.) the mean temperature of July (the month corresponding to January in the south) is as high as 41·5° F., while in Franz Josef Land, in over 80° N., it is not lower than 35·6° F. in the same month. The mean of the Spitzbergen summer (June, July, August) is 37·1° F., contrasted with the corresponding mean given above for the South Orkneys, scarcely 32° F.

The important point is that while the Arctic summer mean is well above 32° F., the Antarctic summer mean is practically always below. This remarkably cold Antarctic summer acts in two ways upon plant life. Firstly, the winter snow lies later on the ground, all the later as the summer is a cloudy and somewhat sunless period, and December is well advanced before the majority of available sites are laid bare, while in February the winter again begins; in the north, for instance at the northern part of the east coast of Greenland, the land is clear of snow from May or early June until September, dates which would correspond in the south with November to March. Secondly, and this is the chief reason, it is doubtful if a flowering plant could obtain the requisite amount of heat needed for its various life functions even to reach the flowering stage, while the maturation of the fruit would be next to impossible. Doubtless this lack of a season of growth gives a quite adequate explanation of the poverty of the south polar vegetation, but the author considers that another adverse influence is at work. Even if a species did obtain a footing in Antarctica, as is not impossible in the lands nearest Fuegia, considering the narrowness of Drake Strait, its continued existence would be menaced by the presence of myriads of penguins which occupy almost every bare spot of land during the nesting and breeding season. There is no parallel in the north to these penguins and the power they have in destroying any vegetable life. Almost every spot where a plant might obtain a hold is covered with penguins in the proportion of at least one to a square metre, and nothing escapes their insatiable curiosity or fails to be examined with their beaks, while in a few weeks such a rookery is in an indescribable state of filth, being covered with several inches of mud and manure through which the penguins are incessantly tramping hither and thither—conditions which would render plant life out of the question. One finds here and there a small expanse—the author saw as much as an acre in one place—of moss-clad rocks which by successive years' growth are covered with six to eight inches of vegetable soil, but these are spots much less accessible from the sea and seldom suitable for rookeries—which is, of course, the sole condition under which this continuous growth of moss from year to year could continue. In such spots one might look in vain for flowering plants and perhaps conclude that the influence of the penguins, though potentially inimical to vegetable life, has never cause to operate, at least against flowering plants; but it must be noted that these moss formations, though in many respects suitable for phanerogamic plant life, are always very late in losing their winter snow, and generally lie in sheltered places where wind-carried seeds would be little likely to arrive. That seeds of Fuegian species of phanerogams occasionally reach Graham Island and the adjacent South Shetland and South Orkney Islands is more than probable, considering the prevalence of winds from the north of west in that region; it is even possible, though less likely, that wind-carried seeds from Kerguelen and Heard Islands occasionally alight on parts of the coasts of Wilkes Land. The occurrence in red snow in the South Orkneys of pollen grains of *Podocarpus*, several species of which grow in Chili, seems indisputable proof of the possibility of wind transport of Fuegian species to Antarctica. Though the likelihood of the transport of seeds by birds is lessened by the fact of there being only one true land bird (*Chionis alba*) in the Antarctic, it is probable that seeds and spores are occasionally carried adhering to the feet and feathers of the giant petrel and other wandering birds, which range from subantarctic to Antarctic lands; where snow-free land occurs on the Antarctic coasts in summer, innumerable birds find nesting places, and these are the places where or near where most of the vegetation occurs. Floating ice probably never acts in the Antarctic as an agency in the dispersal of species; and in contrast with the shores of the Arctic regions, the conspicuous absence of driftwood on Antarctic shores indicates the small likelihood of wave-carried seeds being stranded.

Hence it is not by reason of their isolation alone that the south polar regions have next to no phanerogamic vegetation, but because they are unsuited in one way or another to support it. Skottsberg considers that the formidable Antarctic winds must be another unfavourable condition for higher plant life. The author, while fully admitting the strength of the winds that sweep over certain localities the greater part of the year, does not believe that they could have an inimical influence on any possible vegetation, partly because there are always certain sheltered spots, but largely because the Antarctic summer is a relatively calm period, while the winds of winter could of course have no prejudicial influence through the covering of snow.

The author agrees with Skottsberg in taking the parallel of 60° S. as a more or less natural limit for the Antarctic regions; the South Orkneys are truly Antarctic in all respects, but South Georgia is subantarctic and so in all probability is the South Sandwich group.

The flora of the Antarctic regions as thus defined contains only the two phanerogams already mentioned; *Deschampsia antarctica* was found by the French Antarctic Expedition (1904–5) at Wandel Island, 65° 4′ S., while Charcot's Expedition in 1910 found both this plant and *Colobanthus crassifolius* as far south as 68° S.

Ferns are entirely absent, but mosses are relatively abundant and form almost the chief constituent of the Antarctic flora. Collections of mosses are known from various points around the pole, including Graham Island, South Shetlands, South Orkneys, Wilhelm Land, and Victoria Land, but those from the Atlantic and American sides are incontestably the richer, no doubt because of the nearer proximity of extra-polar land and consequent possibility of migration, but also to some extent because that side has received more careful exploration. Of the 52 species of mosses which up to the present have been described from Antarctic regions, 24 are endemic, 16 are northern and 12 southern species of wide distribution, while the rest are more or less cosmopolitan. Many Antarctic species have close affinities with northern species; Dr Cardot concludes that "en somme la facies de la flore bryologique antarctique est plus boréal que magellanique." The relationship of the Antarctic moss flora with those of South Georgia and the Magellan lands is also notable; there are 17 species common to the Antarctic and South Georgia, of which 6 are widely distributed in other lands, chiefly northern, while 16 species are common to the Antarctic and Fuegian lands, of which 10 are of wide distribution, again chiefly in the northern hemisphere. Excluding 8 species of wide distribution, only 5 species occur in both the Antarctic and Kerguelen, and of these 3 are also found in South Georgia. These facts suggest a migration from Fuegian lands as the origin of the Antarctic flora.

The life conditions for mosses are evidently not too unfavourable, for most of the species show fairly vigorous growth, and do not appear to suffer from the severe environment. Cardot comments on the luxurious growth of Antarctic specimens of certain species with wide distribution in other parts of the world. The author himself while in the South Orkneys noticed that for at least seven months, and in places eight, the mosses were frozen as hard as rock, but this did not seem at all to impair their vitality on the return of spring; farther south—mosses have been collected in the far south of Victoria Land (78° S.)—their frozen condition must last longer. In this relation, it is striking how poor and stunted are the specimens from 77° to 78° S. in Victoria Land compared with those from lower latitudes in Graham Land. Vegetative reproduction among Antarctic mosses appears to be the rule, and fruiting specimens of most species are very rare among the collections of all the expeditions; among the author's South Orkney specimens the only species with many and well-developed fruits was *Polytrichum subpiliferum*, and Cardot states that among all the species of Antarctic mosses he has seen only six in fruit, while in a few others "flowers" have been seen.

Antarctic mosses generally grow in small colonies in which a number of different species may be found together. In the midst of these clumps an occasional hepatic may be found, since the hepatics seldom grow isolated; doubtless this is the only habitat in which hepatics with delicate tissues could survive. Only 6 species of Antarctic hepatics are known, of which 4 occur in South Georgia. In some cases a small tundra of moss and lichen vegetation may be formed, and since these tundras are used as nesting places by gulls and skuas, while other birds build their nests largely of moss and lichen, one can understand the dispersal of the flora by this agency. While several fungi are known from subantarctic islands, such as Tristan da Cunha and Gough Island, the true Antarctic regions support the single species *Sclerotium antarcticum*, found on Danco Island growing among *Deschampsia antarctica*.

The predominant feature of the Antarctic vegetation is the number of lichens—not as species but as individuals. At the South Orkneys, the lichen vegetation is very rich. In winter, when almost everything is deep in snow, a few precipitous rock faces still show a relieving touch of colour among the monotonous white, due largely to various orange-coloured species of *Placodium* (*P. regale*, *P. elegans*, etc.); when the snow begins to melt in spring almost every rock shows a shaggy covering of *Usnea melaxantha*, which grows luxuriantly and fruits freely. Skottsberg mentions the frequency of *Placodium* and *Usnea* in the lands he visited; Turquet notes the colour given to the landscapes of Gerlache Strait and Graham Land by *Usnea* and *Lecidea*; Gain speaks of the almost continuous carpets of *Usnea* at Deception Island.

The multicellular algae of Antarctic seas are abundant as regards individuals, though the species are not very numerous. Only 24 species are recorded from the South Orkney collections, though careful exploration of the coasts of the Antarctic islands at seasons when they are free from ice would doubtless reveal many more species. The littoral region, between high and low water, proved poor both in individuals and species; calcareous species are the most abundant in this zone. The wearing and tearing action of the ice is not compatible with much algal growth in these shallow waters, and no doubt accounts for the absence of the southern kelp (*Macrocystis pyrifera*) from the true Antarctic regions. Most of the algae occur at greater depths; the two red algae *Plocamium coccineum* and *Acanthococcus spinuliger* were extraordinarily abundant in 10 fathoms, the brown alga *Desmarestia Rossii* was frequent in shallower water. Calcareous algae were abundant at 9—10 fathoms, and in places cover the rocks with a continuous incrustation. Our knowledge of Antarctic multicellular algae is practically confined to the Graham and Victoria Land regions. Some 40 species are known from the Antarctic seas, of which about 75 per cent. occur at Graham Land and about 40 per cent. at Victoria Land. Only one species of freshwater alga, other than unicellular and colonial algae, is so far known—the cosmopolitan *Prasiola crispa*, recorded from Graham Land and the South Orkneys; in the latter place it was found in summer and autumn in several small gulleys where a quantity of melting snow above assured a continual supply of moisture.

Unicellular algae naturally form the vast preponderance of the Antarctic vegetation. When the regions of ice are approached, between 50° and 60° S., the plankton changes its character; crustaceans, and in fact all animals, then become rare and give place to increasing numbers of Diatoms until, in the midst of the ice, the Diatoms occur in such prodigious quantities that five minutes' haul of the tow-net produces as much as a pint of gelatinous residue almost wholly diatomaceous, and such a net used about thrice daily becomes useless after about a week owing to the clogging of the apertures in the silk. The species are not very varied, but a large proportion of them bear spines and long arms, while simple forms are comparatively rare. Peridineae occur, but are rather rare. The phytoplankton on the whole seems to favour deep water; in the shallow water about the South Orkneys it was much scarcer. In winter the greater part is apparently frozen into the ice; the author failed to get any appreciable quantity from the water when he bored the floe for this purpose. The first-formed pancake ice is always yellow, and the lower layers of the floe as revealed in the spring upheaval are uniformly discoloured by a layer of diatomaceous ice.

Freshwater algae, though comparatively abundant, are not nearly so plentiful as in the north polar regions. See summary of report by Fritsch on the South Orkneys species below (III).

By far the greater part of our knowledge of the Antarctic flora is due to the expeditions of the last 10 years; several papers on recent collections remain to be published, and even then our botanical knowledge of the Antarctic will have many gaps. Among Antarctic lands from which no plants are known at present are Coats Land, Enderby and Kemp Lands, Wilkes Land, Edward Land, Charcot Land, and Alexander Land; but it is to be expected that their flora is very scanty since they are more or less covered with ice and little bare rock appears. All the known facts, however, point to a Fuegian origin of the Antarctic flora. Not only does an analysis of the distribution of the constituent elements indicate this, but the relative greater abundance of species in Graham Land and vicinity than in Victoria Land, as well as the absence of New Zealand forms, shows that the flora of the Antarctic is due to an emigration of species from Fuegian lands. Winds and birds must have done the work of giving Antarctica its present flora, *via* Graham Land from Fuegia, and thence it must have spread westward *via* the coasts to Victoria Land, but naturally only a small proportion of the species were carried so far. However, it is possible that by the same agencies a certain number of mosses and lichens may have reached Wilkes Land and Wilhelm Land from Kerguelen and Heard Island, while South Georgia and the South Sandwich group may have contributed to Coats Land and the coast eastward towards Enderby Land. The floras of all these subantarctic islands from the Falklands eastward to Kerguelen have been shown to be related to one another and to have strong Fuegian affinities;

and Cockayne has pointed out the relationship between the flora of Kerguelen and that of Macquairie Island. This close relationship to Fuegia exhibited by all these islands means that emigration of a species from any of these islands to Antarctica amounts to emigration from Fuegia by a somewhat circuitous route. No other lands are near enough to Antarctica to have affected its flora.

Taking into account our incomplete knowledge of the Antarctic flora, the total number of species occurring in Antarctica may seem large when all must have been brought by such chance agencies as wind and birds; yet the author believes that the existing species in Antarctic regions represent a small proportion of those that have reached there. The probability of seeds and spores reaching a location suitable for growth is small, and even then only specially favoured species could survive the adverse conditions of life with which they have to contend. The high proportion of endemic species among the mosses in particular is, of course, the outcome of this most specialised environment.

The northern element of the Antarctic flora may appear to present a difficulty in the way of the acceptance of this theory. Cardot found a large proportion of northern forms among the mosses of both Antarctic and subantarctic regions, and he suggests that the spores of mosses and lichens may be transported on the feet and plumage of those birds which wander between high northern and high southern latitudes. Wilson's petrel (*Oceanites oceanicus*), which breeds in the Arctic regions, was found during the northern winter off Coats Land; the northern tern (*Sterna macrura*) was found to wander almost from pole to pole; while other birds are known to range between Alaska and Fuegia. The author considers that though there is some degree of probability in Cardot's suggestion, it does not give an adequate explanation of the facts, and he believes a more satisfactory and simpler explanation is found in the idea that the species of mosses and lichens in question are either cosmopolitan, but have not been discovered in low latitudes, or that they are species which have spread from northern to southern regions, or *vice versâ*, by means of mountain ranges or bird and wind transport, but which have failed to prosper in low latitudes either by inability to become adapted to the physical conditions, or by stress of competition.

The author, though considering that the foregoing explanation seems to solve the problem of the origin of the Antarctic flora, proceeds to examine other solutions which have been put forward.

It has been suggested that the present flora represents the relics of a richer flora from preglacial days, which doubtless reached Antarctica by land connections with America and Australia. The existence of these land connections has been established by the work of various expeditions, yet it is doubtful if they explain the origin of the flora. In every part of the Antarctic regions proofs of a former great extension of glaciation have been found, and this at a date posterior to those late Mesozoic and early Tertiary land connections. For instance, Gerlache Strait was once filled with an immense glacier; Moose Island, 200 m. high, in Gerlache Strait shows indisputable signs of ice action on the top; at Borchgrevinck Nunatak, Graham Land, 66° S., the ice sheet was formerly at least 300 m. above its present level; the ice sheet of Wilhelm Land, now some 300 m. thick, was at one time over 400 m.; McMurdo Sound was probably once filled with a branch of the Ross Barrier, whose general surface was then over 300 m. above sea-level, in contrast to 45 m. to-day; and there are many other instances of this greater glaciation in the past. Under these conditions of glaciation little if any land can have been exposed, unless it was a mere mountain top or cliff side. Moreover, there are signs that after this period of maximum glaciation the land rose; signs of this emergence of the land have been found at several localities in Graham Land, while the raised beaches of Victoria Land have been attributed to such emergence, to the extent of about 40 m. Assuming that there was depression of the land during the extreme glacial period, perhaps due simply to the enormous superincumbent weight, the great majority of the low-lying places near the sea, including many small islands, which at present harbour the flora of Antarctica, must have been under water while all those more elevated places of to-day which now bear vegetation were enveloped in ice. The present loci for the scanty flora of Antarctica can only have become such when glaciation had for some time diminished; it is difficult to believe that any species, unless possibly a lichen or two, can be a survivor of an older Antarctic flora. At the period of severest glaciation the subantarctic islands were heavily glaciated, but probably not to such an extent as to exterminate any pre-existing flora, only greatly to diminish it, though there are indications that in South Georgia and Macquairie Island the flora was wiped out.

The author points out that it is probably in the ring of islands girding the Antarctic seas that the most fruitful botanical collections of future expeditions will be made, and indicates the likelihood that such collections may throw light on the questions of the origin of southern floras and former land connections. Reference is made to the interesting affinities of the flora of the New Zealand group of subantarctic islands; of the 194 species of flowering plants known from these islands (Snares, Aucklands, Campbell Island, Antipodes, and Macquairie Island), there is a New Zealand element of 133 species, an endemic one of 53, and a Fuegian-South-Georgian-Kerguelen element of 8 species unknown in New Zealand. The endemic element shows in some cases New Zealand affinities, in others none at all; the first part was doubtless derived from New Zealand in the remote past, the second represents the relics of some older preglacial flora. The Fuegian element has probably been introduced by wind and bird transport; while the fact that of the 88 genera of phanerogams in these islands no less than 56 have representatives in Fuegia obviously points to some most intimate link between the floras of these islands and that of Fuegia in the past—such a link could only have been made by land connection, and it is probably at the time of the last stages of the former wide northward extension of Antarctica that this deep-seated affinity between these floras must be dated. Possibly these land bridges were available as late as Eocene times; after they were no longer in existence, the floras of the various islands developed each along its own lines, and the endemic species were evolved, the only later additions being by wind and bird transport from Fuegia and from New Zealand.

The author concludes this extremely interesting and valuable paper by pointing out that the pole-encircling islands and the coasts of Antarctica are more likely to be well explored as the importance of the vast southern oceans begins to attract the attention it deserves, and when the day of record-breaking pole-hunts is over, as it soon must be now that Amundsen has won the race.

Some of the detailed botanical results given in the reports included in this volume are perhaps sufficiently indicated in the foregoing abridgement of Rudmose Brown's paper. In his report on Antarctic bacteriology, Pirie notes that some of the birds and seals contain bacteria, though some are sterile; the air collected at the crow's-nest, and the deep sea samples, were always sterile, but in most cases the surface water of the sea yielded bacteria. Denitrifying bacteria are very scarce, in contrast to warm seas where the nitrogen continually added to the water is largely eliminated by bacterial denitrification; this is held to explain the extraordinary abundance of individuals in the polar seas in spite of the relative poverty in species.

(III) In the collections made by Rudmose Brown at the South Orkneys, Fritsch has found 68 species, of which 5 are new; most are unicellular and colonial. In addition to the red snow common in polar and alpine regions, Fritsch describes a yellow snow, due to an association of 18 species of algae and 2 of fungi; most of the algae are green forms, belonging to Protococcales, but a few Diatoms occur. The yellow snow occurs in the warmest season, though even then, as stated above, the mean temperature is not above 0° C.; the colour is bright, the algae are on the surface or may extend into the snow to a depth of about 4 mm. and most of the algae include in their cell-contents a quantity of apparently solid fat in large refractive masses, the yellow pigment being probably included in the fat. The storage of fat may be regarded as an adaptation against the intense cold. Red snow has been recorded from other parts of the Antarctic regions (including Graham Land and Victoria Land) besides the South Orkneys. That of the latter is considerably poorer in species and individuals than the association causing yellow snow, but most of the algae seem to contain fat in many of their cells. The red colour appears to be due to *Chlamydomonas nivalis*; the author describes a new genus (*Scotiella*) with two species (*S. antarctica* and *S. polyptera*) and considers that Chodat's *Pteromonas nivalis*, found in the red snow of the Alps and in Norway, is a species of *Scotiella*. The whole of the algal flora has a plankton character, and the author suggests that this and other snow floras may have arisen by wind carriage of plankton forms to the snow surface. Very few reproductive stages were found even in the material collected at midsummer, and the author believes that many species only reproduce during very limited periods under specially favourable conditions; the rarity of Diatoms and infrequence of Desmids are notable features in the freshwater flora of the South Orkneys, where none of the new forms of Diatoms in the "Discovery" and "Nimrod" collections were found.

(IV) In his report on the lichens of the Swedish Antarctic Expedition, Darbishire adds to his descriptions of the species an interesting summary and discussion of the distribution of lichens in the Arctic and Antarctic regions generally. The Swedish Expedition brought back no fewer than 145 species, of which 33 are new. An analysis of the results of Antarctic Expeditions up to and including Charcot's (1905) shows that at present 105 lichens are known from the land which lies strictly within the Antarctic limits, and that of these 32 occur also on Subantarctic America, 25 in New Zealand, and 16 in South Georgia, showing a very close affinity between the Antarctic lichen flora on the one hand and the American and New Zealand flora on the other—the difference to the disadvantage of the latter being accounted for by the greater nearness of the Subantarctic American region to the extreme limit of the southern drifting pack-ice. The lichens of Subantarctic America and New Zealand are also very closely allied, for out of the 133 lichen species of the former flora, 113 are found in New Zealand, 32 in the Antarctic, and 31 in South Georgia, the latter being evidently, from the phytogeographical point of view, a half-way house on the road from Subantarctic America to the Antarctic area. Moreover, practically half of the Antarctic species occur also in the Arctic regions.

Of the 106 Antarctic lichens, 69 are crustose, 18 foliose, and 19 fruticose; of these the numbers found in Subantarctic America are respectively 16, 5, and 11. Of the 67 species found only in the true Antarctic area, 49 are crustose, 10 foliose, and 8 fruticose. The Subantarctic American flora includes 306 species, while 740 lichens have been enumerated from New Zealand; of the species common to the two regions, 50 per cent. are fruticose, 30 per cent. foliose, and only 20 per cent. crustose. The affinity of the lichen floras of Subantarctic America and New Zealand lies mainly in the fruticose lichens, which are the oldest and probably the least variable forms. The encrusting lichens are more variable, and have adapted themselves more readily to local conditions, thus giving rise to new species.

An interesting point arises from a comparison with northern lichen floras. The Arctic area has nearly 500 species, of which over 70 per cent. are found in Tyrol; hence the relation of Arctic to Alpine lichens is much greater than that of Subantarctic American to New Zealand species, indicating that the latter are further from the point of common origin.

The author raises the interesting question of the resistance to cold by lichens, and suggests some experiments which might be made on these plants in the very coldest regions. For instance, it would be of interest to determine the amount of water contained in the lichen thallus at different times and seasons, in what condition the lichens exist during the long winter, at what temperature assimilation begins, etc. It is of little use to try experiments on the plants in warmer climates, if we wish to ascertain how these lichens can live under the adverse conditions prevailing in the polar regions. Lichens are found everywhere on the outer limits of vegetation, and their chief ecological factor is their power to become quite dry and yet remain alive. No doubt it is this power which enables them to spread slowly but surely into the bleakest and most inhospitable regions. They are making their way towards the North and South Poles, and so far have been beaten in their race only by the perpetual covering of snow. There is little doubt that if bare rocks are found in the neighbourhood of the Poles themselves, lichens will be found growing there.

(V) In this paper, Skottsberg gives a general account of the botanical discoveries made by the German and Swedish expeditions in South Georgia. A large part of the island is covered by land ice, which is of alpine type—large glaciers extending down the valleys and reaching the sea in fiords. South Georgia has a short and very cool summer, with a mean temperature of about 4° C., frequent snowstorms, and a long winter of snow covering. The distribution of the vegetation is largely conditioned by (1) exposure, with resulting differences in the melting of the snow in different situations, (2) the prevailing winds. The grasses *Poa flabellata* and *Festuca erecta* give rise to a kind of moorland formation; the former forms pure patches over wide areas, few other species being able to grow between the individuals of this tussock grass, which is halophilous and restricted to the neighbourhood of the sea, and there is a sharp limit between this *Poa* association and the inland grass tundra which covers larger areas and forms the characteristic facies of the land vegetation. The marshes are characterised by a rush vegetation, dominated by *Rostkovia magellanica* (Juncaceae); the aquatic vegetation consists of mosses (*Philonotis*, etc.), besides *Montia lamprosperma*, *Callitriche antarctica*, and *Ranunculus biternatus*. On rock faces the vegetation consists chiefly of crustose lichens, while in rock clefts there occur various vascular plants (*Poa flabellata*, *Colobanthus subulatus*, *Hymenophyllum falklandicum*, etc.) and mosses. Mosses are abundant and of luxuriant growth, species of *Polytrichum* and *Dicranum* in particular often forming extensive tundra-like patches. As regards the vertical zonation of the vegetation, the upper limit of the grass tundra is important, though its height varies greatly (between 50 and 200 m.) according to exposure and other factors; none of the vascular plants show marked alpine distribution, though *Acaena tenera* and *Polystichum mohrioides* occur chiefly on the highest points of the island.

The subantarctic region is characterised by a chamaephyte climate, though this represents a quite different type from the chamaephyte climate of Greenland or Spitzbergen, and the chamaephytes are more dominant than in the Arctic region. The 15 phanerogams of South Georgia include 7 chamaephytes, 6 hemicryptophytes, 1 cryptophyte, and 1 therophyte, the percentages of the four "biological types" represented being therefore 47, 40, 7, 7. In discussing the origin of the flora, the author suggests that during the first of the two periods of glaciation distinguished by Andersson, South Georgia was almost entirely covered by ice; the only parts free from ice were some nunataks where a sparse tundra might have existed, and small islands near the coast which were probably covered by a tundra of mosses and lichens. Vascular plants were doubtless absent during the first glacial period, and the existing flora is regarded as of later, inter- and post-glacial, origin. Since no land connection has existed between South Georgia and other land-masses in post-tertiary times, the seeds of the few higher plants found in the island must have been carried from Fuegia of the Falkland Islands—all these plants occur in the Magellan region. Among the mosses, however, there are several endemic types, belonging to the pre-glacial flora and including some peculiar forms like the genus *Skottsbergia*.

(VI) The same author here discusses the vegetation of Graham Land, with some data regarding the climatic conditions. The mean temperature on Snow Hill Island (64° 22′ S.) during the warmest months (December to February) in 1902—3 was 2·14° C.; the soil temperature for January at a depth of 30 cm. was never less than 0° C., but in the uppermost layer, saturated with melting snow, and in the moss patches, the surface of the soil was only thawed for a few hours about midday. The best sites for plant growth are usually found on small islands and on the coast, where the surface is kept clear of snow by the high winds; the vegetation occurs chiefly on the dioritic rocks forming the main chain and on the outcrops of cretaceous sandstone and the basaltic lavas and tuffs covering the latter. The basalt blocks are chiefly colonised by crustose lichens; the basalt dykes bear a richer lichen flora, including foliose and fruticose species; while the sandstone forms an unsuitable lichen substratum owing to its looseness and liability to erosion through melting ice and snow.

The following plant communities are distinguished in the vegetation of the South Shetland Islands, the western coast of the mainland with its fringing islands, and the tableland of the east coast. (1) A moss tundra consisting of *Pogonatum* (*P. alpinum* and two forms of this species) or of *Polytrichum* (*P. strictum* and *P. alpestre*), on more or less level and not too stony places. (2) More or less pure mats of *Brachythecium antarcticum*, developed locally on favourably exposed slopes with abundant water supply. (3) Mats dominated by *Andreaea* and *Grimmia* on stony substrata and otherwise bare rocks. (4) A variegated community of rock-inhabiting lichens, dominated by crustose forms, of which *Placodium* spp. give colour to the landscape, while the foliose and fruticose forms are chiefly species of *Gyrophora* and *Neuropogon*.

From both the physiognomic and systematic points of view the Antarctic flora strongly resembles that covering the wind-exposed parts of South Georgia. The moss flora of Antarctica presents the greatest affinities with South Georgia and the Magellan region. There occur in Graham Land and Victoria Land, which are separated by completely glaciated territory, three endemic mosses, among them *Sarconeuron glaciale* representing the only endemic genus. This fact, as well as the high percentage (45) of endemic moss species found in Antarctica, leads the author to conclude that the present flora of the south polar continent represents the last relic of the Antarctic plant world, probably with the addition of species which migrated later; but since the Antarctic region was once much more fully glaciated than now, and at the time of maximum glaciation ice-free places probably did not exist, he agrees with Cardot and Brown that the present flora is of post-glacial age, with the reservation that this view does not fully clear up the present relationships of the Antarctic flora.