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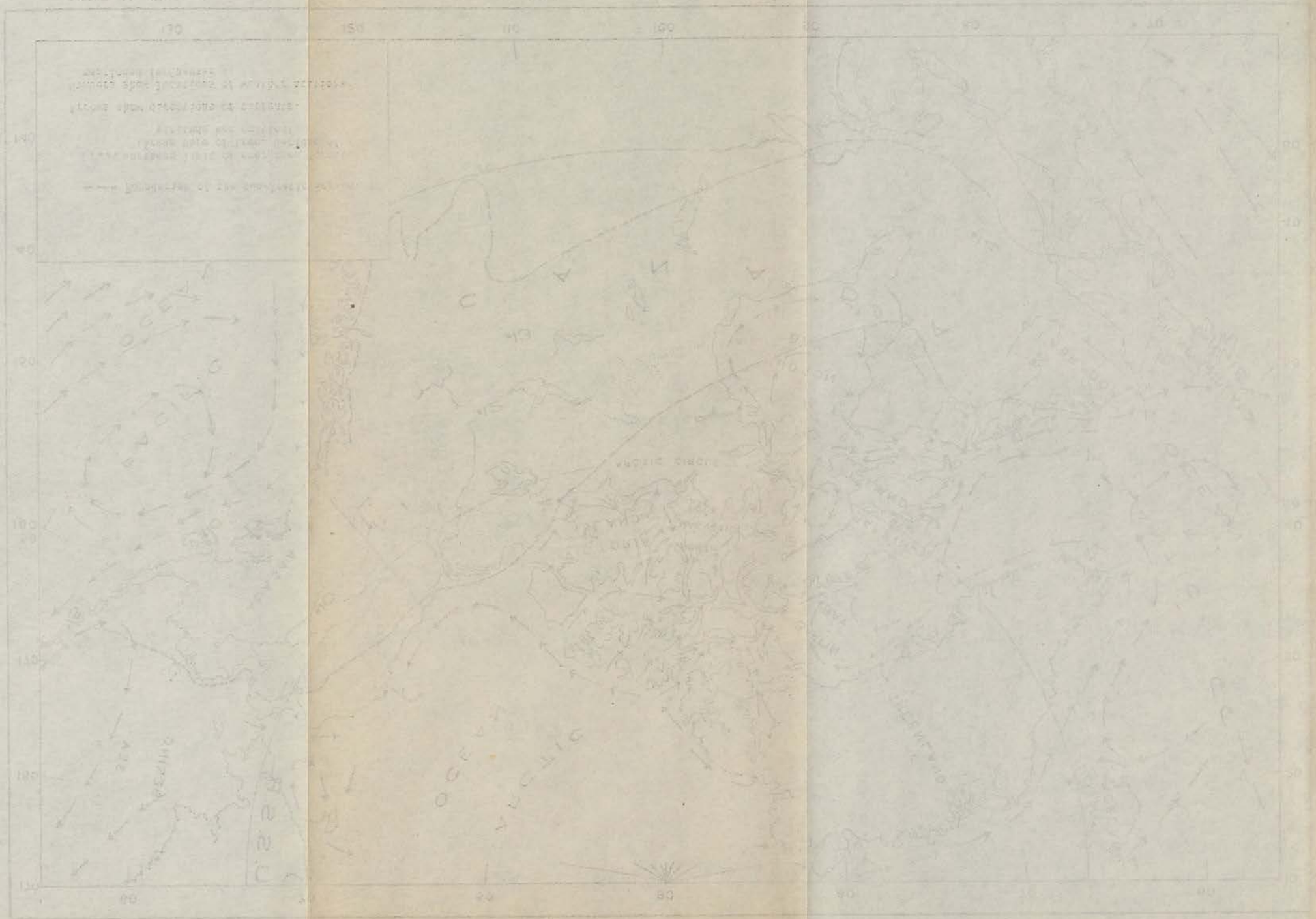
WAR DEPARTMENT

TECHNICAL MANUAL

ARCTIC MANUAL

17 January, 1944



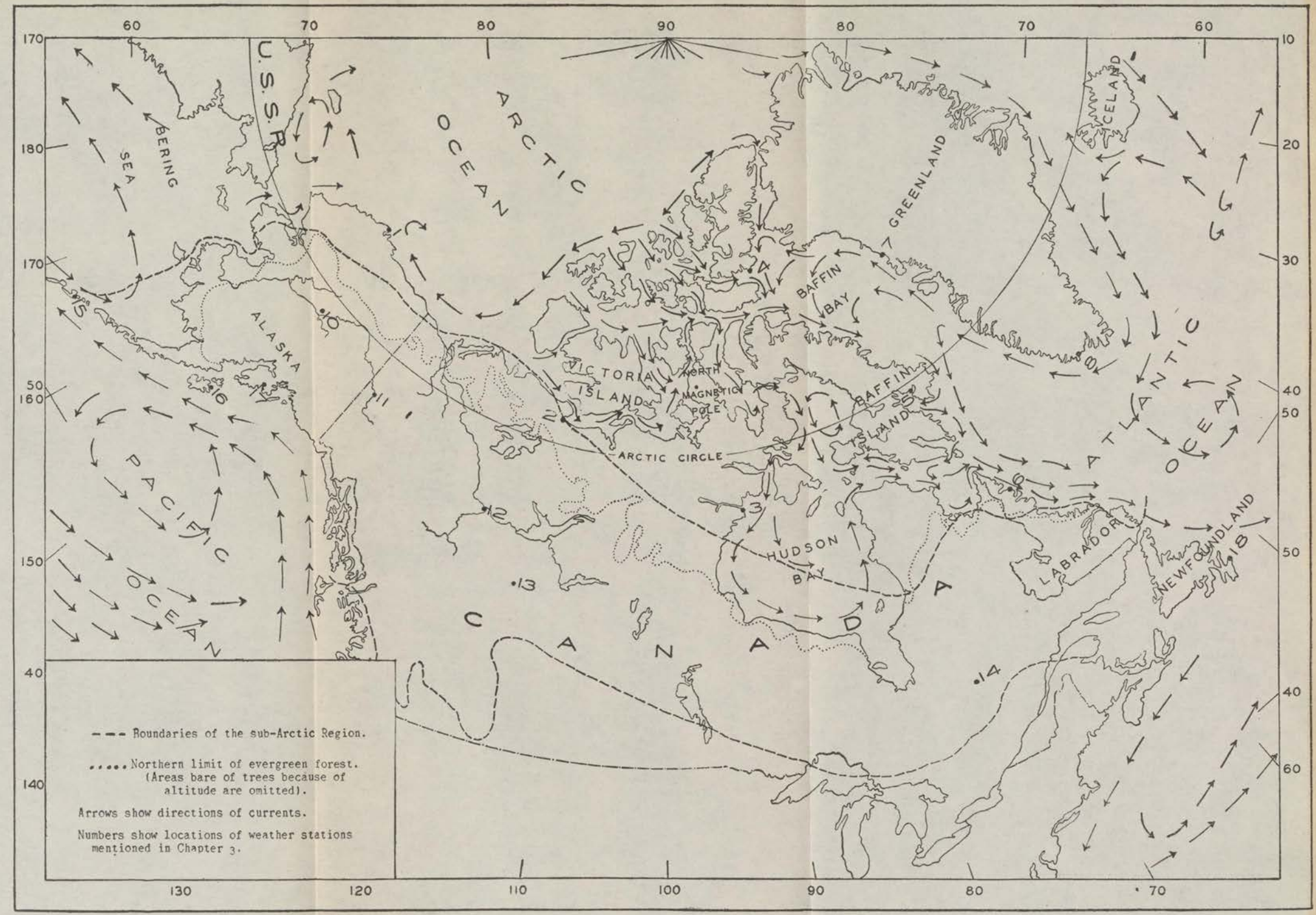


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FIGURE 1.—American Arctic and sub-Arctic regions.

FOREWORD

The viewpoint adopted in this manual is primarily that of Army personnel who will have to travel in the Arctic and live away from permanent posts. Although this group is in the minority, its problems are so much greater than those of men stationed at established posts that this emphasis seems proper. However, nearly all of part one and chapters 1, 4, and 7 of part two contain much information that is valuable to anyone stationed anywhere within the Arctic and sub-Arctic. Because of space limitations, this manual deals particularly with Arctic North America and omits discussion of Arctic Europe and Asia.

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TECHNICAL MANUAL
No. 1–240

WAR DEPARTMENT,
WASHINGTON 25, D. C., 17 January, 1944.

ARCTIC MANUAL

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PART ONE

CHARACTER OF THE ARCTIC COUNTRY

CHAPTER 1

TOPOGRAPHY, DRAINAGE, AND GLACIERS

SECTION I

GENERAL FEATURES OF THE ARCTIC AND SUB-ARCTIC REGIONS

1. Definition of Arctic and sub-Arctic regions.—*a. General.*—The far north is commonly divided into an Arctic region and a sub-

Arctic region, not by the Arctic Circle (lat. 66°33′ N) but by climatic differences.

b. Arctic region.—The Arctic region is defined on a temperature basis. It is the region in which the mean temperature for the warmest summer month is less than 50° F. (fig. 1). In many places this temperature boundary is located only very roughly, but as far as is known it coincides fairly well with the northern limit of the forest. The Arctic region includes the northern coasts of Alaska and Canada, the Canadian Arctic Archipelago, much of Labrador, and all of Greenland—though south coastal Greenland is transitional into the sub-Arctic.

c. Sub-Arctic region.—The sub-Arctic region is a belt of variable width south of the Arctic region. Within it the mean temperature of the warmest month is higher than 50° F. Newfoundland, southwestern Labrador, most of Alaska, and most of interior Canada are sub-Arctic.

2. Forests.—Forests are characteristic of the sub-Arctic region, though there are a few areas that are treeless. In the Arctic region there are no forests. Shrub willows, however, are common, and in some places they grow in clumps 7 to 8 feet high.

3. Tundra.—One of the distinguishing features of the Arctic region is the vast stretches of treeless land covered with tundra. The tundra is a variable cover of grasses, lichens, and shrubs. Unlike prairie country which it generally resembles, tundra to a large extent is poorly drained and marshy. "Niggerheads" (hummocks of vegetation) abound in the marshy areas and the soil everywhere is poor.

4. Frozen ground.—Most of the tundra and parts of the forested sub-Arctic region are permanently frozen a few feet beneath the surface. During the summer the ground thaws to a depth of a foot or more, but because of the underlying frozen ground, water cannot sink below the thawed layer. Consequently the ground is kept moist in many places. Frozen ground is thus responsible for the marshy charatcter of the tundra and for the poor drainage of large parts of the far north. Also, it is in part responsible for the many lakes.

5. Drainage.—*a. General.*—The Yukon and Mackenzie rivers, draining the far north, are among the largest rivers in the world. Lesser streams are numerous but many of them are quite small and wander aimlessly. This is particularly true of the areas underlain by permanently frozen ground. Following a very small stream, therefore, may lead one nowhere at all.

b. Floods.—Because drainage is generally poor and because permanently frozen ground prevents moisture from seeping far beneath the surface, both rain and water from melting snow or ice are likely

to swell streams rapidly, causing frequent floods. Damming of a partly thawed stream or river by ice and debris almost invariably causes an already swollen stream to overflow its banks and flood a large area on either side. Therefore spring with its melting snows and break-up of rivers and lakes is generally the time when floods are most common.

6. Lakes.—*a. General.*—In the far north there are lakes by the tens of thousands. Most of them are the direct result of the poor drainage induced by the presence of permanently frozen ground. In areas where bedrock is at or near the surface, the major cause of the lake basins was the scooping action of the former great glaciers of the Ice Age that plowed their way across many far northern regions.

b. Landing sites.—The numerous lakes are in large part responsible for the development of transportation and communication in the far north. They afford favorable emergency landing sites and bases for pontoon-equipped planes in the summer and for ski-equipped planes in the winter. For several weeks during the spring break-up and autumn freeze, lake and river landings are hazardous.

7. Glaciers.—*a. General.*—There are two basic kinds of glaciers—*ice caps* and *valley glaciers.*

b. Ice caps.—As their name implies, ice caps cover large areas of land without regard to the underlying topography. An outstanding example is the Greenland ice cap, the largest in the Northern Hemisphere. Much smaller ice caps cover parts of Baffin Island, Bylot Island, and Ellesmere Island, in the eastern part of the Canadian Arctic. The western part of the Canadian Arctic is free of them, with the possible exception of Meighen Island in the far northern section.

c. Valley glaciers.—These are essentially rivers of ice confined to valleys. A valley glacier may be connected with an ice cap much as a stream is connected with a lake, or it may be an independent unit. Valley glaciers occur wherever there are ice caps. They are also found in the mountains of Alaska and the Yukon. All glaciers move with a slow-flowing motion, some exceedingly slow and others at rates of several tens of feet a day.

d. Crevasses.—The brittle surfaces of both ice caps and valley glaciers are characterized by great gaping cracks called *crevasses.* They are commonly many tens of feet in depth, and are caused by the slow-flowing movement of the ice far beneath. Generally speaking, the steeper the slope and the more irregular the bed of the glacier, the greater the profusion of crevasses. They are the more dangerous because often covered with snow. A free fall into a crevasse is usually fatal (par. 164).

Section II

NATURAL SUBDIVISIONS OF THE ARCTIC

8. Alaska.—*a. General.*—The greater part of Alaska is not Arctic but sub-Arctic. The truly Arctic part is more or less confined to a broad zone that includes the coast from the Seward Peninsula to Point Barrow, and eastward to the International Boundary at Demarcation Point. The Brooks Range is part of this zone, as is Seward Peninsula, whose tip, Cape Prince of Wales, lies only 57 miles from Siberia on the opposite side of the shallow Bering Strait.

b. Coastal region.—The Arctic coast of Alaska is generally low and flat except for parts of Seward Peninsula and the vicinity of Cape Lisburne. For example, Cape Prince of Wales has an altitude of 2,300 feet, while the altitude of Cape Lisburne is 850 feet. Coal occurs in some abundance at the latter place. In the vicinity of Point Barrow, the low coast reaches its greatest width. Here there is a wide triangular plateau, with the tip of the triangle near Barrow on the north and the base abutting against the Brooks Range on the south. The region near the coast is supposed to have considerable oil reserves. Along the entire coast from Seward Peninsula to Demarcation Point, harbors are few. In many places, too, the bottom is gently shelving so that large boats have to stand some distance out from shore.

c. Brooks Range.—The Brooks Range extends roughly east-west in the northern Arctic part of Alaska. Actually it is not a single range but is composed of a series of ranges, some of which reach altitudes of more than 8,000 feet. Both the western and eastern ends of the range approach close to the coast, the western end being near Cape Lisburne and the eastern end near Demarcation Point. The middle section, however, lies farther inland, being about 125 miles south of Point Barrow. The Brooks Range is very imperfectly known, but should be counted among the great mountain ranges of North America.

9. Canada.—*a. General.*—Arctic Canada includes the Canadian Arctic Archipelago and most of the north coast of Canada. Both regions as a unit are commonly divided into the western Arctic and the eastern Arctic. The boundary between the two is rather indefinite but is generally regarded as lying along the axis of Boothia Peninsula and Somerset Island. The basis of distinction between the western Arctic and the eastern Arctic is twofold; first, the regions themselves differ topographically, and second, they usually are ap-

proached from different directions and there is almost no travel between them.

b. Western Arctic.—(1) The western Canadian Arctic comprises the mainland coast from Demarcation Point to Boothia Peninsula, and the islands to the north. The largest of these is Victoria Island, the second largest in the Archipelago and about the size of Great Britain. Other important islands are Banks Island and Melville Island.

(2) Most of the western Canadian Arctic is low-lying. There are few mountains and, as a result, there are few glaciers. In a few localities, however, there are perennial snowbanks. The mainland is rocky in many places, except around the mouth of the Mackenzie River, and most of the rock is granite or gneiss. On the other hand, the islands consist chiefly of sedimentary rocks, widely concealed beneath tundra vegetation, mud, and sand.

(3) Boat travel to Canada's western Arctic is chiefly via the Mackenzie River, and to a much lesser extent via the Arctic coast of Alaska. Commercial flying is well developed, the Mackenzie Valley being the major air route. A branch route goes to Coppermine, on Coronation Gulf just south of Victoria Island. Within the western Canadian Arctic there is active communication by boat and sledge as far east as Cambridge Bay at the southeast end of Victoria Island, and much less frequent communication as far east as Boothia Peninsula.

c. Eastern Arctic.—(1) The eastern Canadian Arctic comprises most of the mainland coast from Boothia Peninsula to Labrador, and the islands to the north. Of these, Baffin Island, about 2½ times as large as Great Britain, is the largest in the Canadian Arctic, and Ellesmere Island is the third largest.

(2) In contrast with the western Canadian Arctic, the eastern Canadian Arctic is generally high and in places very rugged. The east coast of Baffin Island and the eastern and northern parts of Ellesmere Island have mountains the maximum altitudes of which approximate 8,000 feet on Baffin Island and 11,000 feet on Ellesmere Island. Both islands have numerous valley glaciers in their mountainous parts, and both have small ice caps in addition. Glaciers are also present on Bylot Island, Devon Island, and Axel Heiberg Island. Well developed fiords penetrate the coasts of most of these islands, especially Baffin Island and Ellesmere Island. Bare rock surfaces are more common in Canada's eastern Arctic, particularly in the mountainous areas, than in the west, yet low, tundra-covered regions also occur. On the mainland, for instance, the entire west coast of Hudson Bay is low, flat, and in most places characterized by tundra.

(3) Travel to Canada's eastern Arctic is by railroad to Churchill on the west side of Hudson Bay, by boat past the Labrador coast, or by

airplane. Travel within the region itself extends as far west as Fort Ross, a Hudson's Bay Company post on Bellot Strait. This strait divides Boothia Peninsula from Somerset Island, and is the chief point of contact with the western Canadian Arctic.

10. Northeastern Labrador.—Although Labrador, which is under the jurisdiction of Newfoundland, lies entirely south of the Arctic Circle, its northeastern part is truly Arctic. This part of Labrador, like much of Canada's eastern Arctic, is mountainous, particularly in the northern part where the Torngat Mountains reach a maximum altitude of just over 5,000 feet. Fiords penetrate the coast in many places in the northern half; in the southern half there are only a few fiords, but one, Hamilton Inlet, is several times as large as any other in Labrador. No trees grow in the northernmost part of Labrador, but the southern part is forested. Practically all of Labrador is formed of granite or gneiss.

11. Greenland.—*a. General.*—Greenland is not only the largest of the Arctic lands, but also the largest island in the world. More than three-fourths of it is occupied by an ice cap that covers all of the interior and leaves only a relatively narrow ice-free strip along the coasts.

b. Ice cap.—Next to the Antartic ice cap, the Greenland ice cap is the largest in the world. It is roughly dome-shaped, reaches a maximum altitude of about 10,000 feet, and is constantly but very slowly flowing outward. Not much is known concerning its thickness except that in some places it is probably 6,000 to 7,000 feet thick. Near the margin of the ice cap there are numerous crevassed areas; these make travel very dangerous and in some localities almost impossible. Crevasses have been reported from a few places in the interior also. Many valley glaciers extend outward from the ice cap to the coast. These are the outlets through which the slowly flowing ice is discharged from the ice cap into the sea.

c. Coastal region.—(1) Most of the Greenland coast extends out beyond the ice cap, although there are a few stretches, especially in northwest and northeast Greenland, where the ice cap descends directly to the sea. Much of the coastal zone is mountainous. On the east coast individual peaks rise to altitudes of 10,000 to 12,000 feet. Watkins (Gunnbjorns) Mountain (lat. 68°55′, long. 29°50′) with an altitude of 12,139 feet is the highest known, but there may be others not yet measured that are even higher. On the other coasts maximum altitudes are generally less than 6,000 feet. Here and there isolated peaks (called *nunataks*), surrounded by ice, project through the margin of the ice cap.

(2) Fiords cut deeply into the Greenland coast. Many of them

have glaciers at their heads. These glaciers discharge large icebergs which drift out to sea and become dangerous to navigation. Many of the fiords are magnificent. The East Greenland fiord system is one of the most imposing in the world. Scoresby Sound, which extends inland more than 150 miles, is the longest fiord in the world, and Franz Josef Fiord with its precipitous varicolored walls exceeds the splendor of the Grand Canyon.

Section III

NATURAL SUBDIVISIONS OF SUB-ARCTIC REGION

12. Alaska.—*a. General.*—The sub-Arctic part of Alaska, which comprises most of the Territory, can be divided into two main regions—the sub-Arctic coastal region and the interior region. These differ from each other in topography (discussed in the following paragraphs) and in climate (ch. 3).

b. Sub-Arctic coastal region.—(1) The sub-Arctic coastal region comprises the territory south of the Seward Peninsula, the Aleutian Islands, the Alaska Peninsula, and the south coast of Alaska.

(2) The region south of the Seward Peninsula is generally low-lying. It includes the broad deltas and alluvial plains of the Yukon and Kuskokwim Rivers.

(3) The Aleutian Islands and their continuation in the Komandorski Islands form an almost perfect arc, concave to the north, stretching across the northern Pacific Ocean to Kamchatka. Formed of volcanic rocks, the islands are generally rugged and mountainous. Altitudes of 4,000 to 5,000 feet are common, and several mountains are considerably higher. Glaciers radiate from many of the peaks, most of which are volcanic cones. Some of the volcanoes are still active.

(4) The Alaska Peninsula is a mainland continuation of the Aleutian Islands and is much like the island arc in general character. Altitudes, however, are commonly greater. For instance, Iliamna Volcano and some other peaks are more than 10,000 feet high.

(5) The south coast of Alaska is composed of rocks different from those of the Aleutian arc and has no recent volcanoes. However, it is even more mountainous. The Kenai Mountains rise to more than 5,000 feet, and Mt. Marcus Baker in the Chugach Mountains farther inland, is 13,250 feet in altitude. Farther southeast, the St. Elias

Range boasts Mt. Logan (in neighboring Yukon Territory) and Mt. St. Elias, with altitudes of 19,850 and 18,008 feet, respectively. This region contains large glaciers, including the great Malaspina and Hubbard glaciers.

c. Interior region.—The mountains of the southern coastal region of Alaska continue into the interior, forming an arc known as the Alaska Range. Mt. McKinley, the crowning summit of this range, has an altitude of 20,300 feet, and is thus the loftiest peak in North America. Farther north the broad valley of the Yukon River is the major feature of the interior region. The river itself, with a length of about 2,000 miles, is one of the major waterways of the world. From early June to late September it is navigable into Yukon Territory by steamboats of Mississippi type. The valley is fertile in many places and is the center of population.

13. Canada.—*a. General.*—A very large part of the Canadian mainland is sub-Arctic. Even the north coast is, in a few places, sub-Arctic rather than Arctic. The principal natural regions are the western mountains, and the interior lowland, which comprises the Mackenzie River Valley and the broad expanse of generally flat country that characterizes the rest of the sub-Arctic mainland.

b. Western mountains.—The little known Mackenzie Mountains and some other ranges of northwestern Canada, together described as the western mountains, represent the northward continuation of the Rocky Mountains of the United States and southern Canada. Altitudes of 7,000 to 8,000 feet are common, and some of the peaks carry snow the year around.

c. Interior lowland.—(1) The Mackenzie River, like the Yukon, is one of the great rivers of the world. From early July to mid-September it is navigable for steamboats from the Arctic Ocean to Fort Smith on the Slave River south of Great Slave Lake, a distance of 1,300 miles. In many places the Mackenzie Valley is well forested and fertile. In the vicinity of Fort Norman it is rich in oil. Notable gold and other mining developments are located near Great Slave Lake and to a lesser extent near Lake Athabaska. Gigantic Great Bear Lake, noted for its radium ore, is separated from the Mackenzie Valley proper by a short and low range of mountains. Other smaller lakes are scattered throughout the region of the Mackenzie Valley.

(2) East of the Mackenzie Valley lies a broad, comparatively flat plain the surface of which has a maximum altitude of about 1,400 feet and slopes gently downward to sea level around Hudson Bay. The northeastern part is treeless and truly Arctic. The sub-Arctic remainder is forested and forms a broad basin around James Bay, the southern extension of Hudson Bay. Most of this part of the interior

lowland is underlain by granite, gneiss, and other similar rocks. Some of these rocks are so highly mineralized that they have produced several of the richest mining camps in the world. Countless lakes constitute another notable feature of the region.

14. Southwestern Labrador.—Unlike much of the northeastern (Arctic) part of Labrador, the southwestern sub-Arctic part is well forested. It is also less mountainous, and gradually merges with the sub-Arctic interior lowland of Canada.

15. Newfoundland.—The island of Newfoundland, which is under the direct jurisdiction of Great Britain, has a very irregular shoreline similar to that of Labrador. However, the coast itself is generally much less abrupt, and the island as a whole is low-lying in comparison with Labrador. The most marked topographic feature, aside from the irregular fiordlike shoreline, is the Long Range, which extends northeast-southwest along the west coast, and reaches altitudes of 2,000 to 3,000 feet.

CHAPTER 2

NORTHERN SEAS

SECTION I

AREA RELATIONS

16. General.—The principal northern seas of the Western Hemisphere are the Arctic Ocean, Greenland Sea, Bering Sea, Baffin Bay, and Hudson Bay. The first three also are common to the Eastern Hemisphere. Each of these seas occupies a distinct basin or otherwise easily delimited region. Each is essentially Arctic.

17. Arctic Ocean.—The Arctic Ocean is by far the largest of the northern seas. Parts of it are given local names such as the Beaufort Sea on the north coast of Alaska and the East Siberian Sea north of Siberia. The Arctic Ocean fills the Arctic basin, which in turn occupies the central part of the polar region. In this respect the Arctic differs markedly from the Antarctic, the polar region of which is a high continent rather than a basin. Surrounding the Arctic basin is a shallow continental shelf over which the ocean extends. This shelf lies at a depth of several hundred feet and is of varying width. Off Siberia, abreast of the New Siberian Islands, it is 435 miles wide, but off Point Barrow its width is only 60 miles. Most of the Canadian Arctic islands lie on this shelf. From its edge an abrupt slope leads down to depths of several thousand feet. The greatest known depth in the Arctic Ocean is nearly 18,000 feet.

18. Greenland Sea.—North of Iceland and between east Greenland and Spitsbergen lies the Greenland Sea. Although its surface waters have a broad connection with the Arctic Ocean, it occupies a distinct basin, and for this reason is regarded as a separate body of water. Its maximum depth is almost 16,000 feet.

19. Bering Sea.—Bering Sea lies north of the Aleutian Islands and separates Alaska from Siberia. It is divided into two parts, a southwestern basin with depths as great as 13,000 feet, and a northeastern shelf with an average depth of only about 330 feet. Bering Sea connects with the Arctic Ocean through the Bering Strait, which is both narrow (57 miles wide) and shallow (not much more than 150 feet at the narrowest part).

20. Baffin Bay.—Baffin Bay separates Baffin Island on the west from Greenland on the east. It has an independent basin more than 6,000 feet deep. On the north and west, Baffin Bay connects with the Arctic Ocean through various channels of the Canadian Arctic Archipelago, and on the south it joins the Atlantic Ocean through Davis Strait.

21. Hudson Bay.—Hudson Bay is strictly a shallow inland sea. It reaches the North Atlantic Ocean through Hudson Strait, a lane 500 miles long that separates Baffin Island from Labrador. Foxe Basin, a northern continuation of Hudson Bay, connects through the narrow Fury and Hecla Strait with the channels of the Canadian Arctic Archipelago. Depths in Hudson Bay are generally less than 650 feet. The bottom is gently shelving so that the water is shallow for some distance off shore. As a result, retreating tides uncover extensive mud flats.

Section II

ICE OF NORTHERN SEAS

22. General.—There are two principal varieties of sea ice—a kind that is constantly moving (pack ice) and a generally immobile kind (fast ice). Both types consist of frozen sea water and are therefore salt to begin with. However, they eventually lose their salt content and become fresh. They are *not* icebergs, which are always fresh and are commonly more massive than sea ice.

23. Fast ice.—Fast ice remains immobile except when it breaks up during the summer. It forms in bays and straits free of strong currents that otherwise would keep the ice in motion. Generally, fast ice affords better sledging routes and emergency landing places than does pack ice.

24. Pack ice.—*a.* One of the outstanding features of Arctic seas is the ever-moving pack ice. This includes not only individual ice floes (cakes of ice a few feet to a few hundred yards in diameter) but

also great ice fields the limits of which cannot be seen from a high masthead. No matter how extensive, the pack ice is always moving under the influence of currents and winds. Sooner or later during their movement, fields and floes crack apart and develop narrow *lanes* and broad *leads* of open water, even in the middle of winter. However, winter leads soon freeze over, forming smooth patches of ice. Sometimes instead of being pulled apart, the fields and floes are shoved together by currents and winds, with a force more than strong enough to crush the strongest ship. To those who have experienced it, the slow grinding and crushing of floes being pushed and piled up over one another is an experience never forgotten.

b. In thickness, pack ice varies from a normal of 7 to 12 feet to as much as 200 feet. Thicknesses greater than 12 feet, however, are almost always the result of telescoping and piling up of floes. The pack ice surface may be smooth enough to make an ideal sledging route or even an emergency landing site for a plane. Commonly such places are leads that have frozen over. On the other hand the surface may be so jagged that sledge travel and the landing of planes are impossible.

25. Icebergs.—Glaciers that end in tidewater have great terminal cliffs from which large blocks of ice are constantly breaking off. These blocks float around and become part of the Arctic pack ice. They are generally much thicker than floes of sea ice, and consequently they rise much higher above the water. Large icebergs are a magnificent sight. However, if you are in a small boat, keep away from them. They frequently roll sideways or turn upside down without any warning, creating waves that can easily swamp small craft. Because they are derived from large glaciers, imposing icebergs are more common in the large glacier-occupied fiords of Greenland than in any other place in the Northern Hemisphere.

Section III

CURRENTS

26. General.—The climate of various parts of the Arctic is strongly influenced by currents in the sea (par. 40). An example is the cold current flowing from the north past the coast of Labrador, for it keeps the Labrador coast cold in comparison with other coastal areas in the same latitude. Also, by controlling the direction of movement of sea ice, currents influence the navigability of certain waters. For instance, the current that flows southward along the east coast of

Greenland brings ice that in some years blocks that coast. Currents also leave driftwood along some Arctic shores, driftwood that has saved many lives in the past and will probably save more in the future. However, some stretches of coast have already been depleted of their precious supply.

27. Arctic Ocean, Greenland Sea, and Baffin Bay.—*a.* Most of the surface water in the Arctic Ocean drifts from Alaska and Siberia across the region of the North Pole toward Greenland and Spitsbergen. Some of this water flows eastward through the Canadian Archipelago. Then, joining a small part of the transpolar drift, it flows southward along the west side of Baffin Bay and Davis Strait and eventually feeds the Laborador Current. The bulk of the transpolar drift, however, turns southward along the eastern coasts of Greenland and Spitsbergen. As a result, pack ice brought from the ice-covered Arctic Ocean slowly drifts past these coasts during a large part of the year. Part of the East Greenland Current rounds the southern tip of Greenland and flows northward along the east side of Davis Strait and Baffin Bay. At the north end of this bay it swings west and south and joins a southward directed current in its progress down the west side of Baffin Bay and Davis Strait.

b. An exception to the general transpolar drift from Alaska and Siberia toward Greenland and Spitsbergen is the current in the Beaufort Sea, which lies west of the Canadian Arctic Archipelago and washes the north coast of Alaska. This current probably flows southward near the western side of the Archipelago and then westward along the Alaskan coast as far as Point Barrow. Here it meets a northeast current. As a result an offshore drift is frequent at this place.

c. Some expeditions in ships or on floating ice have allowed themselves to drift along the routes of various currents. The drift of the ice-locked ship *Fram* across the polar basin in 1893–96 and the ice floe voyage of the Soviet Papanin group, which began at the North Pole in 1937, are memorable illustrations.

28. Bering Sea.—In most parts of the Bering Sea the currents are greatly influenced by tides and winds, but there is a general counterclockwise rotary drift. Thus along much of the northern side of the Aleutian chain the current commonly moves east, and along the west coast of Alaska it commonly moves north. The northward trend is particularly marked on the eastern side of Bering Strait. On the west side of the strait the trend is southward out of the Arctic Ocean.

29. Hudson Bay.—Hudson Bay has a current similar to that of the Bering Sea in that it has a counterclockwise rotation. Moving southward along the west side of the bay past Chesterfield Inlet and

Churchill, it swings eastward near the south end of the bay and then northward along its eastern shore to Hudson Strait. Here it turns eastward and follows the south side of the strait to the ocean, where it joins the Laborador Current.

Section IV

TIDES

30. General.—The tides in the Arctic seas vary widely from place to place. Tide ranges are almost always smaller along straight parts of a coast than at the heads of funnel-shaped bays along the same coast. Frobisher Bay, in the southeastern part of Baffin Island, has a funnel shape and its tide range is 20 to 35 feet. Yet at Clyde Inlet on an open stretch of the northeast coast of the same island, the tide range is only 2 to 3 feet. In most parts of the Arctic small tides are more common than those of greater range. However, winds are an important influence. On the north coast of Alaska and Canada, winds sometimes raise or lower the normal tide by 2 to 3 feet, depending upon the direction from which they are blowing.

31. Arctic Ocean.—In the American and Canadian sectors of the Arctic Ocean tidal ranges are generally slight. Thus along most of the north coast of Alaska the range is less than 1½ feet. Also tides are small in the channels leading from the Arctic Ocean into the Canadian Arctic Archipelago. In Coronation Gulf, for example, the normal tide is only about 8 inches. At Winter Harbour, Melville Island, the range varies between 1 foot and 4½ feet.

32. Bering Sea.—Tides are commonly small in the Bering Sea, except near the heads of funnel-shaped bays such as Bristol Bay, where the range may amount to as much as 18 feet. Around the Pribilof Islands, St. Matthew Island, and St. Lawrence Island it is usually less than 4 feet. In the vicinity of Bering Strait it is too small to be of practical importance.

33. Baffin Bay.—Baffin Bay has a highly irregular coast with many funnel-shaped fiords. As a result its tides vary considerably from place to place. At Craig Harbour, in the southeastern part of Ellesmere Island, the tide range is 5 to 6 feet. At Bylot Island off the northeastern coast of Baffin Island it is 12 to 15 feet, but at Pond Inlet immediately to the south it is only 2 feet—about the same as at Clyde

River in eastern Baffin Island. Although Pangnirtung, somewhat farther south, has a moderate range of 6 to 8 feet, Frobisher Bay, a large funnel-shaped fiord on the southeastern part of the same island, has a range of 35 to 45 feet.

34. Hudson Bay.—*a*. On both shores of Hudson Strait the tides are uniformly large. From east to west along the north shore, typical ranges are: Lake Harbour, 30 to 36 feet; Chorkbak Inlet, 20 to 25 feet; Ashe Inlet, maximum 30 feet. However, Dorset at the western end has a range of only 6 to 8 feet. From east to west along the south shore, ranges are: Port Burwell, 17 to 21 feet; Chimo, maximum 25 feet; other places in Ungava Bay, maximum 45 feet; Stupart's Bay, 18 to 24 feet; Sugluk, 11 to 14 feet.

b. Within Hudson Bay itself tides are less extreme. At Chesterfield and at Churchill, on the west coast, the tide is only 6 to 8 feet; farther south it is 11 to 15 feet. At the south end of the Bay it is about 5 feet. On the east coast, at Richmond Gulf, the tide is 3 to 6 feet, about the same as at Port Harrison farther north.

CHAPTER 3

CLIMATE AND WEATHER

SECTION I

GENERAL CHARACTER OF ARCTIC AND SUB-ARCTIC CLIMATE AND WEATHER

35. Delimitation of Arctic climates.—*a. Basis.*—The Arctic has the lowest *mean annual* and lowest *summer* temperatures in the Northern Hemisphere. Specifically, all climates of the Northern Hemisphere are considered to be Arctic if the mean temperature of the warmest month is below 50° F. and if the mean annual temperature is 32° F. or less. This temperature boundary is well chosen, for in a general way it also separates the characteristically treeless Arctic region from the well-forested sub-Arctic region. However, because weather stations are widely spaced in the Far North, the boundary is only roughly located in many places.

b. Regions.—A true Arctic climate is found over most of the Arctic Ocean, the coastal regions of Alaska north of the Alaska Peninsula, the islands and most of the mainland coast of northern Canada, and over all of Greenland and some of Labrador. Much of this territory extends well below the Arctic Circle (lat. 66°33′ N.), but the greater part of Alaska is, strictly speaking, not Arctic (fig. 1).

36. Delimitation of sub-Arctic climates.—*a. Basis.*—Sub-Arctic climates characterize a broad belt of country south of the regions having truly Arctic climates. This broad belt is sub-Arctic rather than Arctic because it is so far south that the mean temperature of the warmest month exceeds 50° F. In winter, however, the temperatures of both Arctic and sub-Arctic regions may be much alike. For instance the winters in the sub-Arctic interior of Alaska and Canada are colder than the winters at many places much farther north. On the other hand, the winters of the sub-Arctic Aleutian Islands are totally unlike those of the Arctic. In the sub-Arctic, both temperature and precipitation vary from place to place considerably more than in the Arctic region. Most of the sub-Arctic region is forested.

b. Regions.—The south coast of Alaska, the Alaska Peninsula, the Aleutian Islands, most of the interior of Alaska, most of Canada, all of Newfoundland, and southwestern Labrador have sub-Arctic climates. However, the broad sub-Arctic belt does not extend into the United States.

c. Sub-Arctic maritime and continental climates.—Sub-Arctic climates vary especially widely according to whether or not they are influenced by the sea. Therefore, two kinds of sub-Arctic climates are recognized: those strongly influenced by the sea—*maritime climates*—and those characteristic of continental interiors—*continental climates.*

37. Temperature, precipitation, wind, and fog.—*a. Temperature.*—Strange as it may seem, the Arctic is not the coldest region in the Northern Hemisphere. Rather, the coldest spot is in the sub-Arctic and is more than 200 miles south of the Arctic Circle. Temperatures in Wyoming, Montana, and North Dakota are often lower than any temperatures usually encountered in the Arctic. Moreover, temperatures that would be considered high even in Florida are common in the Arctic and sub-Arctic. Temperatures of 80° F. in the shade have been recorded frequently at many places, and a record of 100° F. in the shade has been set at Fort Yukon, Alaska, on the Arctic Circle. Nevertheless the Far North has the lowest *mean annual* and the lowest *mean summer* temperatures of the Northern Hemisphere.

b. Precipitation.—Contrary to popular belief, the Far North is in general a place of little snowfall and rainfall. Over large areas the precipitation [1] is less than 15 inches annually, an amount corresponding roughly to that found in the semiarid parts of the western United States. Near the entrance to Franz Josef Fiord in east Greenland, it

[1] Precipitation is measured in inches of water and includes both rain and snow. Snow is expressed by its water equivalent, obtained by weighing or melting the snow. Ten inches of snow approximates one inch of water.

approximates no more than the amount found at Death Valley, California. In some parts of the Arctic, however, precipitation is abundant. In the Aleutian Islands, for instance, it is more than 60 inches. On the southeast coast of Baffin Island it averages 15 to 20 inches, a maximum for the Canadian Arctic. On the south coast of Greenland the precipitation is more than 40 inches. Although most of Greenland is covered by a vast ice cap, the annual snowfall upon its surface is not exceptionally great. Throughout the Far North, low rates of evaporation and melting help to counterbalance low precipitation. Even so, the low-lying north tip of Greenland is too arid for the formation of glaciers. Pangnirtung, on the eastern part of Baffin Island, is a spot comparatively moist by Arctic standards. Here the average depth of snow on the ground at the end of March, when the snow lies deepest, is only 1.4 feet, even though the yearly snowfall is about 9.5 feet. Naturally in the Arctic there is rain as well as snow. At Pangnirtung, for instance, one-third of the total precipitation is rain.

c. Winds.—(1) The strongest winds on record are not in the Arctic nor sub-Arctic, but on Mount Washington in New Hampshire, where gusts of 230 miles per hour have been recorded. Although it is true that many places in the Far North are very windy, at more places the winds are moderate. Generally winds are stronger on or near land than far out at sea.

(2) The most intense storms occur on or near land, especially where high land faces the sea. Western Greenland is an outstanding example; its coastal region probably ranks as one of the windiest belts in the north. Gusts of 162 mph have been measured in southwest Greenland. Winds of gale violence, however, do not usually extend more than 10 or 15 miles out to sea. In the vast ice-covered central area of Greenland winds are much less severe.

(3) Winds are disagreeable enough when associated with cold, but when they are also accompanied by drifting snow they are wicked and at times make traveling almost impossible, whether the season be autumn, winter, or spring. Winds of 9 to 12 mph will raise the snow a few feet off the ground so that the blowing snow obscures surface objects such as rocks and runway markers. This is particularly true of those parts of the Far North where there are no trees to break the wind. From the air you can see small objects on the ground if you are directly above them, but in all other directions the ground looks smooth from a distance. Winds of 15 mph or more will raise snow high enough to obscure buildings. At wind speeds above 30 mph snow may be whisked up 50 or 100 feet and appear like a low cloud. Drifting is

common in the Arctic because the snow, being dry, remains light and fine and can be easily stirred by the wind long after it has fallen. In the open, however, it packs hard rather than remaining fluffy as in sheltered places.

d. Fog.—In the Arctic and sub-Arctic, as elsewhere in the world, some places are notable for their frequent heavy fogs, whereas other places have almost none. The western part of the Aleutian chain is a particularly foggy area. In the Far North fog is especially dependent upon seasons and the variations of temperature and wind that accompany them.

38. Climate and weather contrasted.—Weather is the total effect of temperature, precipitation and wind over a short period of time. On the other hand, climate takes account of the average weather and its departures from the average over a long period. The weather at any particular place at a particular time may be quite different from the general climate.

39. Influence of latitude.—*a. General.*—A major factor in the climate of any region is the amount of heat the region receives from the sun. This amount depends on two things—the angle at which the sun's rays strike the earth and the length of the day, both of which vary widely with varying latitude.

b. Angle of sun's rays.—The farther north you go the less directly the sun's rays strike the ground, and therefore the weaker is the effect of the sun (fig. 2).

c. Arctic "Day" and "Night."—Because of the inclination of the earth's axis while the earth is rotating around the sun, the lengths of day and night vary greatly with latitude (fig. 3). At the North Pole the sun stays above the horizon for 6 months, while at the Arctic Circle it is up all day only on June 21. In winter there is an equal amount of time, latitude for latitude, during which the sun is hidden below the horizon. These simple rules are astronomically correct, but the sun's rays come in at such a low angle that they follow a curved path in the dense air near the ground. At low temperatures, the rays curve so much that the sun is often seen when it is really below the horizon. Twilight is similarly lengthened at high latitudes. Winter is definitely not a period of total darkness. South of latitude 84° N. there is some light from the horizon even on December 22. In addition, the Arctic is favored with particularly long periods of bright moonlight. As a result, in many places people are able to travel throughout the winter. One exception, however, is the Greenland ice cap, where winter winds and temperatures are particularly severe.

40. Influence of topography.—*a. General.*—Topography is an important factor determining temperature, precipitation, winds, and fog.

b. HIGHLANDS AND MOUNTAINS.—(1) Normally temperature decreases as altitude increases. Therefore, highlands are commonly cooler than lowlands. An exception to this rule occurs in places where air circulation is restricted. Cold air is heavier than warm air, and consequently it tends to sink and become trapped if there is poor air circulation. Thus air may be colder on the floor of a valley than on surrounding hills, and pilots often find the upper air warmer than the ground air.

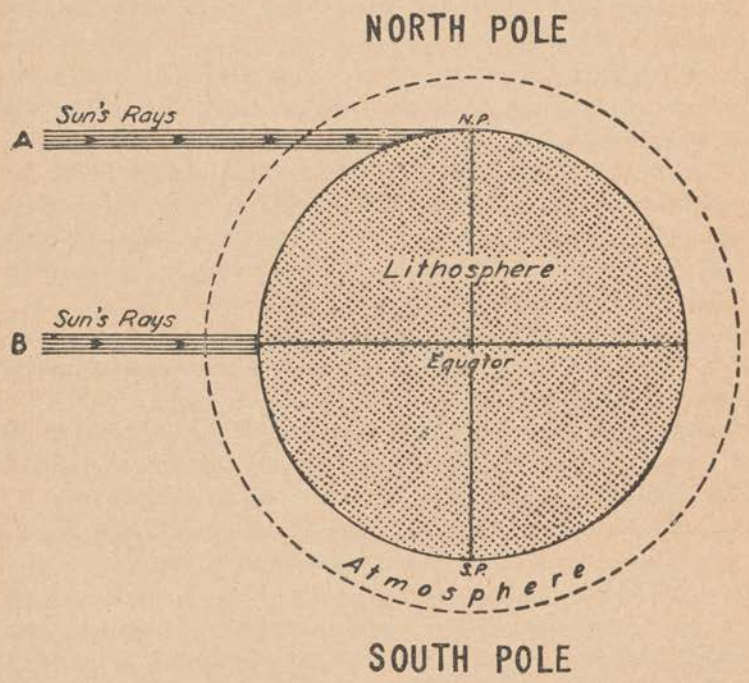


FIGURE 2.—Difference in energy delivered by oblique and vertical rays of the sun. The oblique ray *A* delivers less energy at the earth's surface than the vertical ray *B* because its energy is spread over a greater area, and because it passes through a thicker layer of atmosphere which absorbs, scatters, and reflects it.

(2) Where winds blow against a highland the air is forced upward and is cooled. Since precipitation results from cooling of moist air, rain and snow are normally greatest in mountainous areas. The presence of mountains is largely responsible for the many glaciers of Baffin Island, Ellesmere Island, and Greenland, and the absence of mountains explains the lack of glaciers in Canada's western Arctic.

(3) The high and dome-shaped Greenland ice cap has a unique

effect on winds. Air in contact with the ice becomes cooled and heavy. It settles and flows down the sides of the dome, creating gravity winds which speed up as they approach the margin of the cap. When these winds are accelerated under the influence of a storm system, the combined effect produces the strong seaward-blowing winds sometimes met with on the Greenland coast. Some of these winds from the ice cap are surprisingly warm.

c. Large bodies of water.—(1) Seacoasts commonly have cooler summers and warmer winters than do the interiors of large land masses. The reason is that large bodies of water do not change temperature very easily. Therefore, they tend to stabilize temperatures in their vicinity. The effect is most marked in summer when there is open water. Ocean currents play a major part in determining the temperature of the sea and hence the time and place of freezing.

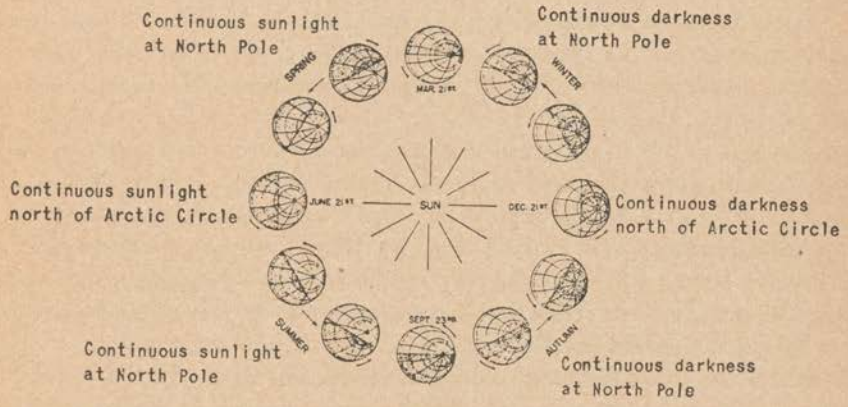


FIGURE 3.—Relationship between seasons and sunlight in the Northern Hemisphere.

The most famous of these is the warm Norwegian Current that gives Norway and Spitsbergen much milder climates than these northern countries would otherwise have. The cold Laborador Current flowing from the north helps to give coastal Laborador a truly Arctic climate. In the North Pacific, the warm Aleutian Current and its northern branch, the Alaska Current, give relatively warm winters to the Aleutian chain and the south coast of Alaska.

(2) Large bodies of water have another climatic significance in that they are the ultimate source of all rain and snow. Since a large part of the Arctic Ocean is covered with ice the year around, the winds cannot pick up by evaporation the amount of moisture they could obtain from an ice-free sea. This fact, coupled with the low temperatures that prevent the air from holding much moisture, accounts in large part for the low annual rainfall and snowfall of the Arctic.

d. Coastal areas.—Coastal areas are favorite places for fogs because of sharp differences in air temperature over bodies of water, whether ice-covered or open, and over land. Warm land airs blowing over a cool sea become chilled, so that their moisture is condensed and fog is likely to result. Similarly, a situation where warm moist air moves from the sea over cold land is favorable for fog. When cold, dry winds blow from land or ice over relatively warm water, the dry air soaks up moisture which condenses and may produce "steam fog." A fog dissipation process occurs when foggy air moves from a cold sea over warm land and is dried out.

e. Strictly local effects.—Topography is important also in that it may so modify the general weather that the weather becomes strictly local in character. Thus along some coastal cliffs, when gravity effects are added to the general wind flow, cold dense air literally pours over the cliffs like a waterfall and creates strong local winds.

41. Influence of traveling air masses.—In addition to the permanent influence of latitude and topography, transitory air masses exert a profound effect on climate and weather. These air masses may be warm or cold, moist or dry. They follow rather well defined routes and are the immediate cause of most changes in weather. In winter a favorite route of such air masses is from the Arctic Ocean southward up the Mackenzie Valley and then eastward over southern Canada and northern United States. But as the year advances the eastward turn takes place farther north, so that by summer these air masses tend to pass from the southern islands of the western Arctic toward southeastern Baffin Island.

42. Physical effects of cold.—*a. Condensation.*—Cold of −30° F. to −60° F. has some peculiar effects. One of them is to dry the air, because the colder air becomes the less moisture it is able to hold. The inability of cold air to hold moisture causes condensation of a person's breath which, even in more southerly latitudes, commonly forms a white fringe of frost around his parka hood. The hand steams when it is pulled from a warm mitt, for moisture is always coming from the body's pores. Bodies of open water that are ice cold (but still warm in comparison with −40° F.) generate clouds of mist. Such clouds rising from flooded rivers, or from open water (leads) in an ice-filled sea resemble the smoke of forest fires and are called "steam fogs." Animals and power vehicles leave trails of fog behind them.

b. Visibility.—If the effects of condensing moisture are eliminated, cold greatly improves visibility. A person can see farther than normally and consequently one finds it hard to judge sizes and dis-

tances correctly in places where there are no houses or trees to serve as a scale.

c. Sound.—Sound travels farther in cold air than in warm. On a still day in the Arctic winter one can hear the barking of dogs or the sound of an ax miles away and is likely to think he is nearer the source than is actually the case.

43. Mirage.—The appearance, in the sky or on the horizon, of objects that are normally hidden below the horizon is a common occurrence in the Far North. This phenomenon depends on the bending of light rays as a result of abrupt changes of temperature with increasing altitude. Images, sometimes upside down, may appear well up in the sky, or appear to be resting on a pedestal or to be floating just above the horizon. These effects, known as *looming*, are a particularly common form of mirage.

44. Northern lights.—Northern lights (Aurora) constitute one of the most interesting phenomena of the Arctic and sub-Arctic. Although by no means confined to these regions, they are most noticeable here. When best developed they appear in the sky as a white or variously tinted light that is constantly changing in shape and intensity. The light may appear at one time like a vibrating curtain draped across the sky, then change to a luminous haze or to a number of bright darting shafts. Northern lights are sometimes only a faint glow in the sky, but at other times they create as much illumination as the moon.

45. Seasons.—*a. General.*—Seasons are a true expression of climate, for they represent the weather over periods of weeks or months. Although in the Far North seasons are not precisely delimited, there is general agreement as to what conditions characterize a given season within a given region. Summer and winter with their extremes of temperature are well marked, but autumn and spring are more indefinite, especially in very high latitudes. All seasons except winter become shorter and shorter as one goes farther and farther north. Seasons are also strongly influenced by topography, which may either neutralize the effect of latitude or enhance it many times. The following picture of the seasons is fairly representative of the Arctic and, in many respects, also of the sub-Arctic continental regions.

b. Summer.—As already noted in the Far North there is no generally accepted definition delimiting the seasons. It may be said arbitrarily that spring merges into summer with the general melting of the snow, the more or less complete break-up of ice on rivers and lakes, and the appearance of flowers and numerous birds. Shortly

after summer begins, sea ice starts to break up along Arctic coasts, permitting navigation in many places. By August, about three-fourths of all land north of the Arctic Circle has become free of snow. Most of the remaining snow and ice is in the interior of Greenland, although parts of Baffin Island, Devon Island, and Ellesmere Island are also ice covered. Compared with other seasons, summer is characterized by a profusion of plant and animal life on the lands, and by open water in the seas. Continuous daylight during early summer is a notable feature of far northern latitudes.

c. Autumn.—Again it may be said arbitrarily that the Arctic summer merges into autumn when birds start south, and temperatures drop to near freezing at night, when the weather becomes unsettled and snow flurries appear. A little later subfreezing temperatures become common, lakes freeze over, then streams, and finally the bays and inlets along Arctic coasts. By this time the days have become short and there is some snow on the ground. During the freeze-up when ice is forming on lakes and sea, there is generally little sledge travel or flying with seaplanes.

d. Winter.—When temperatures stay low, when snow whitens the landscape, and when ice thickens over most of the Arctic Sea, autumn merges into winter. Winter is dominated by the persistent cold which controls all activities, and by the long nights. South of the Arctic Circle, and hence over much of the sub-Arctic and some of the Arctic, the sun appears above the horizon every day. On the Arctic Circle no sun should appear on December 22, but mirage effects may make the sun visible from as far as 60 miles north of the Circle. If one goes far enough north there will be no sunshine for many weeks. But the time that the sun is below the horizon should not be thought of as a period of total darkness. It is far from that in many places. There may be light from the horizon, from the moon, and even from the northern lights and the stars, and what light there is multiplies itself by reflection from the snow. On a bright moonlight night a sledge track may be seen glimmering a quarter of a mile away. Winter flying is common and sledging continues uninterruptedly at many localities, although storms bring interruptions, and there are places such as the Greenland ice cap where winter travel is extremely difficult and at times impossible.

e. Spring.—Late winter merges into early spring with the increasing hours of sunshine, which become continuous before long. Low temperatures are not uncommon and stormy winds may prevail at times, but the weather gradually turns milder and is best for flying over most of the Arctic in March and April. Snow starts melting on land a little later. Flowers sprout, at times through drifts, and seals take

sun baths along Arctic coasts. The land is freed from snow in a few more weeks, birds arrive, rivers break up, lakes open, and finally summer is at hand. Spring is the most active sledging season until the break-up comes. Then, as in the period of freeze-up, there is little sledge travel or seaplane flying.

Section II

ARCTIC CLIMATE AND WEATHER

46. Regions.—In order to see the average conditions over a wide area in the Arctic, one has merely to turn to the map and notice the distribution of the following places. Their numbers correspond with those on the map (fig. 1).

	Latitude	*Longitude*	*Altitude (feet)*
1. Barrow, Alaska	71°23′ N	156°17′ W	13
2. Coppermine, Northwest Territories	67°49′ N	115°10′ W	13
3. Chesterfield, Northwest Territories	63°45′ N	91°50′ W	13
4. Craig Harbour, Ellesmere Island	76°12′ N	79°35′ W	12
5. Pangnirtung, Baffin Island	66°09′ N	65°30′ W	50
6. Hebron, Labrador	58°12′ N	62°38′ W	49
7. Upernivik, west coast of Greenland	72°47′ N	55°53′ W	62
8. Ivigtut, west coast of Greenland	61°12′ N	48°11′ W	98
9. Eismitte, Greenland ice cap	70°54′ N	40°42′ W	9,941

Note that all the stations except Eismitte are located along coasts. Unfortunately, there are practically no weather records from inland places in the Arctic. Hence the conditions which will be discussed apply chiefly to coastal areas and, except for the climate of the Greenland ice cap, the climate described should be designated as Arctic maritime. An ice cap climate constitutes one type of Arctic continental climate. Another type occurs in ice-free continental interiors, which probably have higher summer and lower winter temperatures

than those of the Arctic maritime climate. However, in the Arctic, contrasts between maritime and continental conditions are probably less marked than in the sub-Arctic.

47. Temperature.—*a. Warmest month.*—Throughout the Arctic the warmest month is generally July. Mean temperatures for this month at the selected stations vary from about 12° F. at Eismitte to about 50° F. at Coppermine on the north coast of Canada. Thus Coppermine is located on the boundary zone between Arctic and sub-Arctic climates (pars. 35 and 36). Barrow, Craig Harbour, and Upernivik have a July mean of about 41° F., Pangnirtung has a July mean of 46.5° F., and the rest of the stations have means of 48° F. to 50° F. But even far northern stations have considerable variations from the mean. At Craig Harbour the July minimum is 29° F. and the maximum 61° F. At Chesterfield on the northwest coast of Hudson Bay the highest is 84° F.; at Coppermine it is 87° F.

b. Coldest month.—Generally the coldest month is January or February. The mean temperature of the coldest month at the places selected varies from −53° F. at Eismitte to about 18° F. at Ivigtut in southern Greenland. Thus the Greenland ice cap is the coldest part of the Arctic. But Ivigtut, which lies a few miles beyond the border of the ice cap, is only about 3° F. colder than Eastport, Maine. Upernivik and Hebron have means of about −10° F. and −6° F. respectively, and are therefore much alike in spite of the fact that Upernivik lies much farther north than Hebron. The rest of the stations vary from about −27° F. at Chesterfield to −18° F. at Pangnirtung. These are mean temperatures only; the extremes differ from the means by many degrees. The extreme low for the coldest month at Pangnirtung, for instance, is −46° F., but the same month has also witnessed a temperature of +48° F.

48. Precipitation.—*a. Annual.*—At the selected stations the annual precipitation varies from 5.3 inches at Barrow to 44.8 inches at Ivigtut. Pangnirtung and Hebron are much alike with 17.0 inches and 19.3 inches, respectively. The remaining stations vary between 8.6 inches at Craig Harbour and 10.9 inches at Coppermine. These figures exemplify the relatively high precipitation of south Greenland, southeastern Baffin Island, and Labrador; also the aridity of the greater portion of the Arctic. The proportion of rain to snow varies considerably. At Pangnirtung and at Chesterfield about half the precipitation is in the form of rain, but at Craig Harbour only about one-third of it is rain.

b. Seasonal distribution.—(1) Over most of the Arctic the greatest amount and the greatest probability of precipitation occur in the

summer, although in some localities these peaks may come in the spring or autumn. July or August is the wettest month of the year at all the places listed above except Upernivik (about equal precipitation in August, October, and November), Ivigtut and Hebron (wettest month September), and Pangnirtung (November). Nevertheless, the maximum average monthly precipitation at all of them except Ivigtut (about 6 inches) and Hebron (3.3 inches) is less than 2.5 inches. At Barrow and Upernivik, it is only about 1 inch.

(2) The minimum precipitation commonly occurs in the winter. This is true for all the stations except Pangnirtung (minimum in May) and Ivigtut (April). For instance, the average January precipitation at Barrow, Coppermine, Chesterfield, Craig Harbour, and Upernivik is less than 0.6 inch, which is equal to about 6 inches of snow. However, so much snow is raised from the ground and blown around by winter winds that it gives a false impression of the total amount of snowfall.

49. Winds.—*a. General.*—At all times of the year Greenland is noted for its seaward-blowing winds (par. 37). Throughout much of the Arctic, however, wind direction and wind strength vary greatly with the seasons. In general, winds of the polar pack are less severe than those of the land. The strongest winds next to the surface of the polar pack ice far from land are seldom more than 50 miles per hour.

b. Seasonal distribution.—(1) Summer winds are mostly light and variable. Northerly and northeasterly winds prevail on the borders of the polar pack. Along the Arctic coast of Alaska they often blow offshore and are gentle compared with those of other seasons. Northerly winds are dominant in the western Arctic Islands, the exact quarters depending on local topography. In Canada's eastern Arctic the most important winds are easterlies; these winds are stronger than the summer winds of the other areas mentioned.

(2) Autumn winds are less variable than summer ones, but they are generally much stronger. In the eastern Artic, winds are more severe during the autumn and the calms fewer than at any other time of the year.

(3) Along the coast of Alaska the strongest winter winds are from the west or southwest, and the next strongest from the east or northeast. In the western Arctic Archipelago and south Greenland, winter is a windy season. On southern Melville Island in the western Arctic, for instance, the stormiest month in 1908–1909 was February, during which there were seven storms with velocities of over 40 mph. Two of these had velocities of over 60 mph, and one a velocity of over 100 mph. Among the western islands the prevailing wind appears to be

northwest. In the eastern Canadian Arctic, winter winds are likely to be less severe than those of autumn or spring. In January prevailing winds here are north and northeast or south.

(4) When temperatures begin to rise in the spring, storm tracks shift northward and bring to some areas winds stronger than the winter winds. Spring is the windiest season on southern and eastern Baffin Island.

50. Fog.—*a. Polar pack fogs.*—Fogs are most frequent and dense over the Arctic Ocean during the summer, when they occur about 30 percent of the time. But during the winter, from December through March, they are practically absent, at least near the center of the Arctic pack. In the autumn and spring they are of intermediate frequency.

b. Coastal fogs.—(1) Coastal fogs tend to be local. During the summer, Arctic lands are generally warmer than the seas, so that winds are likely to produce a fog belt parallel with the shore (par. 40). Most of these fogs lie lower than the topmasts of a ship. Off the north coast of Alaska whaling captains used frequently to be able to see each other, crow's nest to crow's nest, above the fog, while sailors on deck could not see from ship to ship. In general, summer is believed to be a season of relatively few coastal fogs. Nevertheless, on Baffin Island summer is the worst time for dense fogs, and summer fogs are extremely common on Bering Sea and along the west coasts of the western islands in the Canadian Arctic.

(2) Next to spring, autumn is said to be the worst season for coastal fogs in most places. The reason is that the sea, as long as it remains unfrozen, is considerably warmer than the land, which cools rapidly. Once this temperature difference is established, fogs are prevalent.

(3) Coastal fogs, like polarpack fogs, are least frequent during the winter.

(4) Spring, however, has the deserved reputation of being the worst season for coastal fogs. These fogs appear after land areas are largely free from snow. During that stage of spring the ice-covered sea is much colder than the dark land heated by the sun. In fact, the maximum temperature differences between land and sea, and hence the conditions most likely to cause fog, are set up then. In late spring such fogs are common on the Canadian coast between the Mackenzie River and Cape Perry, and on the west coasts of the western islands in the Canadian Archipelago.

c. "*Spicule fog.*"—In addition to the familiar type of fog, there is "spicule fog" (ice fog) that is characteristic of the Greenland ice cap. Formed of extremely fine ice crystals, spicule fog is a kind of snowfall that results from condensation during cloudless periods of

low temperature, high humidity, and calms or light winds. At times it completely obscures the ground and makes flying extremely hazardous. It has been known to extend up as high as 1,000 feet above the ground.

SECTION III

SUB-ARCTIC CONTINENTAL CLIMATE

51. Regions.—The sub-Arctic continental climate prevails over most of the nonmountainous parts of interior Alaska and interior Canada. The following stations are more or less typical. They are located by number on the map (fig. 1).

	Latitude	*Longitude*	*Altitude (feet)*
10. Tanana, Alaska	65°10′ N	152°06′ W	220
11. Dawson, Yukon Territory	64°04′ N	139°20′ W	1,050
12. Fort Simpson, Northwest Territories	61°52′ N	121°15′ W	415
13. Fort Vermilion, Alberta	58°23′ N	116°03′ W	950
14. Mistassini Post, Quebec	50°30′ N	73°55′ W	1,255

Stations are rare on the mountains of the interior, but in general the climates of such places are a rough compromise between Arctic and sub-Arctic climates, and partake of some of the characteristics of each.

52. Temperature.—*a. Range.*—The sub-Arctic continental summers are sometimes warmer than those of a more southerly temperate climate, and the winters are commonly colder than those of a true Arctic climate. As a result there is a large range between the mean temperatures of the warmest and coldest months. For instance, at Dawson and at Fort Simpson in the Mackenzie Valley this range is about 81° F., and at Fort Good Hope on the Mackenzie River it is even greater. If extreme rather than mean temperatures are considered, the range at Dawson and Fort Simpson is approximately doubled, and at Fort Vermilion, on the Peace River, it is 174° F. Only interior Siberia has greater ranges than occur in the region between eastern Alaska and Hudson Bay.

b. Warmest month.—The warmest month is generally July. Among the selected stations the mean temperatures for this month vary but slightly, the lowest being 59° F. at Tanana, Alaska, and the highest

61.6° F. at Fort Simpson. But temperatures sometimes soar into the nineties or plummet below freezing. At Dawson, for instance, the July extremes are 95° F. and 29° F.

c. Coldest month.—Commonly the coldest month is January. At the representative stations the mean January temperature varies from −6° F. at Mistassini Post to −22.4° F. at Dawson. Fort Vermilion has −14° F., Tanana has −16° F., and Fort Simpson −19° F. At Dawson the highest temperature recorded in this month is +30° F. and the lowest −68° F. Fort Vermilion, however, has an extreme low of −76° F. These temperatures show that during the winter much of the sub-Arctic is colder than the Arctic. At Dawson and at some other sub-Arctic stations the January mean is lower than that of many Arctic places. Moreover, the extreme lows of all the selected sub-Arctic stations are lower than the extremes of most stations in the Arctic.

53. Precipitation.—*a. Annual.*—In the interior regions of the sub-Arctic the annual precipitation is generally less than 15 inches. At Tanana, Dawson, and Fort Vermilion it is 12 to 12.5 inches, and at Fort Simpson it is 13.5 inches. Yet at Mistassini Post it rises to 32 inches. At these places rain accounts for half to three-quarters of the total. Although precipitation is low, evaporation also is low, and much of the precipitated moisture is frozen and stored in the ground. During spring and summer when thawing is in progress, this moisture is slowly released. Consequently the ground is kept wet enough to support thriving forests in spite of the low precipitation. The fact that trees generally grow in the sub-Arctic but not in the Arctic, therefore, is not the result of differences in precipitation. It is the result of the longer growing season, the warmer summer temperatures, and the better soil conditions of the sub-Arctic.

b. Seasonal distribution.—(1) In the interior of Alaska and Canada as in the Arctic, the greatest precipitation generally occurs during the summer. The total for the wettest month at the selected stations varies from 1.6 inches at Dawson to 3.7 inches at Mistassini Post, the wettest months there being August and July, respectively.

(2) The least precipitation is most likely to occur in the winter or spring. At the selected stations it is the latter, March being the driest month at all except Fort Vermilion (February) and Tanana (April). The driest month brings 1.65 inches at Mistassini Post, but at the other stations it brings only 0.25 to 0.5 inch.

54. Winds.—In the interior of Alaska and Canada winds are likely to be variable, except where topographically controlled. At Fairbanks, Alaska, the dominant winds are southeast and southwest, the former being due to the sweep down the Tanana Valley and the

latter to the sweep up the Kuskokwim Valley. In general, winds close to the ground in the Yukon Valley blow up or down the valley, but well above the ground the directions may be quite different. High ground velocities are rare, the maximum, about 50 mph, being seldom attained. But again, at greater altitudes conditions are different. Velocities there are sometimes 90 to 100 mph.

55. Fog.—*a. General.*—In most parts of the world, and especially in the sub-Arctic, interior fogs are much less common than coastal fogs. In general, what fogs there are (excepting town fog) coincide with the periods of greatest rainfall.

b. Town fog.—Alaskan and Canadian flyers report that at extremely low temperatures (−50° to −65° F.) fog is usually noticeable over more or less densely inhabited places, because of the conflict between locally generated warm air and the surrounding cold air. "Town fogs" may cause faulty identifications in contact flying. However, they soon "burn off" if there is any sunshine.

Section IV

SUB-ARCTIC MARITIME CLIMATE

56. Regions.—The sub-Arctic maritime climate is characteristic of the low-lying parts of the Alaska Peninsula and the adjacent south coast of Alaska and of the Aleutian Islands, Newfoundland, and a small part of eastern Labrador. The following stations are representative. The numbers give their locations on the map (fig. 1).

	Latitude	*Longitude*	*Altitude (feet)*
15. Dutch Harbor, Aleutian Islands	53°53′ N	166°32′ W	13
16. Kodiak, Kodiak Island	57°48′ N	152°24′ W	152
17. Seward, south coast of Alaska	60°06′ N	149°27′ W	55
18. St. Johns, Newfoundland	47°34′ N	52°42′ W	243

Although stations on coastal mountains are few the climate of these mountains, as far as known, combines the climatic features of the interior mountains and of the low-lying parts of the sub-Arctic coast.

57. Temperature.—*a. Range.*—In the sub-Arctic maritime climate seasons are much less marked than in the sub-Arctic continental or Arctic climates. The sub-Arctic maritime regions are far enough south so that the sea remains unfrozen. As a result the summers are cool and the winters are relatively warm. Among the stations listed, the smallest temperature range between the warmest month

and the coldest month is 19° F. at Dutch Harbor, and the greatest range is 38° F. at St. Johns. These figures are small compared with the corresponding ranges in the sub-Arctic continental climate, which in many places are more than 80° F.

b. Warmest month.—At places such as Dutch Harbor and Kodiak, July and August have almost the same mean temperatures. At the selected stations the mean temperature of the warmest month varies from 51° F. at Dutch Harbor to almost 60° F. at St. Johns. Kodiak has a mean of 54° F. in July and August and Seward has a July mean of 56° F.

c. Coldest month.—Because the Aleutian Islands reach into warm Pacific currents they generally have higher winter temperatures than Newfoundland and the south coast of Alaska near Seward. Thus at Dutch Harbor and Kodiak the mean temperatures of the coldest month are 32° F. and 29° F., respectively. On the other hand, at Seward the mean temperature is 20° F. and at St. Johns 22° F. However, sub-Arctic maritime winter temperatures do drop below 0° F. for temperatures as low as −25° F. have been recorded in Newfoundland. At Kodiak and at Seward January is the coldest month, but at St. Johns February is the coldest. At Dutch Harbor the two months are nearly alike. On the south side of the Alaska Peninsula harbors are free of ice throughout the winter.

58. Precipitation.—*a. Annual.*—A high annual precipitation is one of the typical features of the sub-Arctic maritime climate. This is another way, then, in which this climate differs markedly from that of the Arctic or the sub-Arctic continental areas. For example, the annual amount at the selected stations varies from about 54 inches at St. Johns to almost 64 inches at Dutch Harbor—three to four times as much as in most parts of the Arctic or in the interior of Alaska or Canada.

b. Seasonal distribution.—(1) In contrast with the Arctic and sub-Arctic continental regions, the maximum precipitation in the Aleutian Islands and the south coast of Alaska generally occurs in the autumn and winter rather than in the summer. In Newfoundland it occurs from June to October. Average precipitation for the wettest month at the selected stations ranges from about 6 inches at St. Johns to about 10 inches at Seward. At St. Johns the wettest month is commonly November; at Seward, September; and at both Kodiak and Dutch Harbor it is October, with about 7.3 inches and 9.0 inches, respectively.

(2) The driest month at the selected stations is June or July, but in some other places it comes in the winter or spring. The average precipitation for the driest month varies from 2.3 inches at Seward to 3.5 inches at St. Johns.

c. Winds.—In the summer, westerly and northwesterly winds predominate in the Aleutians, but southeasterly winds are commonly stronger and are often accompanied by rain or mist. On the Alaska Peninsula and along most of the south coast of Alaska, summer winds, although variable, are dominantly southeast and southwest. Gales from these directions are likely to bring rain and thick weather. During winter and spring very strong northwest winds are frequent on most of the south coast and the Alaska Peninsula, where they often reach gale intensity. A peculiar Alaska wind is the *williwaw*, a gust that sweeps with great force down mountain slopes. In Newfoundland as in Alaska, winter is windier than summer. The prevailing directions are westerly and northwesterly, but the greatest storms come from the east and southeast.

d. Fog.—The Aleutian Islands are famous for their fogs. So prevalent are they that there is but little sunshine, even in midsummer when the sun is above the horizon for 17 or 18 hours. On the Alaska Peninsula fog is particularly common with southeast winds. Often it hangs about headlands and entrances to bays, even though the upper parts of the bays are clear. Fogs are much more numerous along the south coast of Alaska than in the interior. In Newfoundland also, fog is most prevalent on the coasts, the east coast being far foggier than the west coast.

Chapter 4

LIFE

Section I

PLANTS

59. General.—No matter how far north, any land that is free from snow and ice during even a few weeks in the year has plants growing on it. The world's northernmost land, the north tip of Greenland, supports many kinds of plants in such abundance that herds of musk oxen find adequate pasture. If you have seen an alpine meadow above timberline on a high mountain you can picture in a general way the vegetation of the Arctic—the Arctic tundra. The tundra gives way southward through a broad transition belt to the sub-Arctic forest which, in turn, merges into the more familiar trees of the Temperate Zone. These belts of vegetation are described in the paragraphs that follow. The practical uses of the plants are discussed in chapter 5, part two.

60. Sub-Arctic forest.—*a.* Northward from the boundary between the United States and Canada, the light green of hardwood forests and the variegated patch-work of fields and pastures are succeeded by an expanse of dark evergreen forest, broken only by lighter patches of bog (muskeg) and numerous lakes. At first the forest is a variable mixture of many kinds of trees. Further north one kind after another disappears until eventually the landscape becomes a vast montonous stretch of sub-Arctic forest, reaching across southern Canada and central Alaska to within a short distance of Bering Sea. Black and white spruce predominate. Interspersed among the spruces are the eastern larch (tamarack), aspen, balsam poplar (balm of gilead), and paper birch. The trees grow close together and are often draped with gray lichens. Soft spongy moss and lichens cover the ground almost entirely.

b. Scattered through this dense forest are innumerable lakes and bogs. Because of the growth of grasses, sedges, and peat moss (sphagnum) about their margins, many of the lakes are gradually becoming bogs. The plants form a mat which floats on the water and quakes when you walk on it. As this mat gets thick, cranberry, Labrador tea, leather leaf, and other shrubs appear. These are followed by alder, black spruce, and larch. Many lakes have been completely filled in and are now covered by dense forest.

c. Summer travel on foot is difficult. Trees grow so close together it is hard work to press through them, and you get tired quickly as you sink into the soft ground cover at every step. This land can be treacherous too. You may easily fall into half-concealed holes in bogs and bog forests.

61. Sub-Arctic vegetation of Aleutian Islands.—The absence of trees and the general appearance of the vegetation on the Aleutian Islands gives the impression of an Arctic region. The plants, however, are not those of the Arctic tundra; they are a special sub-Arctic group. The westernmost islands support alder and other shrubs tall enough to shelter a rich carpet of flowering plants. In sharp contrast, the eastern islands produce low-growing and less luxuriant plant life. Here and there on the lower slopes of the islands are meadows. Higher up the slopes are willow thickets 3 to 6 feet high. Above the willow thickets the exposed areas are covered with heaths (shrubs) while meadows occupy the hollows. Still higher up heaths are ever present, giving way in the uppermost regions to large tracts of bare earth.

62. Vegetation of southern tip of Greenland.—The southern tip of Greenland lies in the transition zone between the sub-Arctic and the Arctic. It is not surprising, therefore, that bushy willows grow 8 feet tall and have some branches that are 6 inches thick at the base. These willows branch profusely at the ground instead of having a large central trunk. None of the dominant trees of the sub-Arctic forest occurs in Greenland.

63. Transition from forest to tundra.—The transitional belt of vegetation consists of a patchwork of forest and tundra. Tundra first appears in small openings in the forest. Northward the patches of tundra increase in size and abundance until they equal the forest in extent. Still farther north the trees disappear entirely as the transition to Arctic tundra is completed. Thus the northern edge of the sub-Arctic forest is not a definite line. From the main mass of the forest slender strips of trees reach north along the river valleys where the soil and moisture are favorable. Isolated clumps of trees form outposts far north of the main mass of the forest. Thus on the Copper-

mine River remnants of the forest extend to within six miles of the Arctic Ocean, while the surrounding rocky upland is gray tundra. An approximate line connecting the northernmost trees from the Atlantic to the Pacific is shown in figure 1. South of this boundary for some distance there are very few trees. Although as the tree limit is approached the size of the trees usually decreases, there are frequent exceptions. In protected places where the soil is good, white spruce trees are as tall as those a thousand miles farther south. White spruce and balsam poplar (balm-of-Gilead) are the northernmost trees of the forest.

64. Arctic tundra.—*a.* Lichens, grasses, and sedges (grasslike plants) and several types of shrubs are the predominant plants in the Arctic tundra. In spite of the wide geographical extent of the tundra, its composition varies little from one area to another. There are no deadly poisonous, thorny, or climbing plants in the tundra. Most of the plants branch freely at the ground level and many form dense cushions or rosettes.

b. In the winter landscape of the Arctic, plants are inconspicuous. Although the snowfall is meager it is sufficient to form a thin cover over most of the low-growing plants. In windswept areas the snowy expanse is often broken by the tops of projecting plants.

c. Large areas of the Arctic tundra (par. 3) consist of heath, a plant community in which low shrubs predominate and lichens and mosses are abundant. For a short time during early spring blue, yellow, and purple flowers brighten the dull green tint of the heath. During the rest of the year the plains present a dreary aspect. The shallow depressions between the low hills are occupied by extensive meadows that somewhat resemble prairies. Most of the meadows are dotted with tussocks of vegetation called "niggerheads." Swampy areas abound. A characteristic Arctic plant, the spectacular cotton grass, grows in all the swamps as well as along streams and lake shores.

d. On rocky and sandy ridges flowers are rare, and dark colored "rock tripe" lichens cover the rock surfaces. These and other lichens intensify the sombre hue of the landscape. The tops of most ridges are covered with reindeer lichen, although some support scattered grasses and a few flat-lying shrubs.

e. The borders of lakes and streams and well watered slopes generally support a more luxuriant vegetation. Here the abundant, large plants are a refreshing change from the drab communities of the upland. Shrubs stand upright and form dense thickets. In especially well protected places willows grow as tall as 7 feet and have stems 6 inches thick.

SECTION II

ANIMALS

65. Animals of the pack ice.—*a. General.*—The polar bear, seal, walrus, fox, and wolf either live habitually on the pack ice or visit it from time to time.

b. Polar bear.—These large mammals belong to the pack ice rather than to the land. They are rarely found far from salt water, since they live almost exclusively on seals. While they are great swimmers and may be found 20 miles from the nearest ice field or land, they cannot catch seals by swimming but must rely on creeping up on them stealthily on the ice. In winter they live on floe ice and on rocky headlands near which strong tidal currents insure open water and hence a good supply of seal. Pregnant bears hibernate in snow caves or snow-buried rock fissures. In summer, polar bears are likely to be found anywhere along the shore as well as on the pack ice.

c. Seal.—Seals are widely distributed, and several kinds are found in various parts of the Arctic. A hair seal known as the *netchek* is particularly common. In winter the *netchek* come to air holes in the ice to breathe, and here they are hunted by Eskimos. During spring these seals bask on the ice near their holes into which they dive when they are alarmed. In summer another species, the *kashigiak*, gathers in numbers at sand bars, rocky headlands, and islands. The fur seal is common in the northern Pacific, to which it is confined.

d. Sea lion.—Steller's sea lion is really a very large seal of the North Pacific. It breeds in the Aleutians and other islands off Alaska and moves southward in winter as far as California. A full-grown male is a big-headed, thick-necked animal weighing half a ton or more. These animals are found on rocky islands more frequently than on pack ice.

e. Walrus.—There are two kinds of Walrus, the Pacific and the Atlantic. The former is most common in Bering Strait, while the Atlantic species, although decreasing, is still found about Greenland, in northern Hudson Bay, and on the Belcher Islands. Walrus are large, thick-skinned, more or less shapeless creatures that live mostly on clams dredged up in shallow parts of the sea. A big walrus may weigh a

ton and a half. Although they are naturally aquatic and are expert swimmers and divers, they are not as agile as seals and cannot catch fish. Being unable to make breathing holes as the seals do, the walrus are found, not in continuous pack ice, but in places where leads and lanes of open water are common. Their long tusks are used for climbing up on rocks and for digging clams.

f. Whales.—The white whale or *beluga* is small—only 12 to 16 feet long—and inhabits all Arctic waters, especially sheltered bays and estuaries. It may even ascend the mouths of rivers such as the Yukon, Koksoak, Churchill, Great Whale, and St. Lawrence. Adults are pure milky white, while the young are gray or quite dark at birth, becoming lighter from year to year. These whales swim in schools of 12 to 20, coming close to shore at night and blowing with a peculiar rattling noise. The Greenland or bowhead whale is found only in the deeper Arctic waters in summer, but is far less common because of centuries of pursuit by whalers. A full-grown Greenland whale is 50 to 60 feet long and is black with a broad horizontal tail. The finback or rorqual and also the narwhal are sometimes found in Arctic waters. The narwhal has a single long tusk projecting forward from its head. The black and white killer whale (sea wolf) is 20 to 30 feet long and, unlike the others which live on minute animals or fish, kills seals, sea lions, and porpoises and will attack even the largest whales.

66. Animals of Arctic tundra.—*a. Caribou.*—The Arctic animal of first importance is the caribou, or reindeer as it is called when domesticated. It is abundant. Probably there are five million caribou in the American Arctic alone. Because of its uses for food and clothing it is of great value to all inhabitants of the Arctic. It is the one large game animal found across the entire American Arctic, both close to and far from the sea. Caribou move about in herds, though not invariably so. They migrate in many areas from grassy lands in summer to lichen-covered ground in the autumn. During this migration they move southward on the Canadian mainland, but on some of the larger Arctic islands they may move northward. Caribou are found even in the extreme northern part of Greenland.

b. Moose.—Moose inhabit the sub-Arctic forest and reach the Arctic Ocean only along the Mackenzie Valley. They are rarely found far from water and usually keep to the bush except in midsummer, when they try to escape the flies by getting out into the open.

c. Musk ox.—Formerly these woolly cattle ranged far down into Canada and Alaska, but there are no more than 500 left now on the mainland, except in one Canadian game refuge. In all the Canadian islands there are probably no more than 13,000 head, with about 9,000 more in northern Greenland. Musk oxen are peaceful grazing ani-

mals, peculiar in that they seldom attack and never run away but form a circle when approached, facing outward as an instinctive defense against wolves. Like the caribou they paw the snow for winter food but do not wander far from the hilly country. Musk oxen are valuable for beef and their wool can be spun and woven into cloth.

d. Arctic wolf.—Arctic wolves are large, brownish-white animals, extremely wary, swift-footed, and strong. They prey chiefly on caribou but will eat trapped foxes and rabbits when they can get them. Contrary to popular belief they do not appear to hunt in packs, although family groups may remain together. They keep at a safe distance from man and are not likely to fight unless cornered. They may, however, attack and kill dogs.

e. Arctic fox.—The white fox becomes pure white in winter but in summer has a brownish-gray back and a yellowish throat and belly. It is found north of the tree limit and in winter it ventures out on the pack ice far from land, where it feeds on seals killed by polar bears. Inland, in the autumn, it digs through the snow for lemmings.

f. Mountain sheep (bighorn).—The "bighorn" of the Arctic and sub-Arctic is white all year around. It has yellowish-brown horns, a short tail that is black above, and sometimes a darkish patch on its rump. It is found in mountainous parts of northern Alaska west of the Mackenzie River where it inhabits cliffs and steep slopes, rarely descending to willow bottoms in summer. Because of the sheep's habitat, hunting them is precarious, but bighorn are the only large animals found in these barren mountains.

g. Mountain goat.—The mountain goat inhabits the high country of southern Alaska. It is a sure-footed animal that scales the steepest cliffs and crags and is white at all seasons.

h. Arctic hare.—The Arctic hare is much larger than the varying hare or snowshoe rabbit of the sub-Arctic forest and may weigh as much as its enemy, the Arctic fox. It is smoky gray in summer and white with black ear tips in winter. This hare is found as far north as there is land and in winter may be met with far out on the salt-water ice—miles from any food supply. These animals frequent rocky hillsides and keep close to crevices in which they can escape the owls that prey on them.

i. Ground squirrel.—These animals are about the size of gray squirrels but have shorter tails. Their color is a spotted brown. They hibernate underground.

j. Lemming.—Other hillside dwellers are these plump, short-tailed Arctic mice. They do not hibernate, yet they spend most of their time underground or under the snow. Here they build spherical nests of

grass where the young are born in midwinter. Lemmings are constantly preyed upon by shrews, weasels, foxes, and owls. So dependent are other animals, such as the fox, on the lemming supply, that the abundance of foxes fluctuates with the abundance of lemmings.

67. Animals of sub-Arctic forest.—*a. Bears.*—The sub-Arctic forest is the home of three kinds of bears. The Alaska brown bear may weigh as much as 1,500 pounds and is the largest carnivorous animal in the world. It is found only in the coastal region of Alaska and nearby islands. The grizzly bear ranges farther east to Great Slave Lake, Great Bear Lake, and the Arctic tundra. The black bear is more restricted to wooded country but does reach the Arctic at the mouth of the Mackenzie River. All these bears hibernate. They live largely on small game such as rodents, and in summer on salmon and berries.

b. Canada lynx.—On the northern fringe of the forest this large cat lives chiefly on rabbits, but in the south it may kill deer as well.

c. Wolverine.—This large weasel is sometimes called "the glutton," because of its habit of robbing traps and food stores (caches). It is usually found in the woods and also ranges out on the tundra.

d. Snowshoe rabbit.—Brownish-gray in summer, this rabbit changes to pure white with black ear tips in winter. During the cold season it follows hard-beaten runways in the spruce woods, where it can be snared easily.

e. Marmot.—The hoary marmot or mountain whistler is a good-sized, woodchucklike animal. It lives along the edges of meadowlands near the tree limit in the sub-Arctic Rocky Mountains, and in the mountains of Alaska. It is strictly neither an Arctic nor a forest animal but is typical of subalpine areas in the west. It utters a shrill whistle when alarmed, whence the name "mountain whistler."

f. Porcupine.—This is a true forest animal, becoming rare near the northern forest edge. "Quill pigs" do not hibernate but subsist in winter on the bark of trees. Near their rocky dens their presence is shown by the gnawed places on trees, which they sometimes completely strip of bark to the smallest twig. Buds and twigs also are consumed. Porcupines are generally found in trees, and in spring they are seen swaying in the tops of aspens.

68. Birds.—The Arctic islands are the nesting places of large numbers of migratory game birds such as geese, ducks, and swans; also terns, gulls, and similar shore birds. Inland lakes teem with loons and ducks, while the island cliffs are the homes of puffins, dovekies (little auks), and murres. Guillemots are medium-sized black and white birds. Snowy owls and other birds of prey inhabit the sub-Arctic forest and the nearby tundra, where they live on mice and other rodents. Ptarmigan are Arctic grouse which turn pure white

in winter save for black tail feathers that show only in flight. In summer their plumage is mottled and barred gray to match their surroundings.

69. Fish.—Fish are one of the chief foods in the Arctic. The Arctic and sub-Arctic peoples, whether they be Greenland Eskimos, Labrador fishermen, or Alaskan salmon canners, depend for much of their livelihood on fish. Salmon, cod, and other salt water fish are found in the bays and fiords. Salmon swim up the Alaskan rivers to spawn and during the spawning season may easily be caught in the shallow water. Cod are especially numerous off the coasts of Greenland and Labrador in summer. Smaller fish include several kinds of herring, suckers, a kind of whitefish, flounder, sculpins, and ling. Fresh water lakes and rivers the year around have fish—lake trout, salmon, trout, connies, Arctic grayling, and pike.

70. Insects.—Insect life in the Arctic is less varied than in temperate and tropic regions, but during the brief summer of long days and nearly continuous sunlight some kinds of flies and mosquitoes are present in hordes. Insects found in one part of the Arctic are very similar to those found in another part. Butterflies, bees, and mosquitoes extend as far north as the northernmost land. Dragonflies are not found north of the tree limit.

Section III

HUMAN POPULATION AND SETTLEMENTS

71. Sparse population.—The Arctic and sub-Arctic regions are sparsely populated. The native population consists of Eskimos and Indians. Within the Arctic region (fig. 1) there are about 17,000 Eskimos in Greenland, 9,000 in Arctic Canada and Labrador, and 4,000 in Arctic Alaska. In addition to this total of 30,000 Eskimos, there are a very few Indians in the Arctic region. In sub-Arctic Alaska there are 11,000 Eskimos and 18,000 Indians and Aleuts. In sub-Arctic Canada there are 73,000 Indians, making a total of about 102,000 natives in sub-Arctic North America. The grand total of native population in Arctic and sub-Arctic North America is thus about 132,000.

72. Seasonal distribution of population.—*a.* Many of the natives are nomads. They move from place to place in search of food and furs. Since these people depend primarily on animals for their

very existence, and only secondarily on plants, they move with the seasonal migrations of animals which themselves are moving in search of food. Exceptions are the Eskimos of the west coast of Greenland, who maintain fixed winter settlements and disperse only for hunting in summer.

b. With the coming of warm weather the Eskimos of the Canadian Arctic shores move inland to hunt caribou in their summer feeding grounds and to get timber for tent poles and spears. Others seek salmon streams or the breeding grounds of ducks and geese. But hunting on land is secondary. In the North American Arctic, man is predominantly an island and coastal dweller.

73. Uninhabited areas.—Many parts of the Arctic, and even the sub-Arctic wooded country, are almost uninhabited and are rarely visited even by hunters. Such areas include the interior of the vast Quebec Peninsula between Hudson Bay and the Atlantic Ocean, much of the interior of the Keewatin district northwest of Hudson Bay, the western part of Baffin Island, and the islands directly north of Victoria Island and Banks Island. In Greenland the east and north coasts are uninhabited, as, of course, is the ice-covered interior.

74. Settlements.—Not many communities in the Arctic (except certain mining centers) have more than a few hundred inhabitants each. Most of the settlements are situated on large lakes or bays or at the mouths of rivers. The reason for this is that the Arctic has lacked roads, railroads and, until recently, airfields, so that the chief means of travel and transport has been by boat. Hence, because most of the population subsists by fishing, sealing, whaling, and fur trading, the sea, in contrast with the barren tundra away from the shore, offers a livelihood. Moreover, trapping and hunting are often best near lakes and rivers. In consequence, if you are stranded in the Arctic, follow large streams and shores as the best paths to the nearest settlements (par. 203).

PART TWO

LIVING IN THE ARCTIC

CHAPTER 1

HABITABILITY

75. The Arctic a hospitable region.—*a.* The Arctic region is neither forbidding nor inhospitable. Because of the exaggerated stories of some explorers, it has acquired in the minds of many people a wholly undeserved reputation for unlivability. White men settled in the Arctic 500 years before the time of Columbus. And continuously during the last 275 years, resident managers of the Hudson's Bay Company have lived in contentment at permanent posts, many of which are in isolated places. As for the native peoples, scattered evidence suggests that they may have made their first appearance in the North American Arctic as long ago as 20,000 or 25,000 B. C. At present the Eskimos are perfectly happy without most of the articles that are considered essential to civilized existence. These people are not an inferior race. Within the limits of their resources they have learned to live in the Arctic more successfully than many so-called civilized peoples in less rigorous climates. Hundreds of white men—trappers, miners, and missionaries—have spent their lifetimes there. They have learned to know the North, to live comfortably in it, and to love it. To be sure, permanent settlement is small, but it has been limited not so much by climate as by lack of natural resources and inadequate communication with the rest of the world.

b. These facts should not be interpreted to mean that anyone can live anywhere in the North without forethought, skill, and endurance. The Arctic imposes its own natural rules and regulations on its inhabitants, and the secret of success in living there lies in working *with* rather than *against* nature. The main purpose of this manual is to acquaint those men going to the Arctic with some of the rules, and to help them learn to live in harmony with the Arctic environment.

CHAPTER 2

SHELTER, HEAT, AND LIGHT

SECTION I

SHELTER

76. General.—*a.* In cold countries people too often have a tendency to seal up buildings overtight, with the mistaken idea that thus they keep out the cold. Actually, the temperature within a building depends largely on insulation. Besides, hermetically closed buildings exclude fresh air and are therefore unhealthful.

b. For two reasons ventilation is essential. One is that if the moisture in a building is not allowed to escape it may condense inside. Your quarters should have a vent near the top to insure the outflow of enough moist air to minimize condensation and the accumulation of hoarfrost. The most primitive northern races—such as Indians, Eskimos, and Lapps—recognize the need for such a vent. The white man is the worst offender in seeking to hide from the cold in airtight lumber camps, trapper shacks, and Arctic huts.

c. The second and main reason for proper ventilation is that a continuous supply of fresh air is necessary for healthful living. The incomplete combustion of fuels used for cooking and heating results in the accumulation of carbon monoxide gas. This gas is a deadly poison and is particularly dangerous in that it is odorless. One may be overcome by it quite without warning—awake or asleep. Take every care, therefore, to see that shelters containing lamps or stoves have steady ventilation. Especially avoid sites in which your hut or tent might be buried by snowdrifts.

77. Choosing location.—Selection of the site for even a temporary bivouac for the night deserves careful thought. Dryness is usually the first requirement. If near the seacoast, be sure your camp is above high tide. Ice may be forced inland far above high tide at some seasons; and even on inland lakes in the spring, ice may be forced up over a beach. An exposed site is preferable to one likely to be inundated or covered by drifting snow. In stormy weather you may be tempted to seek lee positions at the bases of cliffs or cut banks. This, however, is not advisable in the Arctic; drifting snow may bury your tent. If you do decide to take shelter in the lee, remember the danger. In the sub-Arctic forests, drifting snow is less common and, here, camping in the lee is general practice. Always avoid camping under snow cornices (overhanging shelves of consolidated snow), also, actively building snowdrifts, and the bases of slopes subject to avalanching.

78. Temporary shelters.—*a. General.*—Anything that can be thrown together from wrecked airplanes or boats can be used for temporary shelter. An ingenious person will use the material at hand to best advantage if he understands the type of protection required. Soaking rains are less to be feared than cold winds. Protection from the wind is important in winter as well as in summer, and protection from rain is particularly necessary in late summer and autumn.

b. Tents.—Special tents designed for Arctic and mountain conditions have been developed and tested, and improvements are constantly being made. A person forced down in the Arctic will have to make imaginative use of whatever fabric can be found. For instance a tent can be improvised from a parachute. If the tent is pitched where snow may drift, the tent opening should be sideways to the wind rather than in the lee, to prevent its being blocked by snow. Likewise, articles of equipment should not be left in the lee of a tent or snow house, lest they be buried. Put them in your quarters or in places where snow will not accumulate. If tent pegs are lacking or cannot be driven, the edges of the tent may be weighted down with stones or lumps of ice. Another method of anchoring tents pitched on ice is to run the guy rope through a small U-shaped tunnel in the ice, known as an ice anchor (fig. 4). To make the ice anchor, chisel two holes about 6 inches apart, working down at an angle so that the holes meet a few inches below the surface. As you chisel, enlarge the holes at their outward edges till it is possible to use your implement almost flat in chopping out the underground connection. The tunnel should lie at right angles to the length of the rope.

c. Windbreaks.—Camp must often be made on open snow plains exposed to drifting snow. Without some windbreak, pitching tents

or heating and cooking can be difficult. If compacted windblown snow is at hand, a curved wall of snow blocks should be built immediately. Erect it to windward of the tent and as close to it as you can work. Even a comparatively low wall is of great aid in protecting the base of a tent from driving wind. Level the snow in the cavity resulting from the removal of snow blocks and pitch the tent in it. Often it may be desirable to build a wall more or less completely around the tent. Keep the wall within 10 feet of the tent, so that drifting snow cannot bury the tent completely and thus cut off ventilation. Should water be available and the weather very cold, add water to the snow wall to improve its resistance to wind abrasion. If there is no snow, cakes of ice, rocks, or sod may be used for building a windbreak.

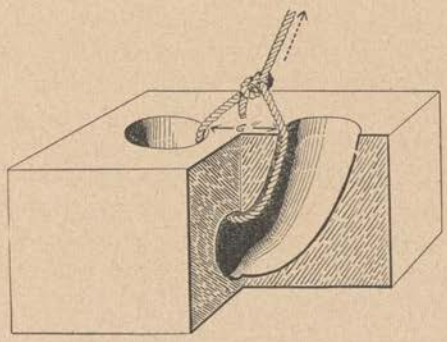


FIGURE 4.—Ice anchor.

d. Snow houses.—(1) Detailed directions for constructing snow houses are given in FM 31–15. Snow conditions are not always favorable for constructing elaborate houses of this kind, nor are saws or knives for cutting blocks always available. A party faced with the necessity of getting under cover quickly may do better to make a snow cave by burrowing into a substantial drift. Or, if you are on a flat plain, dig down into the snow and make a roof of any handy material, such as pieces of crust or thin ice. (Do not lie directly on snow, however, for the snow melted by your body heat will wet your clothes and destroy their insulating properties.) Either of these measures is preferable to the risk of prolonged exposure that is involved in seeking just the right material for a snow house. With a book of instructions you should be able to build a domed snow house on the first try.

(2) Even without instructions it is easy. Here are the essential rules:

(*a*) Construct the snow house on a drift 4 or 5 feet deep that has formed during one storm.

(*b*) Build down into the drift as well as up. That is, cut your blocks from within a circle over which the finished structure will stand, and work from inside.

(*c*) With a snow knife, big bread knife, or saw, cut blocks about 2 feet long, 1 foot high, and 8 to 10 inches thick.

(*d*) Fit the blocks together by trimming off projections with the knife as you proceed. As they rise, the walls should lean in considerably.

(*e*) The entrance and the final keystone block at the top of the house are tricky—here you will have to learn from experience.

(3) Little experience is required to make a shelter of snowblock walls with a tarpaulin roof weighted down by snowblocks. If you do not have a tarpaulin, lean snowblocks against each other to form a peaked roof. The latter type of shelter necessarily is low and narrow; as a rule it is large enough for only one person.

e. Snowholes.—Recently parties needing emergency shelter on snowfields and on the Greenland ice cap have been successful in digging caves and tunnels in the snow. Whereas these "snowholes" have not been thoroughly tested out, they are said to require less skill and effort in construction and to be more weatherproof than snow houses. In snowdrifts, a shovel will do the job; in old compacted snow, an ax and a heavy saw are necessary. An easy method of construction is to dig a 3- by 8-foot opening that extends 10 feet vertically downward into the snow. This opening is then continued as a horizontal tunnel. The first blocks removed from the tunnel are used to build temporary steps up which the remaining spoil can be carried. The tunnel is wide at the floor and narrows upward to a rounded top to avoid drips. From this main corridor short side tunnels are dug to make one-man sleeping rooms, a cooking room and a latrine. The entrance is covered with a tarpaulin or other available fabric. Every few days all interior surfaces are shaved clean and the spoil thrown out. The floor is provided with duckboards made from ration boxes or other improvised materials. A snowhole of this design can be made to accommodate any number of persons and is said be light, clean, and secure.

79. Permanent shelters.—*a. General.*—If you appear to be in for a long stay in the Arctic you will want as much protection and comfort as you can get.

b. Materials available on the site.—You can make a shelter of stones, chinking the cracks with mud or moss. Or you can stack sods brick fashion in vertical walls. If wood is available as well as sods, you can

build a Lapland tepee. Stack the poles as for a tepee and, using them as a frame, build sods around them. Then lay more poles, stones, or brush against the sods to prevent the wind from displacing them. Be sure to leave an opening at the top so that smoke can escape from your house. If the ground is not frozen, excavate the floor below ground level as deep as possible while yet permitting good drainage. If the ground is frozen it need not be excavated but must be insulated to prevent thaw after the shelter has been built. In timbered country a log cabin makes a fine shelter. At the onset of winter insulate the cabin by placing grass or rushes against the outside walls, holding them in place by banking them with earth or snow.

c. Combating cold floors.—Whatever kind of shelter you build, it should have a raised platform of some kind for keeping your feet off the cold ground. For sleeping, benches or wide shelves well above the ground should be provided. Cover these with dry grass, boughs, or some other insulating material before you place sleeping bags on them.

d. Imported materials.—Prefabricated huts made of lumber, plywood, or insulating board are now in use. For these, shredded asbestos and rock wool are excellent insulating material. Cabot insulation, made of seaweed stitched between layers of impervious paper, has long been a favorate insulator. In any case, windows with double layers of glass separated by an air space are indispensable.

80. Shelter in wooded areas.—In addition to all the resources available in treeless wastes, wooded areas provide timber, poles, brush, and evergreen boughs; also wood for fuel. Moreover, the standing forest or bush gives protection from bitter winds. A lean-to shelter is easy to construct. Support a pole between two trees at a height of 4 to 6 feet from the ground by resting it on branches or by binding it to the trees with a rope, thong, or even tough bushes or spruce roots. Next, lean poles against this ridge pole, close together and slanting gently down to the ground. Leave short branch stubs on the upper sides of the poles to assist in holding the boughs which are laid on next as a thatch. Turn the boughs downward like shingles. Start at the bottom and work up, so that the upper boughs overlap the ones below. If snow is available, pack a layer of it on the boughs to make the roof tight against the wind. If you expect to have a considerable fire in front of the lean-to, omit the snow, otherwise it will melt and drip down inside. Close the ends of the lean-to with more poles and boughs. The front opening should face away from the wind. Facing the opening sideways, as explained in paragraph 78*b*, in this case is unnecessary because the surrounding trees will prevent drifting of snow.

If the trees are too scattered to provide support for the ridge pole, cut partly through a single tree a few feet above the ground and push it over. The branches will hold it in a more or less horizontal position and will provide the framework for a fair shelter. If you have no ax you can break off small dead trees to make a framework. A wall of green logs behind your fire will reflect heat toward the lean-to. Before spreading out your bedding, sweep the ground clear of snow both inside the lean-to and where the fire is to be built outside, and place a layer of boughs, moss, or other soft dry stuff on the ground to make a comfortable floor.

81. Warming up the ground.—Winter campers in places where the ground is not frozen sometimes prepare to bed down for the night by building a small fire on the area where they are going to sleep. When the ground has been well dried out and scorched, the fire is tramped out, and green boughs are spread over the smoking moss, but care should be taken that no live coals remain. Bedding is then spread on the boughs.

82. Heating closed tent.—You cannot build a fire in a small tent without a stove and stovepipe. Here is the place for the gasoline stove, and make sure that the tent is well ventilated. If you have no stove, a large candle will give a surprising amount of heat. Or you can warm the tent by heating stones in a fire outside and placing them in a tin can which is then brought into the tent and set down on a couple of sticks to keep it from contact with the ground cloth. Water dripped on the hot stones will give the equivalent of the steam bath long used by the Finns and by Indians too.

83. Sleeping in the Arctic summer.—Newcomers to the land of the midnight sun tend to go easy on sleep, just because the light makes activity possible all around the clock. This is a mistake. It is essential to conserve strength and prevent fatigue by getting a normal amount of rest through following a normal daily routine. This often involves darkening your sleeping quarters at "night," bandaging your eyes with a dark mask, or wearing sun goggles with pieces of dark paper inserted in them. To sleep during daylight hours and travel at night (or what passes for night at this season) may mean carrying fewer bedclothes and therefore a lighter load.

84. Bathing.—In very cold weather, frequency of bathing should depend upon how much you exercise and how much you perspire. If your skin goes too long unwashed your clothing will become soiled and you will run the risk of skin infections. In quarters where water can be heated, a sponge bath is usually possible. Ponds and streams are commonly useless for bathing because as soon as they have thawed in spring they are infested with numerous mosquitoes.

SECTION II

FUEL AND HEATING

85. General.—*a. Special difficulties.*—Heat for cooking and warming of buildings and shelters in the Arctic presents certain special difficulties beyond the mere combating of low temperatures. One difficulty is the lack of materials for constructing stoves and fireplaces. Another is the comparative lack of fuels.

b. Importance of fuel economy.—In the Arctic, fuel of any kind is scarce. Use it sparingly. Do not burn it to melt ice and snow for water if you can avoid doing so. If fresh water is unobtainable, place a few small pieces of ice on a dark object (such as a rock) exposed to the sun. As the ice melts catch the dripping water in a container. In cooking, use fuel sparingly too.

c. Kindling.—Pick up kindling and fuel wherever you can find them along the trail, even if you do not expect to make camp for hours. Birch bark, dry lichens, driftwood, resinous shrubs, or even bits of fat (but compare par. 86*c*), feathers, or greasy rags should be gathered against the possibility of a kindling shortage at the camp site. Good kindling includes anything that burns easily, especially light weight materials that can be lighted with a match directly and that will furnish heat enough to ignite the larger pieces of wood, coal, or fat that constitute the principal fuel. Tufts of dry grass, sedges, and black, dry lichen ("old man's beard" moss) that covers the twigs of black spruce and tamarack, can be touched off with a match. To be sure of kindling carry with you a piece of camphor gum, solid alcohol, or a candle. As soon as it has served its purpose blow it out, retrieve it, and save it for the next time.

86. Local fuels.—*a. Coal.*—Outcrops of coal at the surface of the ground or lumps of coal washed up on beaches may be found in some places. The coal, commonly of a soft variety, produces a black smoke and an odor like asphalt. Keep the smoke and soot away from clothing and tentage. It may be hard to ignite this coal directly. Therefore, use whatever kindling is available—wood, fat, or pitch. Start with a very small fire (2 to 4 inches in diameter) and enlarge it only

when the coal is burning thoroughly. If kindling is scarce, you may find it advisable to keep the fire burning all night.

b. Wood.—Even in the Far North you will find some clumps of low-growing willows or birch. These can be split up into fine pieces and burned green. At high altitudes and in the Far North birch is quite oily and, if split fine, will burn even when wet. In addition to standing timber there are limited sources of dead wood. In some places you can find driftwood along the seashore where it has been cast up by storms, or in the slack waters of river mouths. Driftwood is found even on treeless Arctic shores because it is a great traveler. A piece may have traveled hundreds or even thousands of miles before you pick it up. Because of the prevailing winds it is more common on beaches facing west than on those facing east. Inland lake shores have such flotsam only if trees grow along the lake or its inlets. Select pieces that are highest above the water, where the oldest and driest driftwood is likely to be. "High and dry" is a good guide here. The wetter the wood, the finer it must be split or whittled before it can be lighted. If no hatchet or knife is at hand, break up the wood by pounding it on stones.

c. Animal fats.—If you are in any danger of running short of food, do not use as fuel anything that can be eaten. You get more heat value from food eaten (raw, if necessary) than from food burned. Similarly, clothes worn on your back are a source of greater continued warmth than the same clothes used as fuel. If you have plenty to eat, you can use animal fats as fuel or as kindling to start other fuels. A piece of ½-inch board 3 inches wide and 18 inches long, whittled or split and burned with ¼ pound of caribou suet, will cook enough meat to last three men all day. Start the fat with wood. The fat makes the wood go farther and last longer, just as you can make a match burn many times longer by rubbing wax or grease on the stick below the head. Blubber or fat from many kinds of animals and birds can be burned provided the oil has been extracted from the animal tissue, otherwise the fire will sputter and fly. If wood is not available, pile up bones (or prepare some other kind of open framework) and place a few strips of blubber on top. The fat will melt and trickle down over the bones if a small flame is introduced at the bottom; a grease-soaked rag, perhaps no more than an inch square, will make the right kind of flame. When this oily film is ignited, a hot blaze flares up. The blaze will continue as long as blubber or other fat is supplied at the top. Such a fire gives off thick smoke which leaves a gummy deposit; the smoke therefore should be diverted.

d. Miscellaneous fuels.—If you can find neither wood nor coal and do not succeed in burning animal fats or oils, there are still other sub-

stances in the Arctic that can be used for fuel. Lichens have furnished fuel to parties for an entire winter. Dry and crisp reindeer lichen (par. 145) can be found on many ridge tops and on ground blown free of snow. Rock tripe (par. 145) is found on numerous dry overhanging ledges. Many low shrubs and willows can be burned, roots and all. The widespread Arctic white heather (fig. 5) has a resinous woody stem and is the Arctic's most important emergency fuel. Kindle a little at a time, adding more only as the fire blazes up. Break the stems up into short pieces, and pile them close enough so that the flame can pass easily from one to the other. Peat, the decayed remnants of these plants, also will burn when it is dry enough. In some areas thick

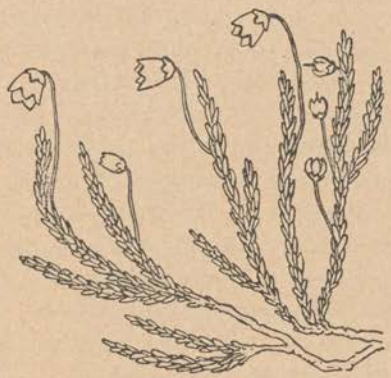


FIGURE 5.—White heather (*cassiope tetragona*). Height 4 to 12 inches.

peat deposits are exposed along river banks and lake shores. If dry, the older, well decomposed peat will burn best. It should be torn into small strips and burned with sticks or other fuel; otherwise it may become only a smudge. Although hardly ideal, even animal dung, a common fuel in Mongolia and interior China, can be used when nothing else is obtainable.

87. Fuel in sub-Arctic forest.—*a.* Most sub-Arctic lands are timbered, hence fuel in these regions usually will be wood. Wood is a much more satisfactory fuel than oil or coal. The driest wood is found in dead standing trees. In living trees the branches above snow level are driest. Branches from which the bark has fallen are drier than those covered with bark and lichens. Break the branches up into fine pieces and lay them compactly, leaving only a small hole for the draft. If too loosely laid, the fire will soon burn out. In snow or rain, start with a small fire, putting larger pieces on only when there is heat enough to ignite them. After a fire is well started, green birch and alder will burn well, especially if split. Tamarack also is good. Spruce and

fir are the poorest green fuels. Cedar, if obtainable, is the best kindling. Driftwood is excellent because the bark has been rubbed off.

b. If you must build a fire on the snow, lay a floor of logs first; otherwise your fire will melt a hole, fall down, and go out or be put out by meltwater. If you are on high land and the forest litter is dry, lay your fire on a floor of green logs; otherwise you may start a ground fire that will be hard to put out. Such fires have burned for years in muskegs. In any case, before leaving the camp site, always put your fire completely out.

88. Methods of heating.—*a. General.*—Imported stoves and fuels such as kerosene and gasoline are superior in every way to improvised heaters and fuels. However, here are some on-the-spot methods of heating when emergencies arise and ordinary means are lacking.

b. Stoves and fireplaces.—A fireplace will heat a room, but a stove will do it much more efficiently. You can make a usable stove out of an oil drum or a large can. Or you can bend metal parts of crashed planes into a boxlike shape and create a workable stove. If you are clever you can even make a stovepipe. Plug the cracks with mud. To form a base for the stove, pile stones and earth along its sides. Also, smooth stones heated near the fire may be useful for drying or warming clothes. Be sure to wrap the stones with moss or similar stuff before you use them so they cannot burn you or scorch your clothes. If you are near the coast, do not admit that you lack metal until you have searched the beaches. But if all sources fail, you can still make a reasonably good stove and chimney with flat stones. Another possibility is an open fire with retaining walls of earth or sod. Place it so that smoke can escape easily at the top of the shelter. If a continuous fire draws in too much cold air and fails to keep you warm, try this method: make a stone fireplace in the middle of your shelter and three times a day (at cooking times) make a roaring fire, having both roof vent and door open. When the fire has burned down to coals, shovel the embers outdoors and close the vent and door. The hot stones will keep your shelter warn until time to build your next fire. In all fires, even with ready-made kerosene stoves, be sure that proper ventilation is provided and that there is adequate intake of air at the bottom. Carbon monoxide poisoning (pars. 195 to 198, incl.) is a very real danger with indoor fires. The danger is intensified by the usually poor combustion of low grade fuels in makeshift burners.

89. Emergency methods of fire making.—*a. General.*—Have plenty of matches on hand and keep them dry. Matches with parafined sticks burn a long time and are very useful. Water proof the heads as well with paraffin; before striking a match, remove the wax with a thumbnail. Cigarette lighters also are useful. In addition,

carry a small bit of camphor gum, "meta" (solid alcohol), or a candle to serve as kindling. However, if you lack both matches and a lighter you can still have a fire by using one of the following methods:

b. Preparation of tinder.—Before attempting to strike a light and kindle a fire first, prepare some tinder. (Tinder is any dry stuff that will smoulder when ignited.) It must be *bone dry.* Finely shredded cloth, especially scorched linen, or any kind of fabric can be used. Also useful are rotten wood (especially cedar), pussy willow fuz, cotton grass, or the central parts (pith) of dry stalks and tree branches. You can dry such material by exposing it to the sun and wind, but take care that it does not blow away. When dry, tinder should be stored in a tight box or waterproof paper. For starting a fire, a pile about 4 inches square is necessary.

c. Lighting fire.—(1) *Stone or steel.*—Flint, chert, and pieces of steel are good spark makers. Strike two pieces together to produce sparks and direct the sparks onto the tinder to start it smouldering. If the weather is very cold, wrap the pieces with leather or tape to provide a better grip and, more important, to keep your hands from freezing to them. When the tinder begins to smoulder, fan it gently until it bursts into flame. In very cold weather, do not blow on it with your mouth as the condensation of moisture from your breath may put out the fire. When the tinder is in flames, place it under a small pile of kindling.

(2) *Burning glass.*—Any magnifying glass can be used to focus the sun's rays on a small spot in the pile of tinder, if you have a glass and if the sun is shining. In an emergency the lenses from a camera or binocular can be used, or you can improvise a lens from a bit of broken bottle.

d. Making a fire in the wind.—To protect a fire from the wind, build it in a hole dug in the ground or in a fireplace of stones or sods. Cooking fires built in a hole in the ground are especially effective because all their heat is conserved and directed upward against the bottom of the pot. The shorter you are of fuel, the more precautions you must take to avoid wasting heat.

90. Fire prevention.—*a.* Many permanent shelters for Arctic troops have been destroyed by fire because of carelessness in handling stoves and in the disposal of lighted material. It is obvious that many emergency insulating materials (such as dry grass) are serious fire hazards, though useful in temporary and improvised shelters. If stoves and stovepipes have been improvised, be sure that no wood or cloth is in contact with the pipe where it goes through the roof. Should you lack tin or asbestos insulation, leave a 1-inch space around the pipe. Keep grass and other litter away from the stove or fire-

place. If you are using animal fat or pitchy fuel that sputters and throws sparks, be especially careful. The same holds for matches and cigarettes—be careful with them.

b. Lamps, candles, and other lights must be hung with plenty of protective space between their flames and the ceiling. Remember to test occasionally the roof above any flame to make sure it is not getting too hot. Hot air goes straight up, and a spot at a surprising height above the flame sometimes becomes intensely hot. If a candle or lamp close to the ceiling is necessary, put a protective guard above the flame, for instance, a piece of fireproof material suspended 1 or 2 inches below the roof.

c. Gasoline and kerosene should be stored at some distance from your living quarters. Never fill a gasoline stove while an unprotected flame is burning in the room.

d. Means for extinguishing fires should be at hand. In the absence of chemical extinguishers, keep one or two buckets of sand in your quarters. It is safer to use on an oil or fat fire than is water. Be sure it is dry, for wet sand is likely to freeze solid.

91. Caution about airplane gasoline.—One-hundred-octane gasoline is highly volatile. It is unsafe to burn in ordinary stoves or lamps, and only extremely small quantities of it should be used for kindling fires. Do not burn 100-octane gasoline except in the one-burner M1942 and M1943 gasoline cooking stove, which has been specifically adapted to its use. Even in this stove it fouls the burners, which must be replaced after 40 to 75 hours' use.

CHAPTER 3

FOOD AND WATER

SECTION I

SELECTING FOOD

92. General.—There is no essential difference between nutrition in the Arctic and nutrition anywhere else in the world. Every sound thing you learned about food at home pertains to food in the Arctic. You need food for maintaining your body and for producing energy. In the Arctic, food problems consist largely of supply and proper care.

93. A few reminders on your diet.—*a.* Food is needed for *maintenance* of the body and for *fuel.* The kinds and amount of food needed for maintenance are the same in the Arctic as anywhere else, but the amount of food needed for energy will depend upon how much work you do and whether you spend most of your time indoors at a desk or outdoors in cold weather.

b. A simple plan for meeting food requirements follows. If you eat according to this plan you are assured an adequate diet. Should you modify the diet because of necessity or because you do not like some particular food, select alternatives with the same food value. You need not eat every "essential" food every day; if you do not have meat one day, you can easily make it up the next. Also, if you are living at an established Army post you need give little thought to your diet—Army dietitians have worked out the details for you.

(1) *Milk.*—One pint or more daily. Evaporated or powdered milk is just as good as fresh milk.

(2) *Eggs.*—One or two per day. Dehydrated eggs are as good as fresh eggs.

(3) *Meat.*—One serving per day, preferably with some fat. Liver and fish at least once a week. If meat is scarce, eat an equivalent amount of similar foods such as fish, liver, eggs, or beans.

(4) *Vegetables.*—One or more yellow or leafy green vegetables lightly cooked, or raw in salads, at least once a day. Frozen or dehydrated spinach, carrots, peas, and other vegetables are as good as fresh vegetables provided they have been processed to retain most of their vitamin content.

(5) *Fruits.*—One or more servings daily, either raw or cooked. Citrus fruits and other fruits high in vitamin C (antiscurvy vitamin) are very important. Dried fruit and some fresh fruits furnish little vitamin C but may be of value in the diet as sources of other vitamins, minerals, energy, and roughage.

(6) *Remainder of diet.*—Having satisfied the requirements in (1) to (5) above, fill up according to the dictates of your appetite on additional energy yielding foods—potatoes, beans, cereals, breads (preferably made with enriched flour), fats (preferably butter), and sweets. Do not be surprised at the size of your helpings—you need plenty of calories for hard work at low temperatures.

(7) *Vitamins.*—By eating a diet of good quality foods based on the plan given, you will have plenty of vitamins. Eating additional vitamins will not improve your efficiency. However, if there is real doubt about the quality and vitamin content of the foods available and you must live on such foods for several months, supplement your diet with vitamin concentrates.

c. With a diet having a full quota and proper balance of carbohydrates, fats, proteins, salts, vitamins, and water you will be able to perform at maximum efficiency, but such a diet does not guarantee you abundant energy. The amount of work you get done on this diet will depend on your morale. If your efficiency seems to be slipping, it is probably your morale and not your diet that needs attention.

94. Food in winter.—In very cold weather and in isolated Arctic stations try to avoid monotony of diet. If you have to eat the same things day after day you are likely to lose your appetite, and inefficiency may result simply because you do not eat enough. Of course, when there is plenty of outdoor work to do, your appetite will be good and you will eat enough food to take care of your bodily needs.

95. Native foods at small stations.—At large bases it is not practicable to use native foods, except possibly fish, because the supply of native foods usually is limited. At small stations, however, you can hunt animals and catch fish to add variety to your menu. Details are given in chapter 5, part two.

SECTION II

CARE OF FOOD

96. Summer refrigeration.—*a.* Even in the Arctic, refrigeration of some sort is required during the summer to keep foods fresh. If you have no artificial refrigeration system, there are ways of developing natural ones. In many regions the period of high temperature is limited to a few hours in the afternoon. If night temperatures are low, you can ventilate the house in which your food is stored by opening it during the night and closing it during the day. If you are on the coast, icebergs or pieces of last year's sea ice may be left high and dry on your doorstep when the tide goes out. (This is a fine source of ice for ice water or for making ice cream.) Such ice will not be present all the time, so store up a supply in an improvised ice house. If all the snow and ice in your locality are likely to disappear during the summer, cut ice from a lake, river, or fiord during the winter and store it in an ice house. (Fiord ice tastes salty but is satisfactory for refrigeration.) To insulate the ice house, bury it or build it with double walls. Pack the ice in excelsior, peat moss, or similar material.

b. In many localities you can keep a small storehouse cool by circulating through it the water of a cold stream. Or attach a steel drum to a wooden platform and float this rig in the water offshore. The cold sea water will keep cool any food stored in the drum. One of your biggest problems will be to prevent repeated freezing and thawing of food, because such treatment may damage some of it.

c. The chill of the frozen ground itself is an excellent cold storage agent. If the ground consists of frozen soil and not rock, you can dig a hole (with a pickax—a shovel will not do the job) which in itself will be a fine icebox.

97. Winter procedure.—*a.* In winter, in places where regular facilities for storing food are lacking, the simplest way to preserve perishable foods is to allow them to freeze. Only as much food as is needed at a single meal is brought into the kitchen and thawed out for cooking. Frozen meat thawed and refrozen two or three times is quite tasteless and watery. Fresh fruits, vegetables, and eggs can be kept frozen and in fairly good condition all winter, but they will deteriorate if they are allowed to thaw and freeze repeatedly.

b. Most canned foods can be frozen without loss of food value, though the flavor of some products may be affected. Occasionally a can may burst in freezing. In such cases the food may be spoiled and should not be eaten unless it is certain that the food has remained con-

tinuously frozen (without thawing and refreezing). Take care to keep salt water and salt spray away from cans as even the salt present in the air at beach sites will cause rusting. Rusting weakens cans so that if frozen they are more likely to burst. Freezing does not harm powdered or evaporated milk. Evaporated milk that has been frozen curdles when added to coffee or tea, but it can be used for cooking. Cheese may lose some flavor with freezing but dehydrated cheese is not affected. Bottled fluids such as ketchup expand as they freeze and may break their containers. When frozen, home-baked bread keeps amazingly fresh. Cool the loaves first to allow the steam to escape, then wrap them individually in paper and set them out at once to freeze. Thaw a loaf only as you need it. If the thawing is done quickly in the oven, the thawed loaf is as good as fresh bread. A good storage place for canned goods can be made inside buildings by laying boards across the rafters, but do not use such storage unless the rafter area is cool. If your house has a low foundation tightly boarded in, a cellar only a few inches deep will maintain a temperature above that of an unheated building and can be used as a storeroom. All food, canned or otherwise, should be stored on a raised floor or platform to prevent its freezing to the ground in case the ground becomes wet.

Section III

COOKING

98. Hints for the kitchen.—If you know that you are going to be at a small outpost and will have to do your own cooking, it will be wise to take along a cook book. Here are a few extra hints.

a. Thaw out frozen meat before cooking. Partly frozen meat may cook on the outside while the center remains raw.

b. Cook vegetables only until they are tender. Further cooking reduces their vitamin content. Cook vegetables in the smallest possible amount of water; this improves the flavor and prevents extensive loss of vitamins. You need not completely thaw out fresh vegetables; simply drop the small frozen pieces into boiling water.

c. Soak dried fruit overnight in cold water, then simmer slowly in the same water until tender. Sweeten to taste.

d. All meats should be heated sufficiently to kill parasites. In cases of urgent necessity, of course, you will eat raw meat (parasites and all) rather than starve to death.

e. Canned foods are cooked and require little heat to make them edible. Do not waste fuel by overcooking them. The juices in canned

vegetables are tasty, and contain vitamins and minerals. Drinking them will conserve your water supply and your fuel supply, too, if you depend upon melting ice as your source of drinking water.

f. Frozen potatoes are hard to peel. Dip them in hot water, scrape off the skins, and before they have thawed, drop them into boiling water—one by one so the water will keep boiling. Whenever possible, cut up the potatoes to shorten cooking time.

g. Thaw out frozen oranges and apples in cold rather than hot water; this helps to preserve good flavor.

Section IV

TRAIL RATIONS

99. Selecting supplies.—*a.* When you take to the winter trail in the Arctic you do so not for the sport of it but for the accomplishment of a definite mission. Consequently you expect to leave the comforts of a permanent camp behind. You will want food that yields the most energy per pound. But you should not complain if your diet is low in variety. The more quickly and easily your trail food can be prepared, the better you will like it.

b. Explorers generally agree that for the Arctic trail the ration should contain concentrated foods such as pemmican, biscuits, oatmeal, chocolate, dried fruits, sugar, and tea.

(1) Pemmican is a mixture of dried meat and fat. Many formulas have been used, and each explorer likes his pemmican made a slightly different way. At present no commercial pemmican is available, but the Army is experimenting with several formulas. If you plan a trip on which you must travel light, it will be well to try home-made pemmican as part of your ration.

(2) You can make pemmican essentially as the northern Indians made it. Dry thin strips of very lean meat slowly before a low fire. Pound the dry meat thoroughly into fine shreds and put them into pans. Melt hard fat and pour it over the meat in the proportion by weight of one part of fat to one part of meat. Mix thoroughly and allow to cool. Cut into bars 3 or 4 ounces in weight.

(3) An easier way to make a somewhat more palatable pemmican is to grind together 16 parts of beef and 3 parts of hard fat (suet or tallow). Heat the mixture in a pot over a low fire and stir constantly until most of the water has cooked off. Then spread the material in a thin layer in a pan and place it in a warm (not hot) oven

to complete the drying process. Beef of average quality contains about 65 percent water, 20 percent protein, 13 percent fat, and 2 percent residue (largely salts). Therefore, after all but 1 ounce of water has been removed, 16 ounces of meat plus 3 ounces of fat should weigh finally about 8.5 ounces. It is not important that you observe these directions and figures exactly, but the preparation keeps better if nearly all the water is removed. While the mixture is still hot from the oven, stir in about 2 ounces of finely powdered biscuit (C ration biscuits are excellent). Pour into a pan, compact the pemmican, cool, and cut into bars. Wrap the bars in wax paper.

(4) Pork with beef fat (suet) can be substituted for beef, and you may prefer it. Other meats may be used as well, though if you use other meats you may have to change the proportion of meat to fat. An interesting variation can be made by using 2 ounces of sugar instead of powdered C ration biscuits.

(5) If vitamin C tablets (25 mg. ascorbic acid) are available, mix 2 to 10 powdered tablets into each pound of pemmican just before it is cooled. The vitamin C provides protection against rancidity and, of course, is valuable in itself. This product does not require refrigeration provided the fat used is hard fat and the air temperatures are not high. One bar of such pemmican (eaten as it is, or made into a stew with a little water), plus 1 or 2 ounces of biscuit and a couple ounces of dried fruit, makes a very substantial meal. One day's ration of this type, sufficient to allow ordinary outdoor work (3,300 calories) weighs about 24 ounces. Thirty-two ounces should be allowed per man per day for extremely hard work.

c. For variety in your diet you may add other items such as chocolate, raisins or other dried fruits, nuts, or oatmeal. The drink most satisfying to men on the trail is hot tea with plenty of sugar.

d. Army rations may be used if available. The Army mountain ration (discontinued but still available) provides food for four men for 1 day or for one man for 4 days. It weighs about 10 pounds when packed, and furnishes enough food for all but extremely hard work. Although many of the items it contains are excellent, its preparation on the trail in very cold weather is somewhat elaborate. The K ration is very simple to use and is satisfactory for short trips. Some men will want to supplement the K ration, especially for hard work.

e. If neither pemmican nor any Army rations are available, make up your own ration. Make it compact and light in weight. Try to imitate the basic Arctic trail ration of the explorers, and as far as possible avoid using heavy bulky foods that require a great deal of cooking. Avoid overloading yourself with watery foods if your route lies over country where water is easily procured.

100. Cooking on the trail.—Cook as much of your food as possible before you start on the trail. In winter the food stays frozen and need only be heated. To cook frozen meat, cut it into small chunks and place them on top of pieces of ice or snow in the cooking pot. By the time the water has boiled a few minutes, the meal will be sufficiently cooked. If the snow is "dry" (that is, fluffy and absorbent), occasional stirring will prevent it from absorbing the water at the bottom and so burning the pot. To save fuel, hot pots and thermos flasks may be used as fireless cookers for additional cooking if their heat is conserved by wrapping them in grass, furs, or clothing.

Section V

EMERGENCY RATIONS

101. Importance of reserve supply.—Arctic weather is changeable. An unusually long period of bad weather may delay the shipment of supplies to your station. Or if you are on the trail a storm may force you to hole up for several days, lengthening your trip and so reducing your food supply. Under such circumstances, emergency rations must be drawn upon. At a small station, always set aside an extra amount of the usual rations as emergency food. In preparing for the trail, make allowance for an extra supply of concentrated foods.

Section VI

SOURCES OF WATER

102. At permanent stations.—Any station in the Arctic will be near water in one form or another. In the fall you can get water from your summer water hole by removing the few inches of fresh ice formed each day. When this supply freezes up solid, you will have to melt ice or snow. Because ice is denser than snow and therefore yields more water for a given volume, it is preferable to snow. Several potential sources are rivers, lakes, glaciers, icebergs, or last year's sea ice. If you have to use snow, use the most compact snow available. For melting snow and ice, improvise a big metal reservoir beside a stove. A 45-gallon drum is excellent for this purpose. Place it so you can shovel snow into it directly from the outside. Incidentally, keep dogs away from your supply snowbank or the melted snow will look like tea. Your reservoir must be emptied and thoroughly washed from time to time.

103. On the trail.—*a. On sea ice.*—Sea ice loses its salt with age. Last year's ice seldom has a noticeable amount of salt while ice 2 years old is probably purer than average river or spring water. Fresh sea ice has a milky appearance, and is angular where broken. Old sea ice is rounded where broken and is likely to be pitted and to have pools on it. Its under water part has a bluish appearance. In the summer, the pools of water that accumulate in hollows on sea ice are fresh if you get far enough away from the edge of the ice so that salt spray has not reached them. Icebergs, being composed of fresh water ice, always yield fresh water.

b. On land.—Water is abundant during the summer in lakes, ponds, or rivers. Be sure to make river water safe to drink by boiling it or by treating it with halazone or iodine. The milky water of a glacial stream will not hurt you. Let it stand in a container for a few hours and it will clear up a little as its coarser sediment settles. During the winter, ice and snow are ever present sources of water. If you are near a lake or river, try chopping through the ice to get water. If the ice is not too thick your efforts will be repaid by a good supply of water. To keep ice in the water hole at a minimum, cover the hole with snowblocks. It is all right to eat snow if you use common sense. Do not swallow snow in lumps; let it melt slowly in your mouth. If you are cold or hot and tired, go easy on eating snow. It will, of course, lower your body temperature, and it makes some people more thirsty. Remember that the temperature of the snow approximates the air temperature. If you try to eat snow at 30° F. below zero without warming it up first with your breath or hand, you will freeze your mouth. In general, it is best to eat snow often and in small quantities rather than waiting until you are thirsty.

CHAPTER 4

CLOTHING AND EQUIPMENT [2]

SECTION I

FUNCTION AND DESIGN OF COLD WEATHER CLOTHING

104. General.—Good clothing and its proper use are more important in cold country than anywhere else in the world. If you use the proper technique and equipment you can work safely and comfortably even at very low temperatures. On the other hand, subzero weather is brutal to troops that are badly equipped. If you underestimate the dangers of the Arctic and fail to wear adequate clothing, or, worse, fail to use adequate clothing properly, you may suffer the loss of a hand or foot, or even risk death.

105. Function.—In the Arctic the primary function of clothing is to keep your body warm. Heat is transferred from a warmer object to a colder one until the temperature of the two becomes nearly the same. Clothing prevents, or rather slows down, the transfer of heat from the body to the outside air somewhat as a rubber glove prevents the jumping of electricity from a charged wire to your hand. One of the best insulators is still air. It retards the transfer of heat through it. That is why cold weather clothing is designed to *hold a considerable amount of air.* A soft, spongy material that holds thousands

[2] For greater detail, see Training Circular No. 37, War Department, 1943, as changed by Training Circular No. 79, War Department, 1943.

of little air cells between its fibers is better than a tightly compressed material that holds very little air. On the other hand, loose, air-holding material is not of much use as long as the air is allowed to be blown through it by the wind. For this reason an outer shell of tightly woven cotton cloth is necessary to keep the cold air out and the warm air in.

106. Design.—Not only should the material used for your Arctic clothing be loosely woven so it will hold plenty of air between its fibers; it also should be resilient; thus it does not pack down and become compressed. Your clothes *must* fit loosely. When they are tight, they contain little air and do not insulate. Use several thin layers instead of one thick one; additional insulation will be provided by the dead air trapped between the layers, and you can then easily remove or add clothing to maintain your body at a comfortable temperature. The outer layer should be not only windproof, as stated in paragraph 105, but also large enough to accommodate the maximum amount of clothing that might be worn underneath it. Another important reason for wearing loose clothes is that tight clothes impede the circulation of blood in arms and legs. If circulation is cut off only slightly in your arms or legs, they will soon grow cold and may freeze. This point is especially important with footwear. When extra size shoes are not available, it is much better to wear but one pair of socks if a second pair will mean tight-fitting shoes.

107. Underclothing.—Two-piece issue underwear is absorbent and light in weight and permits the easy escape of perspiration. Be sure it does not bind at any point. Two-piece underwear permits the separate removal of either drawers or shirt; if you fall through ice or wish to strip to the waist, this is an advantage.

108. Footwear.—*a. General.*—Your footwear is the most important single item of your clothing. Except for your face, your feet are the parts of your body most likely to freeze. This is because your shoes form a rather tight casing that does not allow perspiration to evaporate. Hence you should never wear shoes with linings such as felt or fleece that can not be removed for airing or washing.

b. Leather boots.—Many types of Arctic footwear have been used with success. If you wear the issue leather boots they should be two or three sizes larger in both width and length than you ordinarily wear. They should be so large that when worn with a ¼-inch insole and two or three pairs of heavy wool socks, they do not bind your feet. The need for such large shoes is hard for an inexperienced man to understand, but it is very real. Leather boots must be carefully broken in. However, leather boots are not suitable for really cold weather—for temperatures less than about 20° F.

c. Mukluk boots.—These boots, copied from the Eskimo *kamik*, have a dry-tan leather or rubber sole, and canvas uppers extending up to just below the knees. Not being waterproof, they are not adapted for use in wet and slushy snow, but they are excellent in extreme cold. Lace them so that they do not fit tightly around your calves.

d. Footwear for wet snow.—Shoepacs are a serviceable type of boots for use in wet snow. They are laced boots with rubber feet and leather uppers. They are not suitable for cold weather and should not be used in temperatures below 0° F. Even above 0° F., socks and insoles must be thoroughly dry in order to keep the feet warm.

e. Eskimo mukluks.—The best boot for sedentary occupations at extremely low temperatures is an Eskimo mukluk made of caribou skin.

f. Insoles.—All Arctic footwear, regardless of type, should be worn with insoles. They can be made of felt, burlap, or fur. A good substitute is dry grass, found throughout the Arctic. Pack it not only in the bottom of the boot as an insole but also around the foot for additional insulation. Insoles absorb moisture from your feet and provide additional insulation between foot and ground. This extra insulation is necessary because the socks become compressed under the weight of your body and hence their ability to hold air in their fibers is reduced.

g. Socks.—Several types of socks are suitable. They may be of the ordinary knitted variety or made out of blanket cloth in a design similar to that of a baby's bootee. Some men find that jute or burlap socks worn outside the wool socks help to evaporate moisture from the foot. Take care that your socks are large enough, so that when you are wearing two or three pairs the outer socks are not stretched. It is a good idea to have two sizes and wear the larger pair on the outside.

109. Handwear.—*a. Mittens.*—The best all-round type of handwear consists of a woolen insert mitten worn inside an outer shell mitten made of leather or windproof cloth. The shell mitten should be large enough to hold two insert mittens, although you may need two only in very extreme temperatures. For troops, both shell and insert mittens have separate trigger fingers. Both mittens should be large enough so that the first finger can be withdrawn from the trigger finger and kept next to the others for warmth. Mittens of fur are good at extremely low temperatures.

b. Gauntlets.—For prolonged exposure without activity at very low temperatures, gauntlets made of caribou or other fur can be worn outside the woolen inserts. The chief objection to gauntlets is that snow easily collects in the gauntlet cuffs.

c. Wristlets.—Wristlets are recommended by some for sealing the gaps between sleeves and gloves and for work that requires the use of

bare hands. In the latter case the wristlet should cover the hands to the fingers.

d. Gloves.—Ordinarily, gloves are not suitable in temperatures below zero but they are sometimes used when a fine sense of touch is necessary. Silk or rayon gloves are particularly good. You can become accustomed, like the Eskimos, to the use of your bare hands even in very cold weather, provided you warm them from time to time.

110. Headwear.—A knitted wool helmet similar in design to a flying helmet is the best covering for your head. It should come well down over your forehead. Likewise, it should fit about your face and extend from your chin to the collar of your shirt. It must have a covering of windproof cloth unless it is intended to be worn inside a parka hood. Whatever other headgear you devise, be sure it covers your ears as they are very easily frozen, but it should not cover your mouth.

111. Body clothing.—Ordinary heavy woolen trousers and shirt are very convenient for use in the Arctic, especially where troops are living in heated barracks much of the time. Many men with Arctic experience do not like sweaters because they are tight and are hard to put on and take off. A woolen vest worn over the shirt and buttoned up to the neck is very warm. The parka shape is best for the heavy outer garment. It is made of wool, wool pile, or fur, with a windproof outer cover (par. 112), slips on over the head, and has a permanently attached hood. It ought to be loose around the body, neck, and shoulders, and should have drawstrings at the front of the hood and around the bottom or at the waist to permit adjustment for ventilation.

112. Windproofs.—Windproofs are worth their weight in gold. They are made of smooth, tightly woven cotton cloth. They are water repellent but are never waterproof, because they must allow moisture from the skin to pass off into the atmosphere in the form of vapor. They must be large enough to fit over the maximum amount of clothing that will be worn. The trousers should have drawstrings at waist and ankles. Avoid a fly of the usual type. One about 2 inches long with a flap behind it is enough. The upper garment is of the parka type with drawstrings at the hood and at the bottom. It should extend below the hips.

Section II

USE AND CARE OF COLD WEATHER CLOTHING

113. Importance of dry clothing.—In the use and care of cold weather clothing, always bear in mind one precaution, *keep your clothing dry.* Water conducts heat faster than does air. Hence wet clothing is cold clothing. Always keep perspiration at a minimum. Do not wear more clothing than is necessary. It is better to underdress and be slightly cold than to overdress and perspire freely. Cold weather clothing is designed to be worn in several layers. When you feel yourself getting too warm, shed clothing to the point at which you have just enough on to keep comfortably warm. On windy days it is better to remove inner clothing than to take off the windproofs themselves. If you perspire while traveling and fail to take off some of your clothing, you will grow cold very quickly and experience great discomfort when you stop at the end of the day's march. Anticipate the perspiration point and remove some clothing before you begin to get wet with perspiration.

114. Perspiration problem.—*a.* Though perspiration may not be noticeable, nevertheless you constantly perspire. Regardless of the outside temperature, the body gives off through the skin about a pint of moisture a day. This is called "insensible" perspiration. There are, then, two degrees of perspiration you must contend with: visible perspiration caused by exertion or overwarm clothing, and insensible perspiration which occurs regardless of the circumstances. The moisture condenses and forms hoarfrost somewhere on your garments.

b. In cold weather the point of condensation may depend upon how much clothing you are wearing. If you are dressed lightly, the frost either will form in the air around you and drift away as fog or will form on your windproofs. When it forms on your garments, brush it off. If you are clad more heavily, the frost will form somewhere within the layers of your clothing. Later, in the warmth of a camp (unless you take precautions), the frost will melt. Still later, when the resulting moisture is exposed to cold, it will turn to ice. To deal with this problem, keep perspiration at a minimum at all times. Wear the smallest amount of clothing necessary to keep you comfortable, and adjust it to allow for ventilation. This will reduce the visible perspiration that results from physical activity and warm clothing. Dressing lightly reduces perspiration; thus most of the frost forms on or near the outside of your garments rather than in them.

c. There are many little tricks you can practice to keep your body below the rapid perspiration point. Taking off your gloves or wearing only the leather shell may be enough to keep you cool. You can pull back the sleeves from your wrists or unbutton your shirt or put your parka hood down. If you are wearing a belt over your parka

coat, remove the belt and pull the parka coat forward at the neck in order to cool your body.

d. Melting hoarfrost makes your clothes wet. Therefore, do not let the frost melt. Before entering a warm tent or house, remove your outer garments and, while they are still dry, beat and brush the frost out of them. If you are going to stay inside for long, hang the garments up inside to dry. If not, leave them outside in the cold where the remaining hoarfrost will not melt.

e. Drying clothes is particularly difficult in crowded living quarters. To overcome the problem, hang your clothes on a rack suspended from the ceiling above the stove, where the air is warmer than at stove level.

115. Care of footwear.—Footwear requires special precautions. Since you cannot prevent your feet from perspiring, at least make sure your footwear does not fit tightly. Likewise, take the trouble to put on dry socks and insoles at the beginning of each day's march. In cold weather, moisture will condense either in the outer sock or on the inside of your boot. You can beat the frost out of the sock, but to get it out of the boot use a small, stiff-bristled brush. The insole should be removed as soon as the boot is taken off; otherwise it will freeze into the boot. Insoles keep their shape better if you switch them each day from boot to boot. Change your socks after getting into camp and dry both socks and insoles over the stove or hang them in the top of your tent. To dry them further, keep them next to your body while traveling, and expose them to the air during the night by hanging them from the guy ropes of your tent. Even though the temperature is below freezing, some drying will occur. Do not attempt to dry them in your sleeping bag unless the temperature is above zero or unless you will be away from your base for only a few days. Leather boots should not be greased in cold weather because grease is a poor insulator and will make the boots colder. Greased boots will freeze stiff during the night. Before sleeping, spread open the uppers of the boots so that even though they may be frozen, you can get your feet into them in the morning.

116. Keeping clothes clean.—Keep your clothes clean. Oil from your body, collecting on your underwear, fills up the tiny air cells that make your underwear warm. To a lesser degree the same is true of your other clothes. Woolens should be washed in lukewarm water with a mild soap. GI soap is too strong and is not recommended. After washing a garment, rinse it well and squeeze out the water but do not wring it out. Stretch it to proper size and allow it to dry (laying it flat, if possible) in a warm place. Do not put the garment where it will freeze. It is especially important to wash both socks and feet frequently.

SECTION III

CARE OF COLD WEATHER EQUIPMENT

117. Sleeping bag.—*a.* The best material for sleeping bags is either caribou skin with the hair on or eiderdown. The bags now being made for military use are part down and part feathers. The outer covering should be water repellent but not waterproof. Some bags are made with two down-filled cases, one fitted inside the other. This type also is advantageous in warm weather since only one case need be used. The bag can be tapered toward the feet but should have plenty of room at the shoulders to allow free arm movement. Slide fasteners (zippers) should be supplemented by snap fasteners or eyelets for lacing in case the slide fasteners fail to work. The bag should have a hood and scarf attachment so that your mouth and nose are out of the bag.

b. Do not sleep with your head in the bag; the moisture from your breath will ice up its interior. Wear only the minimum of clothing in the bag and never get into it with damp underwear. Change to dry underwear before going to sleep and hang the other set up to dry. If you do not have another set, go to bed naked unless you are likely to be called out suddenly in the night. If you are sleeping in very cold temperatures, hoarfrost will form in the sleeping bag just as it does in your clothing. Since you cannot get it out easily, you must be careful to keep its formation down to a minimum. Because you cannot entirely prevent perspiration, open the bag wide just as soon as you get up, and pump air in and out to remove the moist air and reduce the temperature inside the bag. Arctic bags now being issued have cotton liners which can be removed and washed, thus helping to keep the bags themselves clean. Air the bag as frequently as possible. Should the fabric become torn, repair it at once to avoid loss of the feathers on which your warmth depends.

c. Never place the sleeping bag directly on snow or any other cold surface. Generally you will be provided with a mat to place under the bag. If this is not available, use spruce or fir boughs or grass or any other handy insulator. Before you get into the bag, puff it out by shaking it so that there will be plenty of dead-air space in the

down. In mosquito country in summer, netting stretched over the head of the bag is necessary for undisturbed sleep.

118. Rifle.—Do not let snow lodge in the muzzle of your rifle. If the piece is fired in this condition it may blow up and injure you seriously. In lubricating it, use a light cold weather oil which will not become stiff and slow down the action of the piece to the point where it will not fire. If no light oil is available wipe all parts completely dry of lubricant. Put adhesive tape on the trigger, trigger guard, and any other metal part you might be likely to touch with your bare hand. *Bare flesh freezes easily to bare metal.*

119. Watch.—A pocket-size watch is best kept on a string around your neck and directly next to the skin of your chest. Take it out only when necessary and cup it in your hand, or if you must use it for a long period, keep it inside your glove. If you wear a wrist watch, use a leather or fabric band, not a metal one. Keep your watch as far up your forearm as you can. If it is near the cuff of your sleeve it may get so cold that it will stop.

120. Condensation of moisture.—Cold metal objects, if taken into a warm room, will "sweat," that is, the moisture in the warm air will condense on the cold surfaces and cause rifles to rust and binoculars and cameras to fog between their lenses. For this reason, do not take these and similar objects into a warm place unless it is absolutely necessary. Leave them outside. But if you must take them inside, wrap them first in a blanket or paper. This will reduce the amount of moisture that will condense on them. After the objects have reached room temperature, dry them thoroughly.

121. Sunglasses.—The need for sunglasses is explained in paragraph 193. Almost any type of sunglass is satisfactory as long as it is dark enough. A good test of the efficiency of a glass is to look through it at the sun. If the sun can be seen without much squinting or distress to the eye, the glass is dark enough. Green and amber are considered the best shades; amber is the better for use in snow. Lenses that polarize light are not recommended for use in snow because they do not cut out enough of the light that is reflected from rough snow surfaces. Some issue glasses have lenses of plastic which scratches easily and must be carefully protected when not in use. Frames should be of plastic, and should be rounded slightly to fit the face. Metal frames are cold and should be avoided unless the metal parts are taped. The glasses should not fit tight around the face as flying goggles do, because ventilation between eyes and lenses is necessary to prevent fogging. Many men run rubber bands from the ends of the temple pieces around the back of the head so that the glasses, when not needed, can be pushed up temporarily on the top of the hood.

This prevents loss of or damage to the glasses and is a great convenience in cold weather.

122. Flashlight.—If low temperature batteries are not available, you can get satisfactory service from ordinary batteries if you carry two sets and have one set warming up inside your clothing while the other set is in the flashlight. When the set in the flashlight fails because of freezing, exchange it with the other pair. Better still, have two flashlights and keep one warm. You also can put an insulating jacket around a flashlight to keep its heat in.

Section IV

SUMMER CLOTHING

123. General suggestions.—*a.* Away from the coast, summer temperatures in ice-free regions of the north are sufficiently high to make the wearing of winter clothing or even woolen uniforms decidedly uncomfortable. However, even with high temperatures complete body covering is necessary as protection against the hordes of mosquitoes and biting flies. Paragraph 175 gives details on protective clothing.

b. In the interior, if you lack a special summer outfit, wear windproofs over light underwear. An extra shirt and pair of trousers are a useful addition to your kit. As insurance against cold spells, include in your kit a sweater or warm jacket. Coastal regions usually are colder than the interior and require warmer summer clothing than you normally wear inland.

c. Since most summer travel is over wet ground, the best footgear is shoepacs. Wear wool socks in summer as in winter and carry spares.

d. In all the costal areas of the Arctic and sub-Arctic, fog and rain are frequent during the summer. Here rain suits are highly desirable. In interior areas, wet-weather clothing is less necessary. But even inland a light rain jacket or water-repellent jacket comes in handy.

Chapter 5

LIVING OFF THE COUNTRY

Section I

GENERAL

124. Native foods.—While you are on the trail, living off the country will help to stretch your closely rationed food supply. In most areas edible plants and animals are an important source of emergency food. However, don't wait for an emergency before getting acquainted with food sources. Learn to recognize the edible plants, observe their surroundings, and study the habits of the edible animals. Some day this knowledge may save your life.

Section II

FOOD ANIMALS

125. General.—In most parts of the Arctic, animals are to be found all year around, on land, in lakes, and in the sea. Remember

that virtually all animals are edible. However, if you are forced by necessity to live for several weeks on an all meat diet, be sure to eat plenty of liver.

126. Caribou.—*a.* The importance of caribou has already been mentioned (par. 66). Here are a few hints to the caribou hunter. Carbou usually travel in herds. They are found on the tundra in both winter and summer and sometimes in summer on offshore islands as well. If caribou are common, shoot only as many as you require. Consider the Eskimos, whose need for food and clothing is as great as yours, and whose friendship is essential.

b. In winter dogs can be used to track the animals far afield. But do not expect dogs to run the quarry down. Caribou are swift-footed and have good wind. In shooting, *aim for the shoulder or neck* rather than the head. Antler prongs make the head a deceptive target. Soft-nosed bullets are more effective in bringing down caribou and other large game than are steel-jacketed bullets.

c. Caribou should be skinned promptly, especially in summer. If you do not have time for skinning at least remove the entrails. When skinning, keep the fat with the carcass rather than the skin. (These suggestions obtain for other large animals as well.) The caribou's stomach contents (mixed with oil or blubber) are man food. So are eyes, brain, bone marrow, tongue, and entrails, especially the liver. Your dogs will eat the entrails if you pass them up. Caribou meat freezes quickly in winter. Kept frozen and snow-covered, it will last indefinitely.

127. Moose.—Moose are excellent food animals. Look for them in or near lakes and swamps. In clear, cold weather you can best spot a moose or caribou by climbing a hill or a tree and looking for the animal's "smoke" (par. 42) which rises like the smoke of a camp fire.

128. Musk oxen.—*a.* The musk ox (par. 66), is most abundant today on little known islands north of the continent proper. It lives in the wildest, most remote barrens and seeks meadowlands between hills and ridges. Keep on the lookout for tufts of its long, dark-gray hair and its soft wool on boulders and dwarf willows, and for tracks and droppings in muddy spots. It lives on grasses, heather, and small bushes, and, when necessary, will eat moss and lichen which it must paw from the snow.

b. Musk oxen are easier to stalk and shoot than are caribou. If possible, approach and shoot them from behind cover. If they are startled they may clatter up the nearest hill and bunch tightly together, facing you with lowered horns. In that case your approach is easy. But face and forehead shots are almost sure to be wasted;

a neck or shoulder shot is the surest. Never shoot more animals than you can save, and be careful not to hit your dogs. In winter carcasses must be skinned quickly before the meat freezes solid. Prepare the meat as you would caribou.

129. Seals.—*a. Summer and autumn.*—Seals (par. 65) are widely distributed and generally common. Their flesh and liver are excellent man food. Generally the best way to shoot seals in summer and autumn is from a boat. Seals come to the surface of the water in order to breathe, and as their heads pop up they make good targets. Seals sink in fresh water but usually float in salt water. *Carefully pick one animal and shoot at head, neck, or shoulders.* Seals shot in the lungs or stomach usually escape. Another method of getting seals in the summer and autumn is to catch them in coarse nets made of strips of white-whale skin or rope with a mesh about 9 inches square. The nets are usually floated across narrow channels through which seals are known to pass. An all service, large-meshed net may be equally good for catching seals and young white whales.

b. Winter.—(1) In winter the best places for hunting seals are at openings in the pack ice (par. 24). If there is no open water, seals are hunted at their breathing holes which, by dint of frequent visits and much gnawing, they keep open in the thick salt water ice. Scattered over the ice, the holes are covered with snow and cannot be seen; hence they must be scented out by dogs. Above a fresh hole the snow is scraped carefully away until it is only a few inches thick. The exact position of the hole is determined by probing with a straight wire 2 or 3 feet long. A shorter wire, with a tuft of string tied about it to keep it from slipping through the snow, is set directly above the middle of the sole so it will be struck by the seal as it rises to breathe. Here the hunter waits with gun or harpoon, keeping his eye on the string indicator. He may have to wait hours—even days—because each seal keeps several holes open. When at last he sees the indicator moving, he shoots or strikes. The harpooned animal may dive, but it cannot go far, for the line is attached to the hunter's leg; so the seal drowns. In retrieving the carcass it is sometimes necessary to chop away the snow and ice. The most successful hunts of this sort are those in which several men participate, taking positions here and there all over the pack ice.

(2) Hair-seal (*netchek*) "nests" containing baby seals are sometimes found in April. These are enlarged holes with a platform for the creamy white seal baby. Seals cannot swim for several days after birth, so that such a baby is easily caught. With it you may be able to lure the mother into coming to its rescue. Since she is likely

to be very bold in defense of her young, it is sometimes possible to get the mother without gun or spear.

c. Spring.—In spring, seals lie on the surface of the ice next to their holes and bask in the sun. A basking seal is hard to approach, and unless killed instantly by a shot in the head, it slips down its hole and is lost. There are two methods of approach. One is to push a white cloth shield in front of you with a hole through it for the muzzle of your gun, and the other is to pretend you are a seal yourself. Eskimos know that seals lying on the ice sleep in a series of short naps generally lasting about a minute or less, separated by quick looks around. So the Eskimo lies flat on the ice and works closer, moving forward while the seal naps. Should the seal see him moving and become fidgety, the Eskimo raises his head and looks around as a seal does. Then the chances are that the seal will mistake the hunter for another seal and will no longer be worried. However, the hunter should observe two rules. One is not to dress in white, for if he did the seal might mistake him for a polar bear. The other is not to approach the seal directly.

d. Preparation of meat.—Seal liver is nutritious and flavorful. Eskimos sometimes eat it fresh from the body and raw. You will prefer it boiled or less likely, fried. Boiled seal intestines also are good. Be sure to clean them before boiling. The blood is edible and should be saved at the time of the kill. Seal patties may be made from lean meat chopped up and fried. If you boil seal meat, put some fat with it. Carefully remove all blubber before you store seal meat. Otherwise it turns rancid and is not fit for man. The rancid meat, however, is fine for dogs.

130. Walrus.—The meat and blubber of walrus (par. 65) are edible; so also are the clams you may find in their stomachs. Hunting these beasts, however, can be highly dangerous. Do not attempt it without the aid of an experienced walrus hunter.

131. Polar bears.—Polar bears (par. 65) are difficult to hunt. In stalking bears Eskimos often camouflage themselves with white cloth, or with the white side of a reversible parka, or hold before them a foxskin or piece of bearhide. Polar bear flesh is satisfactory man-food. A steak from a young bear, fried or broiled, can be delicious, though the frozen meat, either raw or boiled, is thought by some to be poor in texture and flavor. *Polar bear liver is poisonous.* Do not eat it. In caching meat of any kind, keep in mind that polar bears as well as brown, grizzly, and black bears are born raiders. Remember, too, that in really wild country where bears have not been hunted, they may be quite fearless, if not aggressive.

132. Other bears.—Other bears are found throughout Alaska, Yukon Territory, the Mackenzie Valley region, and the Arctic coast of Canada. The meat of any of these is excellent, especially in late summer or fall when the animals are relatively fat. Bears are hard to kill and a wounded bear is very dangerous. Therefore, *shoot to kill.* Aim for the neck or just behind the shoulder. If the bear stands up, a throat or a heart shot is preferable. Never play with cubs.

133. Mountain sheep.—If you are stranded in the mountains of Alaska, mountain sheep ("bighorn") (par. 66) may be almost your only source of meat. Because the sheep are usually found high up on slopes, hunting them usually means careful stalking and long shots, and retrieving your game may be hazardous. The hunt is never easy but it may help to remember that all mountain sheep are less suspicious of anything they see or hear above them than of what they see or hear below.

134. Mountain goat.—The goat (par. 66) is not as good to eat as mountain sheep, but meat is meat when you are hungry. Furthermore, the goat is not very difficult to stalk, once you have climbed up to the goat zone.

135. Whales.—*a. White whales.*—In some places in the Arctic, groups of Eskimos drive white whales (belugas) (par. 65) into shallow water and kill a whole season's supply with harpoons and rifles. For this operation, however, ideal conditions are necessary, and you should count yourself lucky to get one whale. Harpooning is the easiest method. If the float is properly attached, a single harpooning may do the trick. Coarse nets (par. 129) floated across river mouths or off rocky points may catch a young whale. Adults, however, go wild if so caught and sometimes rip the nets to pieces. Do not waste shots on these whales, for even if killed they are likely to sink. The outermost layer of white-whale skin may be eaten raw or cooked. The lean meat and blubber are good cooked. You can use the tough inner skin for making nets.

b. Other whales.—Also found in Arctic waters are the Greenland whale, the finback, and the narwhal (par. 65). Eskimos capture the narwhal as they would a beluga. Whale meat, besides being good man food, is excellent dog food, whether fresh or rotten. Also, a whale carcass may attract other food, for sooner or later polar bears, wolves, and foxes gather around.

136. Wolves.—The wolf (par. 66) is edible and its fur may be used for clothing. It is almost sure to be found wherever there are caribou or reindeer. Being clever, it may rob a trap line for weeks at a stretch without allowing itself to be seen by the trapper. Steel traps for wolves must be larger than those used customarily for foxes.

137. Foxes.—Fox meat is edible and is especially good if fat. The fur is warm but not durable; hence it is not much used for clothing. Following are some suggestions for fox trapping.

a. Build up a dome-shaped structure of stones, about 8 to 10 feet in diameter, 5 feet high, and open at the top. The walls should slope in strongly. Bait with a chunk of meat. The fox climbs the structure, jumps into the trap from the top to get the meat, and then is unable to get out. Make these traps in summer when stones are easy to find; then dig them out for winter use.

b. Another method is to up-end a barrel, and construct a pivot for the lid so that the lid will revolve readily and return to the horizontal position. Put meat or rotten fish inside the barrel as bait. The fox enters the barrel from the top, but once in, he cannot get out.

138. Hares.—*a.* The snowshoe rabbit (varying hare) (par. 67) may be snared easily but it is not practicable to snare Arctic hares except in clumps of shrub willows where they feed. In a willow clump, set your snare either along a used runway or in thick shrubbery. A simple snare may be made by attaching a wire noose to a growing twig. Make a passage by thrusting a stick into the earth opposite this twig, and run a fence of sticks out from these two main "pillars" so that the hare is forced to use the opening. The noose (about 4½ inches in diameter) will hang in the opening and should be from 6 to 8 inches above the ground at its base. Try to visit your snares at least twice a day. If you do not, a fox may eat your catch.

b. The simplest method for getting Arctic hares is to hunt them with a rifle. Firing a gun along a cliff will sometimes set a dozen hares running. A running hare is a tricky target; do not waste ammunition on it. But a sharp whistle often halts the hare just long enough for a successful shot.

c. When you eat hare, be sure to eat blubber or other fat as well. Hares are rarely fat and you need fat in the Arctic. Although you will lose weight steadily on a continuous diet of lean hares, it is better to eat hares than to starve to death.

139. Marmots.—The hoary marmot (par. 67), a good-sized animal, makes excellent food. In late summer, before hibernation, it is very fat. A marmot can be shot (but do not fire until it is some distance away from its den and is perched on a boulder) or caught in a steel trap set at the mouth of its burrow.

140. Lemming.—If you cannot get larger game, you may have to eat these Arctic mice. In summer, look for lemmings under rocks, or scuttling along their runways in the moss or grass. Often you can catch them with your hands. In winter their nests are on or near the ground, deep in snowdrifts. If you try to trap or snare lem-

mings along their winter runways, be sure to cover completely the cutaway parts of the burrow where your trap or snare is set, because lemmings seem to avoid light. Another difficulty in trapping these animals is that shrews, weasels, or other lemmings may eat your catch.

141. Fish.—*a.* All Arctic fish are edible. In spring and summer, when rivers are shallow, fish are plentiful as well. Most of the big lakes offer fish the year around. Grayling, white fish, ling, trout, and suckers abound in Alaskan and northern Canadian waters. In general, netting is the easiest method of catching fish. In a lake or a bay, set your net close in and at right angles to the shore, preferably close to the mouth of a stream. A serviceable net could perhaps be made from a parachute.

b. Anywhere in deep water, and especially in some of the fiords of the west coast of Greenland in summer, a man needs only hook, line, sinker (a bullet, perhaps), and bait (or a reasonable facsimile thereof—a bit of red or white cloth) to catch cod. Cod may also be caught right from a steep shore in this manner: attach the sinker close to the hook, lower the hook into deep water and jerk it upward a full arm's length, over and over at the same depth. This is called "jigging."

c. During the mating season in late summer and fall, the large salmon trout of the lakes turn red. At this period they refuse baited hooks, flies and lures, and must be netted, speared, or shot.

d. Anywhere in the Arctic, but especially along Alaskan shores, tidal pools may yield quite big fish if you hunt among the seaweed. Spear the fish with a sharpened stick.

e. Sculpins—sluggish, ugly, spiny-headed fish—are unprepossessing but edible. They are common in shallow salt water, and a bent pin or a piece of wire (if you do not have a hook) with any sort of bait will catch a sculpin.

f. Along the Pacific shore of Alaska and in the Aleutians, dig among beds of mussel shells for eel-like fish which you can kill with a stick or stone.

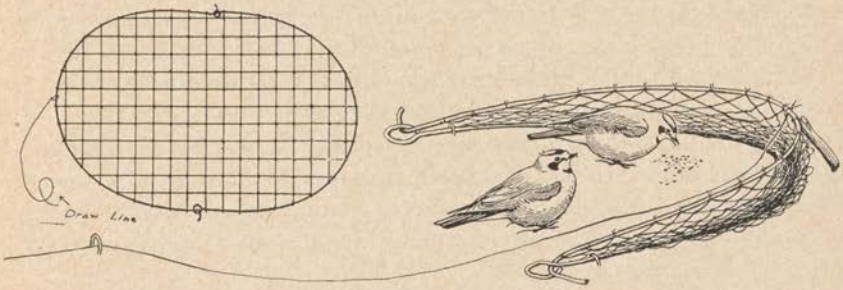
g. Capelin—small, salt-water fish that run in schools—are best caught with a net.

h. Narrowing the channel of a shallow stream along which good-sized fish are moving can be profitable. Use stones for this and hit, net, spear, or shoot the fish as they swim through.

i. If the Eskimos show you a good place for winter fishing, you will get results by jigging with an unbaited native hook made from bone or walrus ivory, and a curved, unbarbed bit of iron. No sinker is needed. If bait is necessary, use a strip of fish. Haul in your catch quickly,

for this hook merely snags the fish by the lips. When you have fished out one hole, chop another in a different part of the lake.

142. Birds.—*a.* All Arctic birds are edible, as are their eggs. In summer gulls are common throughout the Arctic. They can be caught from a moving boat with fishing line and a hook (no sinker) baited with fish liver or guts, or meat. But the best all-purpose bird-trap is the one illustrated in figure 6. It is made of netting fastened to two curved pieces of wire hinged together with round eyes. If no ready-made netting is available, you can make a net of parachute cord. To set the trap, fold the net back on itself, *peg the bottom firmly into the ground*, and prop the top wire up with a 2-inch stick; the net should lie in accordion folds. Then run a long, stout cord, fastened midway on the top wire, through a low, *firmly planted* wicket outside the spot



① Plan. ② Trap set.

FIGURE 6.—Bird trap.

where the net will fall when released. The cord should be long enough to allow you to lie concealed at some distance from the trap. When the prey takes the bait (placed at the back of the open trap), pull the cord quickly. With this trap you can get birds on the nest, birds hunting food, and ground squirrels. If large and strong enough, it will also serve for hares, ptarmigan, large gulls, ducks, geese, and swans. A trap 2 feet in diameter at the hinge line serves for most birds and small mammals.

b. For about 2 weeks, during the midsummer molting season, all ducks, geese, and swans (as well as many other waterfowl) lose their flight feathers all at once and become flightless. Diving ducks (such as eiders and old squaws) usually spend this time at sea; these you must get with a gun. Young eiders, old squaws, geese, and swans hatched on inland lakes far from the coast usually grow up there and during the flightless period are easier quarry for your shotgun. You may even succeed in catching half-grown geese and swans by hand.

c. Auks, puffins ("sea parrots"), murres, etc., nest on certain rocky islands or mainland cliffs in the Arctic. On Greenland's west coast, Eskimos catch the little auks with hand nets. Puffins may be taken at their nests dug in turf, but look out for their savage beaks. Murres are especially abundant on high cliffs such as those at Cape Wolstenholme and the eastern end of Coats Island in Hudson Bay. All these are good food because they are fat.

d. Ptarmigan (Arctic grouse) in summer are so well camouflaged with protective coloration that they are hard to see even when running. In winter they are white, with black tail feathers that show only in flight. Ptarmigan are found both in low country and on ridges. In late summer and early autumn you may come on broods of unsuspicious young; these you can kill with stones. Willow clumps are good places for ptarmigan snares.

e. To obtain the greatest food value from birds, pluck rather than skin them. If you can, pluck geese and ducks while they are still warm.

143. Life on tidal flats and rocks.—*a.* Cold northern waters are richer in edible marine animals than any other waters in the world. Most of the life you will find there is edible. Look for seafood when the tide is out, for then the animals are easy to collect. You can eat them alive and raw, but it is better to steam or cook them—they not only taste better cooked but you are then sure of avoiding infection from disease germs or parasites.

b. Clams can be dug up on mud flats exposed at low tide. They are detected by the jets of water they squirt up through the mud. Mark the spot where you saw the squirt and dig. Avoid dead clams, recognized by their failure to close when touched, and by an unpleasant smell. Mussels grow attached to rocks. On the Pacific coast, during some summer seasons (May to September), some mussels are so poisonous as to have caused many deaths, and cooking does not destroy the poison. It is best, therefore, to avoid mussels entirely in Pacific waters. Mussels in other regions are believed to be harmless. All other shellfish are edible. You can get snails by the handfuls; limpets with their tent-shaped shells are abundant on rocks and are easy to get; chitons have a tough, broad muscular foot that clings tightly to rocks. But again, be careful not to eat dead animals; they will make you sick. Live ones move when touched, or cling even more tightly to rocks, or withdraw into their shells. Throw a handful of snails and limpets into boiling water—a few moments' cooking will give you a substantial and tasty meal.

c. Sea urchins, animated purple or green pincushions, are edible. Punch in the opening at the center of the under side and scoop out the contents.

d. To prepare "sea cucumbers," remove the insides and scrape the surface of the flesh with a knife to remove the slimy skin. Parboil the flesh and then chop up and cook in a stew, or fry. It requires considerable cooking to make it tender.

e. The muscular stalk of the gooseneck barnacle, stripped of its skin, looks and tastes like crabmeat. If you are agile you can catch crabs—all of them are edible.

f. Octopus and squid are common in some places. Cut up the fleshy parts and make a stew. If you are not too fussy you can make a stew of any of the sea worms you find in the sand or mud as you dig for clams.

g. In looking for food when the tide is out, do not neglect the sculpins and other fish you may find in the pools. All these are edible. If shore birds or gulls are abundant, you may be able to shoot or trap enough of them for a stew. The stalk of the huge bladder-shaped seaweed can be eaten raw or cooked.

Section III

FOOD PLANTS

144. General.—Most of the food plants described here are found throughout the Arctic. Lichens particularly are almost universal. *No Arctic plant is dangerously poisonous*, though certain sub-Arctic mushrooms are. One, a mushroom with a reddish top, may make you vomit, but this very characteristic will keep you from eating enough to poison yourself fatally (par. 151). Therefore virtually any plant you pick is edible. Certain kinds, however, have more food value than others. Once you have learned to recognize a good food plant, study its surroundings carefully, so that you will know where to look for it the next time you need it. Watch the animals, especially birds—they will lead you to food sources you might otherwise overlook.

145. Lichens.—*a. Description.*—Though lichens lack flowers, leaves, stems, and roots, they have possibly the greatest food value of all Arctic plants. Caribou live almost entirely on lichens for months at a time. Some lichens contain a bitter acid that may cause nausea

and severe internal irritation, if you eat them raw. However, soaking or boiling the plants in water (if possible, with a pinch of soda) removes the acid. If you cannot cook them, simply soak them overnight, pour off the water, and eat the residue. Lichens taste better, however, after they have been boiled. Do not be repelled by their gelatinous appearance when boiled. They are most palatable if prepared as follows: After soaking, dry the lichens till they are brittle. One way to achieve crispness is to roast them *slowly* in a pan. Thereafter, powder the dried plants between your palms, or pound them with a stone. Soak the powder for a few hours, then boil until it forms a jelly. Use the jelly to thicken soups and stewed vegetables, or cook it with meat, especially if meat is scarce, as the lichen will stretch it out. A mixture of flour and lichen powder may be used as a base for nutritious biscuits.

b. Varieties of lichen.—Rock tripe (fig. 7) is a lichen consisting of thin, leathery, irregularly shaped disks one to several inches across, and black, brown or greenish in color. The disks are attached to rocks by very short central stalks. They are soft when wet but hard and brittle when dry. *Iceland lichen* (fig. 8) is a dark brown, bushy, coral-like plant with individual straplike "branches" that have hairy edges. It grows in dense colonies on sandy soil. When properly cooked this lichen is palatable and nourishing. *Reindeer lichen* (fig. 9) is a grayish, many branched, coral-like plant that prefers hollows or slopes with winter snow cover. It is as nutritious as Iceland lichen. Northern hunters make a stimulating tea from it.

146. Berries.—*a. General.*—All Arctic berries are edible, and berry bushes are abundant. The bushes are low growing; sometimes they form mats. Despite their small size, individual bushes are good producers. Frequently berries remain on a bush throughout the winter, and the following year are even sweeter than those of the current season. At summer's end, berries may be so abundant that you can lay in a winter supply. Eskimos usually preserve them in seal oil. However, olive oil or some other vegetable oil is as good. Keep this delicacy cool to prevent the oil from fermenting. It may be simpler to preserve the berries by freezing them into bricks. Freeze them quickly and thoroughly. With either method, start the process right after the berries are picked in order to preserve maximum food value.

b. Kinds of berries.—The *mountain cranberry* (*lingon*) is a low creeping shrub with leathery evergreen leaves. It grows best in open birch or willow thickets and has red berries that are high in vitamin content. The *blueberry* is a low shrub with small oval leaves that drop off in winter. It grows in open places. The berries are blue to blue

black. The *cloudberry* (*salmonberry* or *baked-apple berry*) has leaves like small maple leaves. The berries, which resemble raspberries, are reddish when immature but yellow when ripe. The raw berries are somewhat laxative. Their flavor is much improved by cooking. The *crowberry* is one of the most abundant and widespread Arctic plants. Its slender leaves resemble fir needles, and its berries are shiny black. It grows along shelves on rocky ridges and hills where the snow is not deep, and therefore can be found even in winter. The *alpine bearberry* is a trailing shrub with shreddy bark and round-tipped leaves that turn bright red in autumn. The berries are black or red and are rather tasteless. Related to this is the *red bearberry* (*kinnikinick*), with coral-red berries that are somewhat mealy and tasteless when raw but very nourishing and palatable when cooked. The dried and shredded leaves make a fairly good substitute for tobacco. The *cranberry* occurs in marshy areas and on shaded upland ledges, particularly where peat moss (sphagnum) occurs. The berries are red and may be rather sour.

147. Edible roots.—Several Arctic plants have roots that store energy-giving starches. All these roots are called *masu* by the Eski-

FIGURE 7.—Rock tripe (*umbilicaria sp.*). Diameter 1 to 3 inches.

FIGURE 8.—Iceland lichen (*cetraria islandica*). Height 3 to 10 inches.

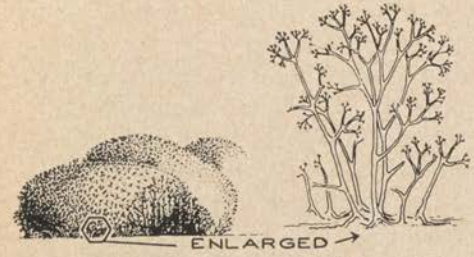


FIGURE 9.—Reindeer lichen (*cladonia rangiferina*). Height 3 to 10 inches.

mos. To get the roots you will need a digging tool, unless you can succeed in stealing them from the meadow mice, which gather them in the autumn and store them in underground runways near the surface. Eskimos use dogs to nose out the caches. Even though you have no dogs, try to spot these stores and save yourself a lot of digging. The commonest root is *northern sweetvetch* (*licorice root*) (fig. 10), which grows in clumps on sandy soil, especially on lake shores or along streams. It has pink flowers similar to pea or clover flowers, while the

FIGURE 10.—Northern sweetvetch or licorice root (*hedysarum boreale*). Height about 8 inches.

FIGURE 11.—Woolly lousewort (*pedicularis lanata*). Height 4 to 6 inches.

leaves resemble those of locust trees or the famous "loco weed" of our western States. Learn to recognize the leaves so you can find the roots even when there are no flowers. The cooked root tastes like young carrots but is even more nourishing. Another valuable root is that of the *woolly lousewort* (fig. 11) which grows in dry tundra. Flowers of this plant are rose colored, resembling those of licorice root in shape but arranged in denser clusters. The flower stalks are thick and strong and are visible long after the flowers have dropped off. During the winter the leaves and flower stalks may be visible above the snow. The sulfur-yellow root is large and sweet. It is edible either raw or cooked. *Bistort* or *knotweed* (fig. 12), also common in dry tundra, has small white or pink flowers that form slender spikes. The elongated smooth-edged leaves come out from the stem near the level

of the soil. The root is about the size of a pecan, and is rich in starch. The slightly acid taste of the raw root disappears when it is cooked. Soak it in water for several hours and then roast it. *Kamchatka lily* (saranna) (fig. 13) grows in meadows and among low shrubs along the Pacific coast of Alaska and on the Aleutian Islands. Its flowers are shaped like other lily flowers. The stem rests in a large bulb surrounded by small bulblets about the size of rice grains. The bulbs

FIGURE 12.—Bistort or knotweed (*polygonum bistorta*). Height 4 to 8 inches.

FIGURE 13.—Kamchatka lily or saranna (*fritillaria camschatcensis*). Height 18 to 24 inches.

serve as potatoes for the natives of Kamchatka because they contain large amounts of carbohydrates. People have lived solely on this bulb for long periods. Roast the bulbs in coals or boil them. Dried and powdered bulbs make good bread, soup, or porridge.

148. Antiscurvy plants.—Scurvy has taken its toll of men in the Arctic. This dread disease results from vitamin C deficiency and may be brought on by a prolonged diet of canned or lean meat and no vegetables. Most plants yield some vitamin C, but several are notably rich in this antiscurvy vitamin. Among these is *scurvy "grass"* (fig.

14) which occurs along sea beaches. It has small white flowers and globular fruits; the lower leaves, borne on short stalks, are kidney-shaped. All parts of the plant are somewhat fleshy. The leaves, stems, and fruit, eaten raw, are valuable antiscurvy food. Black and white spruce occur throughout the sub-Arctic forest and in general reach farther north than any other evergreen trees. They have short, stiff needles borne individually, not in clusters as are pine needles. The cones are only 1 or 2 inches long and have thin scales. Black spruce

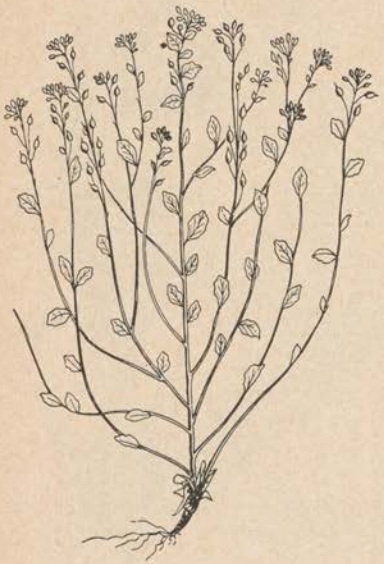


FIGURE 14.—Scurvy "grass" (*cochlearia groenlandica*). Height 2 to 8 inches.

FIGURE 15.—Wild rhubarb or alpine fleece-flower (*polygonum alpinum*). Height 1 to 3 feet.

cones are globular while those of white spruce are slightly elongated. A strong infusion prepared by boiling young twigs and leaves in a covered pot prevents and cures scurvy. The buds, needles, and stems have a strong resin taste, but by chewing them raw you get some antiscurvy vitamin C. The fresh green leaves and inner bark of the *dwarf arctic birch* also are high in Vitamin C. The birch can be distinguished from its companion shrub, the willow, by its thinner leaves and peeling bark.

149. Greens.—Several Arctic plants are fairly good substitutes for the leafy vegetables of our civilized diet. Some of these plants contain vitamins and minerals and all of them give bulk to your diet.

Among the more important one is *wild rhubarb* (alpine fleeceflower) (fig. 15) which grows on open river banks and recent landslides. The stems are reddish and, like cultivated rhubarb, bear pointed leaves with wrinkled edges. The flowers form scraggly clusters. The young stems are bright red and juicy. When cooked, they resemble rhubarb in flavor. Another green is *sourgrass* (mountain sorrel) (fig. 16) living on moist, shady slopes and in ravines. Its fleshy kidney-shaped leaves are borne on long, slender stalks, and its red or

FIGURE 16.—Sourgrass or mountain sorrel (*oxyria digyna*). Height 3 to 20 inches.

FIGURE 17.—Willowweed (fireweed) (*epilobium latifolium*). Height 8 to 20 inches.

green flowers are arranged in plumelike branching clusters. The leaves and stems taste somewhat acid when raw but are very refreshing. When cooked, they resemble spinach in both flavor and appearance. New leaves are produced all summer, thus supplying fresh greens in any summer month. Another leafy plant is the *willowweed* (fireweed) (fig. 17), which grows on sandy or gravelly soil along rivers and on beaches. It has purple flowers and fleshy, slender leaves. The leaves resemble spinach when cooked. A woody plant in this list is the *willow*. This is the "tree" of the Arctic, yet it often looks anything but treelike because it grows close to the ground and spreads out like a cushion. Its cottony seeds are conspicuous dur-

ing the spring when they are ripening and blowing around. The young, tender willow shoots contain a large amount of vitamin C and may be eaten as greens. They have a decidedly sour flavor similar to that of sour dock. *Dandelion*, a weed pest in the United States, is a potential lifesaver to anyone stranded in the Arctic. The young leaves make fine greens. Cook them only a short time, and bear with their bitter taste. Both leaves and roots can be eaten raw. *Marsh marigold* (fig. 18) is found in swamps and along streams and is one of the earliest plants to come out in the spring. The leaves and

FIGURE 18.—Marsh marigold (*caltha palustris*). Height 4 to 12 inches.

FIGURE 19.—Cow parsnip (*heracleum lanatum*). Height 1 to 3 feet.

stems, particularly of young plants, are delicious when boiled. *Cow parsnip* (fig. 19) is abundant on the Pacific coast of Alaska and on the Aleutian Islands. Its large size and characteristic flower cluster make it conspicuous. The entire plant dies down to the ground each winter. Compare cow parsnip with the poisonous water hemlock (par. 152) of the sub-Arctic forest. These two plants belong to the same family and have very similar flower clusters. The leaves, however, are entirely different. The young shoots and leaf stalks of the cow parsnip are edible either cooked or raw. Leaf stalks that have rusty or reddish spots or streaks are better than solid green ones. If there is not fresh water available, chew the leaf stalks of the cow parsnip. They will quench your thirst because they contain much water.

150. Seaweeds.—*a.* Seaweeds should be on your menu whenever possible, especially if you are eating much fish. They contain valuable vitamins and give bulk to your diet. In fact, they do the same thing for your emergency rations that lettuce, cabbage, and many other foods that have little food value do for your normal diet. The bulk they give helps prevent constipation. The gelatinous consistency of cooked seaweed may offend your senses of sight and taste but it is just what is needed to round out your diet. Alaskan Indians, Filipinos, Hawaiians, Chinese, and many other peoples have eaten seaweeds for centuries. Three kinds of seaweed are common.

(1) Brown ribbons several inches wide and amazingly long float in the surf, anchored by a slender stalk.

(2) A profusion of small, brown, branched forms makes a jumbled mass on the rocks exposed at low tide.

(3) Very thin green, wrinkled sheets of "sea lettuce" grow on rocks, driftwood, and other seaweeds; also on mud flats in quiet bays.

b. Take care in the selection of seaweeds for your stew pot. Fresh, healthy specimens have no marked odor or flavor and are firm and smooth to the touch. If the plant is wilted and slimy and has a fishy smell, it is decaying and should not be eaten. The large brown, ribbon-like seaweeds can be either minced and eaten raw, or dried, shredded, and scattered over other food. Discard the stalk and other tough parts and eat only the tender portions. The coarser red seaweeds are best if cooked; they are glutinous and are most palatable if used with fish to make a stew. The broadleaved "sea lettuce" is good chopped and eaten raw or stewed. Do not eat the threadlike or slender branched forms. They are not poisonous but may contain irritating free acid. Disagreeable acids can be detected by crushing a batch with your hands. The released acid causes the plant to decay so rapidly that within 5 minutes it gives off an offensive odor.

151. Fungi.—*a. General.*—Fungi are very abundant in the Arctic in late summer and autumn, especially after a rain. They are very good to eat and taste best when boiled or fried. Gather a big supply when they are abundant and dry them for use as a delicacy during the winter. Store them in a dry place and when you are ready to use them simply soak them in water. All strictly *Arctic* mushrooms are edible except for one species, the *emetic russula*, which is poisonous. Fortunately it is easily recognized because the top of its "umbrella" is pink or rosy when young, and red or yellowish when older. If you eat this mushroom, it will probably make you vomit; hence its ill effects are neither very serious nor lasting.

b. Puffballs.—All the puffballs are edible.

152. Poisonous plants of the sub-Arctic forest.—*a. General.*—There are no plants of the Arctic or sub-Arctic that are seriously poisonous to the touch. A few, however, such as ladyslipper and devil's club, are irritating to some people. There are one or two which are dangerously poisonous if eaten. These grow not on the open tundra but in the sub-Arctic forests. Even here you will seldom find them, but it is well to know that not everything is edible.

b. Water hemlock (fig. 20).—This belongs to the parsley or carrot family, as the feathery toothed leaves and small flowers arranged in

FIGURE 20.—Water hemlock, poisonous (*cicuta maculata*). Height 1 to 4 feet.

clusters suggest. The leaves are streaked with purple, and when crushed emit a disagreeable odor. *Do not eat any part of this plant or plants similar to it*, even though the parsniplike roots look inviting.

c. Fungi (mushrooms and toadstools).—These are represented by at least two poisonous species of cap mushrooms, the white deathcup, (amanita) and the orange-spotted fly agaric. *Do not eat mushrooms from the sub-Arctic forest unless you know them.* Deathcup amanita (fig. 21) occurs in damp forests. Usually it is completely white, but the cap may have tints of olive, purple, or brown. When fully grown

FIGURE 21.—Deathcup amanita, poisonous (*amanita phalloides*). Height 4 to 6 inches.

the cap is 4 to 6 inches wide. When young it is steeply convex on top, but later it slopes downward from the center like an inverted saucer The surface is sticky when moist. Beneath are white gills attached to the under side of the cap but *not to the stem.* The stalk is white and brittle, and has a spherical base that is buried beneath the ground and that rests in a soft white cup which is not visible unless the entire plant is exposed. The fly agaric is a handsome plant with yellow, orange, or red mottled cap, whitish or yellowish scales, and white gills. In extreme youth these fungi may be mistaken for puffballs. Breaking them usually discloses the gills.

CHAPTER 6

TRAVEL

SECTION I

MAGNETIC COMPASS

153. General.—The earth acts as a great magnet. The North Pole of this magnet lies on the Boothia Peninsula in northern Canada, some 1,300 miles distant from the North Pole of the earth (fig. 1). Force from this magnet is directed in paths called *lines of force.* These lines are curves radiating out into space from one pole and bending around to join the other pole; on the return circuit, they pass through the earth. Obeying a physical law, the compass needle (which is a small-sized straight magnet) orients itself parallel with the lines of force and points toward the north magnetic pole. However, since the north magnetic pole does not coincide with the north geographic pole the compass does not generally point true north, that is, it does not point toward the geographic pole but varies from it by an angle known as the *variation* (*declination*) of the compass. The amount of variation at any place depends on the location of that place relative to the magnetic pole.

154. Isogonic lines.—The curved lines on navigation charts are called *isogonic lines.* They connect points of equal magnetic variation and usually are drawn at intervals of 1°, 5°, or 10°. Thus, isogonic lines give a general picture of the magnetic variation in the area covered by the chart and enable a navigator to scale off the approximate variation at any point desired.

155. Weighting the compass.—*a.* A straight magnet so suspended that it is free to swing in any direction not only points toward the magnetic pole but also dips downward. The angle of dip depends

on the distance between the magnetic pole and the compass. Immediately over the north magnetic pole the north end of the needle dips straight down. At the Equator the needle remains almost horizontal. At the south magnetic pole the south end of the needle dips straight down.

b. The ordinary compass needle is designed to swing in a horizontal plane. But since one end tends to dip down, the opposite end must be weighted to maintain the horizontal position. The amount of the weight varies in accordance with the angle of dip. For example, a compass weight effective for New York, where the angle of dip is 72°, will not serve on Baffin Island where, because of nearness to the magnetic pole, the angle of dip is 82° to 89°.

156. Area of unreliability.—A compass needle free to swing in any position can be acted upon by the full force of the magnetic field. Because in the Arctic region this force is nearly vertical, only a very small component of it holds the needle in a north-south direction. At the magnetic pole the force is wholly vertical, and there is no horizontal force. At this point the needle does not respond at all, so the compass is useless. Moreover, it is useless within roughly 300 miles of the magnetic pole, for there the horizontal or directive force is extremely weak. Even beyond this distance the compass may be unreliable.

157. Use of compass.—*a.* Because the directive force of the magnetic field is very weak throughout the Arctic, the needle in that region swings very slowly. Also, friction at the pivot sometimes prevents the magnet from assuming its correct position. The combination of these two circumstances causes the compass to behave sluggishly. Therefore, since friction at the pivot might keep the needle from coming to rest at the correct position, take a compass reading when the needle is at the midpoint of its oscillation rather than when it is stationary. Do not depend upon a single reading. Take several readings and average them.

b. Examining a magnetic chart, you will see that the isogonic lines are closer together in the Arctic than in middle latitudes. As you cross these lines your magnetic course changes. Take account of the changes and alter your course correspondingly.

158. Local disturbances.—In some areas mineral deposits set up local magnetic attraction which makes the compass behave erratically. As you head into such an area the compass begins to change direction much more rapidly than in normal areas, and if you rely on it you will cease to travel in a straight line. In areas of unexplained disturbance use the bearing of the sun, the bearings of landmarks, and wind directions to keep on a straight course.

Section II

TRAVEL PROBLEMS

159. General.—If you are living at a base in the Arctic your life there will be very much the same as it would be at a base elsewhere. Of course you will have problems such as winter cold and summer mosquitoes to meet and overcome. But if you are away from a base, traveling by dog team or tractor or on foot, your problems are multiplied. Hence you must have a knowledge of how to meet the hazards you are sure to encounter, and how to treat injuries when you are traveling without a medical officer.

160. Camping on the trail.—*a.* Establish your camp for the night as quickly as possible. The making and breaking of camp will take much longer than you expect. The entire party should work together in pitching tents, and passing food and sleeping bags into them. Then, while one man is inside the tent preparing the evening meal, others can be outside tethering and feeding the dogs or preparing the tractors or sledges for the night. When the men have finished their outdoor tasks, a hot meal will be waiting for them. Before entering, brush the snow off your clothes and footwear. Be sure to have ventilation at the top of the tent while the stove is lighted (par. 76). Cover pots that contain hot liquids. If you fail to keep down the amount of moisture condensing on the inside of your tent, the tent will grow increasingly heavy from the interior accumulation of frost and ice.

b. Dry your clothing at the fire before you go to sleep. (Fur garments must be kept far from the fire to prevent their being damaged.) No matter how tired you may be after a hard day on the trail, you must take the trouble to assure yourself dry clothing for the next day's work.

c. In breaking camp, one or more men can harness the dogs or start the tractors, while others inside pack sleeping bags and other gear and pass them to the men outside. Then all can pack the tent and finish loading the sledges.

161. Crossing streams and lakes.—*a. Open streams.*—(1) In the Arctic many streams of melt water flowing from glaciers, flow so rapidly that a strong man is unable to keep his footing in water no more than waist deep. If possible, plan to cross a glacier-fed stream early in the day before melting has swelled it to dangerous size. Avoid crossing above dangerous rapids, cascades, falls, or ice tunnels. Crossing a stream at a place where it is subdivided into several channels is usually easiest. An uneven bouldery bottom and the constant rolling of stones along the stream bed are added hazards. A good stout pole 4 or 5 feet long or an ice ax, a rope (particularly if you are not alone), and good protection for your feet are desirable. Shoes of any kind, slippers, or even heavy wool socks are better than bare feet for wading.

(2) Pick an exact route and then attempt to follow it. It is desirable to wade in an upstream direction. Wade slowly and be sure that each foot is firmly placed before you take the next step. Do not look directly down at the water near your feet; it may make you dizzy. Keep an eye on the projected route and on your landing spot on the opposite shore. Feel your way with your pole, particularly if the water is muddy, and use it for support on the *downstream* side. Avoid the quiet-looking water behind large boulders as it is likely to be deep and full of tricky currents. And finally, watch for floating branches or chunks of ice. Unexpected blows from such objects may upset you.

b. Crossing frozen streams.—Look out for thin spots in the ice at the surface of a rapid stream. Likewise risky is the fresh-water ice that, during the spring thaw, forms in vertical pencil-like crystals. Even though more than a foot thick, ice of this kind may not bear your weight. Arctic streams that freeze to the bottom also have their dangers. If there is snow cover, any water that continues to flow from the source floods the ice surface beneath the snow. Before you cross any frozen stream, test it for this hazard as well as for ice strength. Should you break through, get down and roll in soft dry snow if you can. The snow acts as a blotter, absorbing much of the water that might otherwise soak into your clothing. As soon as the snow has absorbed the water, brush it off your clothes before it freezes hard.

162. Use of the rope.—In mountainous terrain or on a crevassed glacier, roping the members of a party together is a safety measure of great importance. The rope is tied around the chest of each individual, below the armpits, with any knot that will not slip. A bowline is suitable for the two men at the ends of the line, while the simple overhand loop or the more efficient butterfly knot is a good knot for the intermediate positions. The rope should be long enough to permit intervals of at least 30 feet; and if enough is available a shoulder loop, made by doubling the strands when the knot is tied, is an additional

safeguard to the leader, as is a double rope between him and the second man. The most satisfactory rope is ⅜ to ½ inch in diameter. If this is not available, any cordage which, doubled or tripled, furnishes the equivalent strength will suffice. For example, the control cables from an airplane, used in conjunction with shroud lines and body harness from parachutes, will answer the need. In a roped party, the most experienced climber should be leader on the ascent; in descending difficult terrain he should be the last man.

163. Rocky terrain.—A roped party can travel over steep, rocky terrain as a group and need not maintain the full interval of the rope. The slack, however, should not be allowed to trail on the ground or become wet, dirty, or worn. Ropes should be carried in coils, each man carrying the surplus between himself and the man ahead. When difficulties make it necessary to travel one at a time, the leader should proceed to a secure position from which he can belay and assist the next member of the party. A belay consists of passing the rope around some fixed object or around the waist of the leader himself. As the second man advances, the rope is drawn in with one hand and the slack is taken up with the other. Each successive member of the party is helped along in the same way.

164. Traversing glaciers.—Glaciers are a special problem in travel because of their crevasses (par 7). Open and obvious crevasses are not dangerous but they can be very inconvenient. Many crevasses, however, are covered by snow bridges which make their detection difficult. Unless the ice is bare of snow or unless the glacier is so smooth and gently sloping that the presence of crevasses is unlikely, a party traveling on it should be roped. Except in an emergency, a roped party on a glacier should be composed of not fewer than three persons. Make full use of the rope interval in order to distribute the weight of the party as widely as possible and to check any fall immediately. The use of skis and snowshoes contributes greatly to safety on a glacier because of the increased areas over which body weights are distributed. When a bridged crevasse is detected, the leader should inspect and test it. During this inspection the leader must be belayed by the second man on the rope, by plunging an ice ax or some similar staff as securely as possible into the glacier surface and belaying the rope around it. Where such a belay is insecure—for example, when the snow cover is thin or when it is unconsolidated—the rope should be belayed around the second man's hips. Having crossed the bridge at right angles to the trend of the crevasse, the leader belays succeeding members of the party until all have crossed in the same manner.

165. Crevasse rescue.—If a roped man falls through a snow bridge into a crevasse and his fall is checked by a belay, proceed as follows. Secure the rope so that farther descent is prevented. Without approaching the hole in the bridge, one member of the party lowers a free end of rope in which a loop has been tied. The suspended man passes the loop down through his chest loop and, after its upper end has been belayed, he uses the free rope as a foothold. He raises himself on this foothold. Then slack is taken up on the body line and belayed from above. He again places his weight on the body line, permitting the foot loop to be raised and belayed. The process is repeated until he has raised himself to the lip of the crevasse. Here he breaks away any overhanging snow, and then, holding both ropes and assisted by other members of the party, he works himself up over the edge. Sometimes he can place his feet against the wall of the crevasse and while he is held from above, "walk" out over the overhanging lip. Because the rope cuts deeply into the lip of a crevasse and thereby increases friction, lay an ice ax, ski (running surface down), or similar object under the rope and parallel with the trend of the crevasse to act as a bearing surface.

166. Rockfalls and avalanches.—*a. Rockfalls.*—These are caused by thawing of the snow and ice that bind loose rocks together. At times of the day when thawing is in progress, avoid passing beneath loose rock faces. Evidence of danger is the accumulation of debris from previous rockfalls. When climbing on loose rock, take care to avoid dislodging rocks that may injure men climbing below.

b. Avalanches.—Any snow slope steeper than 20° is subject to avalanching. After a heavy snowfall, avoid all steep slopes. If you must ascend them, do so in a single track directly upward. Concave slopes are less dangerous than convex ones. Avoid steep slopes in snow that is not firmly consolidated, because the track caused by the party may break the cohesion of the snow and cause it to avalanche. Avoid crossing below precariously balanced masses of ice, or at least cross as rapidly as possible. Snow cornices (par. 77) often form on ridges, and if approached from the windward side the true crest is difficult to detect. Never approach the edge of a cornice. If you must follow a corniced ridge, ascertain the true ridge line and keep well below it on the windward side. Avoid traversing or climbing directly below a cornice. Not only is there danger of the cornice becoming dislodged, but the snow mass immediately below it is particularly unstable.

c. Escape from avalanches.—If you are overcome by an avalanche, try to keep some part of your body, preferably your head, above the surface. Swimming motions will help to keep you afloat. Because

an avalanche flows like a stream, the more horizontal you lie, the better. In a vertical or nearly vertical position, you are likely to be bowled over and buried by the upper layers of snow which move more rapidly than the lower. If you are on skis or snowshoes, discard them immediately. Should you become completely covered by snow, try to create an air space about your head and shoulders. By doing this, avalanche victims have survived many days. If a roped party is overcome by an avalanche and one or more members are able to remain above the surface it is comparatively easy to extricate those who have been buried. If the party is not roped, survivors should begin searching at the point where buried members were last seen, and should continue on the course along which the avalanche would have carried them. If no clues exist as to the position of a buried man, begin the search at the lowest tip of the avalanche and probe the whole snow mass systematically.

167. Landslides, quicksands, and bogs.—In many areas, especially after heavy thaws or spring break-up, steep earth banks may be dislodged and cause landslides. Precautions and measures for escape and rescue are the same as for avalanches (par. 166). Outwash fans of fine sand and silt at the mouths of glacial streams, and sand bars at river mouths are frequently saturated with water, and if you try to walk over them you may sink in. Avoid such areas and cross only when it is absolutely necessary. If your feet get caught and you start to sink, throw yourself flat as you would in an avalanche, no matter how disagreeable this may be in mud. Later in the summer, flooded land is treacherous because gas bubbles from decaying vegetation soften up the saturated soil and you sink in deeply. Snowshoes, skis, or any substitutes that will distribute your weight over a large area are helpful in crossing bogs in the summer, as well as thin or rotten ice on streams or lakes. They also bridge small cracks and holes in the ice into which you might outherwise slip.

168. Dogsled travel over ice.—*a. Crevasses.*—These are of many kinds and sizes. No single method of crossing them fits all conditions. An experienced dog driver uses the type of hitch that gives him the greatest control over his dogs. He also distributes his team as widely as possible over the roof of the crevasse so that there will be minimum weight on any one area. Sometimes the dogs in front break through. The rest of the team usually can be stopped and the sledge kept from tumbling in after them if the sledge is turned completely over or on its side. Should the dogs pass safely over the crevasse roof and the sledge break through, the dogs will dig in with unbelievable energy and often hold the sledge until they can be helped to drag it out.

b. Sea ice.—For sledging over sea ice the fan hitch, developed by the Eskimos, is the one generally used. In the fan hitch each dog is attached to the front of the sledge by his own individual gang line, so that if he falls through a weak spot in the ice or into a crack he will not drag the rest of the team with him. In spring, before summer thaws set in, travel over sea ice (par. 22) is often much more convenient and rapid than travel over land because the surface of the ice is generally smooth and free of deep snow. But if pack ice from the previous summer has frozen in along your route of travel, the going can be very rough. Travel on the open pack is a much more serious matter than travel on ice anchored to the land (par. 23). On the open pack you travel over sections of sea ice ranging in diameter from a few feet to a mile or more. These floes, being under the influence of winds and currents, are in constant motion, and there are lanes and leads between them (par. 24). Very narrow lanes can be crossed by letting the dogs jump them one by one and pushing the sledge after them. If a lane is several yards wide, you may be able to put your dogs and sledge on a small cake of ice and drift or paddle across. Sometimes it is feasible to travel around the open water or to wait until the two floes drift together. For crossing open leads a sledge boat is good. This is made by stretching skins or a tarpaulin under the sledge and using the combination as a boat. Newly formed ice (*young ice*) should be studied well before it is crossed. Generally, new sea ice is not safe to cross until it is at least 5 inches in thickness, and even then you should distribute your weight and that of your sledge over as large a surface as possible. The lower the air temperature at which the ice forms, the stronger the ice. In early winter, sea ice generally is not as strong as fresh-water ice. At thicknesses of about 1 foot, however, the strength of the two becomes nearly the same, except during a thaw, when sea ice is usually the stronger of the two.

169. Blizzards.—If you should become lost in a blizzard, do not give way to panic. Walking about will only tire you out and your chances of finding your way back to camp will be slim. If you are on snow, dig a shelter in it by using a knife or by kicking the snow out with your boot—quite a shallow trench will do. Lie down in it and cover yourself with snow to protect you from the wind. Then get some rest. Keeping awake and active will use up energy that would otherwise keep you warm, and will exhaust you, and it is only if you are exhausted that there is danger of freezing to death while you are sleeping. Normally, if you get cold while sleeping, you awaken. The same is true here. By alternately sleeping and getting up for a few minutes to restore circulation, men have been known to survive blizzards of 3 or 4 days' duration.

Chapter 7

SPECIAL PRECAUTIONS AND FIRST AID

Section I

INSECTS

170. General.—Although the tropic and temperate zones are populated by a multitude of insects, the Arctic region is so far known to contain only about 4,000 kinds. Of these kinds, stinging insects such as bees, wasps, and hornets are confined largely to the sub-Arctic forest and are not often found on the tundra. But mosquitoes, blackflies, midges, and "bulldogs" (par. 174) are so abundant and troublesome during their summer period of activity that a little practical information about them should prove helpful to men newly arrived in the Arctic.

171. Mosquitoes.—The Arctic is justly famous for its mosquitoes. It is estimated that over at least two-thirds of the tundra there are ten times as many mosquitoes per square mile as over any equivalent area in the Tropics. These insects are abundant because of the numerous swamps and lakes, and because the long, sunny days with slight variation in heat from night to day provide ideal conditions for insect incubation. Most Arctic mosquitoes are vicious biters. As you try to protect yourself against them it may be some comfort to you to know

that both malaria and yellow fever, transmitted by mosquitoes in other parts of the world, are unknown in the Arctic.

172. Midges.—These extremely small blood-sucking insects, also known as "punkies," "no-see-ums," and "creeping fire," are found locally in such numbers that they become a terrible pest. Midges are most abundant in middle and late summer and breed in decaying leaves and along stream margins or even in holes in trees. They bite chiefly on cloudy days, in the evening, and very early in the morning. In bright daylight they seek the shade, but as they are attracted by lights it is wise to keep tents and houses dark. Their most troublesome aspect is their small size. They easily penetrate even the finest mosquito netting and are excluded only by 60-mesh silk bolting cloth. Window and door screens may be sprayed (par. 178), though this treatment is effective for a short time only. When such sprays are used, keep lighted matches and other exposed flames away, because the vapor is inflammable. Spraying the interior of a tent with an insect spray and keeping it tightly closed until you are ready to go to bed is helpful.

173. Blackflies.—Small, chunky, blackish gnats called blackflies or buffalo gnats swarm about in large numbers in the northern early summer, chiefly in the sub-Arctic forest. They breed in swiftly flowing streams. They hover about your eyes, ears, and nostrils, making little noise but promptly alighting and sucking blood wherever your skin is exposed, especially behind your ears. While their bites are not especially painful when made, sensitive persons are affected by itching and swelling of the bites. Blackflies are usually active only in daylight and generally are most numerous during June and July.

174. Deerflies, mooseflies, and horseflies.—In the north there are three kinds of large flies which together are called "bulldogs." Deerflies are slightly larger than houseflies and have prominently banded wings. Mooseflies are much larger and thicker bodied, and some of them have a wing spread of nearly an inch. They are dark-colored, sooty, or grayish. Horseflies (stableflies) are usually intermediate in size between deerflies and mooseflies and are rather like houseflies in shape. All these "bulldogs" like the blackflies, frequent marshes and bogs on hot bright days. Strong winds do not keep them down, but cool weather sends them to cover. They are extremely annoying to man because of their continual circling and buzzing as well as their vicious bites. Under certain conditions deerflies are capable of transmitting tularemia. Against "bulldogs," fly dopes are not very effective; nets and gloves give the best protection.

175. Protective clothing, screens, and netting.—*a. General.*—Protective covering for the entire body is the best method of combating insect pests. Repellents (par. 176) in the form of oils and

ointments are invaluable against some kinds of insects. In camp, smudges can be used but are of doubtful value.

b. Clothing.—Select your Arctic summer clothing so that insects will be unable to reach your skin. The cloth should be so thick or so closely woven that insects cannot penetrate it. Otherwise, you should wear at least two layers of clothing; 8.2 chino cloth worn over long-sleeved and long-legged summer underwear gives good protection. Zippered or pull-over shirt fronts are preferable to open fronts. In the interior, clothing with maximum protection against insects and minimum warmth is recommended. To prevent flies from attacking your ankles, wear high shoes, shoepacs, or leggings, or wrap your trouser bottoms around your ankles and tie them with strips of cloth. Gloves are necessary and must be long enough to close the wrist opening. Mittens of windproof cloth can be used, if they are thick enough to prevent bites through the cloth. Gloves should be treated with cresol soap to disguise the skin odor, which attracts insects. Wear either a hat with mosquito net sewed on around the brim, or one of such shape that a headnet can be slipped over it. It must be a wide-brimmed hat, such as the fatigue or service hat, so that the netting will be held away from your face. Be sure the netting is dark—it is almost impossible to see through a white net. The bottom of your net should have a lightweight cloth carrying a drawstring by which the net can be drawn around your collar to inclose your neck. Since headnets are likely to tear if snagged, wire screen of very fine mesh sewn around a hat brim and fitted with a cloth bottom is good in timbered areas. If you do not have a headnet, wear goggles with screened sides and apply fly dope liberally.

c. Screens and netting.—The most satisfactory insect screen for permanent use is wire cloth no coarser than 18 meshes to the inch. The wire can be copper, monel metal, or galvanized steel. Black-painted or japanned steel wire is easier to see through than these, but is not as durable because it rusts. For most purposes ordinary mosquito netting is weak and spreads at the joints; bobbinet or hexagonal mesh is better.

d. Bed nets.—Nets made of fine mesh bobbinet are essential to restful sleep. The lower edge of the netting should be attached to a strip of light, closely woven cloth at least 18 inches wide for tucking under the sleeping bag. Nets are sometimes used as a complete inside lining for tents.

176. Repellents.—*a. General.*—Measures to drive away flies and mosquitoes, and surface applications to prevent biting, include dopes applied to the skin or to screens; also smokes or smudges.

b. Specifics.—Some substances are particularly effective against certain kinds of insects. Wood tar or, better still, oil of tar and oil of lavender repel blackflies; citronella discourages mosquitoes; and creosote, spirits of camphor, and oil of cedar keep off midges.

c. GI dopes.—These include some developed recently and issued by the Quartermaster Corps. Among these are *612*, *dimethyl-phthalate*, and *Indalone*. A mixture consisting of 3 parts 612, 1 part dimethyl-phthalate and 1 part Indalone has been found the most effective mosquito repellent with respect to northern mosquitoes. However, any one of these dopes used alone is only slightly less effective than the mixture.

d. Smudges.—As flies will not attack in smoke, smudges made of punky wood, ferns, or leaves are helpful in camp. To make a smudge, select an area several feet square and clear it of debris and humus down to the mineral soil. Build a brisk fire and let it burn to a bed of bright embers. Meanwhile, gather dry wood and a large heap of green ferns, leaves, shrubs, damp leaf mold, and rotten wood. Then place a few pieces of dry wood on the fire. When they blaze up, cover the whole with the damp material, adding more from time to time. However, it is unsafe to rely on smudges alone. They are frequently more irritating to people than to insects.

177. Palliatives for insect bites.—To relieve the itching of insect bites, bathe the swellings with weak ammonia, 1 percent alcoholic solution of menthol, zonite, or hydrogen peroxide. Moist soap, mud, or mere soaking in water often helps. In severe cases use a few drops of iodine or 1 : 40 carbolic lotion followed by boric acid ointment. Do not scratch the bites; scratching is likely to infect them.

178. Sprays.—Pyrethrum and kerosene and some of the commercial fly sprays are useful in the interiors of tents and houses, which should be tightly closed after spraying so that the vapor will destroy all insects present. Do not use near open flames because some sprays are inflammable. The new spray cylinders containing freon-pyrethrum-aerosol are effective for spraying the interiors of airplanes, camps, and tents. This spray is noninflammable and nontoxic.

179. Location of camps.—In setting up a permanent post, you can control the breeding places of insects fairly well over a limited area. With a temporary camp the best you can do is try to locate it where insects are scarce. High, breezy places are generally less "buggy" than depressions, and coasts with onshore winds are usually relatively free from insects. Remove underbrush to allow the air to circulate and the ground to dry out. Blackflies are especially abundant in the vicinity of swift brooks and waterfalls.

180. Lice.—There is little risk of getting lice when you travel through Eskimo communities. While cold, unless long continued, does not kill lice, it paralyzes them. Hanging up garments in the cold, then beating and brushing them, will help to rid them of lice but not of louse eggs. A louse killer known as S–13451 is said to remain effective for 3 weeks.

Section II

FROSTBITE

181. General.—Frostbite is the freezing of some part of the body. It is a constant hazard in subzero operations, especially when the wind is strong. Frostbitten skin becomes whitish and the flesh becomes stiff. As a rule, frostbite causes numbness rather than pain. Cheeks, nose, ears, chin and forehead, wrists, hands, and feet are the parts most easily affected. Prevention is a matter of taking proper precautions. If and when you do become frostbitten, prompt thawing is required. Neglected frostbite ultimately causes gangrene. With superficial frostbite, the gangrenous part may slough off of itself, leaving good tissue beneath. Where gangrene goes deeper, amputation is necessary. Only a medical officer should decide as to amputation.

182. Causes.—Frostbite is caused by exposure to severe cold, particularly in the wind. Contributing factors are loss of body heat and poor blood circulation, the latter a condition occurring naturally or caused by overtight clothing. Wet clothing especially and also insufficient clothing add to the risk. Further important factors are extreme fatigue, improper diet, and excessive carbon monoxide in house or airplane.

183. Treatment.—*a. Warm the frozen part gradually. Legs and arms* should be thawed in cool, dry air (60° to 70° F.). Elevating frozen limbs slightly also helps. Thaw minor frostbites of the *face* by holding a warm, bare palm against them. To thaw a frozen wrist, grasp it with a warm, bare hand. Frozen *hands* may be thawed against the chest, under the armpits or between the legs at the groin; or hands that are merely cold may be warmed in like fashion for the purpose of thawing a frostbitten wrist, ear, or face. With frozen *feet*, change to warm, dry footgear if possible; otherwise remove the cold shoes and

socks and wrap the feet with skins or sleeping bag. Holding the bare feet against a companion's belly or between his thighs is a good measure. Do not try to thaw by running—you may stub and *break* badly frozen toes. Moreover, running will exhaust you and cause you to perspire. Hands and feet are especially precious in the Arctic. Should they become frozen, *lose no time in thawing them.*

b. Never rub frostbite. This breaks skin tissues and causes open wounds, and in subzero temperatures, wounds heal very slowly. Bending frozen arms, legs, or ears also breaks skin tissues. *Never apply snow or ice;* freezing is increased by so doing. For the same reason, *never soak frozen limbs in kerosene or oil;* these liquids may be so cold that they will increase the frostbite. On the other hand, a frostbitten person should *not get too near a hot stove or other source of heat or use hot water for thawing.* Too rapid thawing increases pain and damages skin tissues.

c. When frostbite is accompanied by breaks in the skin, sprinkle them liberally with sulfanilamide or sulfathiazole powder to prevent infection. Do not use strong antiseptics such as tincture of iodine.

184. After effects.—A burning sensation like that of sunburn follows the thawing of a frozen part. The thawing of serious frostbite may be very painful. Sometimes blisters develop, but only a doctor should open them. If they break, trim off the dead skin with scissors and treat as you would an open wound or burn. After frostbite, the skin may peel. In general, treatment following the thawing is the same as for sunburn. To soothe postthaw burning, apply a good burn ointment, preferably lanolin.

185. Prevention.—*a.* Clothes for Arctic operations should be loose to allow free circulation of air. Keeping them dry is the most important means of frostbite prevention. Avoid becoming overheated, for excessive perspiration means soaked garments. Should you get wet, change as soon as possible to dry apparel. When you do arduous work, loosen your clothes still more and throw back your parka hood. During a pause, however, put on extra clothing to prevent chilling.

b. At all costs *keep your feet and hands warm and dry.* Shoes or mukluks should be big enough to allow two to four pairs of socks without binding. Insoles of felt or senne grass contribute to dryness. When you make camp, change *at once* to dry footgear and lie so that your feet are nearest the fire. Heavy wool mitts with outer mitts of windproof cloth (such as canvas) protect hands against frostbite. Never touch cold metal with your bare hands. If you should do so in the field you may have to be thawed loose, with fresh urine if necessary.

c. In cold weather a beard is a liability. Moisture from your breath collecting on it will convert it into a virtual ice mask that makes the

thawing of frostbites on the face very difficult. Clipping facial hair is better than shaving. But if you shave, do so before going to bed rather than in the morning, to avoid chapping.

d. To guard against a frozen face, wear a fur-edged parka hood that projects well beyond it; this can be adjusted to shut off the wind. A piece of thin windproof cloth pinned to the parka hood just below eye level and hanging loosely is good against a headwind. "Make faces" from time to time and touch your face to test for stiffness. Also, you and your companions should watch each others' faces for telltale spots. Never put your lips to cold whistles or bugle mouthpieces; your lips will freeze to them and will have to be thawed loose.

e. To maintain good circulation in your ears, press them forward now and then.

f. Knitted wristlets are effective. Be sure, too, that parka or coat sleeves fall over your mitts.

g. Alcohol increases the risk of frostbite because it seriously disturbs the body's normal production of heat and the control of body temperature. Never drink alcohol before going out into the cold.

h. Keeping in tiptop physical shape, through adequate rest, proper diet, and the avoidance of overexposure to cold, is a major frostbite preventive.

186. Frostbite prevention for the wounded.—Wounded personnel require special care because they are more likely to freeze than uninjured men. They must be made warm at once with coats, parkas, chemical thermopads—whatever is available—even while essential first aid is in progress. In stopping bleeding, release pressure frequently or the casualty will freeze. If a tourniquet must be applied, warm those parts of the body where circulation is cut off. As soon as bleeding is checked, remove the victim to a warm spot—ideally, a building. When a sleeping bag is used for continued warmth, brush the snow from the injured person's clothes before putting him into it. Shock treatment is essential. If the wounded man is conscious, he should be given hot nonalcoholic drinks, such as strong tea and coffee, as soon as possible.

187. General freezing.—*a. Contributing factors and symptoms.*—Insufficient rest and improper diet greatly contribute to the risk of freezing to death from prolonged exposure to cold. Symptoms of advanced general freezing of the body are muscular weakness, fatigue, stiffness of limbs, and overpowering drowsiness. The victim's sight grows dim; he staggers, falls, and becomes unconscious. If pulse and respiration are detectable, recovery is possible, even though the body is rigid.

b. Treatment.—Take care to rewarm the body very gradually. The patient should be placed in a cool room. If he has stopped breathing, give artificial respiration, continuing as long as his heartbeat is perceptible. Upon his showing signs of recovery, raise the room temperature slowly. When consciousness has returned, give hot non-alcoholic drinks—tea, coffee, cocoa, or even hot water if nothing else is available. Then place the patient in a warm bed or sleeping bag. Even after the return of consciousness and normal temperature there is danger of relapse and sudden death.

c. Prevention.—All the frostbite preventives apply as well to general freezing. The following are particularly important: clothing that is at once adequate, loose, and dry helps to retain body heat (par. 105). Eating well and getting enough rest are equally important in preventing the run-down physical condition that invites the risk of freezing to death.

Section III

SNOW BLINDNESS

188. General.—Snow blindness is both very painful and wasteful of time, but with proper care you can prevent it. Make every effort to avoid the first attack, because it makes you more susceptible to others. Recurrent attacks will permanently impair your vision. In the Arctic, delays are serious and often dangerous. For this reason alone a snow-blinded person is a liability. With a slight attack, he must lie over for at least a day. A severe atttack means a longer halt. The victim's usefulness, moreover, is cut down for a period beyond the point at which he is again able to travel.

189. Cause.—The cause of snow blindness is an overabundance of light produced by reflection or glare from snow. Actually, the eyes are sunburned. Overcast days as well as sunny ones are snow-blinding days; so also are days of light fog. Keep in mind that snow blindness may result from *very* short periods of exposure to glare.

190. Symptoms.—Your first warning is likely to be that your eyes feel sandy, burn, grow red, fail to focus properly, and become increasingly sensitive to light. External irritants such as smoke make them water. The final stage is intense pain. Stop using your eyes the moment you are aware of an attack.

191. Treatment.—The victim of snow blindness should be kept in a dark place or have his eyes bound with a dark bandage, and should rest until recovered. If traveling, he will have to be blindfolded and led. A cold compress (where there is no danger of its freezing) or a compress of tea leaves may give relief. Never use argyrol. Putting a few drops of a ½ to 1 percent solution of cocaine hydrochloride crystals (or pantocaine) in each eye is perhaps the most effective means of relieving pain. Five grains of dry crystals are conveniently carried in a 1-ounce bottle with a screw-cap top. Fill the bottle with cool boiled water just before using this palliative. After adding the water, keep the bottle in an inside pocket to guard against freezing and breakage. To aid in preventing infection, put a few drops of boric acid solution in each eye.

192. After effects.—Normal focus, which is disturbed by an attack of snow blindness, returns with full recovery. At first, however, convalescent victims are fit only for such tasks as do not require precise vision. Return of the ability to aim a gun or read an instrument, for instance, is delayed.

193. Prevention.—*a.* Colored glasses (par. 121) are the surest means of preventing snow blindness. For blizzard conditions, a leather-lined plastic or metal slit goggle is useful. Eskimo goggles have the special virtue of not frosting over, but they limit the field of vision. These are made by burning or cutting slits, of a size to admit a 50-cent coin, in a thin piece of wood. One of these is placed over each eye. They are kept on with a cord about the head. A glare shield may be made also by cutting T-shaped slits in thin pieces of wood or shells; the "lenses" are bound together and kept on with a cord.

b. Wear colored glasses (or their equivalent) *constantly* for daytime operations in snow- or ice-covered regions, and carry spares in case of breakage. When your glasses cloud or frost over, resist the impulse to remove them or try to peer around the rims. A thin coat of glycerin on the lenses will partly prevent clouding. But, if you are without an anticlouding preparation, *keep the glasses on.* Of course you must remove the glasses occasionally to clean them, for this purpose have a handkerchief always handy.

c. Blacking your nose and around your eyes, as well as looking at dark objects as you travel, helps somewhat to reduce glare. But these are merely extra precautions and are not a substitute for dark glasses.

Section IV

SUNBURN

194. Sunburn.—Sunburn is a major source of discomfort in summer operations where there is much snow or ice. It is caused both by the sun's direct rays and by reflection of light from snow and ice surfaces. Lips and nostrils are especially susceptible. Sun blistered lips that become infected can produce serious results. The best preventive is to apply a mild opaque ointment such as vaseline or lanolin along the red line of the lips and at the corners of the nostrils. Resist the temptation to strip to the waist on a very sunny day. Wear at least a light garment at all times. Lanolin cream soothes the sting of sunburn.

Section V

CARBON MONOXIDE

195. General.—Wherever a stove, fire, or gasoline heater is used indoors, there is danger of carbon monoxide poisoning. Therefore a steady supply of fresh air in your living and working quarters is vital. Many cases of carbon monoxide poisoning have occurred among ground crews working in planes and using gasoline heaters for warmth. *Carbon monoxide is a deadly gas and is particularly dangerous in that it is odorless.*

196. How the gas works.—Generally, there are no symptoms. With mild poisoning, however, these signs may be present: headache, dizziness, yawning, weariness, nausea, and ringing in the ears. Later on, your heart begins to flutter or throb. But *the gas may hit you without any warning whatever.* You may not know anything is wrong until your knees buckle. When this happens, you may not be able to walk or crawl. Unconsciousness follows; then death. Or you may be fatally poisoned as you sleep.

197. Treatment.—In a case of carbon monoxide poisoning, get the victim into fresh air at once but keep him warm. In an Arctic winter, fresh air means merely circulating air that is free from gas. Exposure to outdoor cold might cause collapse. If the only fresh air is outdoors, put the patient in a sleeping bag for warmth. Never exercise a carbon monoxide victim. This further reduces the precious

supply of oxygen in his blood, and increases his demand for it. If a gassed person stops breathing or breathes only in gasps, start artificial respiration immediately. In the latter case, the operator's movements must be carefully synchronized with the victim's gasps. Breathing pure oxygen removes carbon monoxide from the blood faster than does breathing air. So serious is carbon monoxide poisoning that a victim who survives it must be kept absolutely quiet and warm for at least a day. Hot-water bottles and hot pads are helpful in maintaining body temperature. Breathing pure oxygen greatly hastens recovery.

198. Prevention.—The only preventive of carbon monoxide poisoning is proper ventilation.

CHAPTER 8

MAKING THE BEST OF A FORCED LANDING

SECTION I

ROUTINE PRELIMINARY NEEDS

199. General.—*a.* In the Far North airmen must be prepared for forced landings at all times, and equipment should be checked before every departure from an airport. Equipment should be divided into three groups: equipment carried on the person; equipment carried in the parachute kit; and equipment carried elsewhere in the airplane. Suggestions for the make-up of each group are given below. As the contents of kits are changed from time to time, and as items may be missing from any kit, thorough checking is essential. Not all the items in these lists can possibly be taken; but having in mind your mission, the size of your plane, and the number of your crew, you can select the items you will need. Items which are checked in the parachute kit may be eliminated from the list of items to be carried on the person.

b. Following is a check list of items that may be carried on your person.

(1) Matches in waterproof match box.
(2) Side arm and ammunition.
(3) Knife.
(4) Pocket compass.
(5) Watch.
(6) Cigarette lighter.
(7) Sunglasses in safety case.
(8) Small adhesive bandages.
(9) Small copper wire for binding or snares.
(10) Hank of stout cord.

c. Following is a check list of items that should be in the parachute kit. (Additional bail-out rations are contained in snap-on kit, type E–6.)

(1) K ration packets.
(2) Bouillon cubes.
(3) Waterproof match case and matches.
(4) First-aid kit.
(5) Pocket compass.
(6) Pocket knife.
(7) Insect lotion.
(8) Headnet.
(9) Fishing kit.
(10) Snares.
(11) Goggles.
(12) Gloves.
(13) Mechanics' gloves.
(14) Ammunition.
(15) Cooking pot.
(16) Machete.
(17) Signal panel.
(18) Signal flares.
(19) Solid fuel fire starter.
(20) FM 31–15.
(21) Signaling mirror.

d. Following is a check list from which to select items that may be carried in the airplane. These items are for reference only. Select those necessary for the safe accomplishment of your mission.

(1) *Personal equipment.*—(*a*) First-aid kit.
(*b*) FM 21–10.
(*c*) Snowshoes.
(*d*) Skis, ski adapters (see TC No. 36, W. D., 1943), and ski wax.
(*e*) Extra clothing (mukluk boots, felt insoles, mitts, parka, socks, and trousers).
(*f*) Snow goggles.
(*g*) Insect netting and repellant.
(*h*) Cigarette lighters.
(*i*) Pocket compass.
(*j*) Maps.
(*k*) Toilet paper.
(*l*) Sewing kit.
(*m*) Rucksack.
(*n*) T. O. 01–1–67 and FM 31–15.

(*o*) TM 1–240.

(2) *Camping.*—(*a*) Tents.

(*b*) Sleeping bags.

(*c*) Gasoline stoves and spare burners.

(*d*) Containers for gasoline, oil, water.

(*e*) Wood ax and whetstone.

(*f*) Ice ax.

(*g*) Square pointed shovel.

(*h*) Chemical heating pads.

(*i*) Air mattresses.

(*j*) Flashlights with extra bulbs and batteries.

(*k*) Sled.

(3) *Mass equipment.*—(*a*) Utensils (E–2 kit or equivalent—includes pots, pans, butcher knife, and spoon).

(*b*) Additional forks, spoons, cups, or mess kits.

(*c*) Matches in waterproof containers.

(*d*) Candles.

(4) *Emergency rations* (for 10 days or more). These include—

(*a*) Dried milk, pemmican, sausages, Spam, corned beef or mutton, pork and beans, biscuits, raisins, dried fruit, cheese, butter, bouillon cubes, oatmeal or other whole grain cereal, sugar, chocolate bars, coffee, tea, salt, and cigarettes.

(*b*) Crew's lunch (for consumption en route or for delays in clearance; includes coffee thermos).

(5) *Hunting and fishing.*—(*a*) Carbine and ammunition, or combination caliber gun with ammunition.

(*b*) Fishing gear (fish line, hooks, flies, leaders, sinkers, spearhead, and candles).

(*c*) Fish net.

(*d*) Snares.

(*e*) No. 0 steel traps.

(6) *Signaling.*—(*a*) Portable transmitter.

(*b*) Ground strip signal cloth.

(*c*) Flares, rockets, and smoke signals (VK).

(*d*) Signaling mirror.

(7) *Airplane utility.*—(*a*) Tools (including small hand jack).

(*b*) Broom (for snow).

(*c*) Ropes.

(*d*) Funnel and chamois.

(*e*) Hand gas pump and hose.

(*f*) Engine covers.

(*g*) Wing covers.

(*h*) Supply containers that can be used as gasoline cans.

(8) *Additional equipment.*—In Greenland and Baffin Island, where there are mountains and where glaciers are widespread, these items also should be carried in the airplane:

(*a*) Crampons.
(*b*) Snowshoes, bear paw type.
(*c*) Packboard, one for each two men.
(*d*) Blankets.
(*e*) Sled, plywood, with collapsible runners.
(*f*) Rain suits and shoepacs for summer.
(*g*) Windproof parka and trousers.
(*h*) Extra mitten shells.
(*i*) Manila rope, 120 feet for each four men.
(*j*) Ice ax, one for each four men.
(*k*) Tarpaulin.
(*l*) Extra gasoline cooker (for heating shelter).
(*m*) Antisunburn cream.

200. Procedure before forced landing.—*a.* Bailing out in the Arctic is not a good procedure if you have visibility and if places for a forced landing are available.

b. Radio your position or estimated location in your distress message. Accuracy is vital.

c. Before you land, study the terrain and look for the best ground route leading out; also pick landmarks to help locate mountain passes and major streams. Spot large lakes, trappers' cabins, mines, and trails.

d. If you must bail out, check security of headgear; disconnect headphones; check fastenings of shoes; see that gloves are snug at wrists; see that pistol is strapped to leg and into holster; make belt knife secure; stuff pockets with food, matches, flashlight, extra ammunition, and maps.

201. Forced landing.—*a. General.*—A favorable area is necessary—a quiet river, a frozen lake, or a sand bar. Check the wind carefully by trees and drifting snow. Drop a smoke bomb if necessary. Do not mistake wind-drifted snow for a light fog blanket.

b. Landing surfaces.—(1) On an ice cap or in deep snow a belly landing generally is necessary.

(2) Beware of snowdrift ripples; if possible, land parallel with the ribs.

(3) Avoid crevasses.

(4) Avoid the areas on lakes where stream outlets prevent hard freezing.

(5) Do not attempt a wheel landing on tundra or muskeg in summer. The surface usually is soft.

(6) Avoid an out-and-out ice landing during the spring break-up and in September and early October; at these times thin ice under a snow cover may look solid but probably is unsafe.

c. Belly landing.—(1) Hold off until your gas is nearly exhausted.

(2) If temperatures are very low, choose a tableland in preference to a valley floor.

(3) Pilot should check safety position of any crew member not provided with a safety belt.

(4) Stall in, wheels retracted; before touching, cut off gas, place throttle in "idle cut off," ignition "off."

Section II

EMERGENCY LIVING

202. Immediate procedures.—*a. On landing.*—Get any injured personnel out and clear of the plane, because of the danger of immediate or delayed fire. Work fast. Take out emergency equipment including all kit items. Take out the ship's gear, including these items: sleeping bags, parachutes, snowshoes and skis, rations, camp stove, rifle and ammunition, fishing gear, flashlights, candles, flares, Very pistol and cartridges, broom, shovel, ax, wing and engine covers, tarpaulins, thermos bottles, maps, seat cushions, extra clothing, rags, flares, blowtorch, mirrors, ropes, wire, tools, containers for liquids, blankets, insect netting, tents, straps, and buckskin thong.

b. Injuries.—See FM 21–10.

c. Oil.—Drain into containers. Save some gas.

d. De-icing tank.—Remove for use as a fuel container.

e. Frostbite and snow blindness.—See paragraphs 181 to 187, inclusive, and 188 to 193, inclusive.

f. Crevasses.—See paragraphs 7 and 164.

g. Anchorage.—See paragraph 78.

203. Travel.—*a.* Usually it is advisable to *stick with the ship.* Aircraft are more easily seen than men.

b. Unless the terrain is favorable and you know your directions, a decision to travel is dangerous. However, if travel should be necessary, careful preparations are essential. Make up a back pack improvised from a parachute case or from paneling. Take all rations, matches, and contents of parachute kit, including first-aid equipment, ax, knife, gun, cooking utensils, sunglasses, socks, clothing, and protection for sleeping (such as sleeping bag and insect netting). It is better to carry duffle than to haul it. If you do haul, a long, narrow sled is better than a short, wide one. Engine cowling, wheel well or bomb bay doors are possibilities for sleds. Leave a large arrow marker by the airplane showing your direction of travel. Do not scatter; travel in a body. Usually head in a direction down some *large* stream (compare par. 5) and toward habitations or the coast. Check your progress with a compass and with visible landmarks. Stick to one course.

c. Make easy methodical progress. In winter be careful not to get overheated. See paragraphs 104 to 116, inclusive, on clothing and the uses of clothing. Do not buck blizzards (par. 169); seek shelter. If none is available, burrow down, back to wind, and wait it out as Eskimos and trappers do. In very low temperatures avoid deep breathing simply by taking it easy. In summer, swamps, brush, and innumerable lakes make travel a drudgery and in many districts almost impossible.

204. Food and water.—See paragraphs 92 to 103, inclusive, and 124 to 152, inclusive.

205. Shelter.—*a. Choosing a site.*—See paragraph 77.

b. Shelter materials (pars. 78 and 80).—Make full use of wing covers, parachutes, and tents. If there are no trees or other natural means of shelter, use parts of the airplane—cowls, bomb bay doors, cabin doors, ailerons, and rudders. Cover with parachute canopy or wing covers. Bed down the floor with boughs, moss, tarpaulins, and cushions.

c. Wing shelter.—On an ice cap a shelter can be made by digging a snow cave under the wing of a bomber. Take the snow out in blocks about 1 foot in diameter and use these to build walls up to meet the wing. Build toward the wing tip rather than toward the fuselage.

d. Ventilation (pars. 195 to 198, inclusive).—Remember that ventilation in your quarters is absolutely necessary.

206. Clothing.—See paragraphs 104 to 116, inclusive, and 123.

a. Footgear.—This is all-important. In winter it should be loose fitting. You can wrap your legs and feet in burlap, canvas, or parachute cloth. If the snow is loose and deep, use snowshoes. Improvise them from large inspection plates, nose-wheel doors, seat bottoms,

or stiffeners. You can make them of willow or other green wood with wood separator, and with weaving of thong, wire, cord, rope, or shroud. If you have come down on a glacier, wear snowshoes or skis to insure against breaking through crusted-over crevasses. Do not tramp around in the snow unless you are wearing suitable footgear.

b. Drying clothing.—Set up racks in your shelter, near the fire or in front of a heat-reflecting metal panel. Poles stuck crisscross in the ground make good clothing holders. To dry shoes, *shake* hot gravel in them. Avoid overheating woolen clothing and shoes.

207. Fuels and fire building (pars. 82 and 85 to 87, incl.).—*a. Outdoor fires in timbered country.*—(1) Clear snow away or build a bed of parallel timbers, gravel, or metal plate.

(2) Build a long fire parallel with the front of your shelter, instead of a round fire. Lay logs, sheet metal, or stones to reflect heat.

(3) Make a log or stone fireplace to confine and control heat for cooking.

b. Fires indoors.—The smoke of a round open fire escapes most readily. Make the fire bed of stones.

c. Oil fires.—An oil fire can be made in three ways:

(1) With engine oil, fed slowly from a punctured can.

(2) With anti-icing fluid (alcohol) squirted from a quart size fire extinguisher.

(3) With gasoline-saturated sand. Half fill a tin can with sand and puncture the sides above sand level to provide a draft. Scallop the top of the can to make a flame exit and a stand for a cooking pot. Saturate the sand with gasoline.

d. Starting fires (par. 89).—If matches are scarce, your plane battery or magneto will make sparks for starting fires, but you must have tinder. Save matches for possible emergency use on the trail.

208. Carbon monoxide.—See paragraphs 195 to 198, inclusive.

209. Sleeping (par. 117).—*a.* Keep sleeping bags *dry*. Convenient insulators are parachutes, tarpaulins, seat cushions, boughs, and moss. Never put a sleeping bag directly on snow.

b. Boughs or moss covered with parachute paneling, tarpaulins, wing covers, or aircraft insulation make a good bed.

c. Rest is important. Avoid getting chilled or overheated.

210. Signaling.—*a.* Conserve your special signals until you hear an airplane. Smoke bombs are the best signals; save these for the right moment. As a constant signal, build three well separated fires; keep them going and when you hear a plane, make a smudge with lubricating oil or green branches or a steam cloud with snow.

b. Use your radio if possible.

c. Tramp a large SOS in the snow—the bigger the better—and fill the letters with boughs, moss, or wood and metal from the plane.

d. Fell leafy trees across a clear area.

e. Spread colored panel signals on the snow.

f. Throw a beam on the rescue plane with your signal mirror; practice with the mirror beforehand.

g. Apply bright orange paint to wing tops; drape the wings with bright orange cloth or spread the cloth on the snow.

h. Remove cowling, nacelle plates, wheel, and bay doors and lay them on the ground, bright side up.

i. At night, use Very pistol flares or rockets on approach of airplane.

j. Keep your plane free of snow.

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BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
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OFFICIAL:

J. A. ULIO,
Major General,
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