1. Introduction

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The purpose of this volume is to present an international synthesis of the research findings obtained from studies of circumpolar human populations carried out in one of the human adaptability projects of the International Biological Programme (IBP). A synthesis of the information about the demography, genetics, odontology, growth and development, nutrition, physiology and psychology of selected Arctic populations is presented in this volume in chapters prepared by the scientific workers who participated in the field research.

From 1967 through 1974, IBP scientists from the USSR, Japan, USA, Canada, Denmark, Norway, Finland, West Germany and France conducted research on indigenous human populations in the circumpolar zone. US scientists studied an Alaskan Eskimo population on the north coast of Alaska in the villages of Wainwright, Point Hope, Point Barrow and an inland population at Anaktuvuk Pass. Canadian investigators worked at Igloolik and Hall Beach in the central Arctic. Scandinavians worked jointly on the Greenlandic populations at Aupilagtoq and Kraulshavn in West Greenland and on the Lappish people at Svettijärvi and Nellim in Finland. The French continued research that had been started in the 1930s on the East Greenlandic population at Ammassalik, and Scoresbysund. Soviet scientists investigated a number of populations in the USSR, and Japanese scientists studied the Ainu on the islands of Hokkaido.

This human adaptability project focussed on populations living in an environment that is characterized by low temperatures, seasonal extremes in light and darkness and relatively meagre ecological resources. Despite those environmental constraints, the populations studied have occupied the Arctic for many generations. Their long-term occupancy in small kin-based groups has provided human biologists with a marvelous opportunity to study aspects of human adaptability in considerable detail. The objective of the studies presented in this volume was to elucidate the biological and behavioral processes responsible for the successful adaptation of aboriginal circumpolar populations to their environment and its resources.

Development of circular studies

Professor Weiner has described the evolution of the Human Adaptability (HA) component of the IBP in Volume 1 of the IBP series (Worthington,

1975). An important event for the development of the HA studies was the symposium held at Burg Wartenstein, Austria, in 1964. The consensus of that symposium appeared in a WHO Technical Report *Research in Population Genetics of Primitive Groups* (1964), and the papers presented at that symposium appeared in a volume edited by P. T. Baker & J. S. Weiner entitled *The Biology of Human Adaptability* (1966). Chapters in this volume written by W. S. Laughlin and J. A. Hildes summarized the state of knowledge available at that time about the genetics, anthropology, health and physiological adaptations in Arctic populations.

The first meeting of the US National Committee for the IBP occurred on 6–7 March 1965. The HA sub-committee then consisted of F. Sargent *chairman*, S. Robinson, D. B. Shimkin, J. V. Neel and W. S. Laughlin. The IBP Eskimo program developed shortly afterwards. The late J. S. Hart *chairman for HA in Canada* suggested to F. Sargent that the US and Canada jointly pursue cooperative inter-disciplinary studies on Arctic populations and he organized a meeting at the National Research Council in Ottawa on 25 November 1966 to discuss the matter. Present were W. S. Laughlin from the USA and D. R. Hughes, G. Beaton, J. S. Hart and J. A. Hildes from Canada. An Air Canada strike disrupted the plans of F. Sargent and F. A. Milan to attend.

At this meeting W. S. Laughlin outlined a study plan which essentially followed the outline presented in the WHO Technical Report, for a human biological investigation which he proposed for the community of Wainwright, Alaska. The committee decided that other Eskimo populations in the central Arctic at Igloolik and in West Greenland should also be studied to compare them with their Alaskan kinsmen. It was agreed that these studies could best be carried out by a number of integrated international teams of scientists for each discipline working across selected study sites in the Arctic.

A second Canadian meeting was held on 30 March–1 April 1967 at the University of Manitoba Medical School in Winnipeg. Present were F. Sargent, W. S. Laughlin, L. Irving and F. A. Milan from the USA and J. S. Hart and J. A. Hildes from Canada. It was decided then that a working party conference should be scheduled for November and should be convened by J. A. Hildes and chaired by F. A. Milan. Milan was appointed scientific coordinator of the joint US–Canadian project by the two HA Chairmen.

The IBP–HA sponsored Point Barrow Working Party Conference held at the Naval Arctic Research Laboratory in November 1967, which was attended by 41 scientists representing all of the northern countries except the USSR, provided the format and methods for the study of northern indigenous populations under the auspices of the IBP. This was previous to the publication of the IBP instructional manuals. Published papers by Milan (1968) and Laughlin (1970) have discussed those plans for the international

Eskimo study. A report of the Working Party Conference by Milan was prepared in mimeograph form and disseminated to attendees and other interested persons.

At that Conference it was decided that each national group would organize its own study team rather than use the method of joint international teams suggested at Winnipeg. Attendees agreed to the establishment of a committee to oversee an 'International Study of Eskimos'. The appointed project directors from each country were members of this committee: US, F. A. Milan; Canada, D. R. Hughes; Denmark, J. B. Jørgensen; and France, R. Gessain. The chairmanship, first held by F. A. Milan, was rotated among the other directors. The function of this committee was to coordinate and review scientific proposals, expedite the movement of scientists between countries and promote the exchange of data for cross-national comparisons. One of the more important aims of the IBP-sponsored studies of northern indigenous populations has always been the comparison of human biological data obtained by similar methods across national boundaries.

Before the Barrow Conference, the HA sub-committees from the four Scandinavian countries had met at Sandefjørd in Norway in December 1966 to decide upon a general course of action for collaborative activities in the IBP. Earlier, in the summer of 1966, H. Forsius, A. W. Eriksson and W. Lehmann, representing Finland and West Germany, had conducted WHO-sponsored biological research on Skolt Lapps at Svettijärvi in Finland. Under IBP sponsorship, these studies were continued the following year at Nellim in Finland and they became a major part of the Scandinavian HA projects. A second part of the HA program was the joint Scandinavian studies in West Greenland organized and led by J. B. Jørgensen of Denmark.

In May 1967, the first in a series of Nordic symposia on human biology and medicine was held at Uleåborg in Finland to discuss the results of the Lappish studies. Papers from this symposium were published in *Nordisk Medicin* (1968). Since that time, HA investigators conducting research on northern populations (Ainu, Lapps, Eskimos) have met annually to exchange data and ideas at HA-sponsored meetings in Copenhagen, Denmark (May 1967); Hurdal, Norway (June 1968); Kiel, Germany (June 1970); Oulu, Finland (June 1971); Husavik and Reykjavik, Iceland (June 1973); and Yellowknife, Yukon Territory, Canada (June 1974). Canadians, Danes and Americans met at the annual meeting of the American Association for the Advancement of Science in Boston in December 1969 to discuss preliminary results of the joint study in a symposium organized by D. Hughes.

At the Kiel meeting in 1970, J. Lange Andersen *Chairman HA for the Nordic countries* organized an 'International Steering Committee for Cross-National Comparisons of Circumpolar Populations'. Members of this committee were J. S. Hart *Chairman* (Canada); D. Hughes *secretary* (Canada); F. A. Milan (USA); T. Lewin (Sweden); J. B. Jørgensen (Denmark); K. L.

Andersen (Norway); A. Eriksson (Finland); R. Gessain (France); S. Itoh (Japan).

At the program review of the Canadian Igloolik Project, Trinity College, Toronto (12–14 March 1971), where the review committee of R. J. Harrison, Oxford; L. D. Carlson, University of California, Davis; F. A. Milan, Alaska; G. Beaton, Toronto; P. Larkin, University of British Columbia; W. H. Cook, Canadian Committee for the IBP; and J. S. Hart, Canadian Research Council, met with D. Hughes and all HA Canadian investigators, international data synthesis was again discussed. J. S. Hart then formulated an agenda for the meeting of the Steering Committee for the next meeting in Oulu, Finland.

It was decided that the Steering Committee should arrive at Oulu the following year prepared to discuss (1) objectives, (2) common elements in all studies with a check list of all measurements, (3) sub-groupings of investigators for international comparisons, (4) plans for the first international workshop and (5) national commitments for support.

The Oulu meeting was held on 20 June 1971. Members of the Steering Committee, who also were attending the Second International Symposium on Circumpolar Health, met at the Medical Technology Institute to discuss the agenda items formulated at Toronto. Present at this meeting were J. S. Hart, D. Hughes, S. Itoh, O. Wilson, R. Gessain and F. A. Milan. J. S. Hart was elected Editor of this volume. The plans for international data comparisons were discussed again at Husavik in June 1972 and at the Vth General Assembly of the IBP in Seattle in September 1972.

Unfortunately, and sadly, J. 'Sandy' Hart died on 6 May 1973 before he was able to conclude the task which he had assumed and pursued vigorously. At the Reykjavik Meeting in June 1973, it was decided by those present that this volume should be written and F. A. Milan was elected to assume the editorship.

IBP representatives from the Soviet Union were present at the meetings in Kiel, Oulu and Reykjavik, and Z. I. Barbashova *Chairperson for Human Adaptability Studies in the USSR*, attended the IBP Seattle Assembly and visited the Institute of Arctic Biology in Fairbanks in 1972.

This particular IBP program was characterized by a certain amount of exchange of scientific personnel between countries, for example, Henrik Forsius, a Finnish ophthalmologist, T. Lewin, a Swedish anatomist and S. Haraldson, a Swedish public health specialist, worked in Alaska as did P. Di Prampero, an Italian physiologist and Jens Brøsted, a Danish student. J. Krog and M. Wicka, physiologists from Norway, Harriet Forsius, Finland, B. Chiarelli, a geneticist from Italy, and W. Mather, US, worked at Igloolik. In addition, D. R. Hughes, Canada, worked at Inari in Finland and R. S. MacArthur, Canada, a psychologist, worked in Greenland.

Theoretical and Practical Justifications for Human Adaptability Research in Circumpolar Populations

At the initial planning meeting at Point Barrow in 1967, W. S. Laughlin made a very succinct statement justifying the study of Arctic populations. He was speaking mainly of Eskimos, but many of his remarks are equally applicable to the Lapps and the Ainu. His statement is quoted here:

'The world's Eskimos are a remarkably successful group of mankind that has demonstrated its ability to adapt to difficult physical circumstances and, furthermore, to expand around a large sector of the northern circumpolar world. If their close relatives the Aleuts of Alaska are included, then they occupy the longest linear distance of any single human population group. This expansion demonstrates their ability to do more than simply survive harsh conditions despite limited natural resources. Archaeological evidence suggests that this expansion began some ten thousand years ago, on the coasts of the now-submerged Bering land bridge with peoples considered ancestral to the Eskimo and Aleut of today, culminating in the occupation of parts of what is now Siberia, Alaska, Canada and Greenland. Circumpolar adaptation, particularly cultural adaptation, may therefore be shown to have considerable time depth by means of this archaeological documentation.

The time involved obviously allows a sufficient number of human generations for the evolutionary agencies of natural selection, genetic drift and hybridization to operate, in conjunction with such environmental stresses as climate, disease and nutrition, to bring about many of the characteristics associated with Eskimos of today.

No one trait or character can be singled out as having played the most important part in this evolutionary process, or to account for this notable evolutionary success. At both the individual and population level of biological organization, therefore, the data of several scientific disciplines must be integrated in any inquiry. This is the main justification for a multidisciplinary approach.

One consequence of the geographical distribution of Eskimos is their citizenship in four different countries viz., the USSR, the USA, Canada, and Denmark. The Lapps, too, are citizens of Norway, Sweden, Finland and the USSR. We shall see that when definitions of circumpolar peoples are considered both the Lapps and the Ainu can fall within the scope of these studies. These circumstances, then, justify the international aspects of the human adaptability inquiry. There are clearly some common environmental factors, particularly during the winter months, that affect these populations, and have affected them for many, many generations. Equally clearly, there are also many significant variations. What factor of human adaptability, then, may depend on these circumstances? Are there common explanations for any of these?' (Laughlin, 1967, 1970).

The Arctic environment

As seen by an astronaut, planet earth is an oblate-shaped spheroid floating in deep space. The 23½° tilt of its axis in relation to its orbital plane and its annual march around the sun gives rise to the seasons. The sun, viewed from the earth, is directly overhead at the Tropic of Capricorn at latitude 23° 50′ S on the winter solstice and at the Tropic of Cancer at latitude 23° 50′ N on the summer solstice. The Arctic Circle, a cartographer's line encircling the earth at latitude 66° 30′ 03′ N, delimits a northern area from which the sun is not visible on the winter solstice and does not set on the summer solstice. The preciseness of the timing of these events is affected by the fact that the sun has an appreciable diameter, and that the sun's rays are refracted when passing through the atmosphere. Thus, the sun may appear on the horizon at the Arctic Circle after the date of the winter solstice (Haggett, 1972).

Precisely delimiting the Arctic environmentally is a difficult task (Ives & Barry, 1974). In a general way, the Arctic is bounded by the northern limit of the tree line, where, according to Köppen (1936), no summer month attains a mean temperature of 10 °C. The Arctic delimited this way includes the tundra and polar deserts of northern Alaska, a large part of Canada north of Hudson's Bay in the east and all of the Arctic archipelago in the north, all of Greenland, Spitzbergen and other eastern Arctic islands, the northern fringe of Norway and the Soviet Union north of latitude 70° N.

The greater part of the Arctic is taken up by the Polar Basin. This covers almost three million square miles, or 80% of the total area. In winter, 80% of the Polar Basin is ice-covered and in summer 60% (Budyko, 1966). The central portion of the Basin is a lifeless desert of floating ice, moving with the wind and ocean currents from the American and Asiatic continents north across the Pole and then to the south along the coasts of Greenland.

Solar energy powers the atmospheric circulation, ocean currents and food chains. Latitude, continentality and altitude account for the largest share of the systematic environmental variation on the earth. Whereas solar radiation is approximately 500 cal/cm²/day year round at the equator, at latitude 85° N, solar radiation varies between 650 cal/cm²/day in June and zero in January (Gates, 1962). Low temperatures at high latitudes in the summer, despite a higher radiation flux than at the equator at that time of year, are due to the high albedo of the snow and ice. An albedo of 0.8, compared with an albedo of 0.4 for the earth in general, reflects much of the incoming radiation back to outer space. Although the Arctic receives higher amounts of solar radiation in summer than the equator, only a small proportion is absorbed (Budyko, 1966).

According to Sater, Ronhovde & Van Allen (1971), the climate of the Arctic may be characterized as follows:

1. A distinctive regime of daylight and darkness with a low solar elevation resulting in a pronounced radiation heat loss.
2. Surface weather systems associated with the large scale, cold-cored circumpolar vortex present in the free atmosphere over the area of the Arctic. This is a function of the differential heating between the equator and the North Pole and the earth's rotation, the so-called Coriolis Effect.
3. Snow and ice cover which reflects some 80% of the total solar radiation back to the sky.
4. A strong temperature inversion above the snow or ice surface resulting from radiational cooling. The development of an inversion is strongest under calm anticyclonic conditions and most pronounced in Arctic regions with 'continental' type climates.

In ecological terms, the Arctic has limited ecological resources and a limited 'carrying capacity' for a human population owing to its climatic characteristics.

Climatic data, collected by long-term weather stations in the Arctic are presented in Table 1.1 as representative of the IBP study areas. Barrow is 90 miles north-east of Wainwright, Coral Harbor is 380 miles south of Igloolik and Karesuando is approximately 220 miles west of Svettijärvi and Nellim.

Of interest to us are the low mean daily temperatures, the low minimum temperatures and the low amounts of precipitation, most of which falls as snow. The high barometric pressures and the direction of the prevailing winds, easterly or north-easterly, are due to the presence of the cold-cored circumpolar vortex discussed by Sater *et al.* (1971). Upernavik's wind directions are influenced also by a katabatic, or gravity flow, of cold air from the Greenland Ice Cap. NE Atlantic Ocean currents and the Gulf Stream have an ameliorating effect on the climate of Fenno-Scandia which is reflected in the winter temperatures at Karesuando.

By way of contrast, Boston, Massachusetts, USA (42° 13′ N, 71° 07′ W), a reasonably habitable place, at least since the 1620s, has a mean daily temperature of 10.5 °C, with a minimum of – 29 °C and a maximum of 38 °C. The annual total precipitation in Boston is 1206 mm and the mean barometric pressure is 992.1 mbar.

The main characteristics of the climate of northern Alaska, the location of the IBP study sites at Wainwright, Point Hope and Barrow are: year-round aridity, low temperatures and frequent high winds with drifting snow in winter and cool temperatures and a high incidence of fog in the summer. The Arctic Ocean is frozen for about eight months of the year and the sea ice attains a thickness of between two and three meters. During the summer, the ocean is covered with progressively disintegrating floe-ice of the present and past years. This floe ice is, as a rule, not far from shore all summer (Milan, 1964). Igloolik is similar to the Arctic coast of Alaska in its climate but has twice as much precipitation. Upernavik, on the west coast of Greenland, is slightly warmer than Wainwright or Igloolik, and Karesuando is warmer than all of the other Arctic locations.

Cambridge University Press
978-0-521-11266-6 - The Human Biology of Circumpolar Populations
Edited by F. A. Milan
Excerpt
More information

Table 1.1. *Climatic data for IBP study areas (data from Landsberg, 1970)*

Location	Barrow, Alaska (71° 18′ N, 156° 47′ W)	Coral Harbor, Canadian Northwest Territories (64° 12′ N, 83° 22′ W)	Upernavik, Greenland (72° 47′ N, 56° 10′ W)	Karesuando, Finland (68° 27′ N, 22° 30′ E)
Temperature (°C)				
Daily mean	— 12.4	— 11.3	— 6.4	— 1.5
Extremes:				
Maximum	25.6	25.0	19.0	32.2
Minimum	— 48.9	— 52.0	— 40.0	— 34.0
Precipitation (mm)	110	249	186	380
Mean wind direction	Northeast	North	East, Northeast	Southwest
Mean wind speed (m/s)	5.4	5.7	1.8	1.5
Mean pressure (mbar)	1016.5	1005.3	1010.7	1011.0
No. of days with fog	65	32.5	35.2	17

By looking at the climatological data, it can be concluded that the Arctic regions of the world are not a hospitable place for man at any state of cultural development. Man is required to make a number of biological, behavioral, technological and cultural adjustments to survive. Yet, according to the archaeological evidence, the indigenous populations have survived and thrived in the Arctic for many generations.

Man and the northern circumpolar regions – a perspective

Finally we come to man himself in the Arctic. The purpose of this volume is to show how man has adapted in a biological and behavioral way to his surroundings. We need some perspective in which to put the information collected.

The precise antiquity of man in the Old World Arctic is still undetermined. Archaeological remains of his presence have been found between the Ob River and Lake Baikal in the USSR, dating back some 10 000 to 12 000 years. This is the time of the Third Würm Glaciation in Europe, and of the Wisconsin Glaciation in North America, i.e. conditions of extreme cold. Man's movement into and through the Arctic regions is therefore a fairly recent event in human prehistory, and there is no doubt, of course, that these early inhabitants of the north were of the same species as ourselves, viz., *Homo sapiens*. With the exception of a few islands in the Canadian Arctic archipelago, there are no large sections of the American Arctic and sub-Arctic, and even of northernmost Greenland, that have not, at one time or another, been inhabited by Eskimos in the north or Indians in the sub-Arctic. Most of the Eurasian Arctic and sub-Arctic has also been occupied for thousands of years, with the exception of some of the off-shore islands and most of the Taimyr Peninsula. It appears, too, that man was not driven into these Arctic regions, or forced to live there – he settled there by his own choice.

Originally, man evolved in the tropics, perhaps five million years ago, spreading northwards and southwards from those latitudes probably some half-a-million years ago. The palaeoclimatology of the Pleistocene period suggests that early bands of hunters in western and central Europe were living in the periglacial zone possibly a quarter of a million years ago, obviously under conditions of great cold.

Culturally speaking, however, it was towards the end of the Paleolithic or Old Stone Age, perhaps 70 000 years ago, that we have the first actual evidence of man having learnt the art of living in a cold environment. From the Aurignacian, Solutrean, and particularly the Magdalenian cultural periods, in the Old World, numerous archaeological finds demonstrate his ingenuity and his adaptability. By this time, he had developed specialized tools and weapons of chipped stone. The presence of scrapers and other tools for preparing skins, and of needles and buttons of bone and ivory, indicate

the manufacture and use of protective clothing of some degree of sophistication. The magnificent cave art of those times shows the numerous animals that he hunted and are characteristic of cold climates. There are pictures of seal, muskox, mammoth, cave bear and the woolly rhinoceros. As the glaciers receded northwards, so these hunters of the Upper Palaeolithic followed them, ranging across the Eurasiatic land mass, until, in the closing phases of the Pleistocene period, bands of northern hunters crossed to the New World. By about 2000 B.C., man had conquered the circumpolar Arctic from Norway round to Greenland, with the few exceptions previously noted.

If we focus for a moment upon Eskimos, we find that to identify their earliest appearance on the Arctic scene we must rely again on cultural evidence. Eskimo culture is distinctive in that it is an adaptation to living in a treeless region. It reflects a mixed hunting economy, with emphasis upon sea mammals such as seal, walrus and whale. The earliest archaeological evidence of this kind of activity, practiced by what we can term Proto-Eskimos, dates back about 5000 years, and is known as the Cape Denbigh Flint complex of northwestern Alaska. At this time, some of the Denbigh people hunted seal in the summer months, probably with boats, whilst others hunted caribou in the interior. The types and styles of tools found show much resemblance to finds at older Asian sites, so that many archaeologists believe that the Denbigh culture originated in the Palaeolithic and Mesolithic of the Far East, and in the early Neolithic of Siberia (4000 B.C.). Obviously these Denbigh people were well adapted, culturally, to survive in the Arctic. With impressive speed they moved eastwards across Arctic Canada to northeast Greenland, which they reached by 2000 B.C. In Canada, this first migratory wave of the descendants of the Denbigh people is represented by the Pre-Dorset culture. By about 800 B.C., the Pre-Dorset stage had evolved into a Dorset stage, with some minor differences in tool-making and in the range of tools made. The oldest skeletal remains of Eskimos in Canada come from a Dorset site on the south side of Hudson's Bay, and are dated to about 500 B.C. The Dorset culture lasted from about 8000 B.C. to A.D. 1300 in certain Arctic areas, but in others it was pushed aside, about A.D. 900, by a new culture, known as the Thule, that was moving eastwards from northern Alaska and was eventually to reach Greenland and Labrador. There may well have been cultural exchanges between Dorset and Thule Eskimos, the latter learning, for example, to make snow houses from the former. The Thule people were even more effectively adapted to life on the Arctic shores, being expert whale hunters. The Thule Eskimo, then, are the direct ancestors of the modern Canadian Eskimo, including the Caribou Eskimo who were to turn inland west of Hudson's Bay.

From the archaeology, therefore, we see evidence of at least 5000 years of Eskimo survival in an extremely harsh environment, accomplished by means of the evolution of a culture highly responsive to environmental change and