THE TASK AHEAD¹

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IN making preparation for the task that is mine this evening I have spent several days reading the Annals of the Association of American Geographers. My object was to learn what other speakers have said on similar occasions, and to get an indication of what the geographers of my generation have been doing. During that search I also made the acquaintance of several books and monographs that were new to me, and I studied the offerings of Geography Departments throughout the country. This has been a revealing experience because I found that there is wide diversity as to the content and method of geography. With some few exceptions, however, the curriculum has become quite standardized everywhere.

OPPOSING CONCEPTS IN GEOGRAPHY

It has been widely accepted that geography deals with the areal or regional differentiation of the earth. As many as twenty-five different regional courses are offered in some Geography Departments, and it would appear that a majority of the academic geographers are busy doing regional studies, writing regional textbooks, and directing regional doctoral dissertations. This development in the colleges and universities has strongly conditioned the training of students who aspire to become geographers.

Some scholars have taken vigorous exception to what is called the regional concept in geography. It seems to me that this opposing view has been expressed most clearly and convincingly in the Annals in three essays by Leighly² and in one by Ackerman.³ Leighly's original dissent came early, at a time when few could see the direction that geography was taking. He recognized that the compilation of information about the various parts of the earth, making it readily accessible as in an encyclopedia, which comprises the writing of regional textbooks or regional studies, was a useful service. He did not agree, however, that the performance of this service could encompass the whole field of geography, if indeed it was geography; nor did he agree that the professional geographer could perform the service as well as professional compilers. In summing up he said:

Systematic regional description has its uses, uses similar to those of lexicography. Like lexicography, it has its own problems and its own techniques for solving them. It seems to me, however, that it can scarcely become a program for any considerable body of scholars, nor reasonably claim a place in the academic world. Facts about the old settled parts of the earth that go into systematic regional descriptions do not come at first-hand from a single class of investigators, but from a whole wide range of sources . . . .

In a classic attack on the shift toward regionalism, Leighly in 1955 urged the revival of physical geography. Using a definition from

Russell Hinman’s textbook of 1888 which says that “Physical geography seeks to trace the operation of the laws of nature upon the earth; upon the air, the water, and the land; upon plants, animals, and even upon man,” he points out that the earth must be approached from the viewpoint of the physical and natural sciences, and studied in its own terms and for its own sake. He charged that geographers do not receive the required rigorous training in physical science and mathematics to work competently in physical geography. Leighly ended with a call to action. “Let us resume the fresh and frank quest that Hinman announced . . . ‘to trace the operation of the laws of nature upon the earth.’ The land, the sky, and the water confront us with questions wherever we look at them with open eyes. These questions, and the privilege of sharing in the quest of answers to them, are a part of our birthright.”

Leighly’s argument supports the conclusion that regional description, as it has been developed by academic geographers, is mere compilation, where the skills required are in writing and in library search, but that this does not provide the proper training for geographic research and can add nothing to our store of knowledge about the earth. Only those who have mastered geomorphology, climatology, hydrology, soil geography, economic geography, transportation geography, population geography, cultural geography, and so on, can do that. I might add that this mastery greatly enhances any regional study, by assuring that it will deal with the truly significant phenomena in the region. Perhaps the best regional study ever to appear in the Annals was done nearly 40 years ago and consisted of four essays on the Great Plains by Marbut, Kincer, Shantz, and Baker, who were all members of the Association but none in academic pursuits.

Ackerman’s essay dealt with the lessons learned during the war. He pointed out the deficiencies of the regional method and of geographic training as revealed by wartime service, but made it clear that the handicaps carry over into peacetime as well. He said:

... The regional method of research ... proved to have [little] value ... Where anything more than superficial analysis was required ... the only possible course was one of systematic specialization. Dependable accumulations of data, and reliable interpretations of those data were not to be had otherwise ... Just being a geographer, even though originally it led to employment, was not enough when it came to performance ... After the first frantic burst of effort very few responsible persons considered the pure regional geographer a specialist — even the best and most experienced among them. The superficiality of the “regionally” trained geographer’s information ... was readily evident ... This view would suggest ... that in the future no student of a region who lacks a systematic specialty should be considered a geographic specialist, or even worthy of a higher degree. Detailed systematic studies would then be considered a basic, inescapable phase of our training and research ...

I should like to underscore Ackerman’s warning that “human geography will never be accepted as a mature scholarly discipline until a more thorough systematic literature begins to take shape in it.” A commentary on his thesis describes the regional approach as trying “to put boundaries that do not exist around areas that do not matter” and “laborous transferring of dead bones from one coffin to another.” In another recent essay Ackerman made the following summary, “Thus the impression arose that the compilation of any set of data in a geographical binding and with a certain seasoning of correlation constituted research in human geography.”

Ackerman’s essay is long and I cannot take the time to quote more of it, but I commend it to you. It is now sixteen years old but still very timely and I suspect that only a few of our present members are acquainted with it.

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8 Ackerman, op. cit., pp. 128, 129.
9 Ibid., p. 141.
I would like to see it reprinted along with Leighly's three thoughtful essays, together with certain others that would be selected, to make them available to the new generation of geographers.

Early in 1961 the Association issued an official pamphlet on "Status and Trends of Geography in the United States 1957–1960." Although it contains chapters on geographers in business and in government and elsewhere, the introductory statement says that geographers have only one task—to teach. First, they must teach undergraduates who need to know some geography but have no wish to become geographers, and second, they must train geographers to do this teaching. The author says that geography is a form of general education like history, and both together provide the basic framework of place and period essential for understanding the social, political, and economic problems of the modern world. By way of amplification, however, he says: "in other words, the profession is called upon to develop regional specialists, and to offer courses in particular regions in academic institutions taught expertly by recognized specialists."14

But according to the pamphlet the profession does not really develop the regional specialist. He becomes a specialist only after a lifetime of study devoted to the many aspects of a particular area. The new holder of the doctorate entering into a teaching position in an academic institution may “possess competence in certain understandings of a topical field,” and a “feeling for the role he is to play in continuing the traditions of his professional field,” but not the “understandings” and “experiences” that would make him a regional specialist.15 This view coincides with that of the Committee on Training and Standards which said in 1946, “Graduate training cannot hope, and therefore should not pretend, to produce regional specialists, but rather to train men so that they will have the ability and the incentive to become regional specialists later.”16

It appears that the great majority of those who call themselves geographers are professors and teachers. They are therefore mainly concerned with the presentation of material to students. For the most part the title “geographer” means University professor, the center of activity of the geographer is the classroom, and a “regional specialist” is one who can organize and teach a regional course in a creditable fashion in a college classroom. The research that would thus be expected of the geographer consists of seeking out and assembling the course material from a variety of sources, organizing it according to some logical pattern, designing accompanying maps, and selecting relevant photographic illustrations. The skills involved are the ones that would enable him to carry out this program. They would include ability to write in acceptable English, read foreign language sources, and have some knowledge of maps.

That growing numbers of geographers entertain different views as to the content and objectives of geography and as to the training required for productive work in the field is attested by the increasing emphasis on quantitative methods. This new development has aroused a certain uneasiness among the regionalists and may have put them on the defensive. It is admitted that “the proponents of the modern methods of quantitative analysis have raised geographical study to a higher level of sophistication,” but “the focus of geographical attention [remains] on the characteristics of particular places.”17 Almost sorrowfully, we are asked to consider the question: “Where is the current trend toward increasing quantification taking us?”18

Thus, arising at the side of Leighly, who charged that the physical problems of the earth are a part of the responsibility of geography, are the geographers who see that economic, social, and cultural problems can have a depth not to be reached by the so-called “standard” geographical techniques. I am sure that Leighly did not exclude those problems when he said, “The land, the sky, and the wa—

14 Ibid., p. 12.
15 Ibid., p. 13.
17 Status and Trends of Geography, p. 12.
ter confront us with questions wherever we look at them.” The difficulty of course is that to get to the bottom of any basic question one needs a different training than is offered for prospective geography teachers by present-day Departments.

There has never been any doubt that to do acceptable work in any of the physical branches of geography such as geomorphology, climatology, hydrology, or pedology, mastery of mathematics and physics, together with an extensive knowledge of chemistry, are required. The present work of the regional scientists being published in the Journal of Regional Science, some of which is outstanding, brings into focus the need for genuine competence in mathematics in regional geography as well. I have been urging this need on the part of geographers for many years. One of my colleagues of a generation ago dismissed the matter by saying, “When I have a mathematical problem I will hire a mathematician to solve it for me.” Needless to say, he never had a mathematical problem because he could not know what mathematics could do for him. During recent years a few young geographers have demonstrated the power of modern mathematical and physical science by using them in the solution of problems in economic and cultural geography and in various population problems. I must admit that some nonsense has appeared also. We have much evidence, however, that the student who has mastered any of the systematic branches of geography, and who has a solid foundation in physical science to back it up, makes a better geographer. These are the ones who can perform creditably when they are required to do something other than train the teachers of undergraduate courses in geography.

THE PLACE OF CLIMATOLOGY IN GEOGRAPHY

I believe that I can make my point clear by use of an example from climatology. Climatology is considered to be a branch of geography, and rightly so. Probably, nearly every Geography Department has a course or two in climatology, but not necessarily someone who is really qualified to teach them. There are no prerequisites, usually, and I suspect that some of the students may not even have had ninth grade General Science in preparation. It is accordingly on the high school general science level.

The students have already been introduced to climatology in the first course in geography. The beginning course describes the origins of climatology in ancient Greece. It explains that climate originally meant slope and referred to the curvature of the earth’s surface which produced a sloping up to the south and a slope down to the north and brought about a threefold division of the earth into Torrid, Temperate, and Frigid zones. It introduces him to Aristotle’s deduction that the “habitable world” was confined to the temperate zone between the Torrid and Frigid zones which were uninhabitable because of excessive heat and cold, and that there must be a corresponding temperate belt in the southern hemisphere, habitable but utterly inaccessible, being cut off by the impassable equatorial zone. The student will learn that the five original climatic zones were eventually subdivided into twenty-four parallel belts or climates delimited by parallels of latitude; the longest day within each belt varying by one-half hour between twelve hours at the equator and twenty-four hours at each polar circle. The professor thereupon warns the student that “Aristotle’s brilliant generalization [of 2300 years ago] concerning the earth’s climatic zones can only be presented as a stage in the learning process, and not as a concept that is valid today.”

The student will be told that the term climate has been used in this sense almost up to modern times, although the geographical exploration that began about A.D. 1450 showed that climates are not simple latitude belts, but are instead usually highly irregular areas exhibiting contrasts in moisture supply as well as solar heat. The pattern of climate is described as a reflection of the general circulation of the atmosphere, which in turn is strongly affected by the distribution, orientation, and configuration of the great land masses and water bodies over the earth’s surface. This new direction was given impetus with the development of instruments, the making of observations, and the accumulation of data which could give quantitative expression

to the regional differences in temperature, precipitation, wind, and pressure.

Carl Sauer brought into focus the geographers' concern with climate by reminding them that "the resemblance or contrast between natural landscapes in the large is primarily a matter of climate" and that "under a given climate a distinctive landscape will develop in time." Geographers have concerned themselves with climate because they have believed that there are on the earth's surface natural climatic regions that are reasonably homogeneous and that have boundaries which can be identified in terms of plant communities, soil groups, and landform types and can be defined in terms of numerical climatic data. In short, they have seen in climate a key to the areal differentiation of the earth. This insight has led to a preoccupation with climatic classification. But not much was really demanded of climatic classifications and Sauer's view of 35 years ago probably expresses the majority opinion among geographers today. Sauer said,

In spite of very scant knowledge of the origin of climatic conditions, the facts of climate have been summarized in terms of their geographic significance most admirably. In particular Köppen's series of trials at climatic synthesis, carefully developed as to biotically critical values, admirably restrained as to genetic explanation, are among the most important if not the most important contribution in this generation to a general geographic morphology.

In harmony with this view, the climatology course for geographers teaches the ground rules for two or three of the classifications and gives the student the task of classifying a few stations according to the various systems. He may also check his results against surveys of vegetation and soils to enable him to say which system is "best." The climatic regions thus established become pigeonholes into which various miscellaneous geographic facts may be filed, and the main body of the climatology course consists of taking inventory of what is to be found in each of the pigeonholes. Here again we see the effect of a preoccupation with teaching. The classification is judged on how readily it can be presented in the classroom and not on how powerful it may be in the solution of geographic and other problems.

NEW DEVELOPMENTS IN CLIMATOLOGY

The science of climatology meanwhile, unknown to most geographers, has made much progress. Two aspects of the field have been organized and both are being cultivated with vigor. They are dynamic and physical climatology. I have previously had occasion to discuss this encouraging development and the next several paragraphs have been borrowed from an earlier paper.

Modern researches in physical climatology show us that climates owe their individual characteristics to the nature of the exchange of momentum, heat, and moisture between the earth's surface and the atmosphere. The climate at a place represents the existing balance between incoming and outgoing fluxes of heat and moisture.

In this sense, of course, the words "incoming" and "outgoing" must be interpreted horizontally as well as vertically. The horizontal component in the total flux is what we call "advection," which belongs in the province of dynamic climatology. In general, advection is slow by comparison with the vertical fluxes; the latter depend on radiative and turbulent exchanges parallel to very strong gradients of temperature and humidity, and are of a higher order of magnitude at most times than advection. The physical climatologist therefore concentrates mainly on determining the vertical heat and moisture balances for a given locality.

To evaluate the heat balance it is necessary to determine rates and amounts of solar radiation, reflectivity, and emissivity of various types of surfaces such as bare soils, vegetation-covered ground, water bodies, and snow and ice where it occurs. It is necessary to measure soil temperature at different depths and to determine the thermal properties of the soil material. Finally, it is necessary to determine the distribution of temperature with
height in the lowest several meters of the atmosphere.

To evaluate the water balance involves knowledge of the amount and distribution of precipitation, the variation in the amount of interception of water by plants, infiltration into the ground, and runoff from the various types of land surfaces and vegetation covers. In addition, the rate and amount of moisture transfer from the soil and vegetation cover to the atmosphere must be measured. To complete the moisture balance it is necessary to know the variation with depth of the soil moisture, the rate of moisture transfer through different soil materials, and the distribution of moisture with height in the atmosphere just above the ground surface.

Thus the proper field for study in climatology is not limited to the atmosphere alone but must include the land surface as well. Any region is a composite of innumerable local climates; the climate of the ravine, of the south-facing slope, of the hilltop, of the meadow, of the cornfield, of the woods, of the bare rocky ledge. Both the heat and moisture exchange vary from the ravine, to the hilltop, and to the rocky ledge, because of variation in the physical characteristics, position, exposure, and aspect of these diverse surfaces. The color, apparent density, heat capacity, moisture content, and permeability of the soil; the characteristics of the vegetation cover; the albedo and roughness of the surface; these are all factors that influence the heat and moisture exchange and are thus important climatic factors. This brief inventory of the content of climatology should leave no doubt that mastery of the field cannot be attained without an adequate background in physics and mathematics. It will also show that climatology is geography.

Ordinarily, the terms macro-, meso-, and microclimate designate different scales of area with microclimate referring to the climate of the very small space. The geographers use four terms that relate to different sizes of area; cosmography is the description of the cosmos or the universe, geography refers to a description of the whole earth, chorography to a region such as southern New Jersey, and topography refers to the description of a place. The old topographies, popular in England two centuries ago, were detailed descriptions of places of very limited area—fields or villages. Thus, by analogy, the climate of a small space might be called topoclimate and its study, topoclimatology.

The word, "topoclimatology," could substitute for microclimatology to mean the study of the climates of a place. But it has a better use, which can be derived by considering the content of climatology itself. Since climates owe their individual characteristics to the nature of the exchange of momentum, heat, and of moisture between the earth’s surface and the atmosphere, then climatology must study the earth’s surface as well as the atmosphere. It would be proper to assign to topoclimatology the task of determining the physical properties of the earth’s surface that share in the development of the climates.

A TASK FOR GEOGRAPHERS IN CLIMATOLOGY

In topoclimatology the study of climate takes a new aspect. Climatology has been an armchair study. The task of the climatologist presumably has been to salvage and analyze meteorological observations as meteorologists discard them. But the complete study of climatology involves field work. It involves detailed study of certain aspects of the land. It is essential in topoclimatology to make surveys and to map the aspects of the soil that affect the heat and moisture balance. These studies involve methods of mapping that have been developed by geographers and soil surveyors. Still, the pedologist has never concerned himself with the mapping of the heat capacity or heat conductivity of the soil. No geographer has ever attempted to map the qualities of vegetation that determine the surface roughness and condition the vertical wind profile or that determine the evapotranspiration and thus the soil moisture. No such maps have ever been made anywhere even experimentally.

Some geographers have experimented with the mapping of elements of slope and with what they call surface configuration. They have never made such maps, however, to assist in the interpretation of the heat and moisture balance. Unless a climatologist has had basic training in geomorphology and in soil science, he will be poorly equipped to work in this phase of climatology. Conversely, ordinary geomorphologists and soil surveyors will not have the understanding of the objectives of
climatology to lead them to make such studies. Teams consisting of climatologists and soil scientists working together could do well in this field.

It is necessary to emphasize the importance of mapping the characteristics of the surface that influence the exchange of heat, moisture, and momentum. Hare and his associates have made a map of albedo of Labrador, Canada, on a scale of 1:5,000,000. Lettau and his students are at work on a corresponding map of aerodynamic roughness. Maps showing the distribution of soil moisture in detail are similarly needed. Those elements which are of importance in heat and moisture exchange vary from season to season and in some instances from day to day. But to understand the heat and moisture exchange, it is necessary to produce maps showing these factors. Some years ago I published small-scale maps of the United States showing the concentration of moisture in the soil at the end of each of the twelve months. These were highly generalized maps. To achieve the program that is herein outlined, it will be necessary to make such maps on large scale. Maps of soil moisture would show the effect of soil texture, slope, and topographic situation on the water content. Such maps of soil moisture would aid immeasurably in an understanding of the water balance of a small area. The ultimate objective of climatology would be to use the maps of heat budget and moisture budget in building up climatic generalizations. Generalization from such local studies would greatly enhance our understanding of climates of large regions.

During the last several months the members of our research group at the Laboratory of Climatology have made some new discoveries in topoclimatology and have gained a new appreciation of its complexity. A problem of the Army had involved us in a study of vertical winds in typical terrain. We developed an instrument system for measuring the vertical component of the wind, and used it for making observations at different heights in a number of different locations in our area around Centerton, New Jersey. We were surprised to find in an extensive, uniform, nearly level field that day after day some spots show a predisposition to updrafts and others to downdrafts. This simple observation was unexpected because it has always been assumed that the mean vertical velocity of the wind is zero—in other words, that updrafts in a place must be balanced by downdrafts there. This assumption is basic to some micrometeorological theory. Since it must be true over any large tract of country, to preserve continuity, it follows that for each area of dominantly upward flow there must be somewhere nearby an equivalent area of downflow, with horizontal convergences between them. This conclusion opens up the prospect that appreciable local differences in total flux of heat, water vapor, and momentum must arise from the adjustment of wind streamlines to topographic obstacles and irregularities. It may well be that in some instances these are the most important differences in determining the locally observed topoclimates.

There is not time to follow this trail further. I will leave it by reminding you that there is much to be done in climatology, and much for the geographer to do. When he gets deeply involved in problems of heat and moisture exchange and of topoclimatology, he will see how inconsequential are the familiar exercises in climatic classification. If "there is a climatology of agriculture, of aviation, of health, of clothing, of housing, of tourism, and so forth," as Stephen Jones avers, then they are all made one through the unifying power of the heat balance and the moisture balance. My associates and I have been working for a long time on problems of heat and moisture exchange, and since 1953 not less than twenty-two of the publications of our Laboratory have dealt with the water balance and have outlined various of its practical applications. I fear that these publications are largely unknown to most professional geographers, although I should like to feel that they embrace the geographical point-of-view and point the
way to the solution of some important geographic problems.

SOVIET AND U. S. DEVELOPMENTS IN PHYSICAL GEOGRAPHY

The very useful new publication of the American Geographical Society, Soviet Geography, gives most of us our first glimpse of what is going on in the Russian geographical world. Every issue in the first half of 1961 has taken notice of the "problem of the heat and moisture balance of the earth's surface." The Third Congress of the Geographical Society of the U.S.S.R., meeting in Kiev in February, 1960, adopted a series of resolutions outlining the role geographers should play in this research. It noted:

... that the problem of the heat and moisture balance has now acquired great significance for the development of the theory of physical geography ... uniting the whole system of geographic scientific disciplines and permitting transition from the descriptive methods of studying the geographic envelope of the earth to more precise quantitative methods ascertaining the physical essence of the interactions between natural processes and phenomena ... it is resolved to recognize the significance of the problem of the heat and moisture balance of the earth's surface for the further development of the scientific theory of physical geography, for the transition of geography to modern research methods and for a sharp enhancement of its general significance in the national economy of the USSR.26

Furthermore, the Russian geographers took note of the new intensification of physical geography and what is translated as "landscape science." Among several resolutions there was one to concentrate the efforts of geographers upon working out methods of quantitative characterization of landscapes on the basis of the study of the moisture and heat balance in landscapes, and to undertake concrete measures to introduce new physical and chemical methods into landscape and paleo-geographic research, including the organization of a commission on questions of the application of modern physical and chemical methods in geography.26

The Russian geographers have outlined a large program for themselves in taking up the problems of the heat and moisture balance of the earth's surface. They have well phrased it in one of the resolutions: "uniting the whole system of geographic scientific disciplines and permitting transition from the descriptive methods of studying the geographic envelope of the earth to more precise quantitative methods ascertaining the physical essence of the interactions between natural processes and phenomena."27 It is a program that arouses my keenest interest, because it is precisely what I have been working on for the major part of my career. It is a direction that geography should take. I think that we should be in as close touch with these important developments as we can be and that in some center of learning in this country we too should undertake to reshape geographic theory on the basis of heat and moisture exchange.

As I return again to Leighly's challenge that "The land, the sky, and the water confront us with questions wherever we look at them," I would remind you that these are traditionally the three branches of geography. Yet today the sky is being investigated very effectively by the atmospheric scientists (as the meteorologists are beginning to call themselves) and the water by the oceanographers. A similar massive assault on the problems of the land is shaping up, and the geographers should participate in it.

I wish that there were time for me to tell you how the atmospheric scientists and the oceanographers have gone about organizing research and teaching in their sciences, how they have sought support for their program, and how successful they have been. Ten-year goals have been established in oceanography, and a program in atmospheric science for the next ten years, which has been hammered out this summer, will be considered by the Federal Council for Science and Technology in its September, 1961 meeting. This is a part of the work of the President's Science Advisory Committee on broad planning for the sciences. That Congress is also taking a hand is shown by a question which Senator Hubert Humphrey asked the Secretary of the American Meteorological Society in a letter dated June 8, 1961: "Do you believe that the Legislative and Executive Branches of the U. S. Government are at present adequately

26 Ibid., p. 71.
27 Ibid., p. 70.
providing on a systematic long-range basis to assure the fullest development of the state of the art of meteorology? If not what should be done on a long-range basis?"

The oceanography program has been launched. In fact, the President of the United States has urged it forward in two of his major addresses. There is little doubt that the program in atmospheric science will move forward with full support of Congress and the Administration. Since it was put together by the best brains of the nation, with the assistance of experts from several foreign countries, under the direction of the distinguished meteorologist Sverre Petterssen, I believe that it is a very good program, indeed.

When testifying before the House Committee on Science and Astronautics, Petterssen referred to the growing importance of the "environmental and resources sciences." He said:

With the projected increase in the world population and with an enormous increase in the standard of living of billions of people throughout the world, the demand on our resources will rise correspondingly, with the result that the sciences which deal with man's environment and the resources at his disposal will become as important tomorrow as are the engineering sciences today. To prepare for the future the universities should amplify their activities in geophysics and planetary sciences by a severalfold factor.28

Working groups organized by a committee of the National Academy in response to a request by President Kennedy have been meeting this summer to determine our national needs for natural resources and to construct programs of research for their conservation and renewal. The latest briefing in the series for the Committee on Renewable Resources was concluded less than two weeks ago, on August 18. Considering the present mood of the Federal Administration to improve and expand research in this country, I am convinced that there will be a rapid acceleration of research in the resource field, and a great increase in support of it. Let us hope that geographers will participate in this important program. Opportunity is knocking.

The research that will gain respect for the geographer in the scientific community will be done by those men who have mastered a systematic field. I can see a vast array of climatic problems that will demand solution as we seek ways to conserve our resources and to utilize them more efficiently. Those in other geographic fields doubtless will have contributions to make. The task here is not to produce surveys or inventories of resources, to map out their geographic distribution, or to write more textbooks on economic geography, but for those who can to show how to stretch or expand the earth's resources to feed, clothe, and house the world's rapidly growing population. What, for example, would it mean to the world if we should find some way to increase the efficiency of use of water by plants so as to reduce the waste from transpiration?

TRAINING FOR RESEARCH

We can learn much from oceanography, which was at one time regional marine geography. Professional oceanographers of the present are in reality marine meteorologists, marine biologists, marine geologists, chemists, and so forth. There is no pretense that "professional" oceanographers can be produced all in one mold by following a prescribed course of study. The problems of the land are far more varied and complex than those of the oceans and it should be apparent that no standardized curriculum for mass-producing geographers can possibly give the needed training for genuinely productive research in geography.

We recognize a legitimate need for two kinds of Geography Department, one to teach undergraduates and the other to teach the teachers. I see a need for a third kind of Geography Department, to do the fundamental research and to train the researchers. It will be argued that such Departments already exist, but if they do, there is room for more of them. It must be understood that the training for future teachers of undergraduate geography is not adequate for future geographical scientists. This Department would be staffed by men who had mastered various of the systematic fields. They would come from the outside. Once the new Department came into existence, student training for research would begin and soon the research effort could be expanded. The teaching responsibility in the research Department is very

important, not only because it would produce the new talent, but also because it would provide a stimulus to the researcher. We must not forget that it is the student who teaches the professor.

My own interests are on the physical side, and if I were invited to make suggestions for the organization of a first research Department of Geography, I would repeat what I have already said this evening: "In some center of learning in this country we should undertake to reshape geographic theory on the basis of heat and moisture exchange." Modern climatology is still in its beginnings. We are still measuring and mapping temperature and precipitation, although we know that our need is rather to measure the fluxes of sensible heat and water vapor. We cannot yet measure these fluxes very well and still have no suitable instrument for measuring net radiation. Even so, the new concepts in climatology stand ready to bring about revolutions in geomorphology and soil science, and certainly in plant geography and phenology. They have already been very influential in hydrology.

The research of this Department would not stop with physical geography. Nearly ten years ago Curry\textsuperscript{29} showed how economic geography could be given new life through the application of these modern climatic concepts, and recently Warntz\textsuperscript{30} has rediscovered this important research possibility; but only the merest beginning has been made. I am convinced that every aspect of geography would be improved and strengthened through application of the heat and water balance, that geography would come to grips with important practical problems, and that shortly new and fresh material would find its way into the teaching Departments. Already a high school teacher in Chicago is presenting the water balance to his students.\textsuperscript{31}

Cultural geography is a respected subdivision of the field, but I have not discussed it because I feel that it has not been neglected to quite the extent that physical geography has. To do good work in cultural geography a mastery of economics, demography, and historiography is required in addition to the requirements for physical geography. With that degree of competence we could expect work which would compare with the Swedish settlement studies, which are as valid and sound as any physical studies could be.\textsuperscript{32}

Physical geography has been neglected in the United States because geographers have neglected mathematics and physics in their undergraduate training. Most geography curricula in this country do not include any physical science whatsoever. This is why there is a distinction between "meteorological" and "geographical" climatology. Leighly said that "we forfeit our claim to respect if we accept that distinction, or admit... that what the meteorologists write is 'beyond the intellectual reach of the geographer.'"\textsuperscript{23} I made essentially the same point several years ago in a book review, suggesting that "there is no real reason why we should have one climatology for geographers and another for meteorologists," and urging that the author should "write the book that needs to be written, leaving it to the student to prepare himself as he should for using it."\textsuperscript{34} Kenneth Hare has warned that the climatic accounts in regional studies must be written with "rigor and sophistication in order to avoid mediocrity."\textsuperscript{35}

The inadequate training in geography has been exposed repeatedly in the methodological literature of the last decade, and some Departments have taken steps to stiffen the requirements. It is still true, however, judging from my study of University catalogs, that most Departments list many courses and permit, or even require, the student to take 25-30 of them, thus preventing him from getting needed courses elsewhere in the University and effectively depriving him of a college edu-


\textsuperscript{31} Markow J. Hracter, "Can the Water Balance Principle Be Taught to High School Students?" (processed).

\textsuperscript{32} For example, see John B. Leighly, "The Towns of Miiardalen in Sweden: A Study in Urban Morphology," \textit{University of California Publications in Geography}, Vol. 3 (1928), pp. 1–134.

\textsuperscript{33} John Leighly, "What Has Happened to Physical Geography?" op. cit., p. 317.

\textsuperscript{34} C. W. Thornthwaite, Review of "An Introduction to Climate" by Glenn T. Trewartha, \textit{Science}, Vol. 120 (1954), pp. 1,067–1,068.

cation. Small Departments may list many courses too, even when there is only one man to teach them all. When a man's offering includes courses in human, political, agricultural, urban, and industrial geography, North America, Latin America, Africa, and the U.S.S.R., and introductory and advanced climatology, they are likely to be so superficial and devoid of substance as to be largely a waste of the student's time.

Whether this trend may be reversed is not for me to say. In one Department the undergraduate requirements for the physical geography major include thirteen courses in mathematics, physics, chemistry, and geology plus only three courses in geography. Any student who has mastered this program will be prepared to enter upon graduate work in physical geography and could work effectively in climatology after having acquired a good background in meteorology. This program is beginning to attract students. The program of study in the social sciences is likewise undergoing revision. A rigorous program of mathematics, mathematical probability, mathematical statistics, and, of course, economics will be prerequisite to work in certain aspects of economic geography. This trend may be accelerated through the influence of the Institute on Quantitative Methods in Geography that has been conducted in the Chicago area this summer. The chairman of one Department reports that the few regional courses that are offered are service courses for non-geographers, and are not open to geography majors. Most of the requirements for the major are satisfied with courses in other Departments. I do not intend to outline a desired course of study for geography this evening, but I know that a thoroughgoing study of needed curriculum revision throughout the country should be undertaken.

The mathematicians are currently wrestling with a problem in mathematics education which should help us to understand the present situation in geography. The proposed solution was outlined recently in an editorial in *Science.* 368 The enrollment in mathematics courses is growing much faster than total enrollment in college. At the same time the number of mathematics teachers with Ph.D.'s is diminishing, because so many are going into government and industry. Accordingly, the members of a committee have proposed that the requirements for mathematics teachers be relaxed. At the present time a candidate for the doctorate in mathematics must pass preliminary examinations and write a dissertation offering some new and interesting mathematical proofs, on the assumption that one must be a creative mathematician in order to teach mathematics. Questioning this assumption, the committee suggested an alternative program of study in which the creative dissertation is replaced by "a scholarly dissertation which could be historical, critical, or philosophical." It was claimed that such research would give suitable preparation for effective teaching and would result in something of value to the mathematical community as well. To distinguish the new program from the traditional one, there would be a new graduate degree in mathematics, the Doctor of Arts. It was feared, however, that a new program of study would create "class distinction among mathematicians, with the upper and lower classes regarding each other with condescension on the one side and envy on the other." A key question posed by the *Science* editorial is whether its proponents really mean it when they say that the new kind of dissertation would be both preparation for teaching and a contribution to scholarship. The mathematicians emphasized the distinction between the "creative" study, which adds to the store of mathematical knowledge, and the "scholarly" study, whether historical, critical or philosophical, which does not. In geography we have historical, critical, and philosophical studies as well as regional studies. They may all be admitted as a form of scholarship, but they do not add to our knowledge of the earth nor give us any new insights into the "application of the laws of nature upon the earth" and would thus be accorded a lower place if we were to adopt the same class distinctions.

It seems to me that the various diverse points of view can be reconciled. We must recognize that there is need in geography for undergraduate and graduate teaching and that the beginning course may very suitably have a regional organization. It must be recognized, however, that the training for teaching such a course does not prepare one for a

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career in research or to work effectively in business, industry, or government. There is thus a need for a more rigorous training of geographers, in which we would be asking our students to get a better education than we ourselves have had. This is my sole thesis. Wherever possible, we should bring into the Department men who can see that the next generation of geographers will indeed be better trained to deal with all aspects of geography. And I would hope that among this new crop of geographers there will be those who will realize that the field of geography is not man but the earth, and that the earth must be "studied in its own terms and for its own sake."37

37 “What Has Happened to Physical Geography?” op. cit., p. 309.