CHAPTER

6

AN END AND A BEGINNING: ALEXANDER VON HUMBOLDT AND CARL RITTER

The fear of sacrificing the free enjoyment of nature, under the influence of scientific reasoning, is often associated with an apprehension that every mind may not be capable of grasping the truths of the philosophy of nature. It is certainly true that in the midst of the universal fluctuation of phenomena and vital forces—in that inextricable network of organisms by turns developed and destroyed—each step that we make in the more intimate knowledge of nature, leads us to the entrance of new labryinths; but the excitement produced by a presentiment of discovery, the vague intuition of the mysteries to be unfolded, and the multiplicity of paths before us, all tend to stimulate the exercise of thought in every stage of knowledge. The discovery of each separate law of nature leads to the establishment of some other more general law, or at least indicates to the intelligent observer its existence.

The two great masters of German geography—Alexander von Humboldt (1769–1859) and Carl Ritter (1779–1859)—loom large across the pages of the history of science. Both lived and worked in Berlin for more than 30 years, and both died in the same year. They were acquainted, but not intimately so. Never before or since have

The quotation above is from the translation by E. C. Otté of Alexander von Humboldt's *Cosmos* (London: H. G. Bohn, 1849–58) vol. 1, p. 20.

geographers enjoyed positions of such prestige, not only among scholars but also among educated people all around the world.

Many writers refer to Humboldt and Ritter as the founders of modern geography, but there are also good reasons for thinking of them as bringing the period of classical geography to an end. Using the large volume of new information resulting from the voyages of exploration, Humboldt and Ritter, each in his own way, produced massive syntheses. Although these syntheses made use of the new concepts and methods of study developed during the preceding two centuries, they nevertheless sought to present universal knowledge, just as Strabo had done and as had been attempted during the Age of Exploration of Münster, Varenius, Büsching, and others. But since 1859 the volume of recorded observations about the world and the individual's place in it has increased many thousands of times. In the nineteenth century the Age of Specialization came into being. No longer could any one scholar hope to embrace universal knowledge. The classical period had come to an end (Hartshorne, 1939:48–84).

ALEXANDER VON HUMBOLDT

Alexander von Humboldt was born into the Prussian landowning aristocracy. His father, an officer in the Prussian Army, died when Alexander was 10 years old. He and his older brother Wilhelm were brought up by their mother, described as "a very aloof and self-contained woman who provided for the education of her sons but gave them no intimacy or warmth. The sons were expected to show her respect and follow her directions" (Kelner, 1963:6). Alexander came to dislike the cold, constrained atmosphere of his home and lavished his affection on his brother and later on his brother's children. Alexander never married.

The brothers were educated at first by tutors, from whom they received an excellent grounding in classical languages and mathematics. Alexander had little interest in science but instead decided to undertake a career in the army. This desire was opposed by his mother, who insisted that he study economics as a preparation for a position in the civil service. However, events outside of his formal schooling combined with an almost insatiable curiosity about a great variety of matters led him toward a career in science. In Berlin his mathematics tutor introduced him to a group of liberals and intellectuals who gathered at the home of the Jewish philosopher, Moses Mendelssohn (the grandfather of Felix Mendelssohn, the composer). Jews and gentiles joined in discussions of the social inequities of an aristocratic society and drew up plans to do something about these things. Alexander also met the physician, Marcus Herz, a disciple of Immanuel Kant, who organized a series of lectures on scientific subjects, including demonstrations of scientific experiments.

When Alexander was ready to attend a university, he was already excited about the various aspects of the physical world. After a short time at a small university at Frankfurt-on-the-Oder, he returned to Berlin to take a course in factory management at his mother's insistence. He also used the time to increase his knowledge of Greek and even began to study botany. In 1789 he went to the University of Göttingen, where he studied physics, philology, and archaeology. In the late eighteenth century, studying a subject meant taking a course of lectures in which a scholar would impart to his students everything that was up to date in the field.

At Göttingen Alexander met Georg Forster, lately returned from his voyage around the world with Captain Cook. From Forster Humboldt became excited about the study of botany. In 1790 these two started on a hiking trip down the Rhine to the Netherlands and thence by ship to England. The notes that Humboldt took on this trip show his interest and his ability to observe carefully such diverse matters as the varying price of wool or the effect of crop rotation on soil. He had a "success experience" in asking questions about the physical earth and human use of it and in finding answers to his questions. Later, Humboldt said that his interest in geography had started with his acquaintance with Georg Forster.

Humboldt then decided to attend the School of Mines at Freiberg in Saxony, where the celebrated scholar Abraham G. Werner was lecturing. Werner was the originator of a widely supported hypothesis that all the rocks of the earth had been formed by precipitation under water and had been deposited in layers. Humboldt attended lectures in physics, chemistry, geology, and mining. In 1792 he was appointed to an administrative post, first as inspector and later as director of mines in the Prussian state of Franconia. But his active mind was always formulating new questions about almost everything that caught his attention. He studied the effect of different rocks on magnetic declination. Underground in the mines, he carried out experiments with subterranean plants he found growing there. His first scientific paper was on the results of these studies, published in 1793 (Humboldt, 1793). He also established a school for the miners and in various ways attempted to improve their living conditions. When he heard of experiments carried out by the Italian scientist, Luigi Galvani, regarding the electrical and chemical stimulation of muscles, he undertook some experiments of his own, as a result of which he came very close to discovering how to make an electric battery. There seemed almost no limit to the range of his curiosity. He also wanted to travel and see for himself what different parts of the world were like. When he visited Bavaria, Austria, Switzerland, and Italy, he observed the rock structure of the Alps and tested some of the ideas of the Swiss scholar, Horace Bénédict de Saussure, who thought the deep Alpine valleys had been cut by the rush of water in the receding flood.

In 1796 Humboldt's mother died, and he came into possession of a small fortune. His part of the family inheritance was an estate on the east bank of the Oder River, known as Ringenwald. Income from this estate freed Humboldt from the necessity of earning a living. It paid for his travels in America and for the expensive publication of his many reports on these travels. In 1797 he resigned his government position and began to plan for traveling.

Humboldt's preparations for studies in the field were unprecedented. In Paris he gathered together an amazing variety of instruments and learned how to make use of them:

> He had been provided with an eight-inch Hadley sextant by Ramsden with a silver circle graduated at twenty-second intervals and a two-inch Troughton sextant, a kind of pocket edition which he called his snuffbox sextant. It was extremely accurate and very convenient to carry in difficult terrain. His barometers and thermometers had been standardized before his departure with those of the Paris observatory. The longitude determinations were made with a Dollond telescope and a chronometer by Berthoud whose rate of variation had been carefully checked. Three different kinds of electrometer, provided with pith spheres, straws, and gold-leaf, allowed him to observe atmospheric electricity. He also possessed a Dollond balance for the measurements of the specific gravity of sea water, an eudometer for the analysis of atmospheric gases, a Leyden jar and the necessary chemicals and glass bottles as well as a cyanometer designed by Saussure. This was an instrument by which the blueness of the sky could be determined through comparison with prepared gradations of blue colours and correlated with the hygrometrically determined humidity. The magnetic measurements were carried out with a Borda magnetometer, a rather cumbersome instrument (Kellner, 1963:62).

Before leaving Paris Humboldt learned from Pierre Simon Laplace how to use the aneroid barometer to determine elevations above sea level.

Several opportunities to join expeditions that were going overseas did not work out. One was an expedition to Egypt that was called off when Napoleon occupied that country. Another was a trip to the Pacific, following Captain Cook's steps. In 1798 Humboldt and a French botanist named Aimé Bonpland decided to go to Marseilles and there to take passage on a ship for Algiers, from which place they intended to travel overland to Egypt. Unfortunately—or fortunately, we might say—these plans also fell through when the ship was wrecked off the coast of Portugal before it ever reached Marseilles. Humboldt and Bonpland then figured they might be more successful in getting passage on a ship from a Spanish port, so they set out overland for the city of Madrid, where all such passages would have to be arranged (Fig. 17). On the way to Madrid, Humboldt made daily observations of temperature and altitude. He was the first to make an accurate measurement of the elevation of the Spanish Meseta.

In Madrid Humboldt's position in the Prussian aristocracy gave him access to the ruling aristocracy of Spain. He made a good enough impression on the Spanish prime minister that he and Bonpland were granted permission to visit the Spanish colonies in America—the first such permission granted to any non-Spanish Europeans since the expedition of C. M. de La Condamine to measure the arc of the meridian along the equator in 1735. Humboldt and Bonpland sailed in June 1799.

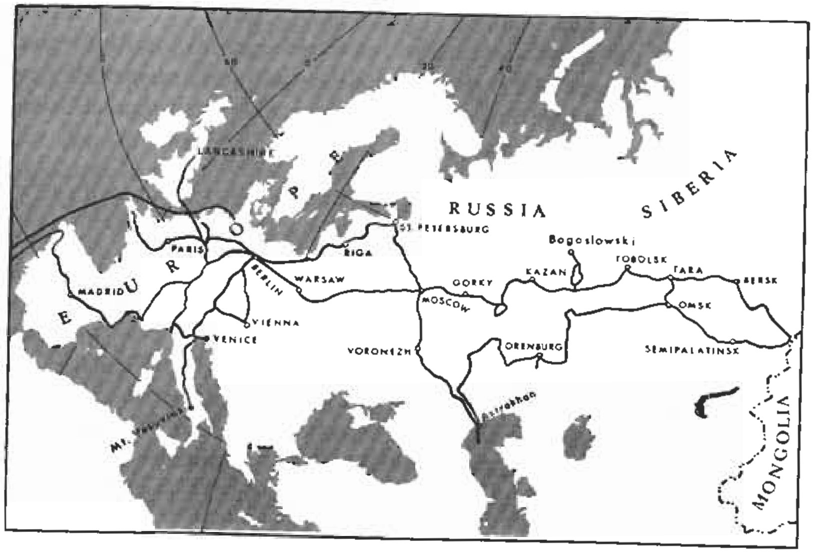

FIGURE 17. *Humboldt's travels in Europe and Russia.*

HUMBOLDT'S AMERICAN TRAVELS

Humboldt's travels in the "equinoctial regions of the new continent" began at Cumaná in Venezuela (Fig. 18). First, the two men went to Caracas and began exploring this long-settled part of the country. One of the first places they investigated was the Basin of Valencia in the midst of which is the Lake of Valencia, some 50 miles southwest of the capital. Humboldt noted that at one time the lake was much deeper and had an outlet to a tributary of the Orinoco but that in 1799 the lake had no outlet. Crops were being grown on the flat lakebed soils from which the lake waters had receded. Why should this event have taken place? The connection between the removal of forests and the drying up of rivers had been presented by Buffon and others, but Humboldt was the first to test this theory by confronting it with observed facts in a particular place. Here is what he had to say about the Lake of Valencia:

> Felling the trees which cover the sides of mountains, provokes in every climate two disasters for future generations: a want of fuel and a scarcity of water. Trees are surrounded by a permanently cool and moist atmosphere due to the evaporation of water vapor from the leaves and their radiation in a cloudless sky. They have an effect on the incidence of springs, not as was long believed by a peculiar attraction for the atmospheric vapor but because they shelter the soil from the direct action of the sun and thereby lessen the evaporation of the rainwater. When forests are destroyed, as they are everywhere in America by the hands of European planters, the springs are reduced in volume or dry up entirely. The river beds, now dry during part of the year, are transformed into torrents whenever there is heavy rainfall in the mountains. Turf and moss disappear with the brushwood from the sides of the hills; the rainwater rushing down no longer meets with any obstructions. Instead of slowly raising the level of the rivers by progressive infiltration, it cuts furrows in the ground, carries down the loosened soil, and produces those sudden inundations which devastate the country. It follows that the destruction of the forests, the lack of springs, and the existence of torrents are closely connected phenomena (Humboldt, 1814–25, Williams translation, 1825:4, 143).

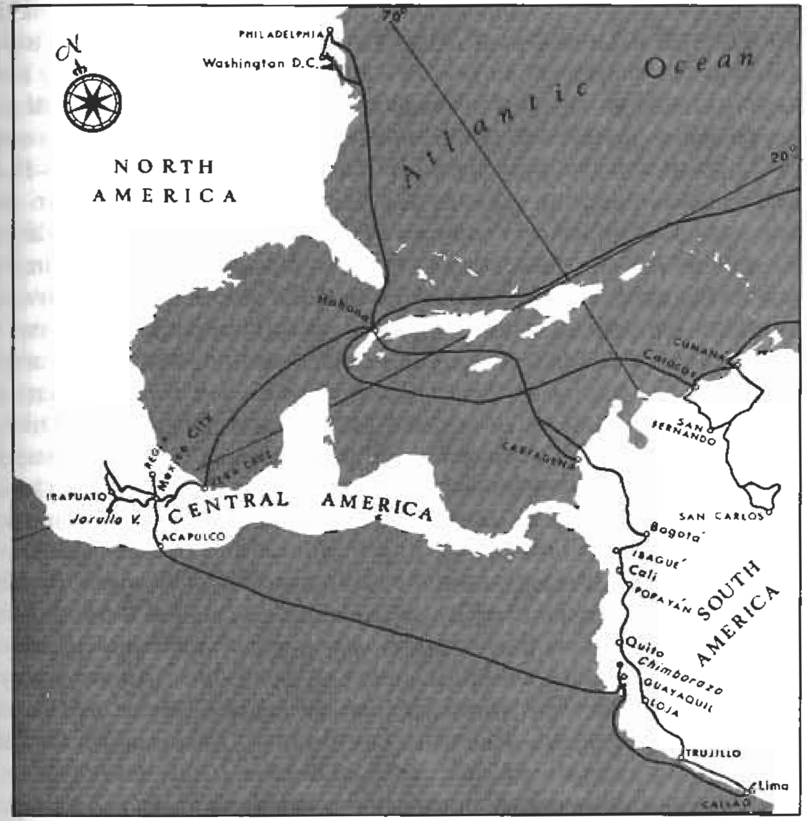

FIGURE 18. *Humboldt's travels in the Americas.*

Around the Basin of Valencia, Humboldt observed that the once continuous cover of tropical forest had been entirely removed and the lands were used for agriculture. The Lake of Valencia became a famous example of the application of a concept formulated by earlier writers but without carefully recorded direct observations to support it. Curiously, the idea that forests cause an increase of rainfall still persists.

During the year 1800 Humboldt and Bonpland carried out what must be one of the great exploratory efforts in man's continuing urge to see beyond the horizon. They mapped some 1725 miles of the Orinoco River, mostly through uninhabited forests. In small boats and canoes they paddled upstream from the junction of the Orinoco and the Apure. Many years earlier de La Condamine had reported a story told by a Jesuit missionary—Father Manuel Ramón—that the water of the upper Orinoco split into two channels, one of which spilled over to reach a headwater of the Rio Negro and the Amazon. This was the Rio Casiquiare. But Philippe Buache, in compiling maps and reports on various parts of the world in accordance with his theory of continuous mountain chains, rejected de La Condamine's report. He showed a range of mountains along the divide between the Orinoco and the Amazon drainage basins. In 1800 Humboldt surveyed the Casiquiare and confirmed Father Ramón's observation of the bifurcation of the Orinoco. Modern geomorphologists recognize this as an example of river capture that is currently ongoing, in which, over long periods of time, the upper Orinoco will be cut off to become a part of the Amazon drainage. The Orinoco, we would now say, will be beheaded.

The trip up the river and along the Casiquiare imposed severe hardships. The travelers had to subsist largely on bananas and fish and were constantly exposed to the bites of clouds of mosquitoes, ants, and other insects as well as to poisonous snakes, man-eating fishes, and crocodiles. Almost everyone came down with fever, but Humboldt himself seemed immune and retained the necessary vigor to undertake whatever travel was necessary for his observations. With his instruments he established the exact latitudes of places and came very close to correct longitudes. He collected thousands of plant and rock specimens, all of which were transported back to Caracas and then to Cuba. Among his specimens were plants from which the poison, curare, is extracted. This kind of poison was first reported by Sir Walter Raleigh, but Humboldt brought back to Europe the first specimen. In November 1800, the two men returned to Cumaná and sailed for Cuba.

In 1801 Humboldt and Bonpland arrived in the Colombian port of Cartagena and from there began their exploration of the Andes of Colombia, Ecuador, and Peru. With altitudes established for the first time by the aneroid barometer, with temperatures actually recorded by the use of the thermometers, and with the exact location of every observation fixed by latitude and longitude, Humboldt was able to give the first scientific description of the relations of altitude, air temperature, vegetation, and agriculture in tropical mountains. His description of the vertical zones of the northern Andes is a classic. He also examined the numerous volcanoes of Ecuador, descending again and again into active craters for the purpose of collecting the gasses emanating from within the earth. Looking closely at the rocks of the Andes, he decided that Werner was quite wrong about the origin of rocks and that granite and gneiss and other crystalline rocks were of volcanic origin.

Humboldt climbed most of the volcanoes of Ecuador. After the expedition of de La Condamine, it was believed that Mount Chimborazo was the world's highest mountain. Attempting to reach its summit, Humboldt and Bonpland, on June 9, 1802, reached an altitude of 19,286 feet, which was the highest altitude that had been reached by man up to that time. This remained the record for 29 years until in 1831 Humboldt's protégé, Joseph Boussingault, reached an altitude of 19,698 feet on the same mountain. (Chimborazo, 20,561 feet high, was finally conquered by the British mountaineer, Edward Whymper, in 1880.) Among the high peaks, Humboldt was able to observe and report on the effect of altitude on human beings and to describe the symptoms of mountain sickness, or *soroche*. He explained the feeling of dizziness as resulting from low air pressure. (It is now known to be due to lack of oxygen.)

Humboldt and Bonpland finally reached Lima. Here Humboldt was able to observe the transit of the planet Mercury across the sun. This gave him an exact measurement of the longitude of Lima and made it possible to check his chronometer, which proved to be quite accurate. On the Peruvian coast he investigated the chemical properties of guano, or bird droppings. He sent some samples back to Europe and as a result started the export of guano as a fertilizer. On a sea voyage from Callao in Peru to Guayaquil in Ecuador, he measured the temperature of the ocean water and for the first time described the movement of ocean water, including the upwelling of cold water from below. He named this the Peruvian Current; he always objected to its being called the Humboldt Current because, he said, he had not discovered the current but had only measured its temperature and velocity. Modern oceanographers have agreed to name all currents by geographical names; therefore, it is officially known today as the Peru Current.

In March 1803 Humboldt and Bonpland sailed from Guayaquil to the Mexican port of Acapulco. The Viceroyalty of New Spain, as Mexico was then called, was at the peak of its prosperity owing to the relaxation of restrictions on trade, to the investment of new capital in mining, and to the presence of an unusually capable group of administrators and ecclesiastical leaders. In 1794 New Spain was the first Latin American country to take a census of population. Humboldt updated the population figures to 1803 by consulting with the parish priests. He also found a rich collection of statistical data on production and trade. Traveling throughout the country, he continued to climb the mountains, measure altitudes, fix locations by latitude and longitude, and investigate the many questions about human-land relations that occurred to his imaginative mind.

In 1804 the travelers sailed to Havana, Cuba. Humboldt now faced a problem that scientific travelers have always faced—how to avoid the loss of notes and specimens painfully collected in the field. He and Bonpland had accumulated a large number of boxes containing notes written on their travels and specimens of plants and rocks of inestimable value. He dispatched the whole lot to Europe by different ships, some of which were destined for

Paris and others for London. Almost all his notes and drawings were made in duplicate, which was amply justified when some of the shipments failed to reach their destinations.

Humboldt and Bonpland's visit to the United States was a memorable occasion. They reached Philadelphia in May 1804. There they visited the American Philosophical Society and then started for Washington by way of Baltimore. From June 1 to 13 they were in Washington, where Humboldt had many meetings with Thomas Jefferson, whose interest in geography has already been noted. Humboldt and Jefferson became close friends, and the great German scientist was given access to the White House without special invitation. Humboldt was greatly moved by the liberal ideas so eloquently expressed by the author of the Declaration of Independence, with whom he was thoroughly in accord. He and Bonpland finally set sail from Philadelphia for the return voyage to Bordeaux on June 30, 1804.[1]

IN PARIS

First, Humboldt returned to Berlin, but especially after the defeat of the Prussians by Napoleon in the battle of Jena in 1806, he found himself isolated from the world of science and scholarship. After a brief visit to Italy to observe an eruption of Vesuvius, he went to Paris on a diplomatic mission but remained there for the next 19 years.

It was in Paris that Humboldt wrote and published the 30 volumes in which the results of his American field studies were presented. In the French capital he was able to secure assistance from other scholars in putting his 60,000 plant specimens in order—specimens that included many species and genera never before known to Europeans. And, too, in Paris he could work with skilled publishers and engravers. The 30 volumes are included under the general title: *Voyage aux régions équinoxiales du Nouveau Continent* (Humboldt, 1805–1834).[2]

[1]For a detailed account of Humboldt's stay in the United States, see Herman R. Friis in Schultze, 1959:142–195.

[2]The contents of the 30 volumes as originally published are as follows: 1–2 *Plantes équinoxiales* . . . , ed. A. Bonpland (Paris: Levrault et Schoell, 1808–1809) (143 plates). 3–4 *Monographie des mélastomacées* . . . , ed. A. Bonpland (Paris: Librairie grecque-latine-allemande, 1816–23) (120 plates). 5 *Monographie des mimoses et autres plantes légumineuses*, ed. C. S. Kunth (Paris: N. Maze, 1819–24) (60 plates). 6–7 *Révision des graminées* . . . , introduction by C. S. Kunth (Paris: Gide fils, 1829–34) (220 plates). 8–14 *Nova genera et species plantarum* . . . , with A. Bonpland, ed. C. S. Kunth (Paris: Librairie Schoell, 1815–25) (700 plates). 15–16 *Vues des Cordillères et monuments des peuples indigènes de l'Amérique* (Paris: F. Schoell, 1810) (63 plates). 17 *Atlas géographique et physique du Nouveau Continent* . . . (Paris: Dufour, 1814). (32 maps; with a supplement of an additional 7 maps published later). 18 *Examen critique de l'histoire de la géographie du Nouveau Continent et des progrès de l'astronomie nautique aux 15e et 16e siècles* (Paris: Gide, 1814–34.) 19 *Atlas géographique et physique du Royaume de la Nouvelle Espagne* (Paris: F. Schoell, 1811) (20 maps). 20 *Tableau physique des Andes et pays voisins (Géographie des plantes*

The *Relation historique* (Volumes 28–30, of which the fourth volume was never published) made an enormous impact on the scholarly world. It was translated into many European languages, appearing in English in 1825 and in German in 1859–60 (London: trans. H. M. Williams, 1825; Berlin: trans. H. Hauff, 1859–60). In his *Ansichten der Natur* (Humboldt, 1808) he declared that his purpose was "to win the attention of educated but non-scientific readers for the fascination of the discovery of scientific truths" (Kellner, 1963:75). Later Charles Darwin said that he had read and reread this account of scientific travels and that it had changed the whole course of his life. There can be no doubt that these volumes stimulated numerous field studies in different parts of the world. Actually, the *Relation historique* (or the *Personal Narrative*, as it was translated into English) dealt with Humboldt's own experiences and hardships very briefly but devoted most of its pages to a sober report on scientific problems that had been investigated and on the results achieved. Yet for a world emerging from the first shock produced by the impact of the discoveries, Humboldt's books were like a fresh breeze because they were filled not only with the excitement of travel in strange places, but also with the reports of careful scientific investigation, the seeking of answers to questions about the interconnections among the phenomena grouped together in rich diversity on the face of the earth. As early as 1805 (Volume 27), he presented a synthesis of his detailed findings as a basis for the study of plant geography.

Another part of his great work that was widely influential was the *Essai politique sur le Royaume de la Nouvelle Espagne* (Volumes 25–26). This was one of the world's first regional economic geographies, dealing with the resources and products of a country in relation to population and political conditions. Humboldt was much impressed with the far greater prosperity he found in New Spain in comparison with the countries of northern South America, and he was curious about the reasons for the difference. His interpretation was based on the theory that the only proper way to increase the general prosperity of a country was to make more effective use of natural resources, of which

équinoxiales) (Paris: F. Schoell, 1805). 21–22 *Recueil d' observations astronomiques, d' opérations trigonometriques, et de measures barométriques, faites pendant le cours d'un voyage aux régions équinoxiales du Nouveau Continent*, ed. J. Oltmanns (Paris: Schoell, Treuttel & Würtz, 1808–1820). 23–24 *Recueil d'observations de zoologie et d'anatomie comparée faites dans l'Océan Atlantique, dans l'intérieur du Nouveau Continent, et dans la Mer du Sud pendant les années 1799–1803*, in collaboration with Cuvier, Latreille et Valenciennes (Paris: Schoell & Dufour, 1805–1833) (54 plates). 25–26 *Essai politique sur le Royaume de la Nouvelle Espagne* (Paris: F. Schoell, 1811). (In later editions with a supplement: *Essai politique sur l'ile de Cuba.*) 27 *Essai sur la géographie des plantes, accompagné d'un tableau physique des régions équinoxiales* . . . (Paris: F. Schoell, 1805) (one large, folded plate). 28–30 *Relation historique du voyage aux régions équinoxiales du Nouveau Continent, faites en 1799–1804 par A. de Humboldt et A. Bonpland* (Paris: F. Schoell, 1814–25). (The account ends with the first part of the travels in Peru in 1801; a fourth volume was planned but never published.) (All 30 volumes are being republished in facsimile, starting in 1970 by Theatrum Orbis Terrarum, Amsterdam.)

Mexico seemed to have an abundance. He supported his explanations with a wealth of statistical data he found in New Spain, organized and enriched on the basis of his own observations. One of the numerous digressions that interrupt the main theme of his work is the suggestion that a canal should be dug across the Isthmus of Central America and that the best place to do this would be in Panama.

In later editions of the *Essai politique* (after 1826) he included a supplement dealing with the island of Cuba (*Essai politique sur l'île de Cuba*). In this short essay, he deplored the institution of slavery and outlined a procedure whereby slavery could be eliminated from Cuba without serious disruption of the economy.

During his stay in Paris, Humboldt enjoyed many stimulating meetings with the numerous scholars concentrated there. He became a close personal friend of the French physicist, François Arago, pioneer in the study of electromagnetism and in the wave theory of light. Humboldt enjoyed universal acclaim and was generally recognized as second only to Napoleon among famous Europeans. People came to visit him from all over the world, including the future leader of the independence movement in northern South America, Simón Bolívar, then an exile in Spain. Humboldt encouraged and actually aided many young scientists, including Louis Agassiz (the Swiss scholar who developed the hypothesis of universal glaciation and later taught at Harvard), Justus von Liebig (the German biochemist), Joseph Boussingault (the French geologist whose ascent of Mount Chimborazo took the altitude record away from Humboldt), and many others.

IN BERLIN

In 1827 Humboldt moved back to Berlin. His own personal fortune had been exhausted by the cost of his travels and, especially, by the cost of printing his books. When he was offered a position as chamberlain in the court of the Prussian king, which included a steady income, he accepted. In 1829, at the invitation of the Russian czar, he went to Saint Petersburg and then on by horse and carriage into Siberia as far as the borders of China (Fig. 17). He visited the shores of the Caspian Sea. The whole trip was a triumphal tour, for as his carriage approached a village or town the inhabitants turned out to line the road and give their distinguished visitor an ovation.

On this trip Humboldt was impressed by his observations of temperature. He could see clearly that temperatures varied at the same latitude in accordance with distance from the ocean. On his return to Saint Petersburg, he urged the czar to set up a network of weather stations at which weather data could be recorded regularly and in accordance with standard procedures to make the results comparable. The czar promised to do this; by 1835 the Russian network of recording stations extended all the way from Saint Petersburg to an island off the Alaska mainland. From these stations Humboldt later received the data that permitted the construction of the first world map

of average temperatures (Fig. 19). Following the example of Halley and Buache, who had used lines to connect points of equal value, Humboldt for the first time used lines to connect points of equal temperature (isotherms). Noting how the isotherms departed from the lines of latitude, Humboldt developed the concept of continentality: that continental climates are colder in winter and warmer in summer than places near the oceans at the same latitude.

On his Siberian trip Humboldt also observed and described the permanently frozen soil, which is now called *permafrost*. He saw the remains of a mastodon that had been frozen in the ground and preserved in this way. But he did not see any evidence of glaciation, and, therefore, he remained skeptical of the idea of a universal Ice Age then being advanced by the Swiss scholar, Louis Agassiz. Humboldt was right—large parts of Siberia were not covered by ice sheets during the Ice Age.

THE KOSMOS

In the winter of 1827–28 Humboldt offered a series of public lectures at the Royal Academy of Sciences in Berlin. His lectures had drawn such large and enthusiastic audiences that he had to repeat them in a larger room. In these lectures he not only made science interesting to the educated layperson, but he also made it acceptable to the religious leaders of the time. Religions, he insisted, offer three different things to humankind: a lofty moral idealism, which is common to all religions; a geological dream regarding the origin of

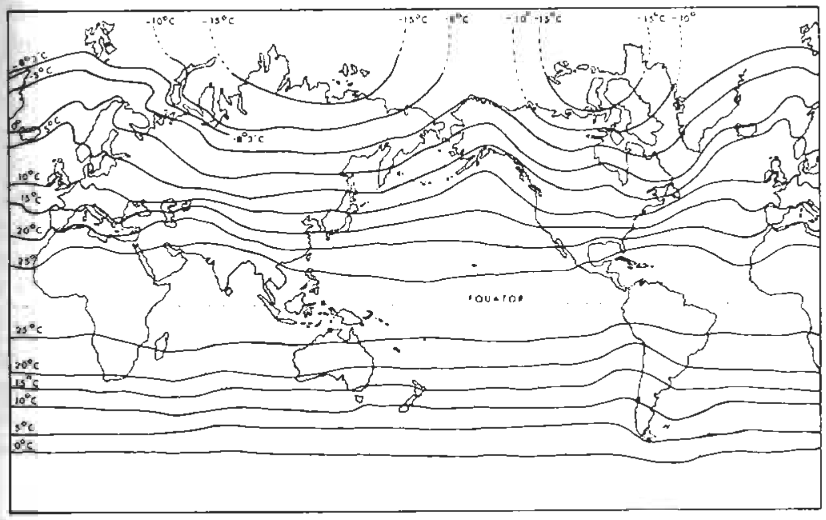

FIGURE 19. *Isotherms of average annual temperature, 1845, according to Humboldt.*

the earth; and a legend concerning the origins of the religion. He always emphasized the unity and coherence of nature; although he made clear the wonder of the universe, some of his admirers complained that nowhere in his lectures or in his books did he mention God (Kellner, 1963).

For nearly 50 years Humboldt had been forming in his mind the plan of a book, or a series of books, that would

> give a scientifically accurate picture of the structure of the universe which would attract the general interest of the educated public and communicate some of the excitement of scientific study to the non-scientific mind. Since he saw nature as a whole and man as a part of nature, and therefore all intellectual and artistic activities as having a share in natural history, he linked his main theme to an exposition of its development through the centuries and to the history of landscape painting and descriptive poetry of nature. . . . The book, when it was finally completed, followed fairly faithfully the scheme of the course of lectures he had given in 1828 (Kellner, 1963:199).

He wrote the book, which he called the *Kosmos*, during the last years of his life. The first volume was published in 1845 when he was 76; the fifth volume, published posthumously in 1862, was based on the copious notes he left.[3] Written in superb literary style, the *Kosmos* became the most prestigious scientific work ever produced up to that time. It was an immediate success: the first edition of Volume 1 sold out in two months, and soon the work had been translated into many languages, including almost all the European languages.

The *Kosmos* put together in one unified work all the various interests and discoveries of Humboldt's lifetime. The first volume makes a general presentation of the whole picture of the universe. The second volume starts with a discussion of the portrayal of nature through the ages by landscape painters and by poets and then continues with a history of man's effort to discover and describe the earth since the time of the ancient Egyptians. Humboldt's enormous erudition becomes especially clear in this second volume. The third volume deals with the laws of celestial space, which we would call astronomy. The fourth volume deals with the earth, not only with geophysics but also with man. Here is what Humboldt had to say about man as a part of nature near the end of the first volume:

> The general picture of nature which I have endeavoured to delineate, would be incomplete, if I did not venture to trace a few of the most marked features of the human race, considered with reference to physical gradations—to the geographical distribution of contemporaneous types, to the influence exercised upon man by the forces of nature, and the reciprocal, although weaker, action which he in his turn exercises on these natural forces. Dependent, although in a lesser degree than plants and animals, on the soil, and on the meteorological processes of the atmosphere with which he is surrounded—escaping more readily from the control of natural forces, by activity of mind, and the advance of intellectual cultivation, no less than by his wonderful capacity of adapting himself to all climates—man everywhere becomes most essentially associated with terrestrial life (Humboldt:1, 378; Otté translation:1: 360–361).

[3]*Kosmos, Entwurf einer physischen Weltbeschreibung*, 5 vols. (Stuttgart and Tübingen: J. G. Cotta Verlag, Vol. I, 1845; Vol. 2, 1847; Vol. 3, 1850; Vol. 4, 1858; Vol. 5, 1862). The best English translation is by E. C. Otté, *Cosmos, Sketch of a Physical Description of the Universe* (London: H. G. Bohn, 1849–58).

Humboldt believed that all the races of man had a common origin and that no race was necessarily inferior to the others: all races, he insists, are equally destined for freedom, individually or in groups.

Humboldt emphasized again and again the need for careful observation of nature in the field and for the careful and precise measurement of observations. Yet he was always seeking to formulate general concepts, or what we would now call abstract models or theory. However, he thought that observation had to come first. In Volume 1 he wrote:

> We are still very far from the time when it will be possible to reduce, by the operation of thought, all that we perceive by the senses to the unity of rational principle. On the other hand the exposition of mutually connected facts does not exclude the classification of phenomena according to their rational connections, the generalizing of many specialties in the great mass of observations, or the attempt to discover laws (Humboldt:1: 67–68; Otté translation:1: 58).

During Humboldt's long life, the need for closer attention to the definition of fields of special study became important. By the time of Immanuel Kant, as we have seen, the course of lectures on physical geography started with a definition of the field. It was quite clear that history dealt with problems of chronology and that geography was concerned with problems of areal association and distribution. In addition, Kant's logical classification of knowledge made room for the specialist in the study of particular processes without reference to time or space. That this was a generally accepted division of the world of scholarship and not an invention of Kant is made clear by Humboldt's earliest studies of the subterranean plants in the mines at Freiberg. In the introduction to this monograph (1793:ix–x), Humboldt pointed out that he was not studying plants as such, but rather the plants in relation to their surroundings. Humboldt reprinted his earlier statement in a footnote (in Latin) in the *Kosmos* (1, 486–487). Hartshorne suggests that Humboldt was probably presenting ideas he had gained from his teacher, A. G. Werner (Hartshorne, 1958:100). In the introduction to the *Kosmos*, Humboldt points out that

> the terms physiology, physics, natural history, geology, and geography were commonly used long before clear ideas were entertained of the diversity of objects embraced by these sciences, and consequently of their reciprocal limita-

tion [Humboldt: 1:51; Otté translation: 1:39]. Geography, which Humboldt called *Erdbeschreibung* (earth description), deals with the variety of different kinds of interrelated phenomena that exist together in areas or segments of earth space. This was essentially the same idea as that suggested by Kant, although there is no evidence that Humboldt was quoting Kant.

CARL RITTER

Carl Ritter was born in 1779, 10 years after Humboldt. His father was a physician, and when he died the widow lacked any means of support for her family of five. At this time Carl, the youngest of the family, was only five years old. By the greatest good fortune, in 1784 a German schoolmaster named Christian G. Salzmann was founding a new school to experiment with the radical innovations in educational methods then being proposed. He wanted a child who had never been exposed to the traditional methods and could be trained from the beginning by new pedagogical procedures. The child he selected for this purpose was Carl Ritter.

THE EDUCATION OF A GEOGRAPHER

In the late eighteenth century, in Germany and France the traditional educational methods were being vigorously challenged. It had long been customary to expect children to memorize selected passages from books, often in Latin or Greek, and then repeat them out loud. To repeat the words correctly was enough whether or not the passages were understood. In 1762 Jean Jacques Rousseau, in his novel *Emile*, outlined a new educational procedure that would end rote learning and would encourage a child to develop inborn potentialities. The Swiss educator, Johann Pestalozzi, further developed the ideas of Rousseau, insisting on the principles that clear thinking must be based on the careful observation of things and that words could have no meaning unless they were matched with perceptions. Salzmann was enthusiastic about these new suggestions and established his school at Schnepfenthal in the Thüringerwald to experiment with them.

The teacher who was selected to supervise the young Carl Ritter was a geographer named J.C.F. GutsMuths, whose own special field of interest was in the observation of natural features and who had already made some contributions to the teaching of geography by the new methods (Hartshorne, 1939:50–51). At an early age Ritter was able to observe the close involvement of humans with the natural features of their surroundings. He was encouraged by his teachers to formulate for himself the concept of the unity of man and nature; from the richly varied landscapes of this region of hills and low mountains, he derived the idea of unity in diversity, which became a basic theme of his mature writings. He could only account for such unity as evidence of God's divine plan. Without Rousseau, Pestalozzi, Salzmann, and GutsMuths, this kind of educational experience would not have been available; but, because of these men, Ritter received the best possible basic training for a career as a teacher of geography.

At the age of 16, when he was ready to go to a university, Ritter was again fortunate in finding financial support. A wealthy banker, Bethmann Hollweg, agreed to pay for Ritter's university expenses if Ritter, in turn, would agree to tutor the two Hollweg sons. At the University of Halle, with the commitment to become a teacher in mind, he took work with the famous educator, Professor Niermayer. Ritter continued his own studies after he started tutoring the Hollweg children at their home in Frankfurt-on-the-Oder. He undertook to learn Latin and Greek and to read widely in geography and history. With his pupils he made frequent field trips around Frankfurt, where in the process of teaching field observation he increased his own competence as an observer. He became a master of the art of landscape sketching, which, even after the age of photography, remains an effective way to preserve field observations for future study. Later he extended the range of his field trips to Switzerland and Italy, during the course of which he had met many of the leading scholars of that period. In 1807 he met Humboldt and was deeply impressed by him. In 1811 he published a two-volume textbook on the geography of Europe, making use of previously prepared maps of the geographic features of that continent.[4]

After one of his pupils died, Ritter went to the University of Göttingen to accompany the other Hollweg son. At that university between 1813 and 1816 he studied geography, history, pedagogy, physics, chemistry, mineralogy, and botany.

RITTER AS A TEACHER AND LECTURER

Unlike Humboldt, Ritter held several academic positions during his life. In 1819 he became professor of history at Frankfurt. He held this appointment for only one year, during which time he married. In 1820 he was appointed to the first chair of geography established in Germany—at the University of Berlin; he continued to offer courses of lectures at this university until his death in 1859. During this time he held other positions. He lectured on military history at the Prussian military school and became the director of studies for the Corps of Cadets. He was appointed a member of a scientific commission on geography and history, and he founded the *Gesellschaft für Erdkunde zu Berlin* (the Berlin Geographical Society). He was the private tutor

[4]These maps, prepared between 1804 and 1806 (*Sechs Karten von Europa mit Erklärendem Text* [Schnepfenthal], were among the first to make use of hypsometric symbols to describe the shapes of surface features. The earliest such map was a world map by A. Zeune, 1804. See the discussion of the use of the contour method in Joseph Szaflarski, 1959: "A Map of the Tatra Mountains Drawn by George Wahlenberg in 1813 as a Prototype of the Contour-Line Map," *Geografiska Annaler*, 41:74–82.

for Prince Albert of Prussia. In addition to these numerous undertakings, he continued to lead field trips each summer to various parts of Europe.

Ritter was a brilliant and influential lecturer. In interesting contrast to his obscure style of writing, his lectures were clear and well organized. He was a master of the art of using the blackboard to illustrate his ideas. After his first two or three lectures at the university, when he found his lecture room empty or with only a few students, his lectures became immensely popular and his lecture room was always full. Many were the young students whose enthusiasm for geography and for Ritter's interpretation of it was kindled by attendance at his lectures and who went forth to spread the word in other countries. Among his famous disciples were Elisée Reclus of France and Arnold Guyot, who became professor of physical geography and geology at the College of New Jersey (later Princeton) in 1854.

Ritter's public lectures were also highly successful. Some of his basic ideas concerning the influence of the earth's major features on the course of history were developed in lectures before the Royal Academy of Sciences in Berlin.[5]

RITTER'S GEOGRAPHICAL IDEAS

Ritter emphasized repeatedly that he was teaching a "new scientific geography," in contrast to the traditional "lifeless summary of facts about countries and cities, mingled with all sorts of scientific incongruities" (Bögekamp, 1863:37). His scientific geography was based on the concept of unity in diversity, which he had developed for himself at an early age. His purpose was not just to make an inventory of the things that occupy segments of earth space; rather, he sought to understand the interconnections, the causal interrelations, that make the areal associations cohesive. Again and again he used the German word *zusammenhang* (literally, hanging together) to refer to this quality of cohesion among diverse things.

To refer to the new scientific geography he made use of the word *Erdkunde*, or earth science. This he preferred to Humboldt's term *Erdeschreibung*, or earth description. *Erdkunde* is a German synonym for the Greek word *geography*. There was never any uncertainty in Ritter's mind that he was studying the earth as the home (*wohnort*) of man and, therefore, that he was dealing with the earth's surface. Later, as we will see, some German geographers took the word, *Erdkunde*, literally and focused their work on the whole body of the earth, not just its surface.

[5]Between 1826 and 1850 Ritter gave five lectures of great importance: "The Geographic Position and Horizontal Extension of the Continents," 1826; "Remarks on Form and Numbers as Auxillary in Representing Relations of Geographical Spaces," 1828; "The Historical Element in Geographical Science," 1833; "Nature and History as the Factors of Natural History, or Remarks on the Resources of the Earth," 1836; "The External Features of the Earth in Their Influence on the Course of History," 1850 (Gage, 1863).

Ritter insisted that geography should be empirical, in the sense that the student should progress from observation to observation in the search for general laws and not from preconceived opinion, to hypothesis, to observation. The student should ask the earth itself for its laws (Ritter, 1822:1:23). By avoiding preconceptions and making his own empirical observations of the surface features of Europe, Ritter was among the first to point out the error in Buache's concept of continuous mountain chains.

Ritter's search for unity in diversity led him to make use of the regional approach to geography rather than the systematic study of individual features. Yet he realized the importance of systematic studies and acknowledged his indebtedness to Humboldt, whose general studies made Ritter's special studies of regions possible. For his larger regional units Ritter made use of the traditional continents and proceeded to formulate generalizations concerning the continents and their human inhabitants. The continued use of continents as major regional entities not only for the teaching of geography but also for the formulation of concepts may have retarded the progress of geographical scholarship. Unfortunately, Ritter's identification of races by skin color and his identification of color by continents has produced only obscurity (Europe for white people; Africa for black people; Asia for yellow people; America for red people).

Ritter's concepts regarding the meaning of the observed geographical patterns on the earth were strongly teleological. Following the philosophers Immanuel Kant and Johann Gottfried von Herder, Ritter saw in all his geographical studies the evidence of God's plan. A Supreme Being, an all-wise Creator, was identified as the author of a plan for building the earth as the home of man, and all through Ritter's writings and lectures are words of praise for the divine creation. Even the arrangement of the continents Ritter saw as evidence of God's purpose. Asia, said Ritter, represents the sunrise—here the early civilizations originated. Africa represents the noon—because of the smoothness of outline as well as the uniformity of climate, the inhabitants are induced to slumber and to shun outside contacts. Europe is especially designed to bring out man's greatest accomplishments—because it represents the sunset, or the end of the day, the culmination of human development is found there. But the discovery of America now suggests the approach of a new sunset and a new culmination toward which man continues to strive. The polar regions represent midnight, when land and people are locked in eternal sleep. Ritter enlarges on the concept of the land hemisphere, as suggested by Buache and developed by Malte-Brun, and points out that this, too, is a part of God's plan. Only in this central location among the earth's land areas can a world-conquering civilization arise.

Ritter's teleological ideas came under fire from his contemporaries. It was Julius Fröbel who said that one might, with equal truth, say that grass had been created as feed for cattle (Fröbel, 1831). Ritter replied that among all the creatures on the earth only man could comprehend the existence of a divine plan and so could adjust his life to it and make maximum use of God's gifts (Hartshorne, 1939:62).

THE ERDKUNDE

Ritter, like Humboldt, produced one great work that represented his major scholarly achievement. This was *Die Erkunde*.[6] The translation of the full German title presents the basic purpose: *The Science of the Earth in Relation to Nature and the History of Mankind; or, General Comparative Geography as the Solid Foundation of the Study of, and Instruction in, the Physical and Historical Sciences*. Before Ritter became the professor of geography at Berlin in 1820, he was still thinking of geography as the basis for the writing of history. The first two volumes of the *Erkunde* (1817–18) were intended to be followed by a study of history. But when Ritter went to Berlin he decided to devote himself to doing a more thorough piece of work on the geography. In 1822 he published a second edition of Volume 1 and in 1832 a second edition of Volume II. But by this time he realized the magnitude of the work he had started. After 1831 he gave up many of his positions so that he could devote himself more fully to the completion of the *Erkunde*. Between 1832 and 1838 he completed six more volumes, and between 1838 and 1859, 11 more. Yet the 19 volumes of the *Erdkunde* Ritter actually finished only covered Africa and a part of Asia.

Unlike Humboldt, Ritter's great work was largely put together on the basis of other people's observations. He said that his field studies in Europe made it possible for him to interpret what other people reported. Fritz Kramer comments on the interesting point that Ritter's descriptions of places he had never seen were vivid and accurate, whereas his descriptions of places he had seen often lacked zest (Kramer, 1959).

In contrast to the clarity of his lectures, Ritter's published works are often obscure. Scholars have struggled to find suitable translations for some of his passages that would make sense in another language and yet not do violence to his ideas.[7] A student of the German language can have endless fun with Ritter. But one must arrive at the conclusion that Ritter himself was neither critical of his own ideas nor resolved about what he wanted to say. He was expressing a general feeling about the subject, and many of his assertions of relationships have never been and could never be subjected to rigorous verification. One may be pardoned the somewhat irreverent observation that one way to gain the reputation for being a profound thinker is to write obscurely.

[6] *Die Erdkunde, in Verhältniss zur Natur und zur Geschichte des Menschen, oder allgemeine vergleichende Georgraphie, als sichere Grundlage des Studiums und Unterrichts in physikalischen und historischen Wissenschaften*, 19 vols. (Berlin: G. Reimer, 1817–18; 1822–59).

[7] For example, see the discussion of the meaning of one of Ritter's frequently quoted statements that geography is the study of "*der irdisch erfüllten Räume der Erdoberfläche*" (from Ritter, 1852) in Hartshorne, 1939:57.

RETROSPECT

So these two great scholars, who died in the same year in Berlin, each in his own way attempted to establish a "new geography." Each tried to embrace the knowledge of humankind concerning the earth as the home of man. Both of them saw the field of geography as dealing with things and events of diverse origin that were interconnected in segments of earth space, as did Kant and others. Both were tireless workers, who wrote many books and whose influence on the scholarly world was very great. Both recognized the need for seeking generalizations, and both recognized that little progress toward higher theory could be made in their time. But both had confidence that continued use of proper geographical methods would eventually bring to light the inner meaning of the universe. Humboldt was an agnostic; Ritter once remarked that, although the *Kosmos* was a magnificent piece of work, one found in it no single word of praise for the Creator. Ritter saw all of his studies of the earth and man as revealing more and more of God's plan.

Yet the two men were fundamentally different in their approach. Humboldt could not look at the world around him without finding innumerable questions demanding answers. He not only described what he saw with care and precision, but he also formulated hypotheses to account for the things he observed—and then he also subjected his hypotheses to the test of new observations. Ritter also had a vision of an ordered and harmonious universe, but instead of asking questions about it, he wanted to communicate to others the meaning he had found. As a teacher he wanted to make clear to his disciples how God's plan was revealed in the harmony of man and nature. Each in his own way was enormously successful, and each enjoyed wide personal prestige.

When Humboldt and Ritter died there was no one to replace them. Classical geography had come to an end—no individual scholar could hope any longer to master the world's knowledge about the earth. The specialization of subject-matter disciplines resulted in the development of new technical jargon, new paradigms of scientific behavior. As a result much that had been called geography was partitioned among a variety of logically defined fields. In Germany no one was appointed to fill Ritter's chair. Some decades later when geography was reestablished as a university study, the scholars invited to teach it had had no previous training in a field called by that name.

What do Humboldt and Ritter mean to us today? Ritter did influence his disciples to identify a new scientific geography based on the organic unity of man and nature (Guyot, 1860). But his teleology, reflecting the contemporary thinking of such philosophers as Kant and Herder, became outmoded and raised a barrier to the continued acceptance of this kind of new geography. Moreover, Ritter's regional studies deal for the most part with such large areas that the material he included had to be highly generalized. The interconnections he described could not be perceived by direct observation.

Today Ritter's *Erdkunde* has chiefly an antiquarian interest. Humboldt's systematic studies are also outdated, although the methods he used represent important steps in the progress of geography. But Humboldt's regional studies "cannot become obsolete" (Hartshorne, 1939:82), especially his comparative studies of New Spain and Cuba, which provide invaluable material for studies in historical geography. Humboldt dealt with areas that were small enough so that he could discuss all the factors relevant to a problem that could be tested by direct observation—for example, the study of the Lake of Valencia Basin in Venezuela. These two great masters of the nineteenth century mark the culmination of thousands of years of effort to push knowledge out beyond the far horizon, and they both point to new horizons to be conquered along the road ahead.

PART TWO

MODERN

A major innovation in the world of scholarship took place in nineteenth-century Germany. The university as an institution first appeared in Medieval Europe when charters were issued by religious or secular authorities giving certain faculties the right to teach. The University of Paris in the twelfth and thirteenth centuries became the chief center (other than Rome) for the teaching of orthodox Christianity. But in 1809 Wilhelm von Humboldt, the brother of Alexander, founded the University of Berlin with the support of King Friedrick Wilhelm III of Prussia. For the first time anywhere, the attachment of either faculty or students to any particular religious creed or school of thought was explicitly repudiated. Hitherto universities were places where the accepted dogma of state and church was taught to students. After 1809 the university as a free community of scholars began to appear.

Geography as a field of advanced study taught by professionally qualified individuals first appeared in Germany in 1874. Within a few decades geography departments offering graduate training leading to advanced degrees were established not only in Germany, France, and Britain but also all around the world. This was the "new geography," and it was guided for the first time in history by professional geographers. A profession had come into existence that could establish the paradigms of geographical study.

We date the modern period in the history of geographical ideas with the establishment of professional staffs in universities.