SCIENCE

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CONTENTS:

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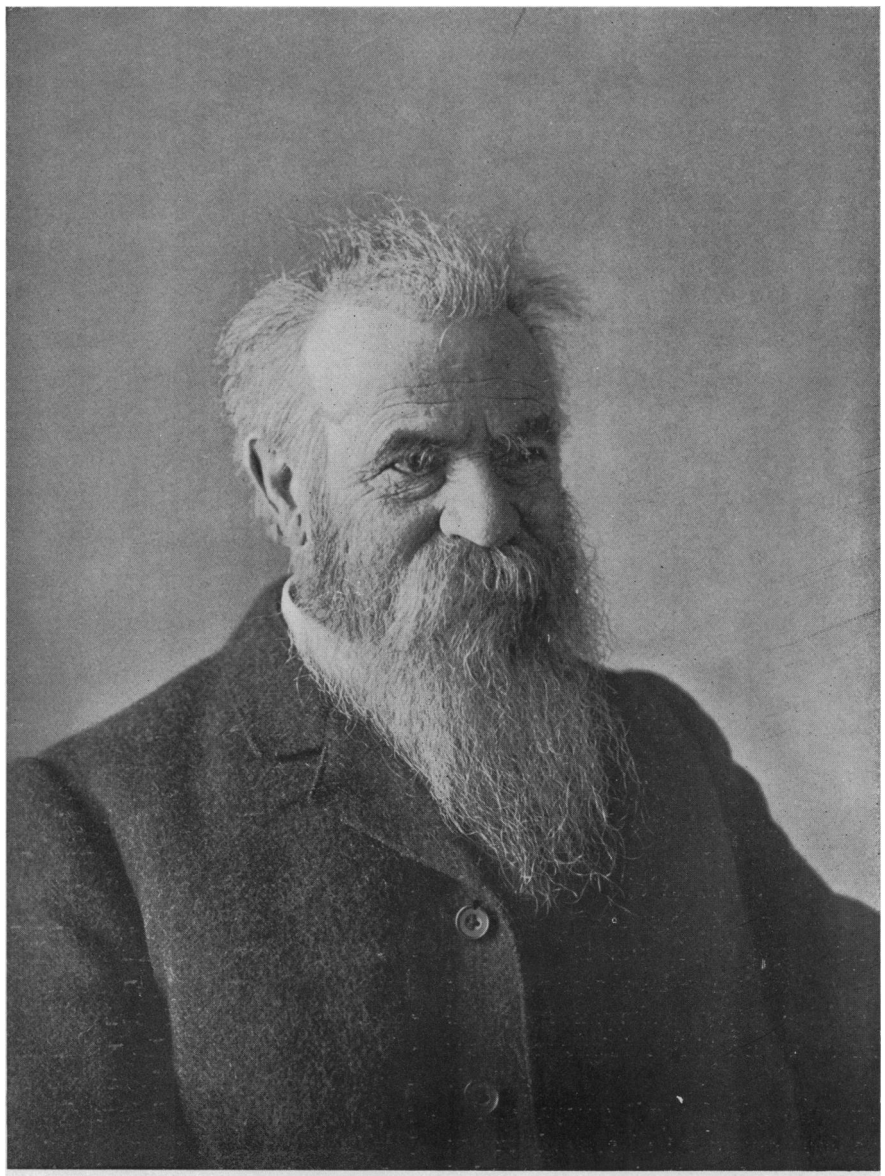
JOHN WESLEY POWELL.

JOHN WESLEY POWELL was born March 24, 1834, at Mount Morris, New York. He died September 23, 1902, at his summer home in Haven, Maine. He was married in 1862 to Emma Dean, of Detroit. His wife and daughter, an only child, survive him.

His parents were English, having reached this country only a few months before his birth. His father was a Methodist preacher and soon removed from New York, living successively in Ohio, Wisconsin and Illinois. His father's occupation took him much from home, and upon the son, while yet a boy, devolved the duty of conducting the farm from which the family derived its principal support. Powell's early schooling was that ordinarily obtainable in a rural community. His scientific bent was acquired by association with an old man by the name of Crookham, and studies in natural history were begun at an early age. His later education was largely independent of schools, but he attended Jacksonville College for a short time, and was at Oberlin two years pursuing a special course. In early manhood he supported himself by teaching, being at the same time a hard student and pursuing natural history studies with enthusiasm. He traversed portions of Wisconsin, Illinois, Iowa and Missouri on foot. He made a voyage of the Mississippi River



in a skiff, starting from the falls of St. Anthony; a voyage of the Ohio from Pittsburg, and a voyage of the Illinois from Ottawa. In these various excursions he was a collector of plants, shells, minerals and fossils, and these collections brought him into relation with various colleges of Illinois. At the outbreak of the Civil War he enlisted in the Twentieth Regiment of Illinois volunteers, and abruptly changed the course of his studies to military science. His successive commissions ranged from second lieutenant to colonel, but the rank of major gave the title by which he was known colloquially in later years. His service was chiefly with artillery, but some of his most important work was of a character commonly assigned to engineer officers. In the battle of Shiloh he lost his right arm, and the resulting physical disability affected his life in important ways. On the one hand, the wounded arm caused him at various periods much pain, and thus weakened an exceptionally strong constitution. On the other, he was led in early manhood to employ an amanuensis, and the resulting freedom from the mechanical factor in writing was a distinct advantage to his literary work.

At the close of the war he promptly returned to civil life, dropping the study of military science as abruptly as he had begun it. A business opening, and an attractive opportunity to enter political life, were declined in favor of scientific work. He became professor of geology at Bloomington, Illinois, and lecturer on geology at Normal, Illinois. In 1867 he organized and led the first important geological excursion of American students, taking a party of sixteen to the mountain region of Colorado. This was before the building of transcontinental railways, and the journey across the plains was long. He remained among the mountains as an explorer after the party had returned east, and in the following years organized a second expedition, with geologic and geographic exploration and research as its chief objects. The necessary funds were furnished by various educational institutions in Illinois and by the Smithsonian Institution, and Congressional authority was obtained for supplying the party with provisions from the military posts of the West. His expedition wintered west of the Rocky Mountains in the valley of White River, and the long period thus spent in a permanent camp was occupied in the scientific study of Indians. In the following spring four boats were brought from Chicago to the point where the newly constructed Union Pacific Railway crossed Green River, and a party was organized for the exploration of the canyons of the Green and Colorado rivers. When this work was begun it was known that the rivers here descend in a distance of 700 to 1,000 miles through the vertical space of 5,000 feet, coursing most of the way between unscalable walls, but the nature of the rapids, cascades and cataracts by which the water falls from the upper to the lower level was altogether unknown. The undertaking was therefore of phenomenal boldness and its successful accomplishment a dramatic triumph. It produced a strong impression on the public mind and gave Powell a national reputation which was afterwards of great service, although based on an adventurous episode by no means essential to his career as an investigator.

The voyage through the canyons was a reconnaissance in an unexplored area and led to the organization of a geographic and geologic survey, for which appropriation was asked and obtained from Congress, the work being initially placed under the supervision of the Smithsonian Institution. By the advice of Professor Henry the gathering of ethnologic data was made a leading function of the organization. In 1869

a boat party began a second voyage through the canyons, the plan being to spend two years in their mapping, and land parties were at the same time organized to cooperate with them. The river was abandoned as a base of operations in the middle of the second season, but the land work continued, with progressive development of plan, for a period of ten years. About the middle of this period the study of the problem of the utilization of the arid region through irrigation and otherwise became a function of the organization, and a special investigation was made of the water supply of the territory of Utah.

Of parallel growth were the surveys developed under the initiative of Dr. Hayden, Clarence King and Lieutenant Wheeler. Their functions were similar and, with the exception of the work by King which had a definite limit, their ambitions included the exploration and survey of all the western domain of the United States. They thus became rivals and there was need of reorganization. After unsuccessful efforts to arrange for the partition of the field and friendly cooperation between the different corps, Powell advocated their merging into a single bureau of the Interior Department, and it was largely through his initiative that the work was finally reorganized in 1879. The Powell, Hayden and Wheeler surveys were abolished and the present U. S. Geological Survey created, Mr. King becoming by presidential appointment its first director. At the same time the Bureau of Ethnology was created to carry forward the ethnologic work, and of this Powell became director. The Geological Survey was made a bureau of the Interior Department, and the Bureau of Ethnology was attached to the Smithsonian Institution.

The study of water supply in relation to irrigation led to the conclusion that the land laws of the United States were ill adapted to the conditions obtaining in all the drier portion of the country, and Powell became much interested in the legislative problems thus arising. Partly at his instance a commission was appointed to codify the land laws and recommend such modifications as seemed to be required. Powell gave much of his time for two years to the work of this commission and a comprehensive report was prepared, which however led to no legislation.

In 1881 Mr. King resigned the directorship of the Geological Survey and Powell was immediately named as his successor. He retained the direction of the Bureau of Ethnology and conducted both bureaus until 1894, when he resigned from the Geological Survey. During his administration the work of the Survey was greatly enlarged, especially in its geographic branch, and the investigation of water supply with special reference to utilization for irrigation was added to its functions.

In the last years of his life Powell practically relinquished administrative responsibility, entrusting the management of the Bureau of Ethnology to his principal assistant, Mr. McGee, and devoting his time to personal studies which passed gradually from anthropology into the fields of psychology and general philosophy.

In summarizing the results of his active life it is not easy to separate the product of his personal work from that which he accomplished through the organization of the work of others. He was extremely fertile in ideas, so fertile that it was quite impossible that he should personally develop them all, and realizing this he gave freely to his collaborators. The work which he inspired and to which he contributed the most important creative elements, I believe to be at least as important as that for which his name stands directly responsible. As he always drew about him the best ability he could command, his assistants were not

mere elaborators, but made also important original contributions, and the ideas which he gave the world through others are thus so merged and mingled with theirs that they can never be separated. If we count the inspiration of his colleagues as part of his work of organization then the organization of researches may properly be placed first in the list of his contributions to the progress of science. Other terms of the list pertain to the fields of geology, physical and economic geography, anthropology and philosophy.

The creation of the U. S. Geological Survey belonged to the logic of events and would undoubtedly have taken place within a few years without Powell's assistance, but his active advocacy hastened the change and his ideas had greater influence than those of any other individual in determining the mode of reconstruction of the national scientific work. He was so prominent as a promoter of reorganization that when it had been accomplished he felt that his motives might be impugned if he became a candidate for the directorship of the Survey, and he therefore declined to have his name presented. It is proper to add that the scheme of reorganization which he advocated was not adopted in full. His plan included the organization of three bureaus to conduct investigation in the fields of geology, geography and ethnology, but Congress created only two bureaus, leaving geography without special provision. The work of geographic mapping was taken up by the Geological Survey as a means for providing base maps for the use of geologists, and thus the Survey has become a bureau of geography as well as geology.

Two years later, when Powell succeeded King in the administration of the Geological Survey, he found the subdivision of the work arranged largely on geographic lines. There were branch offices at Denver, Salt Lake City and San Francisco, each in charge of a chief who directed the geologic and topographic work of a large district. For this classification Powell gradually substituted one based upon function, abolishing the districts and separate offices and creating divisions of topography, general geology, and economic geology, coordinate with divisions of paleontology, physics and chemistry. Areal or geographic classification was still used, but was subordinated to a subject classification.

Careful attention was given to the financial system of the bureau, the machinery by which the public funds were paid out and accounted for, and the wisdom of this attention was afterward fully justified. When in later years the affairs of the Survey were subjected to unfriendly and searching investigation the accounts were found in such perfect condition as to elicit the highest praise of the Comptroller of the Treasury, to whom the results of the investigation were finally referred. The reputation of the Survey for good business methods inspired the confidence of legislators and led them to provide for the growth of the bureau, not only by the increase of appropriations for existing functions, but through the gradual enlargement of function. The most important single addition to its duties was that of studying the water supply of the country with reference to various economic problems.

Except for the original suggestion or instruction by Professor Henry, and except for the votes of funds by Congress, the Bureau of Ethnology may be regarded as Powell's creation. Work on American ethnology had previously been discursive, unorganized, and to a large extent dilettanti. He gave to it definite purposes conformable to high scientific standards, and personally trained its corps of investigators. To men who had previously interested themselves in the study of Indians

he gave new methods and a new point of view, and he succeeded in diverting to ethnology men already trained in scientific method by work in other fields of research. He realized, as perhaps few had realized before him, that the point of view of the savage is essentially different from that of the civilized man, that just as his music cannot be recorded in the notation of civilized music, just as his words cannot be written with the English alphabet, so the structure of his language transcends the formulæ of Aryan grammars, and his philosophy and social organization follow lines unknown to the European. He also realized most fully that the savage is the embryo of the man of highest culture, and that the study of savagery is therefore a fundamental contribution to the broadest study of humanity. With these ideas he informed his ethnologic corps, and in consequence of them the organization of the bureau marks the most important epoch in American ethnology.

The same personal influence extended to the work of the Anthropological Society of Washington. Over the proceedings of this society Powell presided for many years, taking part in all its discussions and making it his special function to point out the bearing and relation of each communication to the greater problems and broader aspects of the science. As the bureau was and is a laboratory of ethnology, devoted to the study and record of the character and culture of the fading tribes of North America, so the society, including the same group of students, was and is an arena for the discussion of the broader science of anthropology. I but echo the general sentiment of those students in saying that the high intellectual and scientific plane on which the work of this society is conducted is a result, direct and cumulative, of Powell's influence and example.

Before turning to Powell's direct contributions to science, mention should be made of his studies in biology. In early manhood he was an assiduous collector of plants, fresh-water shells and reptiles, and this work was accompanied by studies in distribution. But the results of such studies do not constitute a contribution to botany and zoology. The work was properly a part of his education, a training in the art of observation, which bore fruit only when his attention was turned to other branches.

His contributions to geology include a certain amount of descriptive work. He published the stratigraphy, structure, and part of the areal geology of the Colorado Plateaus and the Uinta Mountains. In connection with the field studies in these districts he developed a new classification of mountains, by structure and genesis, a structural classification of dislocations, a classification of valleys, and a genetic classification of drainage systems. His classification of drainage recognized three modes of genesis, of which two were new. With the novel ideas involved in the terms 'superimposed drainage' and 'antecedent drainage' were associated the broader idea that the physical history of a region might be read in part from a study of its drainage system in relation to its rock structure. Another broad idea, that since the degradation of the land is limited downward by the level of the standing water which receives its drainage, the types of land sculpture throughout a drainage area are conditioned by this limit, was formulated by means of the word 'base-level.' These two ideas, gradually developed by a younger generation of students, are the fundamental principles of a new subscience of geology sometimes called geomorphology, or physiographic geology.

The scientific study of the arid lands of our western domain in relation to human industries practically began with Powell.

Early in his governmental work he issued a volume on the lands of the arid region, and he continued their discussion in one way or another for twenty years, setting forth the physical conditions associated with aridity, the paroxysmal character of rainfall, the dependence of arable lowlands on the rainfall and snowfall of uplands, and the generous response of the vegetation of arid regions to the artificial application of water. Emphasizing the necessity of irrigation to successful agriculture, he pointed out the need of conserving storm waters by artificial reservoirs, the need of applying new principles in legislation for the regulation of water rights, and the need of a new system of laws for the control of title in arid lands. These ideas when first advanced were the subject of hostile criticism because they antagonized current opinions as to the availability of our western domain for settlement; but he afterward found himself part of a general movement for the intelligent development of the West, a movement whose latest achievement is the so-called reclamation law.

He pointed out also that our land laws did not permit the lean pasture lands of the West to be acquired by private owners in tracts large enough for economic management, and that overstocking and periodic disasters were the logical results of public ownership; and his ideas as to remedial legislation were embodied in the unheeded report to the Public Lands Commission.

In descriptive ethnology Powell's published contributions are meager in comparison with his body of observations and notes. They are comprised in a magazine article on the Mokis, an essay on the Wyandots, and a few myths, chiefly Shoshonian, introduced in various writings for illustrative purposes. In his 'Introduction to the Study of Indian Languages' he gives instructions for American ethnologic observation, covering not only the subject of language, but arts, institutions and mythology. Other writings belong more properly to anthropology, and deal with its broader principles. In a series of essays, designed as chapters of a manual of anthropology but actually published as occasional addresses and never assembled, he points out the lines of evolution in the various fields of human thought and activity, philosophic, linguistic, esthetic, social and industrial. The ground covered by these essays is so broad that a brief summary is impossible. They include the ideas which have directed the work of the Bureau of Ethnology, and they include also much which has found no immediate application, belonging to fields of thought as yet untouched by others. As to their ultimate value future generations must decide, but they stand nearly or quite unique as a comprehensive body of philosophic thought founded on the comparison of aboriginal with advanced culture.

In later years attention was gradually turned from anthropology to psychology and the fundamental concepts of natural philosophy. His interest in these subjects began in early manhood, and they are briefly touched in various writings; but he gave the last eight years of his life almost wholly to their study. Two books were written and a third planned. 'Truth and Error,' which appeared in 1899, treats of matter, motion and consciousness as related to the external universe or the field of fact. 'Good and Evil,' printed as a series of essays in *The Anthropologist* with the intention of eventual assemblage in book form, treats of the same factors as related to humanity or to welfare. The field of the emotions was assigned to the third volume. His philosophy was also embodied in a series of poems, of which only one has received publication.

In much of his scientific writing Pow-

ell's style is terse to a fault. Usually he is satisfied with the simplest statement of his conclusions. Sometimes he adds illustrations. Only rarely does he explain them by setting forth their premises. It has thus happened that some of his earlier work, though eventually recognized as of high importance, was at first either not appreciated or misunderstood. The value of his anthropologic philosophy, though now widely appreciated, was recognized but slowly outside the sphere of his personal influence. His philosophic writings belong to a field in which thought has ever found language inadequate, and are for the present, so far as may be judged from the reviews of 'Truth and Error,' largely misunderstood. Admitting myself to be of those who fail to understand much of his philosophy, I do not therefore condemn it as worthless, for in other fields of his thought events have proved that he was not visionary but merely in advance of his time.

To the nation he is known as an intrepid explorer, to a wide public as a conspicuous and cogent advocate of reform in the laws affecting the development of the arid West, to geologists as a pioneer in a new province of interpretation and the chief organizer of a great engine of research, to anthropologists as a leader in philosophic thought and the founder, in America, of the new régime.

G. K. GILBERT.

THE ADDRESS OF THE PRESIDENT OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

II.

LIQUEFACTION OF GASES AND CONTINUITY OF STATE.

IN these speculations, however, chemists were dealing theoretically with temperatures to which they could not make any but the most distant experimental approach. Cullen, the teacher of Black, had indeed shown how to lower temperature by the evaporation of volatile bodies such as ether, by the aid of the air-pump, and the later experiments of Leslie and Wollaston extended the same principle. Davy and Faraday made the most of the means at command in liquefying the more condensable gases, while at the same time Davy pointed out that they in turn might be utilized to procure greater cold by their rapid reconversion into the aeriform state. Still the chemist was sorely hampered by the want of some powerful and accessible agent for the production of temperatures much lower than had ever been attained. That want was supplied by Thilorier, who in 1835 produced liquid carbonic acid in large quantities, and further made the fortunate discovery that the liquid could be frozen into a snow by its own evaporation. Faraday was prompt to take advantage of this new and potent agent. Under exhaustion he lowered its boiling-point from *minus* 78° C. to *minus* 110° C., and by combining this low temperature with pressure all the gases were liquefied by the year 1844, with the exception of the three elementary gases—hydrogen, nitrogen, and oxygen, and three compound gases—carbonic oxide, marsh gas, and nitric oxide; Andrews some twenty-five years after the work of Faraday attempted to induce change of state in the uncondensed gases by using much higher pressures than Faraday employed. Combining the temperature of a solid carbonic acid bath with pressures of 300 atmospheres, Andrews found that none of these gases exhibited any appearance of liquefaction in such high states of condensation; but so far as change of volume by high compression went, Andrews confirmed the earlier work of Natterer by showing that the gases become proportionately less compressible with growing pressure. While such investiga-