on one of those prison-like cots, so strange and unhomely to her.

"The letter," Mrs. Martin went steadily on, after a moment's silence, "I had buried with her, but I kept a copy of it. This is it."

I half hesitated.

"I don't think you need mind reading it," she said.

It was very brief. In half a dozen lines Anthony Stottman acknowledged the receipt of a final payment of fifty dollars as wiping out the principal and interest of a debt of three thousand dollars left unpaid in the settling up of Judge Marchbanks's estate.

Ah, it was brief, but to what years of pinching and struggle, and high and tender purpose, that awkward paper testified. I saw all those years in a heart-bursting moment's glance. It was love as much as honor that had sustained little Fanny Marchbanks through that long task, so little in itself, so Titanic for her; no stain must rest on the great name her father left behind him. Through more years than I had lived every hour must have been colored to her by this heroic resolution. It had become her reason for living. When she had accomplished this end, the shock of revolution in her outlook, the withdrawal of the great motive, had been too much; the light that had been sustained so long ceased. Mrs. Martin told me that Mrs. Overman had been restless, had almost ceased to write for two weeks before her death, although she seemed well.

Yes, I knew, I knew how, as with a child, the thought of her great achievement had absorbed her, and how she could not be at ease till the sensible testimony of it was in her hand. That brought her ease indeed. Truly it was a beautiful way to die.

"Where — where did you bury her?" I forced myself to ask.

"I was at my wit's ends, Miss Addington. Those I might have learned something from about her relatives were out of town, and I did n't know which way to turn; but at last I put her in my own plot, where I shall lie some day myself. I thought you would come after a while and tell me what to do. She left nothing but a few dollars, seven or eight, but I had things done decently. I know Mrs. Overman was a lady, and that letter showed she was something more, Miss Addington. I was glad to pay her respect." Mrs. Martin concluded with firm downright reflections, "God bless her!"

Miss Fanny had won for herself, in her last strange need, hospitality instead of charity, and with her letter on her bosom she might well be an honored guest.

Viola Roseboro'.

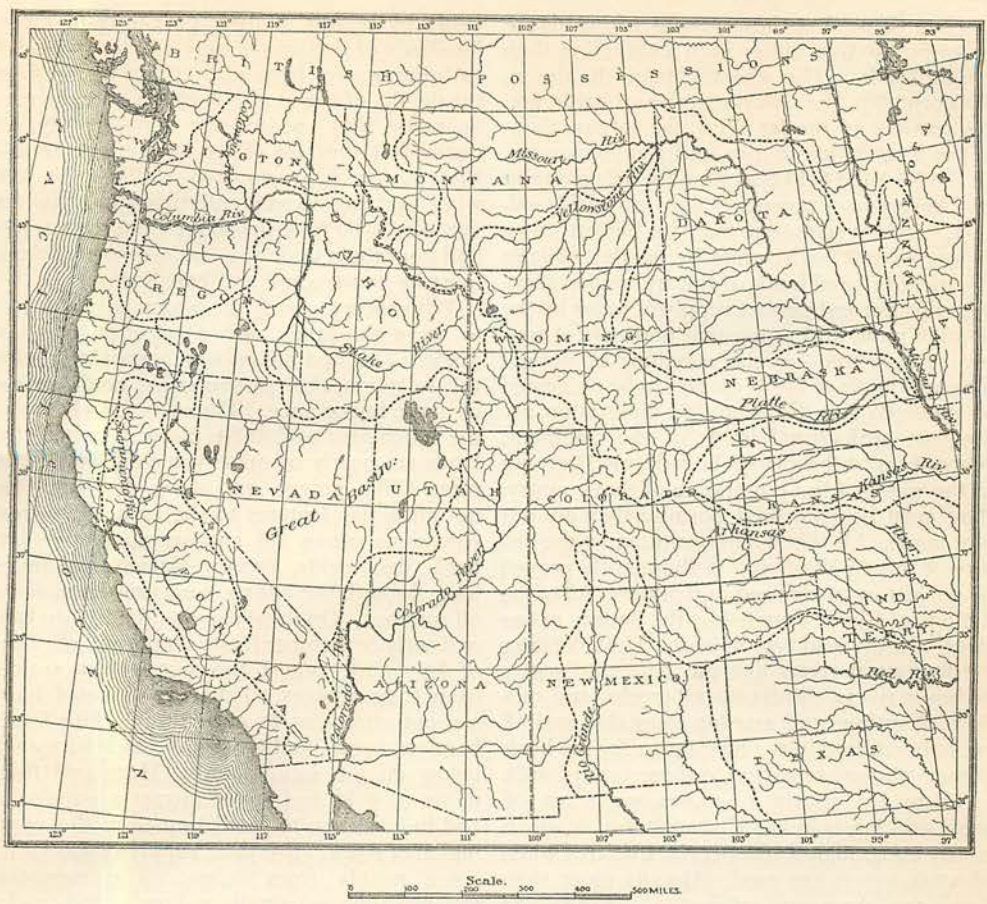
THE IRRIGABLE LANDS OF THE ARID REGION.

BY MAJOR J. W. POWELL, DIRECTOR OF THE U. S. GEOLOGICAL SURVEY.

NEARLY half of the lands of the United States, exclusive of Alaska, are arid. By this characterization it is meant that the rainfall is insufficient to fertilize crops from year to year. In favorable seasons some of these lands receive sufficient rains during the months of growing vegetation to produce fair crops, but the years are infrequent when such conditions prevail, and the areas thus favored are not of great extent. That arid lands may be available to agriculture it is necessary that they be artificially supplied with water; and this is called irrigation. Every farm, orchard, vineyard, and garden is dependent upon an artificial supply of water. The tree on the lawn, the rose on the parterre, and the violet on the baby's grave must have some loving hand to feed it with the water of heaven or it withers and dies.

When the farmer sows his field and waits for the rains of heaven to fertilize it, if the clouds are kind and come with gentle showers, he reaps a bountiful harvest; but when the heavens are as brass, famine stalks abroad, and when storms desolate the land, he plants in vain. But in the western half of the United States physical conditions like those of ancient Egypt and Assyria prevail. The clouds no longer fructify the fields with their showers. They rarely hover over the valleys and plains where the fields and gardens lie, but they gather about the mountains and hurl their storms against the rocks and feed the rivers. The dweller in the valley waits not for showers, or waits in vain; for the service of his fields rivers must be controlled.

But will not the hills of New England, the mountains and plains of the sunny South, and the prairies of the middle region be sufficient for the agricultural industries of the United States? The area is vast, the soil is bountiful, and the heavens kindly give their rains; why should the naked plains and the desert val-



PRINCIPAL DRAINAGE DISTRICTS OF THE ARID REGION.

leys of the far West be redeemed? Why should our civilization enter into a contest with nature to subdue the rivers of the West when the clouds of the East are ready servants?

Gold is found in the gravels of the West; silver abounds in the cliffs; copper is found in the mountains; iron, coal, petroleum, and gas are supplied by nature. The mountains and plateaus are covered with stately forests; the climate is salubrious and wonderfully alluring. So the tide of migration rolls westward and the arid region is being carved into States. The people are building cities and towns, erecting factories, and constructing railroads, and great industries of many kinds are already developed. The merchant and his clerk, the banker and his bookkeeper, the superintendent and his operative, the conductor and his brakeman, must be fed; and the men of the West are too enterprising and too industrious to beg bread from the farms of the East. Already they have redeemed more than six million acres of this land; already they are engaged in warfare with the rivers, and have won the first battles. An army of men is enlisted and trained, and they march on a campaign — not for blood, but for bounty; not for plunder, but for prosperity.

But arid lands are not lands of famine, and the sunny sky is not a firmament of devastation. Conquered rivers are better servants than wild clouds. The valleys and plains of the far West have all the elements of fertility that soil can have. As the blood in the body is the stream which supplies the elements of its growth, so the water in the plant is its source of increase. As the body must have more than blood, so the plant must have more than water for its vigorous growth. These conditions of plant growth are light and heat. While the roots of the plant are properly supplied with water and other elements of plant growth, the leaves must be supplied with air and sunshine. The light of a cloudless sky is more invigorating to plants than the gloom of storm. Abundant water and abundant sunshine are the chief conditions for vigorous plant growth, and that agriculture is the most successful which best secures these twin primal conditions; and they are obtained in the highest degree in lands watered by streams and domed

by clear skies. For these reasons arid lands are more productive under high cultivation than humid lands. The wheatfields of the desert, the cornfields, the vineyards, the orchards, and the gardens of the far West, far surpass those of the East in luxuriance and productiveness. In the East the field may pine for delayed rains and the green of prosperity fade into sickly saffron, or the vegetation may be beaten down by storms and be drowned by floods; while in the more favored lands of the arid region there is a constant and perfect supply of water by the hand of man, and a constant and perfect supply of sunshine by the economy of nature. The arid lands of the West, last to be redeemed by methods first discovered in civilization, are the best agricultural lands of the continent. Not only must these lands be redeemed because of the wants of the population of that country, they must be redeemed because they are our best lands. All this is demonstrated by the history of the far West, and is abundantly proved by the history of civilized agriculture. All of the nations of Egypt were fed by the bounty of one river. In the arid region of the United States are four great rivers like the Nile, and scores of lesser rivers, thousands of creeks, and millions of springs and artesian fountains, and all are to be utilized in the near future for the hosts of men who are repairing to those sunny lands.

There are nearly 1,000,000,000 acres of these arid lands in the United States, of which nearly 120,000,000 acres can be irrigated when all such waters are used. Already more than 6,000,000 acres are cultivated through the agency of canals. Thus the experiment has been tried, and doubt no longer rests upon the practicability of western irrigation. It is fully demonstrated that the redemption of these lands is profitable to capital and labor. An acre of western land, practically worthless without irrigation, when the works are constructed to supply it with water at once acquires a value marvelous to the men of the East. In new California, settled but yesterday, cultivated lands command better prices than in Massachusetts or Maryland, and this is because an acre of land there will produce two or three fold the quantity of food for man or beast that an acre will here, for the average year. We of the East must recognize that while the lands of the West are limited in quantity to comparatively small and level tracts in the valleys and plains which can be served with water by canals, yet the limit in quantity has compensation in quality.

To accomplish the redemption of the arid region capital in large amounts is needed. Some lands can be reclaimed at a cost of two or three dollars an acre; others, ten or twelve; while in some cases, where lands are of great value by reason of their proximity to cities, hundreds of dollars per acre will be expended to bring waters from distant springs or from the depths of the earth. A rough estimate may be made that 100,000,000 acres can be redeemed at the rate of ten dollars per acre—that is, for 1,000,000,000 dollars. In this work vast engineering enterprises must be undertaken. To take the water from the streams and pour them upon the lands, diverting-dams must be constructed and canals dug.

With most streams the water is insufficient to serve the lands, and a selection must be made. The conditions which should govern this selection, though somewhat complex, are of grave importance. The rains fall chiefly on the mountains and high plateaus, where the lands are nearly or quite valueless for agriculture. Cliffs, gorges, and steep declivities are not attractive features to the farmer. At great elevations snows fall and accumulate in vast fields, deep drifts, and icy glaciers, and linger long through the spring, sometimes remaining all summer. On these elevated lands late June and early September frosts come, and the days of July and August are not wholly exempt from their ravages. Thus the elevated lands are not attractive to agriculture. The farms, hamlets, towns, and cities have their sites away below on the sunny lands. Here and there mines of gold and silver attract a population and induce men to build homes in the upper region of snow. But their supply of food must come mainly from below. The mountain streams while yet small, as brooks and creeks, cannot be used to advantage, and when they leave the mountains they are in most cases already great creeks or rivers. A mountain stream flows in a deep, narrow gorge, down which torrents of water roll in mad energy. Such is the crystal river of the mountains. When it strikes the plain it is suddenly transformed. The steep declivity is changed to one of low degree, and a deep, narrow stream spreads into a broad sheet of water ten, twenty, fifty times as wide as above. When the river is thus transformed it undergoes another change; on the plains below it gathers the sands and dust, and the deep, crystal stream becomes a shallow river of mud. Such are the characteristics of the greater number of streams of all the arid region.

The place of transformation, where the mountain stream of pure water is degraded into a lowland stream of mud, is an important point when the stream is to be used in irrigation. If the waters are turned out in the valleys above, they are used where they will perform the least service, for the climate is unfavorable to agriculture. Such lands are chiefly valuable as pasturage. Grass, potatoes, and rye, and in

general the crops of Norway and southern Alaska, may be cultivated with some success; but, in sight of the sunny plains below, it is a waste of water to use the rivers in these regions of ice. On the other hand, the streams cannot be used with the greatest advantage far down their course and distant from the mountains. The storm-waters and fierce winds of the low plains and valleys, that are arid and dusty for most days of the year, fill the valleys and shallow channels of the mud-bearing rivers with vast accumulations of sand. In these broad stretches the waters spread and are largely lost by evaporation. Very many of the streams of the arid regions, perhaps two out of three, are thus swallowed up by the sands, and are called "lost" rivers or creeks. Others have a sufficient supply from the mountains during seasons of flood to enable them to cross the hungry sands and deliver a part of their volume to lower channels in more humid lands, through which they find their way to the sea. They die in seasons of drought and live in seasons of storm. Still other rivers flow perennially but dwindle on their course over the dry plains. The "lost" streams must be used near to the mountains or not at all. The intermittent streams and the diminishing rivers should be used near to the mountains before a large part of their waters is lost. A stream that will irrigate a million acres of land near the mountains would be sufficient to serve only two or three hundred thousand acres a hundred miles away. There are other reasons why the river should be taken out from its channel where it emerges from the mountains. At that point diverting-dams can be constructed with the least expense and maintained at the least cost, and be made to command lands to the greatest advantage in the construction of minor canals; while the waters below, when charged with great quantities of sand, speedily destroy the works of irrigation, and the sands injure the fields.

Most irrigated lands ultimately require drainage. The bottom lands of the great rivers soon become filled with water, and are transformed into swamps and destroyed for the best agriculture. The low plateaus are ultimately far superior to them for all agricultural purposes. Thus it is that the higher lands away from the rivers and near to the mountains should be first served. Only a part of the water poured upon lands for their irrigation is evaporated to the heavens; another, and perhaps larger, part returns to the river. The irrigation of the upland creates many springs, which unite to form brooks and creeks, and the waters can thus be used again and again, but in diminishing quantities. A proper system of drainage not only improves the land drained, but conserves the water to be used again. It is thus that with every system of supply-canals a related system of drainage-channels and canals must be planned for the benefit of the fields first irrigated and for the increase of the area of irrigation.

The season of irrigation is short, varying in different latitudes and altitudes from two to five months. In some regions of country the season of flood precedes and extends into the first part of the season of irrigation; in other regions flood-time comes late, when the time for supplying water is nearly past. In a few cases maximum supply and maximum want are coincident in time. In all cases where they are not synchronous the excess runs to waste; the unused waters are lost in the sea. During all the months when irrigation is not in progress the entire volume is unused, if the only structures are diverting-dams and canals. To save this water reservoirs are needed. In their construction and the selection of their sites many interesting problems are involved. Some of the conditions which govern the selection of sites are of great importance. Evaporation from the surface of water varies, under different climatic conditions, from thirty to one hundred inches. A reservoir most favorably located may lose less than three feet of water during the year, while, under most unfavorable conditions, the loss may be more than eight feet annually. Evaporation is greater in the hot, dry lands below and less in the cold, humid lands above. The law of diminution is complex, having many factors, and is not yet very well known, but the general statement made is substantially correct. For this reason storage-reservoirs should be constructed in the mountains. In many of the northern ranges of the West favorable sites are found. Already many mountain lakes exist that can be used for this purpose by deepening their outlets and constructing gateways, so as to permit the lakes to be filled when the waters are not needed and to be tapped when a supply is demanded. There are many mountain valleys that are morainal basins admirably adapted to this purpose, and where reservoirs can be constructed at small cost. The mountain regions of the West have many lakes of cold, emerald waters, and these are to be multiplied by the art of man and made to hold the waters needed to refresh the arid plains below — treasure-houses where the clouds are stored.

The mountain ranges of the western portion of the United States differ very greatly in their topographic characteristics. Sometimes advantageous reservoir sites can be found in the upper regions; sometimes low valleys, or parks, are found nearly inclosed by mountains

and foothills, while there are many ranges which have such steep declivities and terminate so abruptly on the plains that sites are infrequent. For such reasons not all of the mountain waters can be stored in mountain lakes, and it becomes necessary to construct reservoirs on the plains below. Here the stream-beds cannot be utilized, because of the difficulty of maintaining works on broad flood-plain lands composed of incoherent sands, and because the muddy waters below discharge their silt and fill the reservoirs with great rapidity, so that the life of such a reservoir is too short to warrant the expense of its building. Under such circumstances a river should be turned from its natural course into a canal near the point of transformation, and be conducted into some lateral valley which has been excavated by storm-waters. In general, favorable sites of this character are frequent. The valley is utilized by selecting some point where the inclosing hills converge, and there constructing a retaining-dam.

When all the perennial waters of springs, brooks, creeks, and rivers are used by canals and reservoirs, the total supply of available water for irrigation is not exhausted. All of the arid lands below have some rainfall, varying from three to twenty inches, from year to year, and from region to region. The rains which fall upon these thirsty lands are in part absorbed and ultimately evaporated, but often the storms come with great violence, and local floods arise therefrom. These storm-waters can be caught and stored in basins among the hills and used for agricultural purposes. The amount of water that can thus be saved is no mean quantity. But it must often be stored in small reservoirs of a few acres each; and this means the construction of ponds on farms, scattered here and there among the hills where sites are favorable; and the waters will thus be used on small tracts of land distributed far and wide over the arid plains and valleys. Ultimately the whole region will be covered with a mosaic of ponds fringed with a rich vegetation; and crystal waters, and green fields, and blooming gardens will be dotted over all the burning, naked lands, and sand dunes, alkali stretches, and naked hills will be decked with beautiful tracts of verdure. Not all the storm-waters will thus be caught; much will still fall into the great sand valleys and flood-plains, and there disappear in the sands; but such valleys have a floor of solid rock; and so the waters are stored in the silt of ancient floods, where they may be brought to the surface again by pumps and other hydraulic devices, and be made to irrigate many a stretch of farm land.

There is one more source of water. In the flexing of the strata of the earth through geologic agencies subterranean basins are formed, where rocks below, impervious to water, are separated by water-bearing strata from the rocks above through which the water will not pass. Into these water-bearing strata wells may be sunk, and the water will often flow to the surface. Such artesian wells are often used in irrigation, and they will be used to a much larger extent in the future. Artesian waters are not found everywhere in the country, but only in geologic basins, and to select sites for them a knowledge of the geologic structure is necessary.

By the use of all the perennial streams during the season of irrigation, by the storage of the surplus water that runs to waste in seasons when irrigation is not practiced, by the impounding of the storm-waters, by the recovery of the floods accumulated in valley sands, and by the utilization of the artesian fountains, a vast area of the arid lands will ultimately be reclaimed, and millions of men, women, and children will find happy rural homes in the sunny lands.

From the brief account given it will be seen that in order to redeem the arid lands it becomes necessary: first, to select properly the lands to be redeemed; secondly, to select the reservoir sites where the water is to be stored; thirdly, to select canal sites,—and these should be dedicated to public use, so that individuals may not acquire title to the lands for the purpose of selling them to the farmers when the irrigating works are to be constructed, and thus entailing upon agriculture an unnecessary expense; fourthly, the extent and method of utilizing the flood-waters stored in the sands must be determined; fifthly, the artesian basins must be discovered and their extent and value revealed.

For this purpose there are necessary:

(*a*) A topographic survey, that the mountains, hills, and valleys may be outlined and their relative levels determined, and the whole represented on appropriate maps.

(*b*) A hydrographic survey. The waters of the streams must be gauged, in order to determine the volume which they carry through the different seasons of the year. Then the rainfall must be determined, for the amount of water to be supplied by canals is supplementary to this. Where the rainfall is twenty inches a small artificial supply serves the land; if it be but five inches a large supply is necessary. Then the amount of precipitation for various sites of reservoirs must be determined, to discover the amount which can be saved. And finally, it becomes necessary to determine the amount of water which is needed to serve an acre of land. This is called the "duty" of

water, and in the United States it varies widely. In some regions of country, where the rainfall is great and the soil favorable, the duty of water is large: a given amount of water will irrigate a broad tract of land. But where aridity is excessive and the soils are unfavorable, such given amount of water will irrigate but a small tract. For the purpose of measuring stored water many engineers have come to use an "acre foot" as a unit, which means an acre of water one foot in depth. In some portions of the United States an acre foot of water will irrigate two or three acres of land for one season; in other regions two acre feet are necessary to the acre; but these are extreme conditions. The general average, which largely prevails, may be stated as an acre foot of water to an acre of land; and a lake which contains 100,000 acre feet of water will serve 100,000 acres of land for one year. In the practice of irrigation it is found that it takes two or more years properly to fill the ground with water, and for these first years a much larger supply than has been indicated is necessary. Where a supply has been secured for 100,000 acres by reservoir or canal, the lands which it will ultimately serve can be redeemed only through a course of years. Perhaps a third or a half of the land can be supplied for the first year, and to this new areas can be added, from season to season, until at last the whole duty of water is secured.

(*c*) An engineering survey. The reservoirs, canals, and ancillary appliances must be planned and their cost estimated.

(*d*) Finally, a geologic survey, to utilize the waters of the sand reservoirs and artesian wells.

Such are the scientific problems involved in the redemption of the arid lands.

A brief survey of some of the more important irrigable districts of the West will serve to set forth other interesting facts relating to this subject. In central Colorado the "Continental Divide" is a wilderness of desolate peaks that rise far above the timber line into regions of rime and naked rock. Here, with other rivers, springs the Arkansas, in deep cañons and narrow rocky valleys. Many silver creeks, with water flashing in cascades, unite to form a river which plunges down a steep mountain valley until it passes the foothills and spreads in a broad, turbid stream at the head of the great valley of the Arkansas. Then it creeps over the sands in tawny ripples, down the incline of the plains, becoming less in volume by evaporation and the absorption of the waters in the sands, but growing in size from the accession of smaller tributaries that come from distant mountains on either hand. After crossing the Colorado line it grows perceptibly smaller until a more humid region is reached, where other tributaries join it, and it soon becomes a great river. In the stretch that begins just above the State line and extends across Kansas its channel often becomes dry, and the sands drift in the winds from bank to bank. But in seasons of flood a broad, shallow torrent rolls across Kansas into the State of Arkansas and bears along to the lower region vast loads of mud, choking the navigable stretch below with "sand-bars," that act as dams, by which the floods are turned over the valley, and the fields are ofttimes destroyed. Already the farmers of Colorado have taken the water on their lands, and the river is made to do duty to its utmost capacity in seasons of drought. But the surplus waters yet run to the sea. Some of them can be stored on the plains; but the land available for irrigation is far in excess of the amount which the river can serve. Where shall this water be used? If in the mountain valleys, it will largely be wasted; if in the great valley below, how shall it be divided between Colorado and Kansas? It is worth millions of dollars annually. To whom shall it be granted? If the larger part is to be used in Colorado, how shall it be divided between the several districts through which it passes? The law is practically silent on the subject. Heretofore every man might help himself; but at last the question has arisen, controversies have sprung up, and the States are almost at war.

The Rio Grande flows through San Luis Park, where there is a great body of comparatively level land. Here the waters have been taken out and many hundred thousand acres irrigated. Neglecting the tributaries, let us follow the river across the line into New Mexico. Again the water is taken out to irrigate valley stretches until the White Cañon in the Tewan Mountains is reached and the river rolls through a deep, rocky gorge for more than forty miles. Emerging, its waters are again taken out upon the land from point to point until the entire territory is traversed, and the river passes out of New Mexico and becomes the boundary line between Texas and Mexico. From its source to the mouth of the Chama above the White Cañon it is a clear, deep river; below, it is a shallow river of mud. In this valley irrigation was practiced by the aboriginal village Indians centuries before the discovery of America. Prior to 1600 it was populated by Spanish peoples coming up from Mexico. So the gardens and fields of the territory and the region along the river from El Paso to the Gulf are old. Since the acquisition of the territory by the Government of the United States irrigation has greatly developed in Colorado and New Mexico, along the river itself in part, but mainly on the tributaries. No waters have yet been stored in

reservoirs, but the seasonal flow in dry years is now wholly utilized; and more: the river for hundreds of miles along its lower course is entirely cut off from a supply, and the gardens and farms are now lying desolate and the winds are drifting the sands over vineyard and field. During the past year more new works have been projected than now exist in the valley. How are they to be supplied in scant years? Who owns the water? Shall the men of Colorado take all that falls in their State? and if so, shall the settlements in the valley of the Rio Grande be destroyed by the new settlements on the tributaries? Just across the line of New Mexico the town of El Paso, in Texas, is found; and the town of Juarez lies on the opposite side of the river, in Mexico. Here large areas have been irrigated and many thousand people are engaged in agriculture; but they had little water last year, and the next dry season they will have none. Shall the people who have cultivated the land for more than a century be driven away?

The Green River heads in the Wind River Mountains, and, rolling over elevated cold plains, it at last reaches the Unita Mountains, and plunges through cañons to the mouth of the Grand. At its source the Grand inosculates with the Arkansas and the Rio Grande del Norte and rolls through a succession of cañons to the Green. Then the two rivers, joining in wedlock, become one indeed, and assume a new name, the Colorado of the West, which rolls into the Gulf of California. Its way for nearly 500 miles is through a succession of deep cañons, where it flows from 100 to 6000 feet below the general surface of the land. At last it emerges from the gloom of the Grand Cañon and runs in a valley through the lower portion of its course, now and then interrupted by a low range of volcanic mountains, through which it cuts its way in deep, black gorges. The region drained by the cañon portion of the Colorado and its tributaries and the region drained by the Grand and Green and their affluents are in the main inhospitable. All the streams flow through deep cañons between great blocks of naked rock, which are plateaus with cliff escarpments. Sometimes cañons widen into narrow valleys, and others are found at the foot of the mountains on the east and west, while far to the north are broad valleys inclosed by mountains; but these are cold and desolate. Some agriculture can be practiced by means of irrigation in the broad cold valleys above and the narrow warm valleys below, but a very small portion of the water of the Colorado will thus be used. A mighty river will ever flow from the mouth of the Grand Cañon. The region below the cañon on each side of the Colorado is one of great aridity, with an annual rainfall of not more than three or four inches. It is also a region of high temperature in summer, and it has almost a frostless winter. Here date palms flourish with a luxuriance never known in Egypt. Oranges, lemons, pomegranates, and figs grow and bear in abundance, and the lands are well adapted to sugar and cotton. On the west lie Nevada and California. On the east Arizona stretches away to the summit of the Rocky Mountains. The lands to which the waters can be taken greatly exceed the area that can be served. How shall they be divided? The low flood-plain along the river is narrow, and only small tracts within it can be redeemed. If the waters are to be used, great works must be constructed costing millions of dollars, and then ultimately a region of country can be irrigated larger than was ever cultivated along the Nile, and all the products of Egypt will flourish therein.

The northern third of Arizona is a lofty table-land; the southern part is a stretch of desert valley over which desert mountains rise. The descent from the table-lands to the lowlands is marvelously abrupt, for it is marked by a line of cliffs, the escarpment of a geologic fault. Along this fault there is a fracture in the rocks below, and the table-land side has been uplifted several thousand feet. Through the fissure of the fracture lavas have poured in some places, so that here and there the escarpment is masked by volcanic rocks. All of the perennial streams of the territory, that run to join the sea, head on the table-land or in the Rocky Mountains of New Mexico. The rainfall of the lowlands is insufficient to create ever-living waters. The land has never a carpet of verdure, but a few scattered desert plants are found, many of which belong to the cactus family. Everywhere the landscape is weird and strange. Most of the mountains are naked of vegetation or bear dwarfed gnarled trees of pine and cedar, with aloe and cactus. The flood-waters that pour down these mountains sweep the disintegrated rocks into the valley below, and much of the region is filled to a considerable depth with sand and gravel. The storm-waters that come from the mountains sink into these valley sands and disappear; and the problem of this country is to gather the mountain waters into reservoirs at the foothills, and to recover them from the sands by artesian wells and pumps.

In southern California there is another drop of the land from San Bernardino Mountains to the coast, but its line is not so clearly marked as that of Arizona. From this southward to San Diego and from the coast eastward but a few score miles there is a land

of beauty. It is forever fanned with mild breezes from the Pacific, and thus cooled in summer and warmed in winter. When the rainy season comes its billowing hills are covered with green, and when the dry season comes the hills are covered with gold. The rainfall is almost sufficient for agricultural purposes; springs burst from the hills, and creeks meander to the sea. The little valleys open into broader marshes near the shore that are hardly above the tide, but they are often leveed by the waves of the sea, and wave-formed embankments beat back the high tides and protect the meadows that are inclosed by hills. Among the hills natural basins abound, into which the clouds may be enticed as they fall upon the ground, and into which the fountains may pour their waters. It is a region of country singularly well adapted to lakelet-reservoirs, where every man may construct one or more on his own farm. Little artificial supply is needed, and this can be easily secured; and a region of country about the size of Italy, with the climate of Italy, is rapidly becoming covered with the gardens of Italy.

The Sierra Nevada culminates in altitude near its eastern margin. It is a great plateau declining westward, and carved into transverse ridges and valleys, that extend from the high eastern summit of the system to the low warm valley of California. Between the valley and the sea the Coast Range rises. The San Joaquin River heads in the heights of the south, and runs northward. The Sacramento heads far to the northward, where volcanic mountains stand. The rains and snows that fall on these peaks sink away into the scoria and sands of volcanic cones, and the mountains where the clouds gather and the storms rage are yet streamless; but away from the mountains, where volcanic sands disappear, the mountain waters burst out in mammoth springs, and creeks and rivers are born full grown. The Sacramento and the San Joaquin unite to flow through the Golden Gate. In the southern or San Joaquin valley irrigation is already practiced, and the streams are partly or wholly used during the season of growing crops. The chief development of the area of agricultural lands in this region is to come from the construction of reservoirs for river and storm waters, and through the development of drainage systems, so that the water may be compelled to do double or treble duty. In the Sacramento valley irrigation has been practiced to a very limited extent, for the rainfall is considerable, and the people until the last year or two have been proud to affirm that their climate was humid; but they are now beginning to learn that even with them irrigation is highly advantageous, and that the product of the field may be multiplied more than threefold through the agency of rivers.

It is in the valley of the Sacramento and its tributaries that the great deposits of gold gravels are chiefly found, and that extensive hydraulic mining has been carried on. The rivers of the Sierras were turned into reservoirs, and their waters, under high pressure, through the agency of monitors, were set to tearing down the hills of gravel and washing them away into the Sacramento. But these operations soon choked the stream and caused it to overflow the adjacent lands, and the sands and gravel brought down were deposited over the lands, and thus fields and towns were buried and populous regions were temporarily destroyed. Then the farmers of the valleys, through the legislature and the courts, stopped the mining operations; but strife still rages. The greed for gold and the hunger for fruit and wheat still spur the miners and farmers, and the conflict is irrepressible. Some day or other, when the madness has subsided, they will quietly discover that both parties are equally interested in the control of the rivers; that all of the waters of these regions can be stored in reservoirs and used at will, and that the valley of the Sacramento can be irrigated to multiply its agricultural products and its gold mines worked by the same agency, and that the miners and the farmers have common and harmonious interests in the hydraulic problems of the fairest land under the sun.

In geologic times, not long ago as speaks the scientific man, but very long ago indeed as speaks the chronicler of human follies, there was a deep valley on the eastern slope of the Sierra Nevada at the headwaters of the Truckee River. About this valley towered granite mountains. But earthquakes came, and rents were formed in the rocks, and out of the fissures poured monstrous streams of lava. One of these fissures crossed the lower end of our mountain valley, and through it poured floods of molten rock. Stream after stream issued, to cool in solid sheets and blocks, until a wall was built across the valley two or three thousand feet in height, and above it was a deep basin five or six hundred square miles in area. The storms that fell on the granite and volcanic mountains rolled in rivers to fill the basin, and Lake Tahoe was created. When filled, at last, its waters overflowed the rim of lava, and the Truckee River now springs from the Tahoe fountain. Its deep waters are dark with profundity, like the clouds of a stormy sky, but about its shores a few shallow bays are found, and emerald waters, like festoons of beauty, encircle the deeper and more somber lake. Back from the waters forest-clad slopes rise

towards the heavens, and above are seen naked crags and domes of granite. Farther to the north, Donner, Independence, and other mountain lakes discharge their waters into creeks that join the Truckee. It is thus that a large hydrographic basin is formed in the mountains where torrential rains fall and deep snows accumulate in winter months, and in which the waters are collected to form the Truckee, which leaves the mountains in a dance of delight and with a never-ending song of laughing waters. Sweet valleys are found below, for the people have in many places reclaimed the desert and encircled their homes with verdant fields. But the waters are all caught in California, while the irrigated lands are in Nevada; so the farmers of the Silver State must go to the lands of the Golden State to construct their reservoirs. The water of the lake can be partly discharged each year by deepening its outlet and the water used for irrigation in Nevada, and after the irrigating season is over the gates may be closed and the lake permitted to refill; but this perhaps will mar a pleasure resort. Who shall judge between the States? A very large part of all perennial waters to be used in Nevada have their sources in California. Who shall judge between the States?

In southern Utah a bold escarpment or cliff of rocks two thousand feet in height is presented towards Arizona. This is the edge of a plateau which extends far northward into central Utah. It is cut in two by a river which heads a little back from the brink of the cliffs and runs to the north; and so, except at the very southern extremity, two plateaus are found, which unite between the head of the river and the verge of the cliffs. This one-two plateau lies high and is covered with great forests, where rains and snows fall in abundance, and the waters gather to form the Sevier River. Along its upper course and beside some of its tributaries there are small valleys that are high and cold; yet grass, rye, oats, and potatoes can be raised in the short summer. Forty miles from its source the river enters a deep cañon, and when it emerges a broad and beautiful valley is found. Down this the stream meanders, and then turns westward and vanishes in the sand. It is a lost river. Just above the sink and along the valley through which the river meanders there is good and abundant land—much more than the river will serve; and here the Mormon people, who have institutions and customs like nations of the Oriental world in more than one respect, cultivate the soil by irrigation in the same manner. There are lands above the central cañon and lands below; but the river cannot serve them all. The earliest settlements were below. Later settlements have been planted above, in the sub-arctic lands, and they are taking the waters away from the older towns and farms. And how is justice to be rendered between these conflicting interests?

North of Mt. Nebo lies Utah Lake, which is fed by the Provo River and a number of beautiful creeks. About the lake and along the streams the people are cultivating the land by irrigation. But the surplus water is still discharged into the lake, which constitutes a great reservoir. From the lower end of the lake the river Jordan flows on to the Dead Sea of Utah, the Great Salt Lake, on whose shore the Mormon Temple stands. Large areas in the valley are watered from the river. The Utah Lake divides a hydrographic basin. On the Provo and streams above there are favorable sites for reservoirs, and there are areas of land that can yet be irrigated; but if the waters are used in the upper valley they cannot be used along the banks of the Jordan. All increase of the irrigated area above will decrease the irrigated area below. Who shall divide the waters and relegate them to the best lands in the interest of the greatest number of people?

Bear River has its sources partly in Idaho and partly in Wyoming. Where its upper affluent creeks are assembled it runs northward across the Utah-Idaho line. At this point it expands into a broad sheet of water known as Bear Lake, which is divided into two nearly equal parts by the territorial line. The surface of the lake is about six thousand feet above the level of the sea. The river, after leaving the lake below, runs northward for a long course into Idaho, and then turns upon itself and recrosses the territorial line into Utah. The course of this great curve is through cañons and cañon valleys, but at two or three points the valleys expand so as to present small areas of irrigable land. In general, above the Utah line, the region drained is mountainous. From this point the river flows through a steadily expanding valley until it empties into Great Salt Lake. Now it is possible to use much of the water of this stream in the upper region on mountain valley lands, where hay can be cultivated and some other of the crops of cold climates. Another portion can be used in Idaho, while the great valley along the whole stretch of the river is admirably adapted to irrigation. Bear Lake itself, which lies in two Territories, is ultimately to become the chief reservoir, but others can be constructed above, and still others below. Thus the reservoir system must be distributed between the two political divisions, while the great body of the lands to be redeemed are in Utah. How these lands are to be selected, and water-rights relegated to such lands, is a serious problem which demands immediate solution, for the people are already

in conflict. Angry passions have been kindled, and war would ensue were it an international instead of an interstate problem.

The Snake or Shoshone River heads in the great forest-clad mountains of Wyoming and runs across the line into Idaho, then passes quite across the Territory until it becomes the boundary line between Idaho and Oregon. Passing the northeastern corner of the last mentioned State, it enters the State of Washington, and runs westward for a long reach until it debouches into the Columbia. The Shoshone River is one of great volume, second only to the Colorado. Reservoir sites along its course in Wyoming and Idaho have already been revealed by the surveys, and it is shown that in the upper region water can be stored to an amount of more than 2,000,000 acre feet. This will irrigate at the first usage at least 2,000,000 acres of land; and if they be properly selected, so that the waters can be collected again and again after serving the land, the area redeemed will be more than 4,000,000 acres. There are many other tributaries below that have not yet been examined, and it is safe to say that the waters of the Shoshone with its tributaries may ultimately serve from 8,000,000 to 10,000,000 acres. In its utilization three classes of problems are involved. If the waters are taken out in small canals near to the river and the lowlands served first, and prior rights and interests established on such lands, then but a small part of the stream can be used, and the greater part will run away to the Pacific Ocean; and subsequently the region of irrigation can be enlarged only by buying out vested water-rights scattered along the course of the river. But if at the very beginning the water can be taken out high up the river and carried in great canals to either side and there distributed to the higher lands, and used over and over again on its return, a complete utilization can be secured, and the cost of the construction of the system of irrigation by reservoirs and canals will be greatly reduced per acre. To irrigate 2,000,000 acres of land near to the river by short canals taken out along its course here and there will cost more than half as much as the construction of hydraulic works that will serve from 6,000,000 to 8,000,000; while the scattered minor works will be forever subject to destruction by the floods, and the agriculture secured will be of less value per acre, because the best lands will not be served, and only imperfect drainage will be secured.

The valley of the Shoshone has an interesting structure. In late geologic times it has been the site of great volcanic activity. The eruptions have not produced cones and mountains, but fissures have been opened and broad sheets of lava have been poured out over the region. It is a valley of volcanic mesas or low table-lands. On the basaltic rocks thus poured out a peculiar surface is developed. The floods of cooling lava roll down in waves and bubble up in domes, which often crumble and fall in, leaving many pits, and the general surface is thus exceedingly irregular; but the irregularities are not on a great scale so as to produce high hills and mountains. The process of degradation by frost and heat, by wind and rain, smooth out these irregularities; the higher points are degraded and the lower places are filled. Many of the eruptions in this valley are of such age that their surface has been smoothed out in this manner; but there are many others so irregular that the mesas are covered with pits and naked rocks, and are thus wholly worthless for agricultural purposes. The second great problem is properly to select the mesa lands to which the waters shall be distributed. A part of the storage of the water must be in Wyoming, while the lands to be served must be in Idaho, Oregon, and Washington. These are interests over which nations would speedily be at war; in this country they involve interstate questions, and must be settled by the General Government.

Space fails me to describe the beautiful lands of the Columbia and its tributaries, but interstate and international problems are involved. The Columbia comes from British territory. One of its affluents, the Kootenay, heads in British territory, passes into Montana, and returns to British territory. Passing over to the Missouri, some of its waters head in foreign lands, and Montana, North Dakota, South Dakota, and Nebraska are interested.

Along the hundredth meridian from Manitoba to Mexico there is a zone of semi-arid land. Years ago, when the writer first began investigations into the agricultural prospects of the far West, he abandoned the designation "desert" and adopted the term "arid," as more properly characteristic of the country. For the one hundredth meridian zone he at first adopted the term "sub-arid," but it gave great offense, and the suggestion that irrigation was necessary to its successful cultivation was received with denial and denunciation, for at that time the advantage of artificially supplying water to cultivated lands was generally unknown. Seeing that the term "sub-arid" was a red flag to kindle anger, it was dropped, and the term "sub-humid" was adopted; and now the hundredth meridian zone is generally known as the "sub-humid" region. The average rainfall, which varies much from year to year, is about eighteen inches on its western margin, and increases to about twenty-four on its eastern edge. Passing from east to west across this belt a wonderful transformation is ob-

served. On the east a luxuriant growth of grass is seen, and the gaudy flowers of the order *Compositæ* make the prairie landscape beautiful. Passing westward, species after species of luxuriant grass and brilliant flowering plants disappear; the ground gradually becomes naked, with "bunch" grasses here and there; now and then a thorny cactus is seen, and the yucca thrusts out its sharp bayonets. At the western margin of the zone the arid lands proper are reached. The winds, in their grand system of circulation from west to east, climb the western slope of the Rocky Mountains, and as they rise they are relieved of pressure and lose their specific heat, and at the same time discharge their moisture, and so the mountains are covered with snow. The winds thus dried roll down the eastern slope into lower altitudes, when the pressure increases and they are heated again. But now they are dry. Thus it is that hot, dry winds come, now and then, and here and there, to devastate the sub-humid lands, searing the vegetation and parching the soil. From causes not well understood the rainfall often descends in fierce torrents. So storms and siroccos alternately play over the land. Here critical climatic conditions prevail. In seasons of plenteous rain rich crops can be raised without irrigation. In seasons of drought the fields are desert. It is thus that irrigation, not always a necessity, is still an absolute condition of continued prosperity. The rainfall is almost sufficient, and the artificial supply needed is small — perhaps the crop will rarely need more than one irrigation. A small supply for this can be obtained from the sands of the river valleys that cross the belt. In some regions artesian waters are abundant; but the great supply must come from the storage of storm-waters. The hills and mesas of the region are well adapted to this end. Under such conditions farming cannot be carried on in large continuous tracts.

Small areas, dependent on wells, sand-fountains, and ponds, must be cultivated. It is a region of country adapted to gardens, vineyards, and orchards. The hardier fruits can be cultivated at the north, and sub-tropical fruits at the south. From this region the towns and cities of the great valley and the capitals of trade in the East will be supplied with fruit and vegetables. It is the region of irrigation nearest to them, where gardens and fields produce richer, sweeter products than those of humid lands. Already the people are coming to a knowledge of this fact and are turning their industries in the right direction. The earliest settlements have been planted in seasons of maximum of rain, and the people who came had dreams of wealth to be gathered from vast wheatfields. Now wholesale farming is almost wholly abandoned. In the last twenty years, during which the writer has been familiar with the sub-humid zone, having crossed it many times and traversed it in many ways, he has seen in different portions two or three tides of emigration, each ultimately disastrous, wholly or in part, and settled regions have become unsettled by migration to other districts. But from each inflow a few wiser men have remained and conquered prosperity; and now that the conditions of success are known, he is willing to prophesy — not from occult wisdom, but from a basis of fact — that the sub-humid region will soon become prosperous and wealthy.

The Arid Land is a vast region. Its mountains gleam in crystal rime, its forests are stately, and its valleys are beautiful; its cañons are made glad with the music of falling waters, its skies are clear, its air is salubrious, and it is already the home of millions of the most energetic men the world has ever known.

J. W. Powell.

MEMORY.

SOME years since, Francis Galton, in a most worthy-to-be-read essay upon twins, showed how the original fiber of the human individual asserts itself against training and environment. Nevertheless training and habit are potent factors in determining not only the action, but also the characters of individuals. This is so chiefly because the nervous system has been endowed with a faculty or attribute commonly spoken of as memory. To the consideration of this faculty the present article is devoted.

In entering upon the discussion of any subject it is essential first clearly to define the terms which are to be used. The big-headed, shaggy-locked founder of the English dictionary, Dr. Johnson, defines memory as the power of retaining and recollecting things past, and consciousness as the power of knowing one's own thoughts and actions. Probably he was in accord with the majority of mankind in associating consciousness and memory as two functions of the brain which are so inseparable that without consciousness there is no memory, and without memory there is no consciousness. This is, however, a mistaken idea.

now dancing, anon talking over the old times on the Ulufta. Something in the music of that banjo had an intoxicating effect. Judge Dillard felt fifty years younger, and Rack found it not in the least difficult or tiresome to play for an hour at a time without a moment's rest. The exquisite odor of the pine wood touched the air in the room, and there was a distinct flavor of ripe mulberries straying elusively about.

When I visited Rack's cabin I examined with great care and interest the incomparable banjo which the negro's patient genius had built out of the "singing-board, the over-fed mulberry limb, and the skin of the famous Ulufta 'possum," as the thrifty Yankee proprietor describes it. No one can doubt that science and art were happily married in the making of that superb instrument. A glance shows that the carving, the proportions of the parts, and the fine details of the finishing — from the silvery, translucent skin that covers the head, to the rich purple of the mulberry neck, and the gold-colored hoop fashioned out of the old warped board that had sung so long in the cabin roof — are exquisite beyond description. On the under part of the neck is the only authentic autograph left by Rack Dillard. It is a legible carved inscription of four words: "Dis is de corroliation."

Rack's grave is on the top of the high cliff above his cabin. It overlooks the lovely valley of the Ulufta, and commands a fine view of the Hog Back. To this high tomb of the great negro originator of true dialect romance and minstrelsy have come, as pilgrims to a shrine, many faithful and devoted students to pay their respects to the founder of their school. Wreaths of flowers are laid tenderly on the mound, and in the bold escarpment of the rock are cut ineffaceably some names beloved of all men. Among these, and high in the list, I noticed with peculiar pleasure Joel Chandler Harris, H. S. Edwards, Thomas Nelson Page, and Irwin Russell — the names of men whose stories and songs and sketches have made known to the world the tender, faithful heart, the rich, sunny humor, and the deeper soul qualities of the Southern negro. I hesitated a while; then where no one would be apt to see it, I scrawled my own signature to testify that I too had been there.

Rack must have been a genius, a high type of his race. As in the case of every other genius, he foresaid or forecast the life that was to come after him, while at the same time he was the exponent of the past. His songs and his banjo strains left in the brisk, sweet air of the New South a lasting reminder of the old plantation days. The years he spent so patiently in establishing a close relationship among his materials, and which drew together the three elements of his art, fun, pathos, and music, have served well the civilization of our time, and have added a distinct tint and a new flavor to life. We owe a great deal to Rack Dillard. Peace to his ashes!

Maurice Thompson.

THE NON-IRRIGABLE LANDS OF THE ARID REGION.

BY THE DIRECTOR OF THE UNITED STATES GEOLOGICAL SURVEY.

UN is the father of Cloud.

Cloud is the mother of Rain.

Sun is the ruler of Wind.

Wind is the ruler of Rain.

Fire is the enemy of Forest.

Water is the enemy of Fire.

Wind feeds Forest, and Rain gives it drink.

Wind joins with Fire to destroy Forest.

Constant Rain battles with fickle Wind and mad Fire to protect Forest.

So Climate decks the land with Forest.

There are very large areas of the world unclad with forests, but this is not for lack of rain. Forests, low, gnarled, thorny, and scant, will grow with even less than ten inches of annual precipitation. Such are the forests of sunny Arizona. As the rainfall increases from clime to clime, the forests become more luxuriant, stately, and dense, until with sixty inches of rainfall a growth is produced which almost baffles description. Then giants crowd one another and lift their heads higher and higher in rivalry to bathe their verdant crowns in sunlight. High and straight towards the heavens they thrust their boles, and their boughs push towards the zenith by the shortest way of verticality. The young trees also are slender and straight, and depend on the giants for protection against overthrowing blasts. Around the feet of the giants is a dense undergrowth. But old trees die and fall, and their great stems lie on the ground or are held above it by large branches. Through this warp of living and dead trees there is a woof of vines, climbing the trees, running out on the branches, creeping over logs, and stretching from tree to tree,

branch to branch, and log to log, all woven into a mass of vegetation. Thus the erect and creeping living and the prone and prostrate dead constitute a forest tangle into which man can penetrate only with the greatest toil. Such are the forests that stand about stormy Puget Sound.

Between these extremes there are many degrees of luxuriance in tree growth. When a region is reached with less than forty inches of rainfall small prairies may sometimes be found, and passing on to regions of still less rain the prairies are larger and more frequent. When districts of about thirty inches of rainfall are reached prairie predominates, and the few and smaller forests are called groves. Still passing to zones of less precipitation the prairies become plains, and such forest growth as may be found is mainly ranged along the river banks or scattered over stony hills.

If there were no intervening agency, climate would cover the earth with trees wherever there is more than ten inches of rain. This agency is fire. Rainfall, then, furnishes the potential limit to forest growth, fire the actual limit. On the other hand, rainfall furnishes a limit to fire in such a manner that it becomes less and less destructive, until, under mean conditions of latitude and altitude, forty inches of yearly rain establishes a practical limit to its ravages. In a region where prairie and grove divide the land between them, fire and storm are evenly matched. Fire is king on the plains; storm rules where the forest stands.

The arid lands of the United States are chiefly without trees, although the rainfall is sufficient for their production except in desert areas of Arizona and California; but fire prevents their development or destroys them after they are grown. Still, some areas of the country are wooded. Along the streams grow cottonwoods of value for firewood and for minor domestic purposes. On elevated mesas or table-lands, and on lofty hills, are scant forests, consisting mainly of low, straggling piñons, or nut pines, dwarfed and gnarly cedars, and ragged and deformed oaks. These forests do not furnish milling timber, but they are useful for fuel and for many other purposes. On the higher plateaus and mountains great forests are found, composed of pines of many species, spruces, hemlocks, firs, and sequoias. The timber trees are all coniferous and needle-leaved. The oaks are but bushes, often Lilliputian. Some of the oaks of arid Texas vainly vie with the goldenrods of Illinois; while the cactus plants of the Prairie State would look up with wonder to the cactus plants of Arizona, as pygmies gaze on giants. The oaks of the foothills along the western slope of the Sierras in California attain a greater size, and become orchards of acorns, where Indian hunters and grizzly bears were wont to compete for food in the days when the soil was unscarred by the miner's pick. The forests of the plateaus are not dense, though the trees are stately, and the lands are often variegated with brilliant chaparral and blooming prairie.

The mountains are not uniformly clothed with woods, but here is a grove of pine, there one of spruce, hemlock, or fir. Often these trees are commingled, and in the Sierras of California sequoias stand above them all. By the streams and in the mountain glades silver-stemmed aspens abound, whose wealth of foliage turns to gold when the autumn rime appears. Sometimes a driving wind sweeps through such an aspen grove and brushes the leaves from their twigs, and they float on the air like a cloud of butterflies, resplendent in the brilliant sun of a cloudless sky. Many a mountain side is naked, and many a peak is lifted above the timber line into the region of snow and ice.

We mount our horses at Flagstaff in northern Arizona. In ten minutes we are in the woods and out of sight of the railroad town. We ride for hours among the pines, and from time to time see San Francisco Mountain on our right. Here and there, as we go, a black cinder-cone is lifted for a few hundred feet, aspen groves are seen, and at noon we ride up the slope of a low, dead volcano, and, passing a rim of crunching cinder, halt on the shore of a lakelet in a crater. Then on we ride through an open pine forest, until at last we come down to hills that are covered with piñons and cedars, and rest for the night by a spring concealed among oak bushes. It has been a long ride, and we sleep well. Before the morning sun illumes the hilltop we are on our way again — still to the north, across sage-brush plains and cedar-clad hills; by noon we are once more on the verge of a pine forest, and we lunch by a water-pocket that was filled by a storm two months ago. Then our way is across glades carpeted with flowers, and through open forests where we now and then see a deer bounding on its way. So we pass over prairie and through pine forest until at last we reach the brink of the Grand Cañon of the Colorado. When the days of wonder-seeing are past, we turn to the southwest, riding through forest and across prairie. At intervals of twenty or thirty miles we find a spring or a water-pocket. And so we journey, day by day and week by week, over prairies, through forests, and among cinder-cones and dead volcanoes, glad to find a water-pocket after a long ride and supremely happy to camp by a living spring. But no creek, no river, is ever found. Such is one of the great forest-clad plateaus of the arid region.

Our steeds are now psychic, and we amble through air to Middle Park in Colorado, and camp at the foot of a mountain. Near by rolls Grand River, and there by the rock is a fountain whose waters come from unknown depths, where they have been heated in the caldron of eternal fire. From the boiling waters a cloud of steam arises, loaded with sulphurous odors, and a pellucid brook flows over a carpet of brilliant *confervæ* on its way to the river. When morning comes again we continue our ride on terra firma, among hills and then among mountains. Now and then we come to a stream where our horses must swim, and we wade creeks and leap over brooks until we plunge again into forests beset with fallen timber.

At noon we camp on the margin of Grand Lake, here bordered with stately forests, there walled with precipitous rocks. True, the distance is great for a morning ride, but our chargers are the best — why not? They are imagination-bought, and we have wealth of fancy. For the afternoon we plunge into a dead forest where a fire played havoc ten years ago. Some trees are prostrate and obstruct the way. Falling trees have caught in the branches of those still standing, and lean here and there with varied angles. Trees supported by others, trees prostrate and trees erect, naked white trees with naked white arms, are woven into a maze of ghostly bars to block our way. Over and under and around we pursue our course. Then a storm comes on. The wind sweeps through this ancient battlefield of fire and storm, and the stark, dead limbs crack, break, and crash on the ground. Now and then a great stricken tree falls and fills the air with a roar which vies with the thunder. Dead trees caught in the arms of dead trees sway and shriek, and the tempest runs mad with wild delight. We stand on open ground and gaze on the destruction and listen to the battle-music of nature. When the storm has passed we ride along until live woods are reached, and at night camp where a mountain rill lulls us to sleep. So for days and weeks we ride through dead forests and live forests, and everywhere in the mountains we find rivers, creeks, brooks, springs, and lakes. Such are the forests of the Rocky Mountains.

Once more, on steeds as swift as dancing light, we enter a grove of live-oaks in the valley of California. Where other trees have curves, these have angles; they are all knees and elbows, and they stand akimbo with knotted fists. But, as if to hide deformity, they are covered with a mantle of perennial green. Now we ride over meadows of green and hills of gold until more symmetric oaks and cedars are found; blue pines are seen, and at night we reach the great sugar pines of the Sierra. Then we slowly climb the long, gentle slope to the west. Cedars like those of Lebanon on every hand, pines like those on Norwegian hills, and at last we see a sequoia, the grandfather of trees. Past the big trees, we next day find forest and chaparral contending for the land. The woods are of pines and spruces and firs, and the chaparral is brilliant with the scarlet boughs of manzanita and gnarled mountain mahogany. High up the mountain we climb, and the pines are lost, the spruces disappear, and the firs are dwarfed, until we are among domes of gray granite and pinnacles of trachyte, and down into a vast amphitheater of sheer rock comes a creeping glacier. So on we ride from day to day, week to week, and month to month, from dwarfed fir above to dwarfed oak below, and again from foothill to granite dome, until we have crossed all the rivers that flow from the Sierras and unite to pass through the Golden Gate. During this ride we have seen the great Sierra forest.

For a number of years a survey of the arid lands has been in progress, and the forest areas have been mapped, and they have all been studied more or less. Now surveys are mathematical, for relations of quantity are involved. Numbers perhaps are more arid than land, and hence they are appropriate here. Glance at the following table, and some idea will be obtained of the comparative extent of the forests of which I have spoken.

Approximate Area in Square Miles of Timbered Lands in the Arid Region.

State.	Firewood. Sq. Miles.	Merchantable Timber. Sq. Miles.
Washington	1,050	1,080
Idaho	8,600	9,800
Montana	6,500	21,000
Oregon	3,500	8,700
Wyoming	7,300	15,700
South Dakota	2,400	400
N. Dakota (river bottoms)	200	...
California	20,300	11,000
Nevada	5,400	700
Arizona	26,510	11,700
New Mexico	21,540	14,490
Colorado	15,000	23,500
Utah	14,000	7,700
Totals	132,300	125,770
	125,770	
Grand total	258,070	

Total area of arid lands, 1,331,151 square miles.

It will appear from the above table that about one-tenth of the arid region is covered with firewood timber, but this timber is very scant, and often the open spaces are large. It could all stand on one-fiftieth of the entire arid area and not be crowded. The milling timber also covers about another tenth of the ground, but there are many barren places, and usually the trees are widely scattered, so that they could

MAP OF THE FOREST LANDS OF THE ARID REGION.

all stand on one-fortieth of the space and still have abundant room. So both classes combined could easily stand on less than one-twentieth of the arid region.

The merchantable timber is all on the high plateaus and mountains; hence the lands where it grows are not valuable for agricultural purposes. Cañon walls, cliffs, crags, and rocky steeps are not attractive farming-grounds. But more: at these great altitudes deep snows fall, ice appears early and lingers long, and frosts come on many a summer night.

The agricultural lands are situate in the valleys where the streams flow. Thus forest and farm are dissevered by dozens and scores of miles. So forest industries are segregated in one region, farming industries in another. It is no small task for the farmer and the villager to haul their wood from distant mountains and to bring poles and logs from the upper region, for it is a day's or a week's journey, and roads must be made over hills and along mountain sides. In many places flumes are constructed —great canals in lumber troughs that stand on trestles, into which creeks are turned, and the lumber is floated down to the habitations of man. Then railroads and tramways are constructed for the same purpose. Often "slides" are built by arranging two parallel lines of logs down the mountain side, between which the timber glides. It is thus that the valleys are dependent on the mountains through the agency of a special lumber industry.

The miners are also interested in these forests. As they penetrate with their shafts, drifts, and galleries into the hills and mountains, they carry away to the surface the rock in which the gold, silver, copper, and lead are found, that the metals may be extracted on the ground above. Then they are compelled to support the overhanging walls, that they may not crumble down. When great depths are reached, the enormous weight of superincumbent mountain squeezes the floors of these galleries and causes them to creep up. To prevent crumbling from above and creeping from below the underground spaces are densely propped with timbers; so thousands and mil-

lions of cords of wood are used underground. The forests are also valuable for fuel in metallurgic processes, and to furnish the power necessary for running mining machinery. Many of these mines are in the mountains, and the timber grows near by; sometimes it grows far away, and must be hauled or transported by rail or flume to the mines where it is needed. So the mining operations largely depend on the forests.

More than two decades ago I was camped in a forest of the Rocky Mountains. The night was arched with the gloom of snow-cloud; so I kindled a fire at the trunk of a great pine, and in the chill of the evening gazed at its welcome flame. Soon I saw it mount, climbing the trunk, crawling out along the branches, igniting the rough bark, kindling the cones, and setting fire to the needles, until in a few minutes the great forest pine was all one pyramid of flame, which illumined a temple in the wilderness domed by a starless night. Sparks and flakes of fire were borne by the wind to other trees, and the forest was ablaze. On it spread, and the lingering storm came not to extinguish it. Gradually the crackling and roaring of the fire became terrific. Limbs fell with a crash, trees tottered and were thrown prostrate; the noise of falling timber was echoed from rocks and cliffs; and here, there, everywhere, rolling clouds of smoke were starred with burning cinders. On it swept for miles and scores of miles, from day to day, until more timber was destroyed than has been used by the people of Colorado for the last ten years.

I have witnessed more than a dozen fires in Colorado, each one of which was like that described. Compared with the trees destroyed by fire, those used by man sink into insignificance. Some years ago I mapped the forests of Utah, and found that about one-half had been thus consumed since the occupation of the country by civilized man. So the fires rage, now here, now there, throughout the Rocky Mountains and through the Sierras and the Cascades. They are so frequent and of such vast proportions that the surveyors of the land who extend the system of triangulation over the mountains often find their work impeded or wholly obstructed by clouds of smoke. A haze of gloom envelops the mountain land and conceals from the eye every distant feature. Through it the rays of the sun can scarcely penetrate, and its dull red orb is powerless to illumine the landscape.

During last season I made a trip over the arid lands by rail. On the way through the Dakotas the landscape was covered with a veil through which it was as vain to peer as through a fog at sea. On we went, meandering through the cañons and among the great ranges of Montana, but the smoke covered all the landscape of mountain forms, and for aught that could be seen we might as well have been crossing featureless plains. Then we passed through Washington and Oregon and down through Idaho — ever in a mountain land, and never a mountain in sight. As we crossed the line into Utah a shower came and cleared the atmosphere, and behold! the Wasatch Mountains were in view; a great façade of storm-carved rocks beetled above the desert as proud as if they were not doomed to be destroyed by storms and buried low in the valleys by rivers.

It is thus that, under conditions of civilization, the great forests of the arid lands are being swept from the mountains and plateaus. Before the white man came the natives systematically burned over the forest lands with each recurrent year as one of their great hunting economies. By this process little destruction of timber was accomplished; but, protected by civilized men, forests are rapidly disappearing. The needles, cones, and brush, together with the leaves of grass and shrubs below, accumulate when not burned annually. New deposits are made from year to year, until the ground is covered with a thick mantle of inflammable material. Then a spark is dropped, a fire is accidentally or purposely kindled, and the flames have abundant food.

There is a practical method by which the forests can be preserved. All of the forest areas that are not dense have some value for pasturage purposes. Grasses grow well in the open grounds, and to some extent among the trees. If herds and flocks crop these grasses, and trample the leaves and cones into the ground, and make many trails through the woods, they destroy the conditions most favorable to the spread of fire. But if the pasturage is crowded, the young growth is destroyed and the forests are not properly replenished by a new generation of trees. The wooded grounds that are too dense for pasturage should be annually burned over at a time when the inflammable materials are not too dry, so that there may be no danger of great conflagration.

The area of good timber being very small, it has great value, and its rapid destruction is a calamity that cannot well be overestimated. These living forests are always a delight, for in beauty and grandeur they are unexcelled; but dead forests present scenes of desolation that fill the soul with sadness. The vast destruction of values, together with the enormous ravishment of beauty, have for years enlisted the sympathy of intelligent men. Forestry organizations have been formed; conventions have been held; publicists have discussed the subject; and there is a universal sentiment in

the West, and a growing opinion in the East, that measures should be taken by the General Government for the protection of the forests. This subject is of profound interest; but sometimes factitious reasons are given which detract from the argument for the preservation of the woods.

In humid lands, where rivers flow on to the sea because they are not needed on the fields, the problems relating to the streams are of another character. There the floods are destructive, and every condition which favors their diminution is an advantage. Vegetation lives on water. The roots drink it, and the leaves return all that is unused to the air, where it may float away to form clouds in other regions. A vigorous plant will thus evaporate two or three hundred times the weight of its annual growth. Then a great tree spreads, through the agency of its leaves and branches, a vast surface to the air and the heat of the sun. Altogether no inconsiderable portion of the precipitation of a region is thus returned to the heavens, and so fails to find the rivers. The subject has been more or less studied, but it is complex, and the result cannot be simply stated, for the variables are many. Perhaps it is safe to say that from twenty to forty per cent. of the rainfall of a region may be dissipated in this manner. It is manifest that such a loss from the streams is of no small importance in a humid region, and it is for this reason that the preservation of mountain forests in such lands is often strongly urged. But when the streams have a value which increases with their volume, the economic aspect of the problem is at once reversed. Researches on this subject made in the Wasatch Mountains and elsewhere by scientific men show that a great increase in the volume of the streams may accrue from the denudation of the mountains of their evergreen garments. There is still another condition which tends in this same direction. When the mountain declivities are grassy slopes, the snows of winter drift behind ledges and cliffs and into great banks among the rocks, and they fill ravines and cañons, and are thus stored in compact bodies until they are melted by the summer suns and rains. But when forests stand on the slopes the snows are spread in comparatively thin sheets, and great surfaces of evaporation are presented to the sun and the wind. For all these reasons the forests of the upper regions are not advantageous to the people of the valleys, who depend on the streams for the fertilization of the farms.

But there is an obverse side of this problem. When the waters are stored for irrigation in natural and in artificial lakes the preservation of their reservoirs is of prime importance. Storm waters wash the sands from naked hills and mountains, and bear them on to the creeks and rivers, by which they are carried to the storage basins. Protection from these injurious agencies is chiefly afforded by vegetation. For this purpose grass and chaparral serve well, but woods are better. For the protection of reservoirs, therefore, it is important that their immediate slopes should be forest-clad, and that all declivities above, the waters of which cannot be discharged in large part of their sediments before reaching the reservoirs, should also have their woods preserved. In the utilization of these timber regions, then, as a source for the lumber which the people need, judgment and circumspection will be necessary properly to select the areas to be denuded. It is thus that the people of the valleys are interested in the forests of the mountains. Among the crags and peaks where winter winds howl, and where the snows fall all winter long, there grow inchoate cottages and schoolhouses and the fuel that illumines the ingleside. And the mountain passes are the portals through which the clouds of heaven come down to bless their gardens and their fields, and to fill the fountains from which their children quaff the water of life.

The lowlands of the arid region are dry and hot, and are almost destitute of grasses. The summits of the highest mountains are in regions of almost perpetual frost, and grasses are practically wanting. Between these extremes of mountain top and desert valley there are vast areas of nutritious grasses, scant below, but becoming more luxuriant as one climbs the hills, traverses the plateaus, and wanders over the mountain sides. The lowest lands, those bearing more scant grasses, are the lands to be irrigated, for the waters can be taken to them. The better pasturage lands are usually too high for agriculture.

Climatic temperature decreases from the level of the sea to the summit of the mountains, but it also grows colder from the equator to the poles. Now the lowest lands of the arid country are farthest south. In Arizona and southern California the uninhabitable deserts of America are found; there are districts of country below the level of the sea and other stretches just above it. These low, torrid lands are strewn with pebbles, over which the winds sweep and carry on their way a load of sand as an instrument by which the pebbles are polished. It is thus that the desert in many places is paved with a mosaic of gems that gleam in many colors and blind the eye with their radiance. There are other stretches where billows of sand drift across the desert with the prevailing winds. Still other areas are covered with sand and stony fragments and strewn rocks,

where vegetation gains little foothold. All these lands are worthless. In passing from the Mexican to the British line, where conditions of altitude are the same, the grasses steadily improve, and those of the northern half are comparatively rich. But even here there are waste places, for lava-fields abound that are virtually desert. And there are "bad lands" that yield little vegetation. These lands are hills of clay and sand that are washed by the storms and baked by the sun. When the rains come the hillsides are sloughs, and when the winds come the dried surfaces crack and crumble. Then there are cañon lands that are carved by many winding, branching gorges, and thus are rendered worthless. Then there are alcove lands where every rill of the rainy season heads in a precipitous, rocky gulch. These are also barren. Then buttes are scattered over the mesas and plateaus—fragments of formations left by the destroying storms for their future employment. Then there are cinder-cones, naked and desolate. Often lines of cliff stretch athwart the country—the margins of mesas and plateaus. These cliffs are worthy of further mention. When the winds drift the clouds along the lowlands, such a cliff, a few hundred or a few thousand feet in height, obstructs their way. So the clouds rise and discharge their moisture, and floods are speedily born. In regions of cliff a large portion of precipitation is along these lines, and yet with this increased precipitation they are not favored with great vegetation, for the water glides away on the steep declivities, and a zone of lowlands near by receives them, and here the most valuable forests of piñon and cedar are often found. Then the mountains are not all grassy slopes, for they are often interrupted with rocks and ledges and cliffs that are naked.

Though the grasses of the pasturage lands of the West are nutritious, they are not abundant, as in the humid valleys of the East. Yet they have an important value. These grasses are easily destroyed by improvident pasturage, and they are then replaced by noxious weeds. To be utilized they must be carefully protected, and grazed only in proper seasons and within prescribed limits. But they cannot be inclosed by fences in small fields. Ten, twenty, fifty acres are necessary for the pasturage of a steer; so the grasses can be utilized only in large bodies, and be fenced only by townships or tens of townships. Yet they must have protection or be ruined, and they should be preserved as one great resource of food for the people. When the valleys below are irrigated, so that flocks and herds may be fed when the snows and frosts of winter come, the hills and mountains of the arid region will support great numbers of horses, cattle, and sheep.

The mountains of the far West are full of gold. Ores of the yellow metal are found in fissures that seam the rock, and fill spaces between barren formations, and lie in bodies where lavas have cooled in hill-bound basins. Then the whole mountain region has been plowed with glaciers and swept by storms or buried by river floods, and in these glacial gravels and storm gravels and river gravels the gold has been carried, and here the placer mines are found. In other hills and mountains there are stores of silver and copper, while lead and iron abound. Then asphalt, oil, and gas are found, and the hills are often filled with coal. With slight exception all of these minerals are found in lands which cannot be redeemed for agriculture. The coal lands are chiefly pasturage lands, and the gold and silver mines are under the forests. The coal and iron have been and can be discovered by science, but gold and silver are discovered by prospectors and revealed only by the pick and shovel. These mines of gold and silver furnish the basis of our monetary system, and are the source of vast wealth. During the last calendar year $32,816,500 in gold and $59,118,000 in silver were taken from these regions, and this supply is to be continued through an indefinite future.

When the waters are stored in the mountain lakes, and the canals are constructed to carry them to the lands below, a system of powers will be developed unparalleled in the history of the world. Here, then, factories can be established, and the rivers be made to do the work of fertilization, and the violence of mountain torrents can be transformed into electricity to illumine the villages, towns, and cities of all that land.

Such are the non-agricultural lands of the arid region. They are forest, pasturage, and mineral lands, on which great industries are in process of foundation. More than twenty years ago I entered the region for the purpose of studying its resources. The investigations then begun have been continued to the present time, and in them many of the great scientific men of America have been employed. In that early day gold and silver mining was the chief attraction, and there were inchoate cities and towns in many places. Agriculture and manufacturing were almost wholly neglected. Everywhere men were digging into the heart of the mountains for gold and silver, and armies of men were engaged in prospecting, lured, now here, now there, by rumors of great discoveries. These armies were composed of stalwart men, adventurous, brave, and skillful. Away in the wilderness, without capital, but endowed with brawn and brain, they established industries, organized institutions, and founded a civiliza-

tion which must forever be the admiration of mankind. The physical conditions which exist in that land, and which inexorably control the operations of men, are such that the industries of the West are necessarily unlike those of the East, and their institutions must be adapted to their industrial wants. It is thus that a new phase of Aryan civilization is being developed in the western half of America. On this subject I hope to be heard at another time.

J. W. Powell.

A WORLD-LITERATURE.

IN Eckermann's "Conversations with Goethe" ("*Gespräche mit Goethe*") that poet is represented as having said, in January, 1827, that the time for separate national literatures had gone by. "National literature," he said, "is now a rather unmeaning phrase (*will jetzt nicht viel sagen*); the epoch of World-Literature is at hand (*die Epoche der Welt-Literatur ist an der Zeit*), and each one must do what he can to hasten its approach." Then he points out that it will not be safe to select any one literature as affording a pattern or model (*musterhaft*); or that, if it is, this model must necessarily be the Greek. All the rest, he thought, must be looked at historically, we appropriating from each the best that can be employed.

If this world-literature be really the ultimate aim, it is something to know that we are at least getting so far as to interchange freely the national models. The current London literature is French in its forms and often in its frivolity; while the French critics have lately discovered Jane Austen, and are trying to find in that staid and exemplary lady the founder of the realistic school and the precursor of Zola. During our Centennial Exposition I asked a Swedish commissioner if Fredrika Bremer's works were still read in Sweden. He said that they were not; and when I asked what had taken their place, he answered, "Bret Harte and Mark Twain." Among contemporary novelists Mr. Howells places the Russian first, then the Spanish, ranking the English, and even the French, far lower. He is also said, in a recent interview, to have attributed his own style largely to the influence of Heine. But Heine himself, in the preface to his "Deutschland," names as his own especial models Aristophanes, Cervantes, and Molière — a Greek, a Spaniard, and a Frenchman. Goethe himself thinks we cannot comprehend Calderon without Hafiz,

> Nur wer Hafis liebt und kennt
> Weiss was Calderon gesungen,

and Fitzgerald takes us all back, certainly with great willingness on the reader's part, to Omar Khayyám. Surely, one might infer, the era of a world-literature must be approaching.

Yet in looking over the schedules of our universities, one finds as little reference to a coming world-literature as if no one had hinted at the dream. There is an immense increase of interest in the study of languages, no doubt; and all this prepares for an interchange of national literatures, not for merging them in one. The interchange is a good preliminary stage, no doubt, but the preparation for a world-literature must surely lie in the study of those methods of thought, those canons of literary art, which lie at the foundation of all literatures. The thought and its expression — these are the two factors which must solve the problem; and it matters not how much we translate or overset — as the Germans felicitously say — so long as we go no deeper and do not grasp at what all literatures have in common. Thus in the immense range of elective studies at Harvard University there are fifteen distinct courses in Greek, fourteen in Latin, and twenty each in English, French, and German; but not a single course among them which pertains to a world-literature, or even recognizes that these various branches have any common trunk. The only sign that looks in the slightest degree in this direction is the offering of two courses in Greek and Latin jointly,— only one of which, however, is given this year,— of three in Germanic Philology collectively, and seven in Romance Philology collectively; almost all of these, however, being wholly philological, not in any sense literary.

No study seems to me to hold less place in our universities, as a rule, than that of literature viewed in any respect as an art; all tends to the treatment of it as a department of philology on the one side or of history on the other; and even where it is studied and training is really given in it, it is almost always a training that begins and ends with English tradition and method. It may call itself "Rhetoric and English Composition," but the one of these subdivisions is as essentially English as