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EUGENE WOLDEMAR HILGARD

1833-1916

BY

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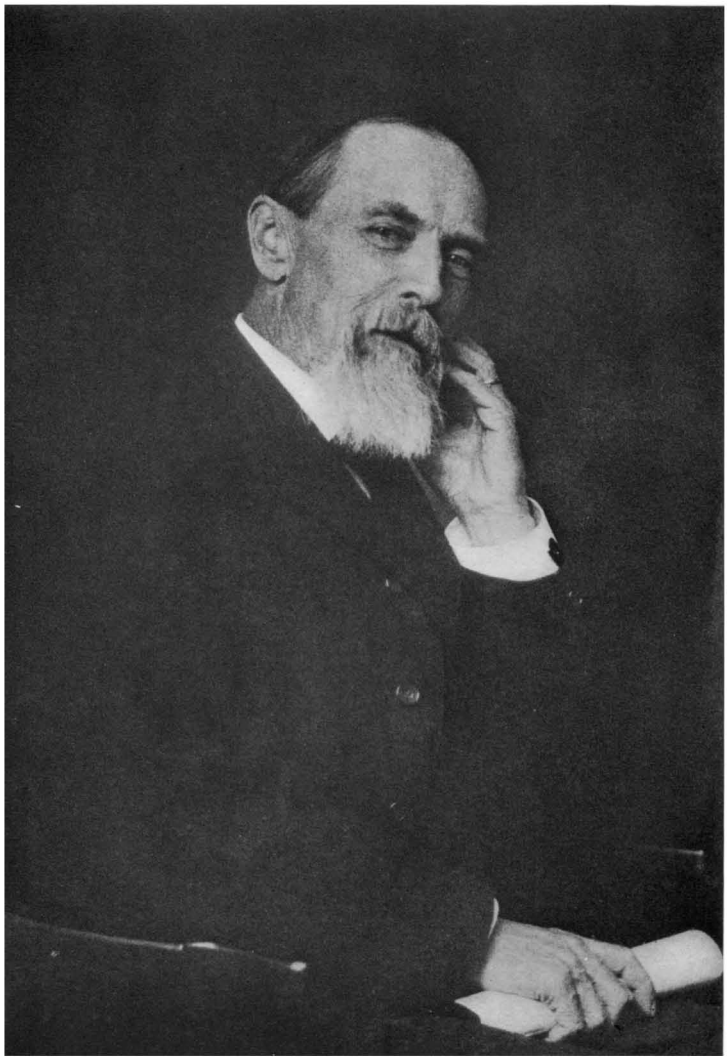

E. W. Hilgard

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Eugene Woldemar Hilgard was born at Zweibrücken, in Rhenish Bavaria, on January 5, 1833. At that date his father, Theodore Erasmus Hilgard, a noted lawyer, held an important position as Chief Justice of the Court of Appeals of the province. His mother, Margaretha Pauli, was a descendant of that Pierre Toussaint de Beaumont who was court preacher to Marguerite, Queen of Navarre, and subsequently canon at Metz, having fled from France during the persecutions of the Huguenots. His son Daniel, known in ecclesiastical history as Tossanus, was court preacher at Heidelberg and afterwards rector of the university there, in which his grandson, also Daniel, in due time became Professor of Theology. The daughter of the latter married Reinhold Pauli, the great-grandfather of Margaretha, who traced her descent otherwise, too, from generations of clergy.

Theodore Hilgard, himself descended from a long line of ministers of the Lutheran Church, and having been born during the impetus of the French Revolution, was of pronounced liberal tendencies. He opposed stoutly the proposal to supersede the *Code Napoléon* by the illiberal laws of the *ancien régime,* and determined finally to resign his office, though standing in the fullness of a successful career. Having rejected repeatedly flattering offers from the government at Munich because the posts tendered would have removed him from a sphere of liberal activity, he reached at length the fateful decision to emigrate to America, the land of liberty, with his family of nine children, among whom Eugene Woldemar was the youngest. In taking this step he followed the lead of a number of relatives and political sympathizers who had already migrated toward the "Far West."

In the autumn of 1835, then, this Hilgard family entered upon the long journey, whose first stage in those days was a drive of fourteen days to Havre, their household goods (including a grand piano) accompanying them on freight wagons. After four weeks' wait at that port, they embarked on the good ship *Marengo* bound for New Orleans, and celebrated Christmas eve by arriving, at the end of sixty-two days. Fortunately a steamboat was soon to leave for Saint Louis, a risky voyage of ten more days against heavy drifting ice, during which the subject of the present memoir recorded his third birthday.

A group of cultured German families, largely exiles for political reasons, were already settled in the neighborhood of Belleville, Illinois, the county-seat of Saint Clair County; and that group the Hilgards joined, establishing themselves on a farm. The colony became known as the "Latin settlement" and its members as "The Latins," on the popular supposition that they actually spoke in Latin or were at least competent to speak it. In truth, however, it was the German language that remained predominant among these settlers and their children, because new German immigrants kept swelling their numbers, and because there were at that time but few educated American families resident around Belleville.

The former chief justice did not resume any legal activity, finding the common law and the court practice by precedent unsuited to his taste; so he returned to literature as an early love, to which he had once thought of devoting himself exclusively. Recalling his predilection for the classics, he undertook presently to make metric translations into German of selected Greek and Latin poets: Ovid's Metamorphoses (printed at Belleville) were among the first of these; and later he finished a part of the Odyssey, which had attracted him as being related in some measure to his own wanderings. He translated Moore's Lalla Rookh also, and issued a small edition for private circulation. While engaged in such work it was natural to share it with the family by reading and discussing portions of it; so in this classic-poetic atmosphere, infused with music and other art, and under strong influence from their father's advanced views about politics and social

questions, the children's lives must have been shaped in unusual ways that were to bear future fruit. As this account progresses, that exceptional nurture will offer the key to much that set Eugene apart among his fellows for maturity and for strength.

The four Hilgard boys found themselves rather isolated, since no other "Lateiner" lived in the immediate neighborhood. Their father thought it inadvisable to send them to the local public school, which was still quite primitive, but instructed them himself instead in mathematics and the languages, with aid from the older sisters, especially in the case of Eugene. Having been educated largely in French institutions, the father was inclined to insist strenuously that the children should all learn French while young. After-dinner readings in that language constituted a regular exercise, and there were two fixed days a week when all communication was to be in French. Neither form of this discipline was entirely popular; the reluctant boys schemed to evade it, escaping to the woods and there in reprisal relaxing into the dialect of the Palatinate which was taboo at home. Apart from some hunting, gardening, and a substratum of farm work such as the conditions required, the occupations and the games of conventional boyhood found only a subordinate place in this mode of living. The woodlands and prairies of the region balanced fairly their rival attractions as fields for botanizing and for collecting insects, and an extensive and varied home library offered an opportunity for spontaneous reading or consecutive study. In the pursuit of natural history, Eugene and his brother Theodore, who was five years older, soon became very assiduous, being specially stimulated by a borrowed copy of Oken's Natural History, and helped, too, particularly in their botany, by a cousin resident in Saint Louis.

This almost ideal state of things might have continued for the boys until the time of natural flight from the parental home but for the intervention of that Nature whom it was then the day-dream of enthusiasts to approach once more through return to simple living. That intervention here took the form of swarms of mosquitoes with consequent fever and ague, whose close interconnection was, however, at that date scarcely

suspected. An epidemic of typhoid fever went progressively through the family, of which the eldest sister died. The disease attacked Eugene last; there was a severe relapse and from this time forward for some years he was to suffer during several months of each summer from fevers—tertian, quartan, or quotidian, or from all combined. It was inevitable that habits of study were much interrupted, especially when the inroads of ague were found to affect the eyes. Meanwhile mosquitoes were allowed free access to such patients, fumigations with pumpkin leaves being the utmost defensive measure employed against them, unless we may add the daily diet of quinine.

In 1842 fate struck again with the death of the mother after a lingering illness; so, naturally, this threw the management of the household and the care for the younger members of the family into the hands of the elder sisters.

In 1846 the favorite brother, Theodore, left home to study medicine in Europe; and this loss of a sympathetically close friend conspired with physical depression attendant upon Eugene's illness, inducing a state of mind that was probably detrimental to his health, already weakened by a persistent obsession with fever and ague and its concomitant troubles. The disability of the eyes increased, as did the chafing against breaking off study. He persevered with work in botany, however, and gradually acquired a knowledge of physics and chemistry from the "Lehrbuch" of Müller-Pouillet and Gmelin's "Handbuch," contriving such chemical and physical experiments as his limited resources permitted. The fundamentals of these two sciences and many of their important details, thus absorbed without any teaching, proved later to be of material assistance to Eugene as a student, placing him in advance of those who were his equals in academic age.

The physicians at last acknowledged the danger of remaining longer in so malarial a climate, and the father decided that Eugene should go where he could attend lectures at least, since he was barred from reading freely. So he left home in the summer of 1848 with his oldest brother, Julius, then returning to Washington, where he was assistant in the U. S. Coast Survey. As a first impression of serious travel, then not so smoothly easy as now, this journey, of course, left a profound

impression. It occupied a full week, being made by steamboat to Louisville and thence to Wheeling; by stage to Cumberland, and by the newly opened railroad to Relay House and Washington. During a stay of four months in that city Eugene met some of the men nationally prominent in science, notably Joseph Henry, the first Secretary of the Smithsonian Institution, and his assistant, Baird; also A. D. Bache, then Superintendent of the Coast Survey. The youth thus introduced to them was not yet sixteen; he felt embarrassed, moreover, by a consciousness of that foreign tinge in his English speech which the German of childhood had left and which he removed fully only by persistent effort. Altogether, he doubted much whether these older men were at all impressed. Yet the sequel showed, through the ready furtherance of his objects at every return to Washington, good proof that at least some of these leaders recognized in Eugene Hilgard the quality that placed him among their logical successors when his ambitions had unfolded into a career.

The time spent in Washington was partly devoted to collection and study of the local flora; but a certain lack of opportunities to attend lectures decided Eugene, in November, to move on to Philadelphia. There he heard the evening lectures at the Franklin Institute by Professors Booth and Fraser and others; also the winter course in chemistry given by Professor Semple at the Homeopathic College. The latter soon discovered that the young student was fitted to act as lecture assistant and engaged him. This duty gave much valuable experience in manipulation and in the preparation of rarer compounds, as well as the stimulus due to personal contact with the professor and sharing his thoughts. Then, besides, since the newer aspirations were not finding full outlet in the experimental work at the college, the younger Hilgard established for himself a private laboratory in a garret room. Here he practiced also electrotyping and photography, for which he contrived his own appliances; and thus the severe winter passed in busy and profitable occupation.

A visit to Professor Booth's laboratory, at that date the only one in this country where students were systematically taught analytical chemistry, brought the suggestion of going

without further delay to Germany, where such studies could be prosecuted more advantageously. This plan having received the paternal approval, passage was secured on the steamer *Hermann,* to leave New York in March, 1849, for Bremen, whence the journey would be continued to Heidelberg, where the brother, Theodore, was then a student. With a self-reliance incidental to sixteen completed years, the trip to join the steamer was entered upon alone; but it is recorded how awed the traveler found himself by the dangers of the big city, how he sought refuge from them overnight on board the boat, and was glad to sail and leave them behind the next day. When nearing Bremen the *Hermann* was halted by a Danish cruiser and searched for contraband of war, the Schleswig-Holstein conflict with Denmark being then in progress; and this occurrence was held to augur more excitements to come, for the revolutionary movements of the previous year were known to be flaming up again for the suppression of "princes, potentates and powers," and making their call too for recruits. From Bremen the remaining stage to Heidelberg by way of Cologne and the Rhine steamers was completed safely, and the reunited brothers, Eugene and Theodore, were able to celebrate their first evening together at a large "Maiwein Kommers." This was for Eugene his first foretaste of German student life.

At the university work in Professor Gmelin's chemical laboratory was begun at once with zeal, and supplemented by attendance upon Bischoff's botanical lectures. But as time went on the general conditions within the university and outside it fell short in several respects of making unreserved appeal to this keen-minded young observer. Some of the lectures heard proved to be perfunctory and uninspiring, or the lecturers failed under test to reveal the scientifically open mind. He could muster but scant sympathy either for the false ideals and the ritual of the "Korpsstudent;" nor did he discover political maturity under the lacks in competent leadership and coherent purpose betrayed by the forms that democratic strivings took. Such impressions and experiences, then, disappointed in some degree the expectations implanted by the early influence of his father, and they consequently gave a certain tentative character

also to the effort of the next two years. Eugene Hilgard was later inclined to trace in them a period of orientation; of search for some combination that would yield a satisfying vocation based upon adequate preparation for it. Such deliberate approach circling round the lifework finally chosen was, however, not uncommon among those men of an older generation who arrived at distinction. There was nothing leisurely or desultory in the process; it was, on the contrary, of necessity aggressive and strenuous, because each man was compelled to break in large measure an individual path. There is good cause to doubt whether the same toughness of fiber can be developed so fully on the present highways laid out and ready to lead into some intensive early specialization.

Eugene and Theodore Hilgard left Heidelberg in the summer of 1849, with no plan that looked beyond an outing for recreation and a visit to their native Palatinate. But at Karlsruhe they came among the uprisings that put the Grand Duke of Baden to flight and led to the establishment of a provisional government, and on crossing the Rhine they found great confusion prevailing. Much enthusiastic shouting for equality and liberty there was, to a loud accompaniment of drums and fifes; much aimless discussion in meetings as well, but a noticeable absence of definite action, except that rudely armed peasants were seen drilling everywhere in squads. With the support of American passports and their locally influential family name, the two travelers opened their way easily past such sentinels and guards as they encountered and reached Speyer, where they found their cousin, Fritz Hilgard, in power as civil commissary, or governor over the eastern Palatinate. His plain forecast of anarchy in the immediate future confirmed their own observation and inclined them to adopt his counsel, according to which they should at once turn back to Heidelberg, make their route thence to Switzerland, and abide there while these troubled times lasted. In fact, they did witness later at Zurich the disarming of the German revolutionary army, and they met again their cousin there, now an exile, escaping sentence of death. Thus some compulsion arising from political conditions determined the migration to the University of Zurich for Eugene and his brother, which was the next stage in their progress.

At Zurich Eugene Hilgard found Professor Oken in person, the charm of whose Natural History had incited to study in the far-off American home; in geology he worked with Escher von der Linth, in chemistry with Professors Löwig and Schweitzer, all notable men. Here, not otherwise than in Philadelphia, he still found himself overtopping his contemporaries in the strength given by preparatory study, and he was soon selected by Löwig to be assistant in the lecture-room and in laboratory investigations. These and similar activities rounded out three semesters at Zurich, which were looked back upon as the most enjoyable of the growing student's training. The next step carried Eugene, in 1850, via Dresden, where a married sister had meanwhile come to reside, to the Mining Academy at Freiberg for advanced study in mining and metallurgy. So he parted company with Theodore, who was proceeding to the University of Vienna, whose medical school stood then, as now, in high repute.

In those years the Freiberg Academy was at its best, with Plattner, Breithaupt, von Cotta, Weisbach, in the chairs of metallurgy, mineralogy, geology, engineering, as well as prominent men in other departments. While as a student he could not but prize such opportunities and avail himself of them industriously, the young man in Eugene Hilgard found the local life much less attractive than at Heidelberg and Zurich. Not only did he miss sorely the beauty of landscape in his surroundings—Freiberg being no exception to the proverbial rule that mining regions are bleak—but he experienced another, and for him more serious, defect in the daily living. There were unsocial conditions prevailing in the community; antagonisms between the garrison and the student body, jealousies of spirit, setting academy against the universities. The effects of the latter especially galled the student with a record of four university semesters, who stoutly refused to acquiesce in the status of "Fuchs" proposed for him among men of little liberal education and shorter apprenticeship than his. So Hilgard was out of tune with the majority of his fellow-students, had some sharp differences with them, and was thrown for his closer associations upon the small body of foreigners, among whom were several Americans.

But he grew into intimacy with Professor Plattner, in whose blowpipe methods of chemical analysis he became so strongly interested that he developed them with important expansions subsequently. In the laboratory of Professor Scherer he carried through an investigation into a new double sulphate of iron and potassium. In his own quarters, moreover, other researches were developing; namely with organic compounds, one of which might have ended life and study together, when hydrocyanic gas was unexpectedly liberated from oxamid and inhaled. Fortunately, though, the effect at the time was nothing worse than a few minutes of unconsciousness, and no further results of the accident appeared. This period shows other risks incurred, however, whose consequences were not so transient, exposure to which was attendant upon a practical course in the smelting works at Muldnerhütte undertaken during one vacation. Here there were fumes of sulphur, arsenic and lead, from the furnaces that the student was set to feed, causing a troublesome cough. In addition, the insidious quicksilver vapor leaking from the condenser in a distillation of amalgam nearly overcame Hilgard on one occasion. And needing then to be sent to a doctor for treatment, he received unawares the shock of being pronounced unfit physically to become a "Hüttenmann." This verdict was presently corroborated by his brother Theodore, whom he visited at Vienna, and who on all scores advised him rather to follow the out-of-door life of a geologist or a botanist.

This crisis, to be sure, was no more than an accentuated recurrence of previous warnings. The persistent attacks of malaria during the critical years of growth had been tenacious in their after-effects, bringing on exhaustion under any severe task; for instance, in Zurich once, when Theodore was obliged to prescribe as a tonic a trip through the Bernese Highlands. Quick improvement in the bracing air had been clearly apparent then; for just one climb from Lauterbrunnen across the Tschingel glacier to Kandersteg, though begun with aching head and eyes and accomplished, forsooth, only under the repeated spur of "Kirschwasser" from the guide's flask, had banished the bad symptoms effectually. Such marked success had encouraged a continuance of the plan throughout that va-

cation, during which the brothers reached points like Zermatt and Chamouni, Eugene finding himself at the end of the trip able to use without hindrance eyes to read and brain to think. Therefore, it was natural that the prescription should be renewed for the following summer, with botanical collecting added to infuse its zest into these journeyings, which now included a passage from the Grimsel over the Aarglacier to Grindelwald by way of Stralegg Pass—a route then rarely attempted. This course of health-giving exercise in mountain air had been repeated in the summer of 1850, when Judge Hilgard arrived on a visit to Germany and among other diversions climbed the Righi again with his two sons.

In view of that unbroken series of good results, it is no wonder that the earnest brotherly counsel again in 1851 was to take to the Alps and seek restoration from the weakening experiences at Freiberg. Accordingly, Eugene Hilgard turned his face to Switzerland once more, though not to the high mountains this time, and made a tour of two weeks, alone and on foot, in the region round the Lake of the Four Cantons. Remarkably improved in vigor, he returned then to Heidelberg, being moved to this decision by the recent appointment of Robert Bunsen, who had been made Gmelin's successor, and was already a power to draw students round him. The known breadth of Bunsen's interests, that not only covered chemistry, but also led him to discoveries in physics and geology, on the one hand appealed attractively to Hilgard's mental habit; and besides, all three fields seemed to bear, each with its own importance, upon his future in so far as that had begun to assume definite outline. We are aware how the long years in store were to bring gradual realization of these inclusive plans for a broadening range of activity. After only a few weeks in the atmosphere of the newly-inspired laboratory, the decision was reached to take the degree of Doctor of Philosophy under Bunsen's auspices; and in due time, on October 3, 1853, the candidate was transformed into Doctor Hilgard. It bears clearest testimony to the capacity and the sustained zeal with which the preparatory studies were carried through, that the degree was bestowed with the highest honor, *"Summa cum laude,"* upon a student who had not yet com-

pleted his twenty-first year, and who had not undergone any apprenticeship of the baccalaureate.

There was only a select quartet of students admitted to the advanced work: C. Bohn from Leipsic, Kjerulf from Christiania, Landolt from Kiev and Hilgard. Their laboratory was primitively quartered in the corridor of an old convent, but they enjoyed that essential advantage of familiar relations with the professor, and were receptive sharers of his contagious enthusiasm. Bunsen's reputation, to which his appointment in Heidelberg was due, had been built upon his investigation of kakodyl that had opened up a series of organic compounds and upon his analyses of the waste gas from blast furnaces. In 1851 he was more specially engaged in perfecting the titration of iodine solutions with sulphurous acid, together with the general methods of gas-analysis; and he easily induced Hilgard to adopt as his doctor's thesis some inquiries into the complicated process going on in a candle-flame, which the professor characterized as a miniature "Hochofen." Under the professor's general guidance then, the young student was left free to attack the details of his problem with entire independence. Under the self-reliant conditions of those days, too, he was obliged to do much toward constructing, graduating and calibrating his own apparatus, so that he acquired incidentally a skill in glass-blowing that served him well through after-life.

In this thesis Hilgard distinguished and defined four parts in the flame of a candle or lamp, of which only three had been usually identified, and the four corresponding processes. Analysis of gases from the inner cone proved, contrary to prevailing impressions, that the air penetrates to the central dark cone abundantly, instead of burning the gases on the outside only. It was established that the heat of the outside veil, or zone of complete combustion, while gasifying the fuel, acts also somewhat like a red-hot tube in forming ethylene, marsh-gas and hydrogen. Water and the two oxides of carbon were found increasing in proportion as the higher parts of the flame are reached, until the high temperature causes the liberation and ignition of the carbon to which luminosity is due in flames from tallow and wax. The blue tint at the base of any flame was shown to result from instantaneous oxidation under unre-

stricted access of air that gives the colors of a mixture of hydrogen and carbon monoxide. The blue cone of the blowpipe's oxidation flame is then simply a prolongation of such a "blue cup" at whose tip the highest temperature exists. Bunsen gave high praise to the investigation, whose general conclusions were fully sustained when Lunge reviewed them, having simplified the conditions by using illuminating gas for fuel.

The candidate filled two years busily with preparation, supporting his major line of work with physics and mineralogy, and the ordeal of the examination at length arrived. We are assured that the test was endured with unshaken composure in the stimulating presence of Bunsen; and without any sense of difficulty, though von Leonhardt, the mineralogist, was rated an examiner formidable in his capricious demands. Associated with Hilgard for the examination was L. Carius, lecture assistant to Bunsen, and the two candidates arranged for a joint "Doktorschmaus," the usual celebration of success. But here Carius had presently to represent both as host, his companion in honors being once more in weak health from overwork and obliged to desert the festival early. It would seem, indeed, that a breakdown might have overtaken Eugene several months before had not his sister Clara (already widowed) been resident then in Heidelberg and able to give him affectionate care.

On the day after the examination, the new Doctor deemed it advisable to consult a physician about his case, who decided that, because of a persistent cough and general poor condition, Hilgard ought to seek a Mediterranean climate promptly, suggesting the Island of Elba. But after conferring with his brother and sister, a journey to Malaga was substituted, where there were family friends who could be helpful if need arose. Some hovering suspicions of consumption made the good-byes among the Heidelberg acquaintances rather serious, but the patient himself seems not to have lost confidence. Taking the manuscript of his thesis with him for a final revision, he started southward by way of Zurich, and after a few days spent with friends there he went on through Lausanne, Geneva, Lyons; thence by steamer to Avignon and by railroad to Marseilles, making the trip at leisure in order to husband his re-

serves of strength. Embarking on a Spanish steamer that made unhurried halts at coast ports, the traveller was given time to look about him at Barcelona, Valencia, Alicante and Carthagena, beside like opportunity at Marseilles during an enforced wait of a week before sailing. After leaving France, however, an entire ignorance of Spanish limited his spoken inquiries to a priest on board who could use Latin and to a German steward, so observing eyes had double duty. That voyage offered Dr. Hilgard a first experience of arid regions and of their irrigation systems, whose peculiar conditions were destined to become so familiar to him subsequently in California, to the successful control of which the matured professor was later to make many valuable contributions. At Alicante the report ran that no rain had fallen in three years. The country must have looked unbearably dry by comparison with Northern Europe. It was noted that the only representatives of green wild plants were cactus and the dwarf palm, and how the peeled stems of the latter were locally esteemed a delicacy, though astringent as unripe persimmons!

The date of landing in Malaga was deferred by all these stops until the middle of November. Then came undelayed recourse to a tried physician, whose diagnosis could scarcely have relieved apprehension, for his prescriptions were recognizably directed against tuberculosis, and the dictum uttered to the friends of his client allowed perhaps three months for the distressing cough to complete its evil work. Unaware of the full gravity of this opinion, Dr. Hilgard set about securing accommodations where only Spanish could be spoken, in order that he might make rapid advance in adding this language to his repertory. Then he buckled down to putting the last touches of revision to his thesis and dispatched the manuscript in final form to Bunsen in February.

This winter taught the usual lesson about the discomforts of that season in a climate deceptively reputed tropical on the evidence of its summer heat. In lodgings upon a third floor and opening by draughty sash-doors upon an outside balcony, the delicate lungs could not well be protected from the air that was often chilled by snow lying thick upon the cathedral's domes. For bodily warmth one might muffle oneself in wrap-

pings of bedclothes, since the charcoal brazier only aggravated the cough with its fumes and failed to heat the room. With the arrival of spring, however, there came also a noticeable improvement in health, that allowed excursions in the environs of Malaga, with good reward through the exercise and in collecting fossils and plants. In those times such walks were attended with some risk if extended far outside the city; of robbery at the least, or even of being held for ransom by real bandits who made sporadic raids from their strongholds in the mountains of Ronda, that were one headquarters for smugglers. Yet nothing untoward befell our exploring geologist and botanist, though he saw his footsteps dogged now and then by suspicious characters. Rather he found himself continually amused by the primitive ignorance of the country folk about any foreign lands, and by their belief in the geological hammer and the plant-press as some uncanny outfit of a "medicine man."

These habitual rambles fell doubtless in a critical time to put aside certain dangers and to yield permanent physical benefit. Nevertheless the scale did not turn decidedly enough toward betterment to justify an immediate return to America with the object of striking into some scientific career there. So to give himself fuller occupation, and as a partial means of support besides, Dr. Hilgard gathered a group of pupils in assaying, undertook to construct for a college a Bunsen battery of fifty cells, and devised on a commercial scale a plant for the distillation of essences from roses and from orange blossoms. His alert mind was of course extracting valuable experience from every activity, no matter how temporary, and he was acquiring quickly that full acquaintance with Spanish language, customs and society which helped to make him remarkable afterwards for cosmopolitan tone as well as for command of scientific horizon. We should not understand those traits in him adequately, unless we had dwelt at proper length upon the adventurous years that were ripening them.

With such aims in view, it was natural to accept introductions into the good families of Malaga; among others into that of Colonel Bello, retired from the army, whose home was noted for many a charming evening of "tertulia," rendered

especially interesting by the musical talent of his only daughter. Here the young doctor was able to contribute with his collection of German music—in those circles a novelty at that date. And so he came into intimate contact with Spanish life, met profitably many people, and gained fluent control of the language. Some six years later the señorita Bello became his wife.

By the spring of 1855 his better health warranted the decision to return to America and enter seriously upon his life-work. But he determined to visit the Alhambra before leaving Spain, and elected to go on muleback in the company of an ordinary mule-train, coming back to Malaga though in the regular stage drawn by ten mules kept at a constant gallop, and found the trip both ways full of novelty. At the ancient royal town of Alhama he chanced to witness an old-fashioned peasant dance on the broad ramparts. Near Velez he saw for the first time fields of sugar-cane. There were two whole days at Granada, spent in roaming through the Castle and about the city. Here he could vouch for the survival of an old custom making boys free to throw stones at whoever appeared on the streets in foreign garb. On reaching Malaga again, being anxious to cross the ocean without further delay, Dr. Hilgard ventured to engage passage on a schooner of four hundred tons bound for New York, though its accommodations were poor. They were to take on their cargo of cork and salt at the port of Setuval, not far from Lisbon, and this circumstance afforded opportunity for a week's stay in that capital and its surroundings. Thus he was enabled to visit the Castle of Penna at Cintra and examine its beautifully chiseled walls; also to inspect that slender stone arch in the neighborhood, whose flexible construction had passed safely through the earthquake of just a century before which in Lisbon itself was recorded by the modern straightness of the streets.

Persistent headwinds were encountered on the ocean, so that the captain was induced to shape his course more southwest than usual. In that particular year this route happened to bring the vessel among the clinging seaweed of the shifting Sargasso Sea, against which the sails were powerless in the light tradewinds. But even this obstruction could be condoned, since it made possible some study of the varied fauna of the

seaweed, including the "fishnests." Passing south of the Azores, they turned northward off the coast of Florida and landed safe in New York on July 4, 1855, after thirty-five days at sea. The fossils and plants collected around Malaga, it is said, would fit no schedule of the customs officer, who was at last puzzled into admitting them duty-free. This unconventional arrival in New York, in sharp contrast with an insipid following of some worn track, was in significant harmony with the whole period that it closed; years of personal initiative and of development from within, crowned now with a distinguished doctorate from the leading chemist of his day.

On reaching Washington, since no desirable permanent position offered itself, an arrangement was made, at the suggestion of Professor Henry, whereby Dr. Hilgard occupied a room at the Smithsonian Institution and could at least continue without loss of time his chemical researches. But this plan was quickly interrupted by a telegraphic summons to Hartford, Connecticut, to meet there Dr. Barnard, professor of physics at the University of Mississippi. He proved to be in search of an assistant to serve with the State Geologist, Harper, who being also professor of geology at the university, seemed unable for that reason and others to progress fast enough in the work of a geological survey. The salary offered the assistant was very moderate, and candid hints were let fall that relations with the future chief might be none too smooth; moreover, scientific colleagues were ready with condolence about the absence from that region of those palæozoic formations which were then occupying almost exclusively the minds of American geologists. Nevertheless, it was plainly an opening field for real employment, and the service was accepted.

Hilgard started southward a few weeks later from Washington for Oxford, Mississippi, by the Baltimore and Ohio railroad that had surmounted the Alleghenies during his absence abroad, stopping by the way, however, for a few days at New Harmony, Indiana. Here Dr. David Dale Owen with some assistants was then elaborating the results of the geological and agricultural survey of Kentucky and Arkansas. He received the visitor so genially, and was so generous in imparting

the methods established by his wide experience as best to pursue in such surveys, that he made the visit permanently fruitful. He emphasized especially the need of close attention to the soils and other agricultural features upon whose proper recognition both the practical utility and the popular encouragement of such surveys would depend, particularly in Mississippi, that was not likely to be productive of much mineral wealth. From Owen was acquired, too, his always valuable scheme for soil analyses, and altogether his counsels of an expert were effective to mark out the first lines for the starting of Hilgard's work. Leaving New Harmony the journey was next continued by steamboat to Memphis, and completed by a stage ride of seventy miles to the site of the State University at Oxford. Here Hilgard was to make his headquarters until the transfer to Michigan in 1873, except for a brief residence in Washington toward the close of 1857, for a summer visit to Europe in 1860, during which he claimed his betrothed in Madrid, and for some disturbances during wartime. Here his three children were born. Entering upon this important stage of his career as a young man scarce twenty-two, those eighteen years of his future were to mature his powers through a varied professional activity involving many side-lights on politics and other aspects of human nature. Those were days of pioneer enterprise, hampered by oblique or halting movement toward any scientific goal, until public opinion in a provincial and uninstructed community could be educated into moral and financial support. Hilgard's own transition between the beginning and the end of this period—shifting his main active interest from geology itself to agriculture in its geological connections—may be read as a reaction upon himself of the educational campaign that was engaging his effort. His main undertaking belonged to an era that afforded fewer good models and that found scanty precedents to make plain sailing. His measure of true success in rendering distinguished service to his State, and at the same time building up a nationally recognized reputation, was achievable only by such alliance as his of sanguine young manhood, unusual training, and zeal for his profession. Other men might have been daunted by the difficulties of the situation and its crudities, or have grown cyni-

cal under repeated disappointment in human nature. In all these relations it seems probable that Hilgard's training, because it was foreign, must have helped him to a certain detachment that would favor freshness in attack and in conception of aims.

The Geological Survey of Mississippi had been authorized by act of legislature as early as 1850, being projected then rather hazily as a sort of complete Natural History Survey. The duty of organizing and directing it was at first superposed upon the professorship of chemistry (or of chemistry and geology) in the university, whose incumbent was Millington; a too familiar composite scheme for overworking one man into ineffectiveness. A first attempt to create the separated office of State Geologist met with failure in 1855, though recommended by the university trustees, and the better fate of the movement in January, 1857, as we shall see, was rather an incident of a political manœuvre, than due to gain in public insight. The financial provision was inadequate, as usual with such work; three thousand dollars per annum originally, while the legislature remained habitually more ready to enlarge the plan and the responsibilities of those placed in charge of it than to appropriate funds on the necessary scale. Naturally, therefore, beginnings could be developed but slowly, yet a good introductory report was got together for printing in 1854 by Professor Wailes, of Jefferson College, Mississippi, who had been secured for an assistant to the nominal director. This report, entirely of geological character, gave evidence of a creditable start toward classifying the cretaceous, tertiary, and quaternary areas of the State, and figuring the collected fossils. When Millington at this juncture resigned his professorship, and consequently these added charges also, it would have been advisable to appoint Wailes his successor. But another candidate, more pretentious though less fit, seized the vacant professorship, and so became automatically the head of the survey. He was that Harper to whom Hilgard was now to be assistant, and whom he was not slow to discover incompetent on all scores, to a degree bordering so closely upon charlatanism that the selection condemns the appointing powers. But Harper showed himself an adept in political manipulation;

even after being forced from his professorship in 1856 for gross incapacity, he was still able to challenge the university authorities and to retain, through action by the legislature, the position of State Geologist as an independent office. Having rendered unintended service to the State in promoting this desirable separation, however, his nullity soon became too notorious. He held his place scarcely a year and disappeared from the scene with 1857.

As aide to a chief of that type, Hilgard was, of course, solely responsible for whatever the survey actually accomplished. He was able to take up field-work in the fall of 1855. He elaborated his notes during the winter 1855-56 and resumed explorations the following summer. We can imagine what internal chafing the talented young assistant underwent within the limitations imposed by such false conditions, and how they might have dulled a less deep-seated scientific purpose or warped a weaker rectitude to disloyalty. Yet, while making steady professional progress in the survey and gaining insight by experience in other channels, his temper of mind remained entirely unspoiled. Though, for example, the president of the board of trustees, Jacob Thompson, prompt to recognize this new driving-force, began already in 1855 to take intimate counsel with Hilgard about the report due from Harper for presentation to the legislature that winter. Indeed, under an appointment as private secretary that really included a general advisory relation about the survey Dr. Hilgard accompanied Thompson to the legislative session, and incidentally witnessed his defeat by Jefferson Davis in a campaign for the United States senatorship that is now historically memorable.

At the close of the season for field-work in 1856, it seemed profitable that Hilgard should confer personally with Tuomey, the State Geologist of Alabama, in the interest of establishing due co-operation; more especially also in order to obtain expert backing for the purchase of a set of reference books sorely needed in identifying collected material. This was intended to combat openly Harper's procedure, who would persist in ignoring previous discoveries and data, going to the absurdly unscientific extent of proposing a new name independently for each species of fossil that Hilgard might collect.

What was learned through this personal contact with Tuomey supported the teachings of current experience about giving full prominence to the agricultural bearings of the survey in Mississippi, and strengthened the growth of that policy whose seeds had been sown by the first suggestions of Dr. Owen; that main idea to which Hilgard adhered consistently always, and which he had adopted already when first confirmed as head of the independent survey. This was early in 1858, after a previous short tenure under the university as acting director, immediately following Harper's downfall.

Hilgard had then been summoned from Washington, whither he had retired in 1857, taking this step in avoidance of working conditions become impossible under the new-fledged State Geologist. The interim had been employed fruitfully in the chemical laboratory of the Smithsonian Institution, where Professor Henry offered a warm welcome. Here Hilgard carried to completion two investigations: the first concerned itself with "The Assay of Chromium by Blowpipe Processes," the method being based upon fusion of any chromium ore with alkaline carbonates, followed by a second fusion with acid potassium sulphate, which can be caused to yield anhydrous and insoluble chrome alum—a unique reaction. The discovery was announced at once to the American Association for the Advancement of Science, and was incorporated into the English edition of Plattner's Blowpipe Methods. The other research attempted to exploit the glass-like texture of metastyrol for optical constructions; but disappointment was met because an extending network of minute fissures finally marred the polished surfaces.

The resumption of work at Oxford marks a phase of advancement. As director of the Geological Survey, Dr. Hilgard was taking already, at the age of twenty-five, a conceded place in his State community, and he had set his foot on the road to a national prominence in his chosen field of geology, that he increased and carried with him when he turned with growing attraction toward that other specialized activity by which his matured powers were to attain widest reputation. Through the years next following, while preserving prudently every advantage of close touch with the university and its resources,

he was engaged strenuously in discharging his obligation to build up the survey on a sure foundation of work in the field and the laboratory. An exponent always of the movement to broaden its agricultural aspects in the light of an assured belief, he endeavored wisely to educate public opinion into supporting him intelligently; for the renewed enterprise could not suddenly throw off the ill-repute caused by Harper's failure, while the antidote in Hilgard's effective scientific methods was not at first popularly grasped. The survey, in fact, did not escape the vicissitudes that commonly beset like attempts; so to give it a firmer foothold was one main aim of the new director's first report, as well as to break the force in advance of some political retaliation that was learned to be impending in the legislature of 1858-59.

In a common-sense statement, accessible to the plain understanding, that report, by the intention of its author: "Discussed the need and advantages of a thorough geological and agricultural survey of the State; recited the causes of the slow progress and failure to satisfy the public, chief among which were inadequate appropriations and the rank incompetency of the late incumbent. Also it gave examples of what had been done in other States, and closed with a recommendation to restore the geological assistantship, in connection with a more reasonably adequate appropriation." In spite of these prophylactic measures, however, an investigating committee went so far as to report a bill "to abolish the geological and agricultural survey of the State," which was suppressed only after vigorous conferences between the chairman and the aggressive director, and the bold challenge of the latter to acquiesce in dismissal for good cause proved, provided that the survey might thus be preserved from interruption. This one symptomatic incident illustrates picturesquely how unconquerable fighting spirit was needed, beside scientific attainment, before momentum was imparted where highest public interest demanded it. The first success in counter-offensive was driven home with a second report at the legislative session of 1859-60, after the open season had been utilized in the field as usual. The outcome was now more favorable; Hilgard's account reads: "The bill reported by the committee and afterwards

passed with little difficulty by the legislature made no radical changes in the previous act defining the objects of the survey, provided for the appointment of an assistant geologist, and enlarged the limits of the annual expenses."

The document thus persuasive of the legislature was preliminary only. The completed report, in which more scientific tone prevailed, could not be printed in full until the necessary funds had been voted. It was in fact held back until 1866 from effective publication, and even after this delay, from the circulation that it merited, by circumstances growing out of the Civil War, though the printed sheets of it were turned over in November, 1860. We find it remarkable in its early perception of a true perspective for these matters which no grounds appeared later to modify, as is evidenced by the authentic summary from which we extract the following:

"In this report I undertook to separate as far as possible the purely scientific part from that bearing directly upon practical points, in order to render the latter as accessible to unscientific readers as the nature of the case permitted; while at the same time giving scientific discussion full swing in its proper place. The volume is thus divided nearly evenly between a 'geological' and an 'agricultural' portion; the former giving under the special heading of 'useful materials' the technically important features of each formation, after its geological characters had been discussed. In the agricultural portion it seemed needful at the time to give by way of introduction a brief discussion of the principles of agricultural chemistry, then but little understood; and to explain their application to the agricultural practice of the State. In the descriptive portion of the agricultural report the State is divided into regions characterized by more or less uniformity of soil and surface features; and each is considered in detail, special attention being given to the nature of the soils as shown by their vegetation and analysis. In the latter respect I departed pointedly from the then prevailing opinions, by which soil analysis was held to be practically useless. My exploration of the State had shown me such intimate connection between the natural vegetation and the varying chemical nature of the underlying strata that have contributed to soil formation, as

greatly to encourage the belief that definite results could be obtained from a considerable number of analyses, of soils classified with respect both to their origin and to their natural vegetation, and a comparison of these data with the results of cultivation. Thus it would become possible, after all, to do what Liebig originally expected could be done, viz.: predict measurably the behavior of soils in cultivation from their chemical composition. The lights then obtained encouraged me to persevere in the same line of investigation, in the face of much adverse criticism, when wider opportunities presented themselves afterwards. By the aid of these I think I may fairly claim that the right of soil analysis to be considered as an essential and often decisive factor in the *a priori* estimation of the cultural value of virgin soils has been well established alongside of the limitations imposed by physical and climatic conditions, and by previous intervention of culture. Even apart from any special investigations of soil composition, the right of the agricultural interests to an intelligent and intelligible description of the surface features of a region, given with respect to its agricultural capabilities, can hardly be denied. Dr. Owen, among the older American geologists, was the one who kept in view most steadily the agricultural interests. And while our personal intercourse predisposed me to follow his example, my further experience has only served to strengthen my conviction in that respect. No troublesome agitation occurred to obstruct the survey in Mississippi after the publication of my report in 1860."

Having succeeded in putting the survey upon a more stable and assured footing, Dr. Hilgard might well assume that he had earned a vacation; and accordingly he made arrangements to spend some four months in Europe during the second half of 1860. This took on the color of a wedding journey, for he brought his wife back with him to Oxford in November; almost on the eve of the Civil War that was to convulse the next five or six years, dislocating normal activities of peaceful progress like the prosecution of the survey. Under the terrible stress brought to bear within the State by the impending conflict, it would have been natural to await complete extinction of the appropriation; but instead the legislature at a called

session in August, 1861, only passed an act: "Suspending the appropriation until the close of the war and for twelve months thereafter, except that the sum of twelve hundred and fifty dollars per annum shall be applied to the salary of the State Geologist, and the purchase of such chemicals as may be necessary to carry on the analysis of soils, minerals and mineral waters, and enable him to preserve the apparatus, analyses and other property of the State connected with said survey." In the form given to this action we can read a newly-enlightened confidence in the director and his work. This appropriation, moreover, was actually maintained through the entire struggle of the Confederacy, and so far as the fortunes of war permitted, the chemical work was continued, and at times also the field-work.

The scarcity of salt suggested utilizing the saline waters common in southern Mississippi, and the pressing need of nitrates led to exploring some promising limestone caves. Hilgard made report on both these subjects to Governor Pettus in June, 1862. Those commissions for the public welfare barred enlistment in army service when the university faculty was disbanded soon after the beginning of active hostilities in Tennessee. Unless Hilgard's detail be so considered, to install calcium lights on the bluffs above Vicksburg and illuminate as targets any Federal gunboats that might attempt to run the gauntlet of the shore-batteries by night. Here, to be sure, delays in obtaining materials and in construction frustrated execution of the plan at the final passage of the fleet, which was not hindered by such searchlights. During most of the wartime, indeed, Dr. Hilgard remained at Oxford, having been officially placed in charge of the university property for its preservation. Here his duties were no sinecure, because he was located in a belt of desolation between opposed armies that swept back and forth over it. The collections of the survey had more than one narrow escape from destruction when the university buildings were later occupied hastily as hospitals, but they came off finally without material injury. On many occasions, too, the "State Geologist" was kept very busy aiding in the care of hospital patients or in preparing medical supplies for them in his laboratory. But

again there fell quiet intervals, and then we see him turning to some investigation. In such a period, for instance, he invented a turpentine-lamp for domestic use, kerosene being unprocurable; and, incidentally to this, he determined the conditions under which the distillate from crude oil of turpentine that has been digested with sulphuric acid contains a maximum of the desirable terebene. He was baffled, though, by an unremovable impurity that incrusted his lampwicks beyond what was practically allowed.

The interruptions of the war-years ceased at length, and regular effort to advance the survey was resumed. This may be dated in July, 1866, when Dr. George Little was appointed Assistant Geologist. He took the field shortly thereafter for an exploration of the loess region from Rodney, Mississippi, to its farthest point in Louisiana. The general results of this expedition were summarized for the Smithsonian Contributions, but the times were still disturbed and no detailed report was ever made. In fact, under the *régime* then imposed upon the State, the insecurity and the difficulties then besetting the office of State Geologist were such that in October, 1866, Dr. Hilgard was induced to accept a permanent transfer to the chair of chemistry in the university. Upon his recommendation, Little was then appointed State Geologist; but in 1870 he in turn exchanged this charge for a professorship, and Hilgard became again director; but unsalaried and relieved from any obligation to carry on field-work personally. This step seemed advisable as the one means of preventing the survey either from being abolished or from falling into wrong hands; being evidently dictated by unflagging interest in the Geological Survey sustained amid the claims of the chair of chemistry. That responsible guidance and supervision of the work entrusted to successive assistants continued until the autumn of 1872, when the survey's appropriation was suddenly withheld under an arbitrary ruling of the State Auditor, and its activities were in consequence peremptorily suspended. We learn that this perverse obstruction was endured with acquiescence until 1906!

While discharging his duties as professor of chemistry Hilgard kept mind and hand constantly upon the geological sur-

vey during his remaining years of service at the University of Mississippi; for this we find clear testimony in a series of published papers belonging to the period 1866-73. These deal at first with geology or its direct bearings upon agriculture; but later include discussion of agricultural education also, as that grew to be a burning question. Some changing orientation of central purpose is reflected probably in a change of his title to "Professor of Experimental and Agricultural Chemistry" that falls in 1871 and could be taken to indicate an incipient shift toward developing that field in which he was to become an authority of first rank. But all this came after he had gained distinction as a geologist; and we shall adapt our account best to that view of the sequences if we round out the recital of what Hilgard accomplished in developing the geology of Mississippi and Louisiana, before proceeding past the transition to his later occupation with other problems.

Overcoming various hindrances whose nature and source can be inferred in the light of preceding pages, Hilgard had made a good showing of results for the years before the war. Orienting himself by a rapid reconnaissance in 1855, the expedition of the next year enabled him to determine the character, stratigraphical relations, and limits of the carboniferous, cretaceous, tertiary, and quaternary beds in the northeastern part of Mississippi. That season he located the "Ripley Group" and made collections from it; also he investigated closely the features and geological relations of the "Orange Sand," and characterized it definitely as a quaternary deposit. The atmosphere being cleared after the removal of Harper, serious tasks could be continued in 1858. A full section across the tertiary area from north to south was verified; the fossiliferous localities of the "Jackson" and the "Vicksburg" stages were subjected to detailed examination; the infra-position of the latter relatively to the "Grand Gulf" group was put beyond question. The campaign of 1859 was devoted mainly to detailing previous outlines, and its net outcome is declared to have confirmed their conclusions as well as completed them, so bearing witness of sound preliminary judgment. The report of date 1860, of whose fateful postponement we have spoken above, contains summary and analysis of all these

particulars. Its author's modest candor did not stand in the way of claiming for it in after years that "In a revised edition the report would, without additional field-work, still form a pretty complete account of the geological and agricultural features of the States; especially through its mapping and study of the cretaceous and tertiary formations."

The survey in Mississippi had in view primarily to benefit that one State and to develop its resources, of course. Yet Hilgard never overlooked the gain for surveys in neighboring States through conference and co-operation, as his meetings sought with Owen and Tuomey could testify. Such supports became more advantageous; or we may say they were seen to be necessary; where it was plain that a certain geological unity crossed geographical boundaries as in the case of Louisiana and Mississippi. Therefore, we must regard it as fortunate that circumstances arose to place in Hilgard's hands the possibility of connected treatment for geological problems common to these two States, that led to the recognition of what he was the first to term the "Mississippi Embayment," and to study of the river in its last stretch to the Gulf.

The initial move toward that end was made in 1866, when General Humphreys, chief of the United States engineers, proposed that Professor Hilgard should investigate the character and the geological age of specimens taken from a well-boring at New Orleans in 1856. This proposal, which was accepted, followed a suggestion from Sir Charles Lyell that the shells collected while boring that artesian well should be compared by some competent authority with those of the cretaceous and tertiary formations on the one hand, and on the other with those now living in the waters of the Gulf of Mexico. It was anticipated that this examination should settle the question whether the "Mississippi River is flowing through the delta region in a channel belonging to a geological epoch antecedent to the present" (Humphreys). Here, again, the consequences of war interfered through damage due to exposure in the suite of specimens available at the New Orleans Academy of Sciences. For that reason mainly the final conclusion could not be rendered until 1870, to be published in the Report of the Mississippi River Commission of that year. Hilgard's verdict

was decisive, in that it established with regard to forty species of shells examined, that four only were not known to be now living in the waters of the Gulf.

A second direct contact with the geology of Louisiana followed upon a proposition coming from Professor Henry in Washington that Hilgard should inquire into the age and origin of the rocksalt deposit in Petit Anse Island which had been a source of supply for the Confederates during the war. This came in 1867, and under the auspices of the Smithsonian Institution; it would involve necessarily, as Hilgard saw at once, a general study of geological structure on the Gulf Coast from the mouths of the Mississippi westward, so far as this was not yet known, and he welcomed the opportunity. In the prosecution of this inquiry the local Academy joined with active interest when New Orleans was reached, after descending the river from Vicksburg with stops for investigation at various points, to secure data for clearing up geological questions.

It was while continuing this journey down the river that Hilgard's attention was first specially directed to the study of the so-called "Mudlumps" and their origin. They were formidable obstructions to the navigation of the channels through the delta; proving unmanageable by powerful dredges, continually replacing themselves or breaking out in new localities. These "Evil geniuses of the passes" had it is true been observed by Lyell as early as 1849; but his explanation of the working causes by which they rise was incomplete, and the geologists coming after him had taken little notice or none of the peculiar phenomenon. It was reserved for Hilgard to conjecture from detailed examination of them upon the spot how the occurrence of mudlumps is correlated with the existence of an impervious substratum of clay extending seaward, on which the bar deposit can dam the mud-layer precipitated from the turbid river on meeting the sea. Extruded by hydrostatic pressure in the channels and marshes above the bar, that semifluid mud constitutes mudlumps wherever local conditions are favorable. This solution was sustained fully by physical, microscopic, and chemical analyses of the oozing mud, and by exhaustive discussion of the prevailing factors that caused mudlumps to be largest and most frequent. The details of

the definitive report are to be found in the *American Journal of Science* for 1871.

The immediate purpose of the expedition in 1867 carried it, after the river mouths had been passed, to the chain of "Five Islands" of which Petit Anse is one. Thomassy had once traversed this ground, describing the islands as due to "Hydrothermal or volcanic forces." This was vague enough to leave the door open for an origin analogous or not to that of the mudlump-cones. On the present occasion the closer examination was confined to Petit Anse and its two neighbors, observation having shown that the five islands were not essentially differentiated. With habitual scientific caution Hilgard pronounced the local results inconclusive until interpreted through their wider connections with the geological formations of Louisiana and Mississippi. This attitude seems to have stimulated provision for a general reconnaissance of the former State, for which funds were supplied through the efforts of the New Orleans Academy co-operating with the State Board of Immigration; a plain instance where enthusiasm and tactful persuasion succeeded in yoking other forces toward pursuit of good aims. In the early summer of 1868 Hilgard and two companions were thus enabled to employ some six weeks on a line extending perhaps six hundred miles northward from New Orleans. Though the exploration was perforce conducted at a rapid pace, it yielded data for determining the salient features of the geology and of the surface conformation; valuable specimens to the number of two hundred and fifty were collected, and a few months later the first geological sketch-map of Louisiana could be submitted to the meeting of the American Association at Chicago. The general accuracy of that map stood well the test of subsequent researches that have amplified it and supplied missing detail; for instance, the State geological surveys under Hopkins and Lockett. The relatively fruitful and permanent outcome of so brief and hurried reconnaissance was due largely to its leader's happy inference that the event so fairly justified, of important geological similarities between Louisiana and Mississippi which allowed some conclusions from the study of one State to be extended to the other. Especially the legend previously cur-

rent was cancelled, that the "greater part of Louisiana is alluvial," on proof that much of the prairie country is underlaid by what Hilgard had in the preceding year first named the "Port Hudson formation." This was found replaced farther north by the marine eocene in the hilly country, and at the Five Islands by formations of cretaceous age, of which their bluffs show the southern outcrop. The careful study naturally requisite for the elaboration of all such important conclusions that were to revise older ideas was carried on through the next four years. Its results, including analyses of rock and soil, being then published by the New Orleans Academy in 1873. And finally Hilgard was able to co-ordinate this reconnaissance with other studies in Mississippi and reach safe decision about Petit Anse; the problem that had shown the need of comprehensive view and set on foot the movement to obtain it. That full discussion was published as No. 248 of the Smithsonian Contributions in 1872.

The solid achievements in geology that are here condensed into briefest account had strongly interested experts like Dana, who counseled wider publicity for the parts embodied in that report of 1860 which the war had shelved temporarily. Accordingly Hilgard published in 1866-67 several articles in the *American Journal of Science* on the geology of Mississippi and the Southwest generally whose matter, as he tells us, excerpted and expanded the earlier substance of the report. Here belong, for example, the papers on "The Quaternary Formations of Mississippi;" and on "The Tertiary Formations of the Southwest." But we begin now to find a parallel line of publication on subjects connected with agriculture and agricultural education to which he was giving increased attention. The first important title there belongs to 1870; it reads "On the Maintenance of Fertility in Soils." So it may be held significant of a new trend that after presenting at the meeting of the American Association in 1871 a discussion of "The Geological History of the Gulf of Mexico," Hilgard went on to Chicago as delegate from his university to the first convention of Agricultural Colleges established under the Morrill Act of 1862, that Mississippi was intending to avail itself of. It is worth remarking that Hilgard and Gilman met for the first

time at this convention; perhaps a fateful conjunction for the former. Gilman was then in the service of Yale, but his keen insight for men's adaptations could not have overlooked Hilgard's quality; and a tenacious memory would hold the impression for use in California a few years later.

With agricultural education as one chief topic before the convention, the so-called "Michigan plan" was advocated by the representative of that university, under which the students' time was devoted in large part to manual labor on a model farm in order to "Maintain the habit of work and prevent them from being educated away from farming pursuits by too much indulgence in academic studies." But Hilgard's independence of judgment asserted itself; both by opposing that view in the convention, and by the poise of the report to his own trustees. It is encouraging to note that such moderation earned respect from Michigan as well as from Yale—subsequent events were to prove this. How clearly that early report held the balance between exaggerating tendencies which Hilgard thereafter maintained steadily is visible in his own summary which runs: "I concluded essentially that neither of the two extreme plans should be adopted, typified respectively by the farm-school idea followed in Michigan and Pennsylvania and by the Sheffield Scientific School at Yale. The chief object of the State colleges should be to educate teachers and leaders of progress in agriculture; uninstructive labor should not be enforced upon the students save to the extent of familiarizing them duly with the actual performance of farm work." The trustees at Oxford were wise enough to begin by following these suggestions; and one part of their action was to select the editor of an agricultural journal to be "Professor of Practical Agriculture," Hilgard's title being changed to "Professor of Experimental and Agricultural Chemistry." The new arrangement had a transient success in gathering a considerable group of students; but they dwindled after a fashion that repeated experience was to make familiar, and nearly disappeared by the close of the session. In another particular, too, that first venture was ominously prophetic; for at the succeeding session of the legislature these results were made a pretext for launching an attack upon the appropriation. With the sequel, also to be

repeated in other States, in a proposition to separate the Agricultural College from the university. Hence, by November, 1872, we find Hilgard in a defensive campaign against this agitation; delivering addresses on such subjects as "Progressive Agriculture and Industrial Education." But the difficulties of the position thickened as time went on, instead of yielding; so it is without surprise that we finally find him accepting in 1873 a call to Ann Arbor as "Professor of Geology and Natural History." This was a repetition, with conditions that improved it to the level of acceptance, of proposals made in 1871 and again in 1872 that had been declined. In August, 1873, the family removed to their new surroundings.

Meanwhile Hilgard continued steadily productive and increased solidly his professional reputation. The article on "Soil Analyses and their Utility" appeared in 1872, whose tone of rather drastic criticism upon Johnson, of Yale, was provoked by some utterances of the latter about the same matter. He was entrenched already behind his meritorious books: "How Crops Grow," "How Crops Feed", while Hilgard was at that period, in his own overmodest estimate, "An unknown writer who had not yet won his spurs." So one rejoices to learn how temperately Johnson made rejoinder; and how a pleasant friendship of the two men, continued by correspondence and at the meetings of the American Association, grew out of the first controversy's warmth, and bore convincing testimony to scientific candor on both sides.

Hilgard then followed that first paper quickly with two others on the physical analysis of soils. And out of his thought dwelling persistently on methods of executing such analyses was evolved his "Soil elutriator" that has since come into such extended use as a standard instrument for its purpose, on account of its perfected improvement in consistency of results. It was a part of the investigation that led to devising Hilgard's form of elutriator to study anew the diffusion of clay in water, with the conditions of its flocculation and precipitation. Here he discovered independently the main conclusions reached by Schlösing somewhat earlier, but whose published form in the *Comptes Rendus* had not arrived at Oxford. The dates of Hilgard's papers on this subject, as

they appeared in the *American Journal of Science,* were 1873 and 1874.

The life at the University of Michigan opened under favorable auspices. President Angell was noted for promoting cordial relations among his colleagues, and between them and groups of their prominent town neighbors. He was a praiseworthy leader, too, in fostering simplicity of living and the types of intimacy that are apt to accompany it; the elaborateness and the scale of expenditure were still absent that have later brought an attendant sophistication into many university communities. Welcomed in this circle, Hilgard was not made to feel either any offensive reminder that he came to Ann Arbor direct from a Southern State. And then, as regarded his title, against whose over-comprehensiveness for a single chair he had not failed to file remonstrance in accepting it, the apprehension had outrun reality. Assistants were duly provided for botany and zoology, relieving Hilgard in those directions of all but organizing supervision, and leaving reasonable freedom to devote himself where his more vital interests in geology and mineralogy called him. Yet, those two years at Michigan were in sum rather a period of marking time, though strewn abundantly with recognition and other pleasant experiences; it seems clear that Hilgard looked upon them in retrospect more as an intermezzo between the two strenuous campaigns of his life, in Mississippi and in California. His classes were large and appreciative; but he found himself fretting noticeably at being debarred from opportunity worthy of his powers for active investigation. It was no satisfactory outlet to inculcate respect for university furniture; nor to lend vigorous support in toning up student discipline; though there again his capacity for leadership soon became apparent. Neither was it a complete consolation to be located once more within easy access to the older civilizations which had been sensitively missed at Oxford, except what correspondence could do. Now frequent personal contact with notable men became possible, and it is certain that Hilgard relished keenly that feature of his new position.

But in some larger things his initiative met with mediocre success. A profitable suggestion that he should make his ex-

perience available to the State geological survey and care for the agricultural aspects of it that were being neglected entirely, was thwarted by a refractory and unsympathetic State Geologist, though advocated warmly by President Angell. Hilgard's natural instinct to infuse a larger quantum of scientific ideas into agriculture was baffled, besides, by the segregation of the Agricultural College into a separate institution at Lansing and the unshakable dominance there of so-called "practical tendencies." He, indeed, attacked that heresy early and with his accustomed vigor at a convention in Kalamazoo, so that he described himself as: "Reading the delegates the riot act about their supineness in advancing rational agriculture in their State; and holding up before them his Mississippi gospel that since world-competition has compelled the use of brains, besides brawn, in farming, it must become indispensable for agricultural colleges to bring forth leaders." But though he brought matters to the pass of discussion in popular meetings, he failed to make sufficient headway against the settled adhesion to this "Michigan plan." After combating at every opportunity that "Low view of their functions," he was obliged to "leave it to the twentieth century to bring about any competent realization of the needed change in policy." Satisfied that the "Farm-school was a plain violation of both the letter and the spirit of the Morrill Act, which calls for instruction in the *sciences related to agriculture* and the mechanic arts," he proceeds, "I once wrote to Mr. Morrill asking for his own interpretation of the act. His reply was that its language was plain enough, but that he wished to allow liberty to each State to adapt the college to its needs. That these needs were not farm-schools only was soon made evident by the establishment of academic departments in all the colleges that at first adopted the Michigan plan; so the event has justified my contention."

Obstructed then by these hindrances to his first choices of activity, Hilgard sought a partial substitute in constructive writing. For his own classes a better adapted textbook on geology; and at Dana's solicitation an extended review of Mallet's frictional theory of vulcanicity that excited general attention and discussion, beside calling forth an appreciative

letter from Mallet himself. But much writing seemed incompatible with the condition of his eyes, which began to trouble him so seriously that an operation to correct strabismus was proposed. Not assenting to this, he was confirmed in that judgment by his brother, whom he consulted in New York, and who recommended again, as in the early years abroad, rather an open-air life to strengthen the nerves. But that idea could not be entertained under the circumstances. Hilgard then used his chance to attend the session of the American Association at Hartford, and thus casually renewed his acquaintance with Gilman who was now, in 1874, president of the University of California. It transpired that he was charged to select a suitable professor of agriculture, the chair being vacant by a dismissal for political tactics. The meeting must have seemed providential to Gilman; without delay he offered the professorship to Hilgard, and met the natural objection to taking so sudden a leap in the dark resourcefully by a compromise proposal. This was to the effect that Hilgard should return with him to California, obtaining a leave of absence from Ann Arbor, "To see and be seen, and to deliver a short course of lectures on agriculture at the University of California." As might have been anticipated, President Angell was up in arms against the plan: "Warning strenuously against going to such a hornet's nest as the university at Berkeley was reputed to be." Nevertheless, Hilgard telegraphed his acceptance of the temporary engagement to Gilman, whom he was able to join at Chicago; so the two men made the rest of the long journey together, which had not yet lost its charm of being a novelty and an adventure. The breadth of the desert belt beyond which the western coast lies has not yet ceased to be deterrent; it speaks plainly of an obscuring isolation that professional ambition will always shun. In those days the separation was felt strongly, sufficing to halt all but the pioneer's enterprise, or a firm enough faith in one's power to make oneself heard from California in the larger world, whose appreciation is success. The apostolic motive had been quick within Hilgard from the beginning of his onset in Mississippi, when he was obliged to find sustenance mainly through internal conviction. But he could enter California

now fortified in addition with an authority conceded to recognized accomplishment. Still, even so, it would have been foolhardy to commit his family fortunes to this hazard without first feeling out the terrain by something like the scouting expedition in which he was here engaged.

In the long course of that journey we see Hilgard exposed to his companion's tried gift of persuasion, directed toward fixing him in secure alliance for that severe campaign which Gilman knew to be impending, and in which the aid would be invaluable of a professor who had served his novitiate already in dealing with legislatures and with reluctant or suspicious farmers. Such a trained instrumentality fitted Gilman's wise tactics to protect the college of agriculture against being dwarfed into a trade-school or derogating otherwise from its function of genuinely capable leadership, by placing a man of acknowledged scientific rank in charge of its development. There is of irony more than a touch in the known sequel; it was Gilman who fell away from the alliance before it could be made really operative. His transfer to Baltimore in 1875 left Hilgard to contend with his difficulties single-handed, bare of that support which alone had made the position look acceptable.

In that preliminary season of 1874, however, everything seemed of good promise on all sides. During six weeks Hilgard delivered an effective course of lectures at the university on "The Origin, Properties and Functions of Soils," to an audience of perhaps twenty-five, comparatively large for the conditions and mostly graduate students, the scope of whose purposes made them available. Though to some the subject-matter might sound a little remote, their unflagging interest was held by this contact with a "prime-mover" of the scientific world, fed from the same sources as Bunsen, but no mere echo of his teacher. The lectures appeared in published form shortly and affected noticeably a larger public; the leaven began at once to work, for we learn: "They served as a basis of conciliation between the patrons of husbandry and the regents of the University." Nevertheless, after even this measure of prompt success, Hilgard assures us that he went back to Ann Arbor: "Not without a lingering thought of returning

to California, but also without encouraging in any definite way the reiterated suggestions of Dr. Gilman to that effect." It appears to have needed the hard winter 1874-75 to turn the scale, by causing reflection whether it would be advisable to remain in a climate that subjected the whole family to such vicissitudes frequently, accustomed as they were to the mild seasons of Mississippi. February brought also a rather serious illness to Hilgard, followed by a slow convalescence and the medical dictum that winters in Ann Arbor were too severe. Upon this situation fell the notification of formal election to the chair of agriculture at Berkeley, to date from October, 1874, with its salary. But still he wavered. "After some hesitation, I wrote a letter of acceptance, amid the protests of my friends in Ann Arbor, especially of Dr. Angell, who said that if I *would* go he would give me chance to repent by holding the chair vacant for six months." Here is the pendant picture of arrival: "When, after an uneventful overland voyage, we landed in Oakland, I found to my intense disappointment that Dr. Gilman was on the point of leaving the University of California for the presidency of Johns Hopkins University, at Baltimore. Had I known this, I might never have left Ann Arbor, and I thought for a moment of turning round immediately. But Dr. Gilman protested that I ought at least to try and study the situation; and, although he was leaving, I would have the strong help of the Board of Regents, and a new and fruitful field of investigation instead of the mere routine of teaching at Ann Arbor. And he gave me as his farewell a numerously attended reception at which he introduced me to a large number of influential people with warm recommendations for aid in my task. So I did not return to Ann Arbor, but resolved to fight it out as I had done in Mississippi before. The fight turned out to be quite as hard as anticipated, for a number of years. But I won in the end; and the climatic advantages proved for myself and my family an ample offset in the prolongation of life and health to the social pleasantness we had relinquished in making the change." Perhaps this account is not wholly free from satirical intent. But penning it in 1912, Hilgard could afford to speak with the generous security of a man who had habitually faced heavy odds and

overcome them; and seeing his term of service to the country at large lengthened, as in human estimate we must believe, he learned to acquiesce unresentfully in the shuffle by which he figured as Gilman's important legacy to California. There is a heavy debit in the balance-sheet, however, wherever a talent like Hilgard's is applied to a second burden of pioneering and in ripened development is confronted with those wasteful hindrances which accompany foundation-laying in newer communities. Unless this is realized properly, his record in California—massive performance though it is—will appear discounted as compared with what those thirty years might have represented in the same tireless continuance of activities already begun. Without the consideration that it qualifies the medium and not the man, we might see some pathetic shadow in this memorial comment, across its else unstinted praise: "Gauged by the time and opportunity, Hilgard's will remain a great work. The results of his labors are in the warp of California's first half-century of intellectual and industrial life, and upon such enduring work as he achieved will be spread the splendid fabric of the coming advancement and development of our State. He did his best work for agriculture in the university by making the greatness of its future secure."

It is enlightening preparation for tracing the sequel, to look back deliberately upon some elements in the combination that Hilgard was asked to shape for the good of California, and that meant for him, through a long series of years to come, deadweight to lift or perverse views to correct. Within the university, the "strong help from the Regents," in the words of Gilman's assurance, was not yet in evidence. Indeed, it was the contemporary judgment about that Board that Hilgard's promptly aggressive campaign was disquieting to them; their counsel of opportunism was rather to await favoring winds placidly. Neither was this policy disturbed by any action of the new president, himself a busy scholar and sympathetic to Hilgard's scientific attitude, but prone to shrink from any array of contending forces. The eyes of the faculty were opened to the danger for the university as an institution of the strong movement on foot to divorce its College of Agriculture. In warding off that ruinous separation there was

much active co-operation from his colleagues. Otherwise Hilgard was in a position to give more than he received from them, by taking a leading part, through the weight of his own broad culture that made him charitable and tolerant for other specialists, in the general effort then engaging the attention of scientific professors to gain due foothold in the curriculum. But we cannot be sure that his tolerance was repaid in full, when it came to the question of supporting loyally his wise view of the fundamentals in agricultural education. There he wielded a free lance for many years before he could carry conviction among his associates. The attendance of agricultural students remained near zero in those first years; so that a man less courageous in cherishing ideals might easily have had recourse to some new recipe more highly flavored to attract a constituency; but Hilgard elected to stand firm and bide his time. Thus it came that he took upon himself the teaching of other sciences not then provided for in the faculty, notably of botany and mineralogy; a widening of actual scope in his chair beyond its nominal obligations that contrasts with the supplementary relief from multifarious duties that had been contrived for him at Michigan.

Outside the university, Hilgard found great nakedness of serviceable connections until he built them up. No State Survey was in existence, at first or afterwards, to stimulate into co-ordinated action—a single effort in the direction of having one organized was so hopelessly rebuffed, the situation being prejudiced by previous unfortunate relations with a United States Geological Survey in the State, that even Hilgard's fighting spirit must judge further attempt futile. In this respect again the comparison was not favorable to California; with either Mississippi or Michigan as the other term. It may sound a hard saying, though it is scarcely an untrue one, that some provincial atmosphere was still clinging about California, one peculiarity of whose history turns at several points upon the reactions of a community that was less far advanced to quickening influences exerted by the College of California and its successor, the State University.

The first two or three years of Hilgard's new official relations were the reverse of encouraging, moreover, on account

of a newspaper campaign against the Regents which did not fail to include attacks upon a professor who had replaced a dismissed popular favorite. So in unavoidable self-defense, he was compelled to divert a good share of valuable energy into a series of articles in local journals, where he argued once more the case for a college of agriculture, founded on progressive scientific investigation of conditions and on improved adaptation of methods, in addition to transmitting a standard tradition about practice. Nor could he in prudence rest satisfied with printed presentation; so he did not delay beginning systematic appearance at farmers' meetings, in order to dissolve opposition and convert adverse opinion. Amid such surroundings we find this favored disciple of Bunsen and geologist of national repute brilliantly successful by his conciliatory tone and tactful utterance, on the testimony of an expert eye-witness in 1876: "The room was not large, and was crowded with men of some prominence in farming and hostile to the university because they really believed that the College of Agriculture ought to be snatched from ruinous association with a so-called 'classical institution.' It was a stormy assembly, but when there came a lull the chairman asked Hilgard to speak. He rose alertly, showing them a slim, graceful figure and a scholarly face illumined with an eagerness, cordiality and brightness of expression which seemed to say to them: I never was in such a delightful place before in my life. When he began to speak in a low, conversational voice, every man was at attention. He was saying that no one could do much for farming unless he had personal knowledge and support of farmers; that he had come to California to try, with their aid, to know California from the rocks to the sky, and proposed to use all that he had learned in other lands merely as a help to begin to know California, which he had already perceived to be different from any other land in which he had lived and worked. On his father's farm in Illinois he learned that soil differed when it came from different rocks, when it was moved about in different ways and when other things were mixed with it, and since boyhood he had been studying the rocks, the soils, the plants in the hope of matching them up, to get the best crops and the most money

in farming—and then followed a charming half-hour with soil formation and movement, tillage and fertilization, without a scientific term, without reference to a chemical formula—all straight farming talk about soils and plants. Finally, he said he had come to find out how these things worked in California. He particularly wished to know whether California farmers had anything so hard to handle as the gumbo soil of the Mississippi Valley; and this was a master-stroke. Before he could regain his seat, questions were fired at him from all over the room, and he answered them readily and confidently, until the meeting closed after half an hour of such friendly and informal conference."

There were repetitions by the score of like sessions during the first few years, resulting in such approval of Hilgard's announced purposes that the segregation of the College of Agriculture from the rest of the university was barred in 1879 by an article in the State constitution of that date; the adoption of which article moreover was significantly moved by the State Master of the very organization in which opposition to Hilgard had centered. But while Hilgard put all necessary thought upon attaining these ends, and his vigor was able to secure a complete victory there, be sure he would rate them always as incidents of his main problem; let us say facts of its setting, duly to be dealt with like any other facts in a scientific procedure. Accordingly, he was continuously and absorbingly occupied, too, in those years with investigations covering the soils and the climates of California, both of which he declares to have presented many new features that demanded material modifications among ideas that he had considered settled by previous experiences. He proceeds in explanation: "Six months of clouds and flowers, six months of dust and sky, were to some extent familiar through my stay in Andalusia; and I saw here in California the very weeds that I had seen on the Mediterranean coast, evidently brought over unintentionally by the Franciscan missionaries in the agricultural seeds they imported. But I had paid little attention to soil conditions while in Spain, and was now confronted by the fact that not only native plants, but also eastern and European trees, remained green and bore fruit during six months of

rainless hot summer. The investigation of this subject, and of the connected topic of 'alkali-soils,' have since become the chief study of my life, the direct inquiries into geological problems being relegated to the second place. I soon found that in order to teach my agricultural students usefully, I should have to become personally familiar with the soils and agriculture of California, as I was with those of Mississippi and the eastern States. Yet, there were no funds with which to travel; and without those means, how could I obtain a competent knowledge of the conditions under which I was to work?"

That question about ways and means, which is the bane of so many scientific undertakings, remained to hamper Hilgard perpetually; up to the time of his retirement he had hardly broken the habit of grudging financial provision for the needs in his rapidly expanded field of usefulness. It proved manageable only in part by rigid economy in outlay and by the slow process of educating authority to loosen purse-strings. Hilgard saw himself driven more than once to expedients that a less determined temperament would not have invented; especially by exploiting for the benefit of his adopted State the combinations of his local pursuits with larger commissions that his national standing brought him: the report on Cotton Production in the United States for the census of 1880; the inquiry into the asphaltum resources of Southern California for the Northern Pacific railroad; the field-work on the Pacific Coast for the Northern Transcontinental Survey. On the foundations for agricultural research laid down by a few such as Hilgard was, a vogue has been built for the application of scientific methods to farming, perhaps not without some popularizing concessions, to which is accorded freely even munificent expenditure. So the item bids fair to stand out curiously and mark the toilsome breaking of ground for this fair harvest, that in 1875 the first Agricultural Experiment Station in the country under the federal act was established in California; this priority being purchased at the moderate cost of two hundred and fifty dollars invested in maintenance. The initiative here was, of course, due to Hilgard, and the parsimony is some measure of the restrictions that were powerless to check his advance.

Hilgard was ready with a first published report in 1877. Beside chronicling the progress up to that date of his special labors in California, he used the occasion to summarize the principles by which he would be further guided. What his creed was, we have learned through contact with its application to Mississippi and to Michigan. It continued to shape his course in erecting the structure that will be his enduring monument. In California, without swerving in direction, his effort gained intensity by focusing upon agricultural development the energy and attention that had once been distributed over a more inclusive field of endeavor. From this time forward he directed unremittingly from the center at Berkeley the work belonging to the successive phases of California's agricultural growth, in flexible conformity to its changing emphasis upon viticulture and phylloxera; upon alkali-soils and irrigation; upon the various aspects of fruit-culture and grain-raising. It is inherent in the human nature of like relations to economic interests that they may involve selfish motives, the personalities of public controversy and similar sordid elements. Hilgard lived through trials of that character; himself not vitally perturbed by them, and never touched with any taint of their infection; persistently driving his saps to undermine every obstructive combination against the scientific welfare of the State as represented in its College of Agriculture. We could regard the culmination in this progress as attained in 1892; the year of a visit to Europe by way of vacation, from which Hilgard returned crowned with abundant and honoring recognition by his colleagues in other countries; were we not told by one who certainly stood close enough to judge the truth how: "After 1893, Hilgard applied himself for more than a decade with his customary vigor, insight and success, upon undertakings which were growing by leaps and bounds because he had started and directed them aright. His last years of administration were his best years; his position of leadership was unquestioned; his physical strength seemed greater than during some of his earlier periods; the demands for instruction and the opportunities for research were multiplied. He labored like one who was realizing the results he had long desired, and his heart was light as his time for greatest

achievement had come." Retirement from office in 1905 arrived then as a breaking off with brain undimmed and capacity not yet on the ebb; a rather infrequent example, in its degree of preservation under advancing age of a vitality that we have seen threatened seriously at the threshold of manhood and first engagement upon heavy tasks.

It is fair to claim that the maturity of Hilgard's life was bound up with California. No adequately detailed impression of his tireless and varied productiveness throughout that space of over forty years must be looked for in a sketch like the present one. That can be gained only by a full analysis of his catalogued writings.* For the character of this biographical outline we must rest content with an excerpt to supplement our account, selecting where marked features or incidents lent a value known to agree with Hilgard's own estimate. On several counts first mention should probably be allotted to his share in the census of 1880. That was of national importance and range and its extended ramifications exhibit his fine quality in organizing and co-ordinating. It was an exemplar, too, of his capacity for ingenious legitimate strategy on a large scale, when he devised that particular backing of his State's welfare with the nation's interest, and delighted one shrewd observer, who is quotable: "As I look back upon it, it seems to me that Hilgard's strategic diversion of 1879 to 1883 was one of the brightest and most effective movements of his career. On the basis of his work in Mississippi he was requested to take full charge of the cotton investigation for the census of 1880. Hilgard seized what he recognized as exceptional opportunity to demonstrate his power. He selected assistants and set them at work studying cotton-producing conditions from the soil to the sky. He reviewed the subject as a whole and in divisions, studied each cotton State, and finally produced edifying and inviting text, illuminated with plates and maps, bristling with tables of analyses and with statistics of production. Every ounce of this report was made in California, and it is emblazoned with the insignia of the Univer-

*A bibliography of these is made part of the publication: In Memoriam—Eugene Woldemar Hilgard (University of California Press, 1916). This is reproduced at the close of the present memoir.

sity of California, but it cost the State not a cent. California was presented as a cotton State and her natural conditions were so thoroughly studied and so ably set forth that a part of the report entitled 'The Physical Features of California' is cited to this day as authority. While his local patrons and employers were wondering how Hilgard could use $2,500, the United States gave him not less than $25,000 to spend in his cotton work—one wide-reaching result of which was that it made California famous."

The intimate history of this project would relate how only the idea in embryo was due to Director Walker, and how its possibilities were enlarged under suggestion. We should see Hilgard overcoming difficulties of personnel; writing at speed a pattern report on Louisiana for his subordinates to work by and editing into fair excellence their manuscripts, dovetailing the ill-matched joints into that final unity and comprehensiveness which are striking in the finished report. All this, too, at a time when he was under almost feverish pressure to complete his individual share, the exploration of the possible cotton-growing portions of California, chief among which was the Great Central Valley. He gives us a glimpse of what that implied: "In each of the three portions of the Valley, I observed a complete cross-section from the Coast Range to the Sierra foothills, also collecting representative soil samples for analysis. I was thus assured that in the great Valley at least upland cotton could be grown from end to end, with moderate irrigation in the southern portion. By utilizing all the sources of information then extant, in addition to my personal explorations, I was enabled to write a fairly complete and correct physiographic and agricultural description of the State north of the Tehachapi divide. But as no cotton had been grown south of that range, I needed some other plea for carrying the exploration into southern California, which was fortunately furnished, but from a private source. For, during the whole of my career in California," Hilgard affirms deliberately, "I have never been afforded by the State any official opportunity for collecting agricultural data, save by driblets on account of special cultures (notably viticulture), or of lectures to farmers, which could be utilized for such observations."

The "private source" here alluded to was an employment by those directing the Northern Pacific railroad's enterprises, to inquire into the asphaltum deposits of California, chiefly in Ventura County. The Northern Transcontinental Survey, financed by the same group, was also forcing the pace for Hilgard through the summer vacations of 1879-83, when he examined the mineral and agricultural resources in their congressional land grant. These expeditions took him into Oregon, Washington and Montana, continually studying the general botanical and agricultural features of the regions traversed, taking samples of their soils and subsoils, and specially noting the depths of the soil mass and the penetration of the roots for the bearing upon vegetative life under arid conditions. It would be easy to infer that the knowledge and experience thus accumulated went directly to increase Hilgard's efficiency in his professorship, whose obligations he accepted punctiliously always, had he not told us explicitly that "Without the wider experience given me by these explorations, which I have taken advantage of extensively, too, for my book on 'Soils,' I should not have been able to give my series of publications the scope they have had." But the Board of Regents, we learn, were at first inclined to read neglect of duty in these scientific employments, and were brought to correct their layman's view only after an unpleasant season of conversion.

From the moment of his recorded first surprise at finding green vegetation sustaining itself, notwithstanding the arid climate in many districts of California, the unraveling of the operative causes was a primary theme of Hilgard's thought until he had deciphered the riddle. That was characteristic both of his acute observation and of his pertinacity in analysis. Much corroborative detail that would have been embodied in a report upon the results of the Transcontinental Survey was withheld from direct publication, first by the suspension of the survey and later by a fire that destroyed the collected material. But his demonstrated conclusions regarding the connected subjects of "alkali-soils" and "arid fertility," as announced in an important group of papers, are undoubtedly one of his weighty original contributions. Even such a sorely condensed review as this of what Hilgard's name will stand for cannot

refrain from some estimate of his success and his priority in that field. And we shall be safest in borrowing the words of his own summary: "I soon recognized, touching this matter of preferred interest, that arid climates and soils are miscalled 'semitropic,' being indeed the very reverse of tropic; and that such soils will, as a rule, be calcareous, through the absence of the leaching process, so that arid vegetation is practically lime vegetation. Now lime vegetation is characteristic of fertile soils, the world over; hence, arid countries should be fertile whenever water is supplied. That this is so is proved by the history of ancient civilizations, which flourished mainly in arid countries—Asia Minor, Egypt, India, Mesopotamia. The exceptional and lasting fertility of arid soils is explained not only by their high content of plant food, but by the fact that as clay substance is but scantily formed under arid conditions, the sandy and silty soils so formed are pervious to air, water, and plant roots to a depth rarely reached in a humid region, thus rendering accessible to plant growth a soil mass many times greater, measured by feet instead of inches and conditioning drouth resistance. Also under proper cultivation rendering fertilization unnecessary for a long time, while the soils of the humid regions must be thus supplemented in a few years. It appeared also that the same is true of the despised alkali-soils in which an excess of salts has accumulated, so soon as that excess is removed by drainage. The enormous areas of saline deserts can thus be made available for food production whenever the increase of the earth's population shall render it desirable and feasible to effect this reclamation. I was the first to recommend the use of gypsum upon 'black alkali' soils to change the carbonate of soda into the sulphate."

Hilgard continued for some ten years to make an attractive center of the family home that had been occupied soon after the removal to Berkeley. His "retirement" affected professional obligations merely, leaving unimpaired the traditions of rich years devoted in that circle to all that can make life best worth while. Many have marveled that a fighting exponent of personal views in the public arena can be radiant of unassuming gentleness at home; as Hilgard was and Huxley be-

fore him, because men of that stamp see a conflict of ideas apart from contentiousness. Many are regretting the limited horizon of the typically modern scientific man, when they remember in sharp contrast Hilgard's catholically embracing concern with the entire gamut of human endeavor. Perhaps the mold was broken in which such men were formed, when the full cosmopolitan range of influences that made them was compressed into an eager haste to acquire paying control of a specialty.

Hilgard lived to his end in a fashion that allowed his span of over fourscore years to set at naught the dictum of the psalmist. There was a gradual decline of physical vitality, natural to advanced age, to be sure; but it was marked in him by little else than a mellowing. And so the close on January 8, 1916, for the daughters who had shared his sorrow at the premature bereavements of son and of wife, was to be read in symbols of fulfillment rather than in sequence with those early losses. When the ripeness of time came, Hilgard could derive legitimate pleasure from his public scientific honors: from the rarely bestowed "Golden Degree" by which Heidelberg commemorated his completed half-century of distinguished record; from the Doctor of Laws granted him in superposition by Columbia, Mississippi, Michigan; from the medals awarded in Munich, Paris, and elsewhere. But he was sensitively humane more than the stiffness of such academic conventions can express. The "thought of his heart" was interwoven with California, through his unique function and chance to retrieve her in perpetuity from the harm of false counsels in the field of his responsibility.

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