it has been possible to see in the chromospheric spectrum a great number of faint bright lines which were wholly beyond the reach of the 12-inch telescope used in my previous investigations. In this way it has been found that carbon vapor exists in the vaporous sea which covers the brilliant surface of the photosphere.

It will be admitted, I think, from what has been said, that great telescopes really have a mission to perform. While, on the one hand, they are not endowed with the almost miraculous gifts which imaginative persons would place to their credit, they do possess properties which render them much superior to smaller instruments and well worth all the expenditure their construction has involved. In answering the question: 'Do large telescopes pay?' it is simply a matter of determining whether the work which cannot be done without the aid of such telescopes is really worth doing. No one who is familiar with this work is likely to deny that it is worth all the money and time and labor that can be devoted to it. I therefore confidently believe that the generous benefactions which during the last quarter century have permitted the erection of large telescopes in various parts of the world have been wisely directed, and that further sums might well be expended, particularly in the southern hemisphere, in the establishment of still more powerful instruments.

George E. Hale.

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*JULIUS SACHS.**

After great suffering, Julius Sachs sank peacefully to rest at six o'clock on the morning of the 29th May, 1897, at Würzburg, the scene for many years of his labors. Wherever scientific botany has a home, and by many outside the narrow circle of specialists, this loss has been regarded as irreparable. By no one has it been felt more keenly than by the writer of these lines, who will always thankfully recall the happiness it has been to him to have been closely connected throughout a long series of years as pupil and friend with him who has passed from our midst.

When I attempt to briefly sketch the life of the man to whose brilliant intellect botany is so greatly indebted, there rises involuntarily to my mind the saying of Petrarch's:

Si quis tota die currens
Pervenit ad vesperam satis est.

Yes, his life was a struggle, a ceaseless, single-minded pressing forward without rest to the goal of knowledge. To him study, research, teaching, were not merely the external activities of his calling that might be laid aside for hours, days or even weeks, and then be again resumed. They absorbed his whole being more than was good for his personal welfare. But the evening came after this long day in which he had so faithfully labored. No one realized this more fully than he himself. A prey to physical suffering, his sharpest pang was that he could no longer work for science with his former energy, and if anything made it hard for him to face death it was the knowledge that he must leave behind as an unfinished sketch much that he wanted to say to the world.

He had been chiefly occupied during these last years with a work which, under the title of *Principien Vegetabilischer Gestaltung* (*Principles of Vegetable Form*), was to set forth his views upon causal morphology. "I should feel it an immense grief if I were prevented from writing this book," he says. "It would embody the thought of forty years, and it is always important that one's ideas should be long and thoroughly brooded over. To finish it would render the last

* A translation for *Science Progress*, by Miss E. D. Shipley, from an article by Professor K. Goebel in *Flora*.

years of my truly miserable existence in some degree bearable." *

Sachs was essentially a 'self-made man,' who found it by no means a light matter to attain the eminence which led the most distinguished German universities each to desire to win him for itself. The story of his early years, as it appears in these pages, is taken from an autobiography intended for his own family, Fräulein M. Sachs having kindly made extracts from it for my use. It will be of great interest to many who only knew him as a mature man occupying an honorable position to learn how literally true were the words 'tota die currens.'

Sachs was born on the 2d October, 1832, at Breslau, where his father was an engraver. For a time his parents lived in the conntry, and this may have contributed to the early awakening of his mind to the beauty of nature, at which he always looked as much with the eye of an artist as with that of an observer. The design that he cherished at one time of writing a work on the beauties of the plant-world was unfortunately never realized. It would have been of the greatest interest if he, an adept in the art of word-painting, an enemy to all affectations and mannerisms, had given us his thoughts upon this theme.

His first experiences of school life were not pleasant. Learning by heart, that purely mechanical acquisition of knowledge, was a burden to him, as it has been to many another highly gifted scholar. Of much greater importance than his school instruction was his father's training in drawing. From his thirteenth to his sixteenth year he drew and painted flowers, fungi and other natural objects, and his artistic talents played, as we shall see later, an important *rôle* in his career.

His family possessed but few books, and the boy felt stirring within him a longing, doubtless inexplicable to himself, for intellectual advantages. And thus his brother's acquaintance with the sons of the physiologist Purkinje,* at that time a professor at Breslau, was of great importance to him. His brother brought home the *Penny Magazine* from these playfellows, and the prehistoric animals depicted in it aroused so great an interest in Julius, then as always thirsting for knowledge, that although he could not understand the English text the 'extinct monsters' appeared to him most realistically in his dreams! Later he himself came to know Purkinje's sons, and this acquaintance shed a ray of light upon his life; for the first time he saw a refined home, free from all petty cares as to daily bread, filled by stirring intellectual life, and dominated in every detail by the imposing figure of the white-haired professor who inspired Sachs with the greatest respect. Julius learned from his sisters to press plants and heard that there were such things as botanical collections; he proceeded to start one for himself. His father, who knew the popular names of many plants, encouraged these endeavors. They made expeditions in the early morning hours, and at fourteen years old Sachs could already determine his plants according to Scholtz's 'Flora.' But his herbarium was stolen, and this was his first bitter, deeply felt grief. He related his loss to every one and could not understand that other people failed to recognize its gravity. He never again collected plants until in later years, as professor, he started an herbarium for the purposes of demonstration. The way in which at the present day so many botanists entirely neglect the practical knowledge of plants was

* The quotations are principally taken from letters.

*J. E. Purkinje (1787–1869) was professor of physiology and pathology in Breslau from 1823 till 1850, and afterwards in Prague. He was the author also of a botanical treatise (*De cellulis antherarum fibrosis nec non granorum pollinarium formis commentatio phytotomica*, Breslau, 1830).

wholly distasteful to him, as the following remark in one of his letters shows: "I strongly disprove of the so-called 'physiologists,' to whom the commonest meadow and garden flowers are unknown, especially as such people generally have but little knowledge of physics." And if he complained many a time in joke of the foolishly unnecessary and tedious multiplication of phanerogamic varieties he was far from undervaluing the knowledge and study of them. Indeed we shall come across instances of the keen interest in the common problems of systematic botany which constantly appears in his writings.

It was his mother who conceived the thought of allowing him to attend the gymnasium, a privilege accorded to none of his brothers, for this considering the family poverty involved no slight risk.

The years he spent at the Elizabeth gymnasium formed a bright picture in Sachs' life. The school work was congenial to him; it lifted him out of the petty surroundings of his home-life into a higher sphere. He attended the gymnasium from 1845 to 1850. Of the masters only one—Dr. Rumpelt—came at all into personal contact with him. He recognized Sachs' exceptional talents and the two became good friends. On the other hand, the natural science master, the lichenologist Körber, only repelled him. Körber could not instruct and had no conception how to impart anything worth knowing about his subject. Sachs, therefore, worked on at his scientific pursuits unaided and undirected. He read eagerly, without its doing him any harm, Oken's 'Philosophy of Nature,' which he had bought at a sale for a few pence, began to make a collection of skulls, and wrote a monograph on the crayfish. Körber's attention was drawn to this work by Dr. Rumpelt; he sent for Sachs and solemnly warned him against devoting himself to natural science, on the ground that it would not bring him in a half-penny! One cannot but rejoice that this advice was not acted upon.

In the year 1848 Sachs lost his father, and in the following year his mother. Thus orphaned, he lived at first with his brother, where, to his great joy, he was alloted a room in the roof which, otherwise unattractive, afforded him the opportunity of carrying on his scientific studies in his scanty leisure. Here, for instance, he mastered the Latin Anatomy of Bartholinus. It became more and more imperative, however, that he should face his position. He left the school (having risen to the upper second form) and wished to go to sea.

In the meantime Purkinje had been called to Prague. He remembered his son's friend and wrote suggesting that Sachs should come to him as a kind of private assistant. He was to prepare natural science drawings and in return to receive the modest salary of 100 florins a year and his keep.

After numerous difficulties with his guardians, Sachs left Breslau on the 14th of February, 1851, for Prague. He found there shelter, it is true, but no home. Purkinje was a man of high attainments, for whose genius Sachs had great respect. But their peculiar temperaments made it impossible for them to understand each other, and the elder naturalist had no word of recognition, sympathy or encouragement for the younger. He was of peasant origin and this stuck to him all his life. Sachs, on the other hand, felt himself—as he said with reason, in spite of the reduced circumstances of his family—to be a born aristocrat, and so there could not fail to be friction between them.

Whilst Sachs was at Prague the question arose whether he should remain simply an illustrator of scientific writings or should carry on his studies further. Fortunately, he decided upon the latter course, and, despite the time that had elapsed since he left

school, successfully passed his matriculations at Prague in the autumn of 1851 with a view to entering that university.

The young student was already too independent and critical to be an ardent frequenter of the lecture room, where it would have required a man of exceptional ability to have secured his attendance, and it was evident that there were at that time but very few such men at the University of Prague. Botany was represented by Kosteletzky, who was lecturing upon Schleiden's works. Sachs attended two or three lectures and then stayed away; the truth was that he needed no teaching on this subject. He paid special attention to chemistry, physics and mathematics. But the only man who attracted and helped him on was Robert Zimmermann,* who invited him to his house. "I went to him with an inclination towards philosophy, but he directed me into the right way," Sachs says, speaking of Zimmermann; "he and my earlier teacher, Rumpelt, are the only two who gave me any real help; apart from their aid I am self-taught." He read a good deal of philosophy after he had become acquainted with Zimmermann—Herbart, Leibnitz, Kant, Locke, Hume and even the Schoolmen. At the same time he was privately working at zoology and botany, and for several years paid special attention to physics and mathematics. In 1856 he was made Doctor of Philosophy, a degree which at that time was hard to obtain at Prague. His outward circumstances, since he had separated from Purkinje, remained precarious; he earned small sums by literary work, drawings of fossils, etc., and at this time made his first experiments in the physiology of plants. In 1857 he was made privat-docent in plant physiology. Up to that time this had not been a recognized subject and there were various difficulties to overcome. "Two lectures are ample for all there is to say upon the physiology of plants," said Rochleder, the chemist, and at that time he was not so very far wrong.

Sachs, who later was certainly the best teacher that the new botany has produced, was by no means a success as privat-docent. One reason for this may be that he took but slight interest in the art of teaching. He lived wholly for science and was beyond measure studious; "it engrossed my thoughts even when I was out walking," he says. This being so, it came to him, according to his own account, more or less as a revelation that what he had to do was not only to acquire as much knowledge as possible, but also to produce some original work. From that time he only sought to work out his own ideas, to attain his own aims. He became acquainted with several of the chief exponents of botany of the day, such as Unger, Nägeli and Alexander Braun, all of whom he met at the Natural Science Congress in 1856 at Vienna; and also about 1857 with Hofmeister who, in the intercourse that lasted between them for many years, influenced Sachs strongly, though, as the latter considered, at times in such a way as to perplex him.

In the meanwhile he was finding his life in Prague almost unbearable. The patriotic Czechs of the National party opposed him as a German, and openly told him that they wanted to drive him away. Whilst this was going on, the attention of Professor Stein, the well-known zoologist, had been directed to Sachs. Stein had formerly devoted some of his time and energy to the Academy of Forestry at Tharandt and introduced Sachs to the chemist Stöckhardt, the director of this institution. Sachs was invited to draw up a statement as to the relation of plant-physiology to agriculture, with the result that he was called to Tha-

* Robert A. Zimmermann, born at Prague, in 1824, studied philosophy, mathematics and natural science, became professor of philosophy at Prague in 1852, and since 1861 has held the same chair at Vienna.

randt as physiological assistant in 1859. He went there in the March of that year. His chief work here was to show that land plants could be raised in aqueous solutions of nutrient salts, but he was busy at the same time with other physiological experiments. 'Die Entdeckungen lagen damals am Wege' was his opinion, 'die Botaniker trieben andere Dinge.' Even then Nägeli, for instance, described Sachs' researches as belonging to the chemistry of agriculture; there was as yet no talk in Germany of the chemistry of plant-physiology.

In summer he started work at four o'clock in the morning, and by so doing found time during the years 1859 and 1860 to study the earlier plant physiologists besides doing his own work. These literary studies caused him, in 1860, to suggest to Hofmeister that they should edit a large hand-book of botany, in which the collected results of what we now call 'general' botany should be critically set forth. The *Handbuch der physiologischen Botanik* remains, as is well known, a fragment; various collaborators who had undertaken certain parts drew back, and Hofmeister fell ill and died in 1877 without being able to complete his share; but in spite of all mishaps the four volumes that appeared rank among the most valuable productions of more recent botanical literature. Sachs had frequently to give addresses at agricultural meetings and so gained the useful knowledge that he had a natural gift for public speaking.

In the winter of 1860–61 he was invited to become the head of the recently established agricultural department of the polytechnic at Chemnitz. His position there bristled with difficulties, and he welcomed the proposal that he should accept the chair of botany and natural history at Poppelsdorf, near Bonn, whither he removed in 1861. Here he married and in time became the father of two daughters and a son.

As regards science the six years spent at Bonn are among his most fruitful. Besides a number of other works, it was here that his 'Experimental Physiology' was written and the 'Text-book' begun. His lectures were highly appreciated, and at the end of two years he was relieved from lecturing upon mineralogy and zoology; henceforward he dealt only with physiology during the winter, and in the summer delivered special lectures on agricultural plants. There was but little intercourse between him and the botanist Schacht, who was then at Bonn, but who was already in bad health, and whose temperament was thoroughly uncongenial to his own. With Schacht's successor, Hanstein, on the contrary, friendly relations ensued. On New Year's Eve, 1866, he received the news that he had been called to Freiburg im Breisgau as successor to De Bary; he went there in April, 1867. A small salary and a poor garden formed two undesirable elements in his life at Freiburg, and after three terms he willingly left to go to Würzburg. There, as we know, he remained, in spite of brilliant offers to move elsewhere. As early as 1869 he received a call to Jena, in 1872 to Heidelberg, in 1873 to Vienna, in 1877 to Berlin, where later they tried to obtan him for the Agricultural College; he was also invited to Bonn under tempting circumstances. When Nägeli retired, the professorial chair at Munich was offered him. It is much to be regretted that he did not accept one of these invitations whilst his health was still good, especially as the climate of Würzburg is hardly favorable to nervous constitutions. It may, perhaps, have been the needs of his family, which pressed heavily upon him, or attachment to all he had acquired at Würzburg and dislike to the loss of time and strength inseparable from each change of place, that kept him there. The government testified its appreciation by investing

him with titles and orders; as early as the autumn of 1871 his colleagues chose him for their rector, and he was repeatedly elected to the Senate.

With the commencement of his professional life at Würzburg, Sachs' 'Wanderjahre' came to an end. They had been, as the preceding facts show, beset with difficulties. "I was thirty-six years old when, with a salary of about 2,000 guldens, I came to Würzburg and found a hole in which to hide my head. During the three previous years, in which I had laid aside the 'Experimental Physiology' and had been writing the 'Text-book,' I had had a severe struggle, in the strictest sense of the word, to provide for the wants of my family. I was thirty-seven years old when I succeeded for the first time in investing 200 thalers in the public funds, and had for twenty years daily worked from fourteen to fifteen hours. As you see, my life has not been an easy one, and yet I wish that things went as well with me now as they did then, for what I have been through since is truly more than a man can bear."

The strong expression that he uses in speaking of the laboratory at Würzburg shows that there was much to be desired both in it and in the gardens attached to it. The laboratory which under his direction obtained a world-wide reputation and attracted young botanists from all parts was housed, together with the clinical schools and the Institute of Pharmacology, in a building that contrasts most modestly with the handsome modern structures that have arisen in many universities. And yet how much he accomplished in it! Little by little the whole of it came to be given up to botanical purposes, Sachs being much too modest to insist on a new botanical laboratory in spite of the fine new buildings that were erected for the other sciences. He contented himself with the addition of a very beautiful and suitable lecture-room. He was particularly anxious about the garden, which was laid out on barren soil made up chiefly out of the rubbish-heap of an old fortress. He gave it his own personal and devoted attention, and was rewarded by a luxuriant vegetation where formerly there had been but a barren waste. Later on he divided off a small part of the garden for special purposes, and this he attended to himself with the help of his laboratory servant. There he made open-air experiments, and there also was the well-known *Schilderhaus* (sentry-box) for experiments in etiolation, etc. The cultivation of strong, healthy plants for the purposes of investigation was in his opinion an essential part of experimental physiological work; he excelled in the art and deemed it worthy of individual, personal attention. There were almost invariably plants growing in his work-room, but in the summer time, when growth was going on in the plant-world, it was essential to him to make constant observations out of doors and to meditate upon his investigations as he strolled about the garden.

The astonishing amount of work that he managed to get through from his earliest days could not but affect his constitution. He said himself that he had paid for each of his books with wearisome ill-health, and even the strongest nerves could not stand such ceaseless labor. Added to this came his wife's long tedious illness which undoubtedly helped to undermine his strength.

Bearing these facts in mind, it is perhaps more possible to form a just estimate of his relations with the outer world. The latter part of his life found him a lonely man who had estranged many of his friends by bitter and sometimes even unjust criticisms. We shall perhaps condone his trenchant animadversions upon the botanical writings of his day if we remember how his sensitive, highly strung temperment must have suffered at times from the irritation of private

affairs. And then again, science represented to him all that is highest in life, and it followed that any work which he considered bad from a scientific point of view seemed to him a crime. More than this, much that appeared of great importance to others had no weight with one who regarded the mission of science from so high a standpoint and whose refined nature could not fail to despise all ambiguity, empty phrases and affectations in its literature. He considered the great defect in this to be that, whilst each isolated investigation is deemed a personal achievement and quoted as such, important generalizations were regarded as impersonal property. He was by no means a man who could not endure contradiction and was always ready to listen to it when well founded; it was only when the opposition seemed to rise from incapacity and stupidity that he was roused to fierce anger. His standpoint is best described in the following words written to a friend at the end of a keen discussion: "After all, in science, as in ordinary life, all hinges upon whether a man accept the general point of view of his opponent; when that is done it is always possible to arrive at some satisfactory conclusion, and I hope this will always be the case with us."

Although the purely intellectual side of his nature outweighed the emotional, he was invariably grateful for the smallest services, and to me he always proved an indulgent, lovable teacher. At the same time he could coldly repel all who were uncongenial to him. He agreed with Goethe, 'Sage nur von deinen Feinden, warum willst du gar nicht wissen,' etc.

As time went on he became more and more dissatisfied with the state of botanical literature. Such dissatisfaction, however, did not keep him from incessant toil whenever he was well enough, and more especially when the sun shone. Like Goethe and many other sensitive natures, he was strongly affected by sunshine or the lack of it. "If you imagine yourself transplanted from Java to Bavaria and that the sun's face has been veiled for the last three weeks by a layer of sail-cloth 100 meters thick, you may form some conception of the vegetation in our garden. The grass and leaves grow as though this were a dairy-farm! Every one is charmed with our luxuriant vegetation, but there are no signs of blossoms. It is as dark at four o'clock as it would be at the same hour at Christmas, and it has been like this for the last three weeks. I should not complain, liking as I do to take things as they come, but unfortunately I cannot live without sunshine and the lack of it makes me ill."

(*To be concluded.*)

CURRENT NOTES ON ANTHROPOLOGY.

THE 'MONUMENTAL RECORDS.'

A PERIODICAL recently started in New York City should be mentioned in these notes. It is entitled *Monumental Records* and is edited by the Rev. Henry Mason Baum. As its title indicates, it is concerned with the discovery of ancient monuments, including those of both the Old and New Worlds. In the three numbers which have already appeared there are descriptions of the ruins in Yucatan and Mexico by Mr. Marshall H. Saville, translations of the Moabite stone, descriptions of the remarkable exhumation of Greek manuscripts in Egypt, a report of Mr. de Morgan's work in the same country and a running series of archæological and literary notes by the editor.

The subscription price for this handsomely illustrated periodical is placed at the moderate sum of $1.50 a year and the address is 'Box 1839, New York City.'

THE PASSAMAQUODDY WAMPUM RECORD.

IN the *Proceedings* of the American Philosophical Society for December, 1897,