exactitude," or, put in another way, "If you succeed in eliminating 19 fallacies, there will always be a twentieth which you cannot get rid of." "The chemists remain riveted to their theories" (he was often at odds with the academic chemists and disapproved of their satisfaction with reactions which after months of work yielded only a few milligrams of product). "The pharmacologists have been content to chart only the dangerous shoals and sunken reefs of therapy, but never a safe haven" (his comment on the then prevalent toxicological studies of drugs).

Ehrlich was much given to thinking aloud and, I believe, whetted his mind on a listener. Such time as he had free for personal work in the laboratory was spent in performing chemical reactions, the apparatus being test-tubes and a Bunsen burner on a large table, which, like the shelves, was covered with bottles of chemicals and reagents, many of them without labels other than those he carried in his head. I guess that the elucidation of the constitution of atoxyl began when he found it could be diazotized and so was not an anilide as then supposed. A credible story was that a monkey which had the run of the laboratory could shake a test-tube over an imaginary flame with precisely the attitude of the master.

The work required of an assistant, at that time at least—investigations on the arsenobenzenes, including salvarsan and arsenophenylglycine, were only beginning when I left—was not heavy, and a great part of the day was free to use or waste at one's own discretion. Provided Ehrlich's moderate requests were met no questions were asked or available materials grudged. One lesson, however, was learned early—never to state the intention to carry out any line of experiment on one's own initiative, but to try it and if something of interest emerged to demonstrate the findings to him. In that event the highest reward came in seeing the satisfaction with which he accepted the result.

Some Personal Characteristics

Ehrlich was a sedentary man; he always drove in a cab to the laboratory in the morning and home again at a variable time after 3 p.m. There must once have been an accidental fire which had impressed him strongly, because he would come, even upstairs, before leaving, to say, "Lampen aus," although work was going to continue for several hours longer. His scientific reading was done with great rapidity and an unerring eye for the important points, and his memory was immense. His recreations, apart from the time passed with his family, included detective novels, Sherlock Holmes was a favourite, and H. G. Wells's *Food of the Gods* pleased him very much. Also, he worked mathematical exercises; he told his younger daughter's husband, a mathematician, "I do mathematics when I am tired." Then there was the inevitable succession of cigars throughout the waking day. Music and art made no great appeal, possibly because they would have taken up time required for thought on his own work, which was almost incessant.

Ehrlich's genius lay in his art of devising experiments which yielded important results, his faculty for correlating facts from his profound knowledge of biology and chemistry and thereby effecting syntheses unnoticed by others, and his capacity for getting things done. He seemed to be able to rid himself of preconceived ideas. As he said, "It is absurd, but we shall try it," meaning by absurd not foolish, but contrary to prevailing opinion. When new facts were discovered, they were stringently verified by repetition and modification of experiments. Publications were made in the light of added knowledge far in advance of that revealed; thus he was usually saved from the need to retract afterwards. While the facts might be largely contributed by his co-workers, the pattern of theory woven attractively round them was his own. He had the gift of holding attention and making what was highly complex sound clear and understandable to those less informed on the subject than himself, and, I believe, he obtained great pleasure from exercising this power. Some of his predictions were inspired, such as that of the side-chain (receptor) theory of nutrition,

recently established firmly by Whipple, according to which direct entrance of protein molecules into cells, as well as their exit, occurs. Like a diviner, he seemed to sense the presence of treasure, and a generation following him has been engaged in digging out a part of it. His self-reliance was supreme, but it was based on a vast amount of skillfully conceived work. Is it surprising if he occasionally missed something, made a slip, or spoilt an experiment? Truly he was a Master Builder.

PAUL EHRLICH

SOME REMINISCENCES

BY

MARTHA MARQUARDT
Secretary to Paul Ehrlich, 1902–15

I regard it as a great and most lucky episode of my life that I was allowed to work for Ehrlich as his secretary day by day for 13 years; and that, observing his actions and hearing him speak to his friends and colleagues, I was given an insight into the wonderful riches and greatness of his soul. Paul Ehrlich appointed me his secretary in November, 1902, "on approval," for he declared that he did not know whether he would get accustomed

In the laboratory.

to dictating his thoughts, letters, and scientific papers. Much later I learned the true reason: once, in Berlin, he had engaged somebody to help with his writings, but the typist, writing down all his interjections and repetitions, produced a strange sort of script. Finally, getting nervous, she was unable to take down his dictation and ran away. Of course, Ehrlich wanted to protect himself against another such experience.

Ehrlich liked to read detective stories, for they could "almost" distract his attention from his work; but even these, as all other books he read, bore on the inside and the covers his notes written in coloured pencil—a proof of not being distracted. He could not return borrowed books when asked for, but had to order new ones to replace them. Scientific articles sent to Ehrlich by their authors would, having been read, show in the margin or on the cover Ehrlich's judgment, such as "good," "important," "must be read carefully"; but sometimes quite frankly "miserable." Once somebody applied for a position and sent to Ehrlich a copy of one of his publications. Later on, having received no

answer, he asked a friend who was working with Ehrlich to say a word about him. When this friend spoke with Ehrlich about the applicant, Ehrlich merely pulled out of the piles of books on the big sofa a small reprint and handed it to him. In large letters there was but the remark on the cover: "Quatsch" (bosh). Both laughed heartily, and the case was dismissed.

"606"

In 1905 the discovery of the microbe causing syphilis was announced. This event was of great importance in medicine. The Kitasato Institute for Infectious Diseases was founded in Tokyo, on his return to Japan, by Kitasato, a friend of Ehrlich's since the time of their studies at the laboratory of Robert Koch in Berlin. And now, after the discovery of the syphilis spirochaete, one of the most talented of Professor Kitasato's pupils, Dr. Hata, started at once with experiments to produce syphilis in rabbits by inoculation, gaining great skill in his work. In the spring of 1909 Dr. Hata was sent to Ehrlich to continue work on these lines at the Speyer-Haus, producing infections in rabbits experimentally and then testing on these infected animals the curative properties of the preparations worked out by Ehrlich. Dr. Hata was delighted to do this work, took all the small bottles Ehrlich gave him, with inscriptions on the labels, and said proudly, with a nod, "418," "606." Dr. Hata, after his first trials of all the substances given to him, soon came to show Ehrlich his records, and said: "Believe 606 very efficacious." Ehrlich would not believe it, and Hata, untiring, did not shirk repeating the experiments again and again until a clear and definite result was obtained that 606 was best. Ehrlich then confessed that he always had had a strong feeling—yes, had been convinced for two years—that 606 must be good. Trial treatments of patients had now to be made again by those collaborators who had already been working with 418 successfully, and finally Ehrlich consented to announce the invention of 606 to the world, following a number of publications showing good results.

Ehrlich had to receive all medical visitors asking for 606, telling him personally what observations they had made, asking his advice about special cases; he had to listen to patients who wanted to be treated by him, and sent them to one of the clinics where treatment was given. Untiring, he had a kind word for everyone and helped wherever he could. Besides all the urgent work at the laboratories, in the chemical section, and in the biological section where continued series of animal experiments required his presence and help, he had to watch over the process of manufacture with every precaution, to safeguard 606 from the influence of oxygen. Later on Ehrlich said himself: "Without the strictest observance of all necessary precautions it would have been impossible to introduce 606 into human medicine."

In addition, something quite different required Ehrlich's attention: from everywhere crazy ideas for treatments and cures were sent in. In spite of all his urgent work, Ehrlich found time to answer inquiries politely. People seeking positions asked for work; many beggars implored his help; children told him that their birthdays were on the very same date as his; people with the same name inquired if they were not relations. To those who asked for help Ehrlich sent a sum of money; he was the kind of helper who did not let his left hand know what his right hand was doing. He simply wanted to help and could not say "no," for this "no" may have made unhappy somebody who urgently needed help. He was always ready to assist members of the medical profession or their families who were temporarily or really in want. Large sums were often involved, and it was understood that they were gifts, not loans.

During the seven months or so following the Wiesbaden Congress until the Congress in Königsberg in September, 1910, much experience with 606—which had been given the name "salvarsan"—had been gained, but Ehrlich did not cease to advise everybody at the Congress not to be content

with a momentary success, but to observe strictly all precautions in using 606.

In the meantime, as was also the case previously, trouble had arisen when using salvarsan, and when Ehrlich returned from Königsberg more unfavourable experiences were reported. Ehrlich now called out in distress: "Those wretched scoundrels are really going to smash salvarsan entirely, because they will not pay attention to any of my instructions," and, clenching his fists, he went on: "But I shall force my will upon them! I shall introduce intravenous injection and insist upon it for all treatment with 606, to put an end to this hoggish, dirty behaviour once and for all!" "They will all object to it," remarked Dr. Sachs critically, "they are not used to intravenous injection—it is given only in cases of extreme emergency." "Then they must learn it . . . I shall demand it and compel them to do it . . . the blood will get the better of all the dirt." And Ehrlich succeeded, though only after another grave incident.

In December, 1910, the chemical works completed big installations for the manufacture of 606, tried it out, and produced quantities sufficient to cover the requirements of all pharmacies for some time. Supplies from the Speyer-Haus were now no longer necessary. Since the announcement of the invention of 606 at the Wiesbaden Congress in April, 1910, more than 65,000 doses had been sent out free of charge.

Honours and Celebrations

On March 14, 1914, Ehrlich's 60th birthday, the daily papers had long articles about him and his wonderful work; some issued richly illustrated special numbers in his honour. The scientific periodicals also celebrated the occasion. Hundreds of telegrams and letters from all countries came in, and many of his friends from abroad arrived to take part in a simple friendly celebration, and all his family and relations were there. His assistants and former pupils had compiled a special book on his work, a volume of 668 pages (*Paul Ehrlich, Eine Darstellung seines wissenschaftlichen Wirkens*, Gustav Fischer, Jena). Dr. Arthur von Weinberg, a helpful and appreciative friend of Ehrlich's for many years, announced that, on his suggestions, the pupils and friends of Ehrlich planned, as a gift to him, to found a new wing to the Serum Institute, with a large laboratory, equipped in the most up-to-date way, and, adjoining it, a pleasant study with armchairs, large writing-desk, book-cases, and an office for me. Paul Ehrlich was deeply touched by these generous gifts and shook hands all round, with a few kind words for everybody. Of course, Ehrlich stayed in his old rooms, as nothing was as yet finished. Later on, the laboratory being almost ready, Ehrlich went over—but once—to see what it was going to look like. Taking a deep breath, he then went back to his old rooms which he loved and where he was happy to work.

In 1908 Ehrlich and Professor Metchnikoff, of the Institut Pasteur, Paris, were awarded the Nobel Prize for their successful studies in immunity. That was for work dating back almost 20 years. When Ehrlich, in December, 1908, went to Stockholm to deliver his lecture before the Nobel Committee, he spoke of "Chemotherapy." On his return to Frankfurt Ehrlich's friends organized a party to celebrate this honour. As his friends knew of his dislike for big official ceremonies, this party was arranged in a big hall in Frankfurt as a so-called beer-party, with much mirth and informal gaiety. Ladies were not admitted, but Ehrlich's wife and daughters, and those of his friends, were allowed to look on from the galleries above. Dr. Adickes, the Lord Mayor of Frankfurt, made an enthusiastic speech, saying that Ehrlich would be capable, if required, of working at and managing any number of institutes for research besides the two he already had. The audience showed their approval by great applause.

Wartime Activities

In August, 1914, war broke out. Newspapers came out with enormous headlines; crowds gathered round the news-

stands, some looking sceptical, some sad, some pugnacious; marching men were everywhere; there were endless goings to and fro. I shall never forget! In the Serum Institute there was great activity preparing serum for the army on a large scale. Every room was used for this work, and every worker. Ehrlich's new laboratory was immediately requisitioned as a control centre for all sera which the chemical works had to produce. In Ehrlich's "reception room" and my office in the new wing cases and chests were piled up, filled with sera ready for use, waiting to be dispatched. Ehrlich had really never liked the idea of leaving his old rooms and moving into the new surroundings. It seems he had a presentiment that he would never work there. Very exhausted from his labours and depressed by continuous attacks from his enemies, Ehrlich had once again gone to Baden-Baden for a holiday; and once again he had to come back to Frankfurt when war broke out.

I shall never forget the distressed look in his face as he put his hands up and cried out: "But this war is pure madness! No good can come of it!" Ehrlich felt quite lost and strange in the noisy bustle at the institute—people running hither and thither, and large cases being continually dragged along the corridor. Only in his old laboratory and his study could he find refuge and a quiet place to think. His staff had planned to take advantage of his absence on holiday to move all his collections and belongings into the new rooms. When he heard of this plan before he left he protested very decidedly: "In my absence nothing is to be touched; I want to take care of all that myself." If this plan had been carried out Ehrlich would not have been able to find anything on his return, and would have had no place to stay; it is impossible to imagine how unhappy he would have been. Once or twice he went into the new wing to see what they were doing there: I can always see how desolate he seemed on coming back, walking slowly down the long corridor into his old rooms, deep in thought, closing the door behind him with resignation.

There were many changes in the Speyer-Haus as well as in the Serum Institute as a result of the war, especially through the call-up for military service. Dr. Bertheim was summoned to his cavalry corps at once, and on the first day in Berlin, going down the stairs in the house where he was billeted, caught his spurs in the carpet and fell, fracturing his skull and dying instantly. Ehrlich now had only Dr. Paul Karrer, whom he had invited shortly before the outbreak of war to come from Zurich and work with him. Ehrlich could discuss all his test-tube experiments with him and entrust to him the detailed working out of his ideas. They were on friendly terms, and some articles on silversilverans were published. Later on Dr. Karrer returned to Zurich, and in 1939 was awarded the Nobel Prize for Chemistry.

Failing Health

During the first year of the war—the last of his life—Ehrlich's health grew worse, and he had to follow strict medical advice with regard to diet. Long years of heavy smoking of strong imported cigars, irregular meals, in fact almost complete disregard of proper food—these combined to produce a disastrous effect on his system. He had to give up smoking, and this he found very hard, though he always pretended that leaving off a habit was really not difficult. But with a complete lack of appetite he found it "an absolute torture" to take the prescribed amount of nourishment. He knew it was necessary, and tried the best he could. About Christmas, 1914, Ehrlich had a slight stroke, but recovered from the obvious effects in a few days. It was a first serious warning; his grave illness progressed imperceptibly, without giving him or those around him any suspicion that catastrophe was near.

Shortly before the war Ehrlich was at last persuaded by his friends to buy a car for more comfortable travel between his house and the institutes. War came, and immediately his car was requisitioned by the military authorities and he had to go back to his old custom of using a horse-drawn cab. In this last year of his life I used to call for Ehrlich

every morning at his house to accompany him to the institutes. In fine spring weather we went by cab only as far as the Hippodrome Riding-School, where the Paul Ehrlichstrasse begins, and then walked down the street. On one side there were no houses, only building sites, the plots surrounded by fences, with bushes of acacias and elder, grass and trees. Ehrlich was always very fond of gay flowers with bright colours and strong scents, and he would pause and breathe in the fragrance of a flower or bush in bloom, his eyes delighted. He paused and looked, and with a slight nod would pass on, saying simply: "Nice, isn't it?" In the car rumbling along the streets, passing the railroad station, over the Wilhelms Bridge, he often sat silent, and I did not venture to disturb him. He was depressed and discouraged by the war, which he said could not end well and ought to have been avoided. Also he was deeply distressed by the interruption of his scientific relations with all his foreign friends. He spoke affectionately of his grandchildren, who often came to see him; he would even laugh at a funny street scene or an odd notice at a shop in passing by.

Sometimes he talked quite cheerfully about his future scientific plans. Once he said to me: "You know, I need never work out anything new at all. If I followed up all the thoughts and problems I have noted down in 'blocks' and put aside in favour of other more urgent work, if I took up all that again, I could keep a dozen chemical assistants busy with work for years. Those 'blocks' are a real gold-mine of discovery." But Ehrlich was now more often in a depressed state of mind. His elasticity had never failed him in overcoming even the greatest difficulties; with tenacious perseverance he had always piled experiment upon experiment to find a really scientific foundation for his theories; his titanic, heaven-storming optimism had inspired all his collaborators and pupils; but now he was discouraged, tired out, and too weary to fight any more.

Last Days

At the beginning of August, 1915, Ehrlich went to Bad Homburg, near Frankfurt, for a holiday and treatment in the sanatorium of a friend, lovingly cared for by his wife, his daughter Marianne, and his grandchildren. It had been arranged that I should go there now and again, to avoid a too great accumulation of work during his holiday. When I was asked to come I was told on arrival the terrible news: Ehrlich had had a second stroke during the previous night and was sinking rapidly. He still recognized me and was able to exchange a few kind words. His elder daughter Stefanie and the two sons-in-law hurried to him when summoned by telegram. His wife, the true companion of his life, and all his family were with him when—on August 20—he drew his last breath and his eyes closed for ever.

Paul Ehrlich is buried in the Jewish Cemetery of Frankfurt. On top of the two high columns at the entrance of the box-edged tomb are, visible from afar, the Star of David and the Snake of Aesculapius. A large slab of marble from the quarries of his native Silesia covers the tomb, upon which only his name and the dates of the beginning and end of his remarkable life are engraved. On a high stone carved from a natural block of marble, at the head of the tomb, was a large vase of porphyritic rock containing trailing rose-bushes with an abundance of blossoms. His resting-place was covered with the falling petals. Despite the ravages of war Paul Ehrlich's resting-place has not been damaged.

Ehrlich dedicated and sacrificed his whole life to the welfare and healing of mankind, never failing in his idealism, his optimism, and his faith, until he finally broke down from exhaustion. Nothing on earth mattered to him except scientific research aimed to overcome suffering and disease, and to increase the happiness of mankind. His unshaking and unwavering faith in the progress of his work was like a warming flame which filled his whole nature and shone forth in all his actions.

Paul Ehrlich will never be forgotten.