NATIONAL ACADEMY OF SCIENCES

# EDGAR FAHS SMITH

*1854—1928*

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*A Biographical Memoir by*

GEORGE H. MEEKER



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## INTRODUCTORY

The memory of Edgar Fahs Smith shall indefinitely, actively and abundantly remain honored in scientific and academic circles as that of an outstanding American chemist, especially electrochemist; of the inspirational historian of early American chemists and chemistry; of a notable collector of chemical memorabilia; of a distinguished university professor of chemistry; and of an admired and constructive head of the University, and of the Philosophical Society, which the great Benjamin Franklin founded in Philadelphia.

The complete human, civic and scientific record of Dr. Smith goes far beyond these, his memorial landmarks; and possesses that extreme rarity, humanly, of freedom from trace of blemish—of aught to overlook or to condone. As a scientist he ranks with those of high distinction, though not with the few of recognized greatness. As a man his qualities and life works were saintly.

In science, excepting Priestley, he surpassed those early, eminent, American chemists to whose histories he gave such devoted and invaluable service. He thought, labored and produced in the Berzelian motif. As is true of most scientists of note, his discoveries, investigations and inventions possess recognized distinction, but have not epochal quality. He types with the admirably robust and fecund men of science, rather than with the titanic ones. As a man, scientific or otherwise, Edgar F. Smith was unsurpassable. As teacher, academician, administrative head in learned fields, none outranks him.

As a scientist Dr. Smith was essentially a chemist; and as a chemist he consciously, consistently and fruitfully, though not exclusively, labored upon the Berzelian model of precise, extensive, facts and figures, pure and applied, in the inorganic and

mineralogic fields. In a lesser degree, organic and medical chemistry also lured his labors, upon Wöhler and von Liebig models. The modern, physical, mathematical and quasimeta-mathematical chemical domain opened and grew during his maturer life as a chemist. Toward the experimentally factual region of that domain, Dr. Smith had his customary keen interest for all facts of chemistry; toward its flood of speculation he was by his wont, tolerant, though dubious; it did not lure him.

From early youth until his end, Dr. Smith's life flowed undeviatingly, deeply, in serenely simple channels. Quietly, kindly, tolerantly, uprightly, optimistically, busily, he lived; and, as he thus lived, he guided, constructed and so wrought as to leave behind him a truly amazing total of accomplishments for any one man, even for his lifespan of seventy-four years.

## ITEMS AND EVENTS

These are to be known through categoried lists which the reader should consult, where hereto later joined, and entitled: "Biographic Sources." In what follows herein, the stated sources have freely been utilized.

## THE CURRENT OF LIFE

### ORIGIN AND DEVELOPMENT OF CHARACTERISTICS

York County, Pennsylvania, bordering on the west bank of the Susquehanna River and east-centrally upon the Mason and Dixon Line, has as its centrally located county seat the important inland city, York. Southwesterly, less than thirty miles from York, lies historic Gettysburg. Somewhat nearer, on the Susquehanna, northwesterly, lies Pennsylvania's State Capital, Harrisburg; and eighty-five miles due eastward lies Philadelphia. This limited region is, essentially, the stage of his immediate forbears and the one upon which the life story of Edgar Fahs Smith began, near York, flowed, waxed and nobly ended, in Philadelphia. His enactments upon other stages were but interludes.

Ancestrally, temperamentally, habitually, Dr. Smith genu-

inely and luminously reflected, in self and in life, Yorkish Moravians, central Pennsylvanian Covenanters and Philadelphian Quakers, in their quiet, sturdy, conscientious and constructive virtues. His genius was no stroke of aberrant biologic lightning. In him was an admirable culmination of his natural selection, and of his existence in the habitat wherein he breathed that historic, rurally urban and urbanly rural, atmosphere ideally suited to his biologic self.

The racial, political and historical atmosphere of Philadelphia, and Gettysburg are too well known to call for special comment here, but it is not so widely known that York was the first permanent settlement founded, by the Penn Proprietors, west of the Susquehanna (in 1741); that the first settlers were mainly German refugees of the Reformation, with some English and Scotch-Irish; that York, as a pioneer settlement, so flourished that it became our young nation's capital, in 1777-1778, when the British troops threatened Philadelphia; that there the Congress passed the Articles of Confederation, there came Lafayette and Steuben as knights-errant in the American cause, there came the treasure lent by France, there Benjamin Franklin's press issued the $10,000,000 of Continental money, and there came Gordon's Confederate troops at the Gettysburg battle.

At his grist-mill by the mill-stream, in West Manchester township near York, in the years just preceding the American Civil War lived a poor miller, Gibson Smith, a son of the region, upright and respected, though without church affiliation, probably of Scotch-Irish strain, and his native goodwife, Susan Elizabeth Fahs (Smith), a devout Moravian, probably of German strain. The only language of the household was English. To this typical York couple, came, May 23, 1854, when the father was aged thirty-two years, their first child, a son, Edgar Fahs Smith, herein memorialized.

To these parents was later born one other child, Allen John Smith (1863-1926). The younger brother displayed, by his life, the same sound and admirable general characteristics as his elder and more famed brother. He became a physician and an eminent author and professor in pathology in the University of Pennsylvania. Gibson Smith soon moved his family into

York, became a grain, wood and coal merchant there, grew with the town, was always substantial, became known as "a man of means," never wealthy, died suddenly, of pneumonia, in middle age, leaving a sizable estate. It was under such modest but comfortable circumstances, and with excellent health, that Edgar Fahs Smith began and lived his life. There is no record of privation, hardship, tragedy or hectic drama; or of super-struggle against bad health, bad luck or adversity. Neither is there record of sudden and thrilling emotion, accession or loss of wealth, position or influence. The current of his life's events flowed quietly, smoothly, deeply, in normal channels, as human life may flow—with no excesses of conduct, joys, sorrows, successes, failures—a model of a good human life-stream—beginning near the millside, gaining volume gradually, surely; no narrows, no floods, no rapids, waxing progressively to metropolitan and national importance, and merging finally into the ocean of historic goodworks. Like all life-streams, it had, of course, its waves, but none was tempestuous.

The young Smith grew as a well-trained inland town-boy, guided strictly, rather sternly, by his father; religiously, sweetly, preceptorially, by his mother; uprightly by both. To such training he was precisely adapted. He did well in his early home and private-school lessons. At the age of nine the horror of Gettysburg thrust itself upon him; and he grew to adolescence and manhood in the North's most active region of postbellum war memorialization—where, indeed, that is still active, seventy-two years after the great battle.

In 1785 there was founded in York, the York County Academy, which became highly reputed in the community as a day-school for precollege studies, with emphasis laid upon classical Greek and Latin. After the completion of his early preacademy studies in the local private school and at his mother's knee (she heard him recite his school-boy lessons; insisted upon perfection therein; and devoutly instructed him in the Moravian virtues), the Gibson Smiths sent their son Edgar to the York County Academy for college preparation in 1867; and these studies occupied the lad until their completion in 1872. In the Academy he began to find himself; our record of him shows that there

he began to exhibit those ideas and qualities which ever characterized him. He became so proficient in Latin that for two years he taught it in the Academy, as a schoolboy, to the younger boys. There he cultivated a fondness for the classics and the humanities which he never lost. Of this period in his life his brother Allen writes:

"He would have been successful under any conditions—his natural bent toward reasonable precision and method guaranteed that; but the measure of his success he owes in particular to two persons—his mother and his old teacher, Dr. George W. Ruby, principal of York County Academy for nearly a generation. Night by night, in the light of an old-fashioned fat lamp, his mother had the boy work out and recite to her all his lessons for the following day, and no half acquaintance with the tasks was acknowledged or allowed. The innate aim for thoroughness was formed into a reality at his mother's side, and what power of analysis and memory nature gave him was educated into a habit of easy practice. . . . It was while attending the York Academy that in association with a coterie of kindred spirits he established and for several years was in turn, or all at one time, editor, contributor, compositor, pressman, and financial agent of a youthful publication known as *'Our Effort'*—a short-lived effort, dying promptly when the boys who built it up passed from the old school into college. He, in this experience learned sufficiently the trade of printing to have been repeatedly accepted in holidays to do substitution and special work as compositor or proofreader in the office of one of the important publishing houses of the town; and his claim to be a typothete fits well the man who has sat in Franklin's old chair in the Philosophical Society, and worked as he has for the glorification of the University that Franklin founded."

A complete file of *"Our Effort"* is to be seen among the memorabilia; and is remarkable for the youth of seventeen years. The *Effort* file shows him even then clearly setting his course for his full life's effort; and he never deviated from the there announced purpose of "forwarding of science." The following excerpts from the first number illustrate his practicality, his style, his aim.

OUR EFFORT

Vol. 1 York, Pa., July, 1871. No. 1

OUR EFFORT

is printed every month, at the low rate of 50 cents a year, in advance.

No subscriptions will be received for less than a period of six months, and none can be withdrawn before all the arrearages are canceled. A failure to notify the printer of a discontinuance at the end of the subscribed term will be regarded as a new subscription.

All letters should be addressed to

Edgar F. Smith
P. O. Box 431,
York, Pa.

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The Formation of the Earth (Title of first article)

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Editorial in first number July 1871.

It is with great diffidence, that we present to you, for the first time "OUR EFFORT" which is INDEED an effort, for it has required a GREAT amount of thought upon the part of the proprietors, whether or not, it would be advisable to publish a magazine edited by BOYS. The trial has finally been made, and we beg of you, kind reader, not to turn away muttering, "Pshaw, what can boys do," but let your charitable feelings predominate, and assist us with your small subscription of fifty cents. We do not expect to compete with the productions of the learned men of the times, which are circulating in the most enlightened portions of the globe; but in our humble position aid as much as possible in the forwarding of science, the love of which has incited us to such an important undertaking, and which has, does and ever will contribute to the happiness of man.

And now we sincerely hope that you will "think before you act," and after a careful consideration, make us happy with the

announcement that you have concluded to assist BOYS. With this short note, we bid you good-day.

One finds from the record of Dr. Smith that the boy who, aged seventeen years, was a teacher of classics, a devotee of science and a writer on science and history so continued throughout life. The *Effort* shows that in science, chemistry and medicine beckoned him. Actually his maturer goal was medicine via the chemical route. In the end, it befell that chemistry held him; but he never lost his active interest in medicine; and as Provost of the University of Pennsylvania he labored earnestly and fruitfully in the development of undergraduate medical education; in instituting graduate medical education; and in the expansion of medical research.

His studies in the York County Academy nearing their completion, in 1872 he planned presently to enter Yale. However, he accompanied to Gettysburg a chum who was applying for admission to Pennsylvania College (since 1917 officially known as Gettysburg College) located there. This chance visit to Gettysburg profoundly influenced the future course of his life. The College authorities examined him; and found that the youth from the York County Academy was so exceptionally advanced in his studies that he rated as admissible to the College as a Junior student. Edgar Smith embraced this opportunity; and entered Pennsylvania College in 1872 as a Junior. His curriculum included Greek and Latin and presumably some other subjects, but majored in chemistry and mineralogy under the late Dr. Samuel Philip Sadtler, a graduate of Pennsylvania College, and the, then, Professor of Chemistry there. In 1874 Pennsylvania College conferred the degree of Bachelor of Science upon this special student. While studying at Gettysburg, a warm personal and scientific friendship developed between Dr. Sadtler and Edgar Smith; Dr. Sadtler admired young Smith and encouraged him in the idea of making chemistry a life-goal—since he considered that an excellent goal, and his young student excellently suited for it. He also advised the youth and his parents that further studies were needed; and that they could best occur in the University of Göttingen, Hanover, Germany, under the famous Professor Frederick

Wöhler. The record discloses that Gibson Smith, with only a minimal education, had become a comparative local success; but, withal, he rather shrank from the expense and was dubious of the necessity of European study. However, he was a wise, broad and farseeing man (Dr. Smith in his later life often expressed his admiration for his father and for his father's prescience, and said, "if only I had a mind as good as that of my father!"); and, becoming convinced by Dr. Sadtler, consented. Meanwhile, in Gettysburg, student Edgar Smith had met townmaiden Margie Gruel. By the time his family had decided that Edgar should go to Göttingen, Margie and Edgar had decided upon their marriage as soon as Edgar returned. Both purposes became fulfilled with high success, as the sequel shows.

Accordingly, in 1874, "Edgarium Fahs Smith" matriculated at Göttingen as a candidate in chemistry; and in 1876 the University awarded him its "Philosophiae Doctorem et Artium Liberalium Magistrum" diploma; which diploma was renewed by the University a half century later, 1926, as a signal mark of honorary recognition of his "fifty years of science as a teacher and investigator."

Dr. Sadtler became, in 1874, Assistant Professor of Chemistry in the University of Pennsylvania, advancing in 1887 to the Professorship of Organic and Industrial Chemistry and to the headship of the department. Dr. Smith, who in 1888 had become Professor of Analytical Chemistry, became Professor of Chemistry and head of the department in 1891, the year of Dr. Sadtler's retirement, and the fine Sadtler-Smith friendship and fellowship became thus climaxed.

Edgar Smith entered Göttingen with no practical knowledge of the German language. Within the two years of his stay in Göttingen it was necessary for him to acquire his German; and to qualify for his examinations. He never became a thoroughly fluent German speaker; but he acquired and retained a good conversational knowledge of it; became very facile in German chemical composition and transcription with English; and his Göttingen examiners complimented him upon his excellent examinations in Latin chemical composition and exposition.

He always enjoyed relating his Göttingen experiences to

intimates; and particularly two experiences concerning his examinations. The first one runs about as follows. He was worried about his progress examination because a German student whom he considered even better prepared than himself had recently failed. He sought advice and was counseled to prepare himself well upon questions concerning platinum ores which Professor Wöhler was "sure to ask." He therefore prepared himself perfectly as advised. In the examination, what with his stage-fright, what with his halting German, and, perhaps, what with imperfect preparedness, he at first felt himself to be submerged. Eventually, however, came the expected "ores of platinum" question. Whereupon, in fluent, perfect Hanoverian German, he astonished his examiners by his sudden German transformation and by his technically complete and flawless answers—for the reason that he had memorized and practiced the answer, verbatim, in Wöhler's own German, and so thoroughly that even his stage-fright gave way to stage-assurance. Later, when Wöhler notified Smith that his examination had been rated successful, the Professor stated that the transformation which occurred in it had puzzled the examiners, and he requested Smith's explanation. The explanation was frankly given, with name of the previous, unsuccessful student. Whereupon Wöhler laughed heartily; told him that it was a foolish thing to do; that the German student had failed because of previous offensive conduct; that it had been decided in advance to "pluck" him; that any student whose work in the laboratory had been done faithfully and who had conducted himself properly need have no fear of the examination.

The other experience concerned his doctorate examination. In the customary, required, top-hat and formal full-dress attire, he reported to his examiners to "defend" his doctorate thesis. The "defense" began in German, and was rather grim and dismal. However a Latin autobiographic sketch was also required, and necessitated defense of his Latin rendition. Here the days with stern old Dr. Ruby and his boys at the York County Academy came to the rescue. He did so strikingly well with his Latinity and classical quotations as, once more, to astonish and enthuse his thirty examiners, who approved him and dis-

missed him with praise—smiles replacing their grimness, and joy replacing his depression.

As the sequel now shows, the American Centennial Year, 1876, was of greater moment to Dr. Smith, to the University of Pennsylvania and to American science than, then, any one concerned could have foreseen. In that year he received his Göttingen doctorate, returned to the United States, became an instructor in chemistry in the University of Pennsylvania, married Margie A. Gruel, and thus began his real life—in the manly, vocational and service senses. It were idle here to remind of the importance of Göttingen in this life-story, of the importance to them of the long, fruitful mutuality between Dr. Smith and the University of Pennsylvania, or of Dr. Smith's public superservice.

But his story would lack an essential element, did we not here dwell, just enough, upon Dr. Smith's marriage in his real "commencement" year, 1876. That marriage joined him to a mate who insured that his whole life of service, fifty-two years beginning in that year-of-auspice, should be domestically serene, and free from worldly cares beyond his worldly service-field. Mrs. Smith not only made for Dr. Smith that happy homelife so essential to his personality and best success, but also attended to all of those matters outside the home, and outside of his service-field, which were essential to Dr. Smith's work, welfare and serenity. One may not say that an unhappy home, or lack of such loving and capable guardianship, would have blighted Dr. Smith's progress, for that is beyond human ken; but one may say that his progress was so complementarily facilitated by his mate as to make the progress a certainty. She has survived him; and from her unaffluent means has continued her care of him in life by her care for his purposes and memory in death, by endowing the Edgar Fahs Smith Collection of Chemical Memorabilia, thus insuring the permanence, indefinite expansion and general service which he began for the benign cause of historical chemistry, and for which he so ably labored as to become that cause's honored American Nestor.

This is an appropriate place in which to speak of that phase of Dr. Smith's character which has to do with money, because

in that phase he thoroughly needed Mrs. Smith's wise oversight. He always had sufficient money to satisfy his personal needs—not because he ever was wealthy, but because he was never too needy for his simple mode of life. Luxuries never appealed to him—would have disturbed him. His modest means cared for his modest requirements; and beyond that he was quite indifferent to money for himself.

He longed for money only for the benefit of others, particularly for the University of Pennsylvania. He turned back to the benefit of the University by his personal expenditures for it, the total of perhaps $50,000 of his administrative salary received from the University during his years of Provostship. His method was himself to pay for anything which he believed the University urgently to need, for which his own funds sufficed, and for which the University Trustees could not, or would not, provide. However, he was also openhanded toward any quarter of need which had a special appeal to him—so much so that Mrs. Smith's brake, anon, became quite necessary to prevent a threatened domestic financial skid due to this indifference or carelessness in their money affairs. She encouraged and indulged Edgar's benign, and lovable, financial imprudence; doubtless took secret pride in it; but she applied the brake when the speed grew risky. He obeyed her simply, and probably acted with the secure and comfortable feeling that she was watching and would halt him at the right moment. Such an arrangement was precisely suited to his selflessness in money matters.

Various of his research results possessed large potential commercial applications and profits; but that did not cause him to patent them or to give such considerations more than passing notice. Notable here were his researches with tungsten, which forecast the successful electric incandescent lamps of today—a huge industry. Had his been the gain from that industry, doubtless he would have enjoyed applying that gain to purposes dear to him; but the idea of pursuit of money for himself, and the deflection from loved pursuits which distasteful money pursuit would have necessitated, so irked him that he would have none of it. We find no patent or commercial record of him in our

Sources; we do have a record that the profitable potentialities of his electrochemical research genius had so impressed certain substantial industrialists that upon his University retirement they tried to lure his services by a $25,000 per annum salary bait. This was a sincere and attractive offer for one whose remunerations had always been much more modest; but it was promptly declined, because he longed not at all for money, and because he did want to continue his researches in pure and historical chemistry in his own philosopher's way.

Dr. Smith's simplicity in money matters has illustration by many remembered and amusing incidents. Let us repeat just one. It happened upon a rare occasion that there came to Dr. Smith what to him was the large free surplus of about $2000. He paid no attention to it, however. Its safety and unearning worried Mrs. Smith, who finally induced the Doctor to agree that it should be deposited in a certain bank's savings-account; but he made the reservation that she must attend to the opening of the account. This duty, quite in the customary channel, Mrs. Smith performed. The banker impressed upon Mrs. Smith the necessity for the bank to keep Dr. Smith's signature on file; but agreed, that since attention to such a matter would irk Dr. Smith, that Dr. Smith might sign a card and send it to the bank by post. Mrs. Smith duly instructed her husband, who promised to obey; but imagine Mrs. Smith's astonishment when she received a letter from the banker complaining that Dr. Smith had mailed his visiting card to the banker, who protested that the same would not suffice.

Our "Introduction" has served to present the high points concerning Dr. Smith; consultation of the listed details of our "Biographic Sources" provides, by categories, a conspectus of his astonishingly large, varied and important achievements and memorabilia; we have been at pains to show the nature of his ancestral background, of his early training and environment; of his fundamental professional preparation; and of his serenely simple home-life and mental habits. Who and what he was and what his works, have been made apparent; but certain commentaries are still needed to complete the picture sufficiently for the herein purposes.

## THE MAN'S WORKS

From what we have learned, it seems clear that with Edgar Fahs Smith and his works nothing of importance appeared by accident. He and his works liken to a mathematically necessary product of the factors which were known when he early emerges as a young man of the defined lineage, home influence, native environment, school-college-university training, mating and initial vocational, service location. While the product of those definite factors could not have been written in 1876, yet after the close of his long life, it is retrospectively plain that in the fifty-two years of his life extending beyond that year, what happened is just what could have been expected. While anyone's life and works may be considered as products of similar factors, his life is rare, perhaps unique, in that it is a life of world-eminence wherein the factors are clear at age twenty-two; and wherein the accidental plays, if any, an insignificant rôle. This conclusion becomes confirmed if one examines into all of the available biographic material. One finds nothing aberrant. Every fact fits smoothly into the pattern.

To the world broadly, the memory of Dr. Smith is that of an eminent American chemist and professor of chemistry, and of a distinguished head of a great and venerable University—more specifically, that of a pathfinding researcher in electro-chemistry, of a researcher in the chemistry of rarer elements, of the leading pioneer historian of American chemistry, and of a Provost of the University of Pennsylvania.

To the narrower world (yet a large one) of those blessed by intimacy with him, his qualities of sheer goodness remain so bright in memory that by a phenomenon of mental irradiation those qualities tend to blur the broader field of the world's retina of memory.

In particularizing upon the works of Dr. Smith one soon finds that the particulars in world-focus are so largely influenced by those of intimate-focus that due understanding of the former necessitates adequate consideration of the latter. Let us, therefore, proceed with a particularization in which, at desire, personal qualities as well as personal works may appear.

# AS A RESEARCH WORKER AND CONTRIBUTOR IN PURE CHEMISTRY AND IN AMERICAN CHEMICAL HISTORY

The general domain of this most important section of Dr. Smith's memorial has been covered flawlessly by Dr. Marston Taylor Bogert in a masterly Memorial-Service address by him (1928).

Members of the staff of the Department of Chemistry of the University of Pennsylvania have provided for an annual lecture, by some specially invited expert, in any selected field of chemistry. To honor the memory of Dr. Smith, this annual lecture is named, "The Edgar Fahs Smith Memorial Lecture." In 1935 the lecturer was Dr. Colin G. Fink of Columbia University. Dr. Fink presented an excellent survey of Dr. Smith's contributions to electrochemistry. In the belief that other treatment would yield a less valuable result there is next presented, largely verbatim, an appropriate and slightly edited selection from Dr. Bogert's address, amplified somewhat by a quotation from Dr. Fink's lecture. Bibliographic references are omitted because they appear in our section "Biographic Sources."

Dr. Smith's chemical career may be said to fall roughly into the following periods, arranging them in chronological sequence and according to the fields of major activity at the time:

I. Organic chemistry
II. Inorganic, analytical, and electrochemistry
III. Historical chemistry

## I. ORGANIC CHEMISTRY

At the University of Göttingen his research work for the doctorate had consisted in a study of "the trisubstituted benzol compounds and the action of chlorine upon benzyl trichloride," in the course of which he investigated the effect of exhaustive chlorination of benzotrichloride, assisted by intermittent exposure to direct sunlight, and isolated a new chloride of carbon, to which he assigned the formula $C_{21}Cl_{26}$ (m.p. 152°–153°), which was reduced by zinc and sulphuric acid to another new

chloride, $C_{22}HCl_{25}$ (m.p. 102°), or by sodium amalgam to various unidentified products.

Heated with aniline at 180°, it yielded a new crystalline and very easily soluble base, the constitution of which was not determined.

After standing for twelve years, the m.p. of this $C_{21}Cl_{26}$ compound fell to 101°, although its percentage of carbon and hydrogen remained approximately the same. (Smith and Keller)

Salicylic acid was one of the organic compounds under investigation in the Göttingen laboratory during Dr. Smith's student days there, so that it is not surprising that we find him directing his own attention next to this interesting acid and its isomers, and in 1877 he published a paper "On a dichlorsalicylic acid and on monochlorsalicylic acid," in which he observed the formation of a dichloro (m.p. 212°–214°) and a monochloro (m.p. 172°) salicylic acid when chlorine was passed into an acetic acid solution of salicylic acid. Salts and other derivatives were prepared of both of these chloro acids.

This work was an attempt to duplicate the results obtained by Rogers (*Inaug. Diss.*, University of Göttingen, 1875), who, by similar treatment of salicylic acid, secured a dichloro acid of m.p. 224°.

Smith's acids were proven subsequently, by other investigators, to be the 3, 5-dichloro and 5-monochloro derivatives. In association with Hoskinson he showed that this same 5-chlorosalicylic acid (m.p. 172°), when treated with bromine in alcoholic solution, gave a bromochlorosalicylic acid (m.p. 229°), from which various salts and esters were prepared. He found, further, that the corresponding bromosalicylic acid, when iodinated in alcoholic solution by the method of Weselsky, yielded an iodobromosalicylic acid (m.p. 208°–209°), from which he also prepared certain salts and the methyl ester.

With Knerr he proved that 5-chlorosalicylic acid could be converted into the iodochlorosalicylic acid by the action of iodine in alcoholic solution, in the presence of oxide of mercury; but that, in the absence of the latter the product was the iodochlorobenzoic acid. Many salts of the iodochlorosalicylic acid were described.

As early as 1880 he effected a synthesis of salicylic acid from benzoic acid by heating copper benzoate and water together in a sealed tube for three hours at 180°, or benzoic acid, water, and an ammoniacal solution of cupric oxide at 220°; although the yields in both cases were very low.

The delicacy of the salicylic acid reaction for ferric iron was tested by him by adding an alcoholic solution of the acid to an aqueous one of ferric chloride and it was found that 1/32,000th of a mg. of iron could be detected in this way. With monochloro (m.p. 172°), or dibromosalicylic acid (m.p. 218°), the test was less delicate.

Smith and Knerr discovered that when nitrous anhydride was passed into an ethereal solution of oil of wintergreen, the 3- and 5-nitro derivatives of methyl salicylate were produced and could be separated easily by their different solubility in ether.

It was known already that the action of fuming nitric acid upon 5-chlorosalicylic acid gave a nitrochlorosalicylic acid (m.p. 162°–163°) and 4-chloro-2, 6-dinitrophenol (m.p. 78°–80°) when Smith and Miss Peirce showed that there was formed also in this reaction another chlorodinitrophenol, subsequently proven by others to be the 6-chloro-2, 4-dinitroisomer (m.p. 110°–111°). Smith noted that the 4-chloro-2, 6-dinitrophenol, which differs from picric acid only in having a chlorine in place of one of the nitro groups of the latter, combined directly with aniline and various other bases to beautiful crystalline compounds apparently in the same way and of the same character as the analogous picrates. Ten years later he extended this reaction to other aromatic bases and to anthracene, and also uncovered the interesting fact that dichloronitrophenol does not form similar compounds with aromatic bases or with anthracene, from which he drew the conclusion that at least two nitro groups must be present on the nucleus of the phenol to obtain such products.

Having studied salicylic acid and its derivatives, it was quite natural that he should turn his thoughts also to the isomeric *m*- and *p*-hydroxy benzoic acids, and in 1888 and 1889 he reported the results of his investigations of the actions of the gases from arsenic trioxide and nitric acid upon an ether solution of the ethyl ester of each of these two acids. In the case of the

*meta* acid the products were the 4-nitro ester (m.p. of the free acid, 230°), a trinitro derivative and unidentified substances. From the *para*-hydroxy ester, he obtained a nitro ester carrying its nitro group *ortho* to the hydroxyl, and from this he prepared the free acid (m.p. 184°–185°), certain salts and the amide.

After 1889, his interest in the organic field seems to have waned, as he became more and more engrossed in the problems of inorganic, analytical, and electrochemistry, and it was only infrequently thereafter that he returned to it, to direct an occasional dissertation of some graduate student wishing to pursue his studies in that direction, like that of Seal (1895) on "The action of acid amides upon benzoin," or of Ryan (1897) on "Derivatives of pyroracemic acid"; or a brief research, as that with Hanna entitled, "Observations on derivatives of aconitic acid." In pursuing his researches in the electrochemical field, organic compounds were occasionally selected for the experiments, as in the application of the electric current to accomplish the oxidation of succinic acid (Clarke and Smith), or of toluene (Merzbacher and Smith), its action upon benzoin and benzil (J. H. James), "The influence of substituents on the electric conductivity of benzoic acid" (A. Tingle), and "An electrolytic study of pyroracemic acid (G. W. Rockwell). Finally, organic compounds were tried as precipitants for the separation of inorganic mixtures as, for example, "The action of salicylic acid upon the metallic acids" (J. H. Müller), and the use of "Aromatic bases as precipitants for rare earth metals" (Alice McM. Jefferson).

## II. INORGANIC, ANALYTICAL, AND ELECTROCHEMISTRY

It was to these fields that he devoted the major part of his fifty-two years of active research and an immense amount of valuable work was accomplished.

### A. Electrochemistry

Perhaps his most important contributions were those he made to electrochemistry, a domain in which he was a pioneer and soon became a recognized leader of international reputation.

In the hands of this master craftsman, the electric current became a tool of undreamed-of usefulness and possibilities, opening up wholly new methods of analysis, separation and determination. About half of all the research papers he published were based upon new applications of the electric current. His introduction of the rotating anode together with the employment of currents of high amperage and high voltage, marked a new epoch in the development of electroanalysis. His books on electrochemistry quickly became and have since remained the standard texts in this country, while the Harrison Laboratory was soon known throughout the world for its leadership in this branch of chemistry.

Dr. Smith's first papers on electroanalysis appeared in 1879 in the *Proceedings of the American Philosophical Society* and in the *American Journal*. Other papers on the same topic followed at frequent intervals from that time on, but it was not until 1901 that a radical change in Dr. Smith's method of electroanalysis was introduced. In that year while experimenting on the separation of tungsten from molybdenum Dr. Smith came upon the idea of rotating the anode. He discovered that "by causing the anode to rotate at a high speed, greater current intensity and higher voltage might be applied with an attending, more rapid precipitation of the respective metals."

Then followed the detailed experiments of F. F. Exner, a student working under Dr. Smith's direction. Exner's Ph.D. thesis was published in June, 1903, and the results recorded "were of such remarkable character that many chemists considered the field of electroanalysis to have been truly revolutionized by them."

Although agitation of the electrolyte by some means or other had been suggested by others besides Dr. Smith, it was he who first suggested the combination of a rotating anode and high cathode current densities. Determinations which had previous to 1901, with stationary electrodes and low current densities, taken two to four hours and more, were now through the findings of Smith and Exner reduced to 5 or 10 minutes. Furthermore, the quantities that could be accurately determined were more than threefold the quantities by the older methods.

If we glance through the numerous records of Dr. Smith and his students, we find that copper determinations were now made in 4 minutes; complete precipitation of cadmium in 10 minutes; bismuth, lead, silver, zinc, nickel, cobalt, manganese, iron, chromium, uranium, thallium, indium, platinum, palladium, rhodium, molybdenum, gold, tin, antimony, tellurium, arsenic—almost the entire periodic table of elements all precipitated, either as metal or as specific compound, in small fractions of an hour instead of several hours. But this is not all—separations of one metal from another could be carried out more readily and more exactly with the use of the rotating anode—a number of the separations not being even attempted previous to Dr. Smith.

In fine, the researches of Dr. Smith, 1901-1903, laid the foundations of all that has followed, and led to our clearer interpretation of the steps in the electrodeposition of metals.

## B. Atomic Weights

The results obtained in the study of numerous inorganic compounds by the older methods and by these newly developed applications of the electric current, led to the discovery of new processes of analytical separation and to the preparation of many elements and compounds in exceptional purity.

This knowledge and these highly purified products were availed of by Dr. Smith and his co-workers in new determinations of the atomic weights of the elements, those fundamental units of our science. New ratios were established with the most painstaking care and accuracy, for comparison with those already in the literature.

For example, Debray had shown, in 1852, that in a current of dry hydrogen chloride, molybdic acid could be completely volatilized as the dihydroxychloride. In the Harrison Laboratory this method was used to expel the molybdic acid from sodium molybdate, leaving only sodium chloride, and also as a means of separating molybdenum from tungsten. This suggested quite obviously a study of the behavior of other metallic oxides when treated similarly, with the consequence that many proved to be volatile not only in dry hydrogen chloride but also in other gaseous hydrogen halides. Such a complete elimination

of certain of the elementary components of a pure compound provided another new way of arriving at atomic weight ratios.

In addition to this method and the electrolytic one of determining these atomic weight ratios, others were invented to meet the needs of special cases.

The elements included in these studies were Ag, Cd, Hg, Sc, V, Nb (Cb), Ta, N, As, Sb, Mo, W, Se, F, Cl, Br, B and Pd, a total of 18, or 20% of all now known to chemistry.

As the methods employed for these important determinations illustrate admirably the type of work then being conducted in the Harrison Laboratory, it will be instructive to consider them for a few moments in somewhat more detail, to appreciate fully the resourcefulness and skill of their directing genius.

### (a) *Electrolytic Methods*

*Silver* is so beautifully and so completely precipitated by the electric current that varying amounts of silver nitrate were electrolyzed in the presence of potassium cyanide, and the precipitated silver weighed. Then silver acetate and silver benzoate were substituted in turn for the nitrate. The general average of these numerous determinations as carried out by Hardin gave the atomic weight of silver as 107.928. The accepted figure today is 107.880.

*Cadmium.*—In 1892, Lorimer and Smith dissolved cadmium oxide in potassium cyanide, electrolyzed the solution, and weighed the metallic cadmium separated. The results indicated an atomic weight for cadmium of 112.055.

Four years later, Hardin and Smith conducted similar experiments substituting anhydrous cadmium chloride and cadmium bromide for the oxide, and obtained a mean atomic weight of 112.045.

The average of all these determinations gave cadmium an atomic weight of 112.048. The figure now accepted is 112.41.

*Mercury.*—Hardin and Smith also electrolyzed mercuric chloride and bromide, in the presence of potassium cyanide, obtaining with the chloride an atomic weight for mercury of 200.006, and with the bromide of 199.883. The electrolysis of mercuric cyanide in platinum dishes gave an atomic weight of

200.071; while the simultaneous precipitation of mercury and silver from a cyanide solution by the same current, gave for mercury the value 199.996. The mean of all these determinations was 199.989. The accepted figure today is 200.61.

*Palladium.*—The determination of the atomic weight of palladium proved to be an exceptionally difficult task. Keller and Smith electrolyzed an ammoniacal solution of palladammonium chloride, plating out the metal on the silver-coated platinum dishes which served as cathodes. The atomic weight of palladium found in this way was 106.914.

Seven years later Hardin heated diphenyl-palladammonium chloride in a current of hydrogen, and obtained an atomic weight of 107.006 for palladium. Using the corresponding bromide, the figure was 107.036. In another series of experiments, he used ammonium palladium bromide instead, and found the value 107.00.

In 1908, Kemmerer heated palladammonium chloride, in an atmosphere of hydrogen and weighed the residual metallic palladium. The results won pointed to a mean atomic weight for palladium of 106.420. Palladammonium cyanide, similarly treated, yielded the figure 106.458. He also undertook to precipitate silver and palladium by the same current, using as anodes pencils of these metals, planning in this way to compare the weights of the two metals separated upon the cathodes and thus to arrive at a direct ratio between palladium and silver. The failure of the experiments was traced to the presence of palladium still in the solutions.

Later, Shinn precipated metallic palladium from an ammoniacal solution of palladammonium chloride by the addition of ammonium formate and by this method arrived at an atomic weight of 106.709 for palladium.

The atomic weight assigned now to palladium is 106.7. In the course of the reductions in a current of hydrogen, it was discovered that great care was necessary to avoid volatilization of palladium double salts and even of the metal itself; while Dr. Smith believed that the somewhat high results of the electrolytic method were not due to occlusion of hydrogen by the precipitated palladium, but to the presence of varying amounts of

derivatives of quadrivalent palladium in the supposedly pure derivatives of the divalent palladium used for the experiments.

*Chlorine and Bromine.*—The quantitative determination of anions by the use of a mercury cathode and a rotating silver anode, was developed to such a high degree of accuracy that Goldbaum decided to make use of it for determining the atomic weights of chlorine and bromine by electrolyzing the corresponding sodium halides and weighing the gain in weight of the silver anode. The results showed an atomic weight for chlorine of 35.459, and for bromine of 79.927; as over against the accepted figures of 35.458 and 79.916.

### (b) *Methods Based upon the Volatilization of Certain Constituents in a Current of Dry Hydrogen Halide*

*Molybdenum.*—When normal anhydrous sodium molybdate was heated to about 300° in a current of dry hydrogen chloride, the molybdenum oxide was removed completely, as $MoO_3$. 2HCl, leaving pure sodium chloride as the residue. By comparing the weight of the residual sodium chloride with that of the initial sodium molybdate, an atomic weight for molybdenum of 96.08 was deduced.

A different method of attack was that of Müller, who succeeded in oxidizing pure molybdenum metal quantitatively to $MoO_3$, and who thus arrived at an atomic weight of 96.03.

The average of these two sets of experiments is 96.055, in comparison with the official figure of 96.0.

*Vanadium.*—McAdam, in the course of his work on the vanadates, exposed sodium metavanadate to the action of dry hydrochloric acid at high temperature, which removed the vanadium and left only pure sodium chloride. The atomic weight of vanadium calculated from these experiments was 50.967, while the figure which has been generally adopted is 50.96.

*Antimony.*—Friend and Smith having discovered that antimony oxide could be removed completely from a mixture by virtue of its volatility in an atmosphere of dry hydrochloric acid, selected potassium antimonyl tartrate as a suitable salt for the establishment of a new ratio for antimony, and an atomic

weight of 120.353 was derived thereby, as over against the present official figure of 121.77.

*Nitrogen.*—Hibbs ascertained that potassium nitrate could be converted quantitatively into potassium chloride by the action of dry hydrochloric acid at high temperature, and used this fact as the basis of a new way of learning the atomic weight of nitrogen. The value deduced was 14.0118. Another series of experiments with sodium nitrate in place of the potassium salt, gave 14.0116. The general average of these two sets, 14.0117, varies but slightly from the value generally adopted, 14.008.

*Arsenic.*—Hibbs was also the discoverer of the fact that arsenic oxide could be removed completely from arsenates by the action of dry hydrochloric acid. Subjecting sodium pyroarsenate to this treatment, and weighing the sodium chloride formed, a mean value of 74.915 was found for the atomic weight of arsenic.

Ebaugh conducted a similar series of experiments with silver arsenate and, from the weight of the residual silver chloride, calculated the atomic weight of the arsenic as 75.004. When the silver chloride was reduced to metallic silver, the weights of the latter obtained corresponded to an atomic weight of 74.975. He subjected lead arsenate to the action of dry hydrochloric acid, and also converted it into lead bromide, the first method giving an atomic weight of 75.022, the latter 75.00.

The general average of all these experiments led to the conclusion that the atomic weight of arsenic was not far from 74.983. The figure accepted now is 74.96.

*Selenium.*—Lenher showed that silver selenite, exposed to dry hydrochloric acid at the proper temperature, lost its selenium completely and left pure silver chloride, from the weight of which the atomic weight of selenium could be calculated. The figure arrived at was 79.325. This figure was checked by reducing the silver chloride to metallic silver, and from the weight of silver obtained, the atomic weight of selenium was deduced as 79.329.

A third method used by Lenher was precipitation of selenium from an aqueous solution of its double ammonium bromide, $(NH_4)_2SeBr_6$, by the action of hydroxylamine. The atomic

weight so obtained was 79.285, making the mean of all these three methods 79.313, in comparison with an accepted value of 79.2.

It is appropriate to recall here that Professor Lenher never lost the inspiration imparted to him by his great teacher or his interest in the chemistry of this particular element, a field in which he soon became a recognized world leader. It is believed that his untimely death was due either largely, or at least in part, to his continuous occupation with poisonous selenium compounds, and that his name should be added to that honor roll of those who have sacrificed their lives in the service of science.

*Fluorine.*—Sodium fluoride was subjected to the action of hot dry hydrochloric acid gas by McAdam and Smith and from the weight of the residual sodium chloride, the atomic weight of fluorine was deduced as 19.015. The accepted value is 19.00.

### (c) *Miscellaneous Methods*

*Tantalum.*—Chapin and Smith, starting with tantalum pentabromide, hydrolyzed this by the addition of water, and evaporated the solution, adding small amounts of nitric acid towards the close of the evaporation, to eliminate all hydrogen bromide. The hydrated oxide so formed was ignited to $Ta_2O_5$ and the latter weighed. From the ratio of the weight of the $Ta_2O_5$ to that of the $TaBr_5$, the atomic weight of tantalum was calculated as 181.80 for the mean of all determinations. The official value is 181.5.

*Columbium* (*Niobium*).—Columbium pentachloride was hydrolyzed by Balke and Smith and the columbium oxide weighed. The mean atomic weight so found for columbium was 93.50.

Later, Smith and Van Haagen subjected sodium metacolumbate to the action of sulphur monochloride and were thus able to eliminate the columbic oxide quantitatively, leaving pure sodium chloride as the residue, from the weight of which residue the atomic weight of columbium was deduced as 93.13. The present accepted international value is 93.1.

*Tungsten.*—This metal and its derivatives have been the subjects of numerous important researches in the Harrison Laboratory. For the establishment of its atomic weight, eight different

methods were used, namely: (1) reduction of the trioxide, (2) oxidation of the metal, (3) weighing the water formed in the reduction of the trioxide, (4) extraction of the water content of barium meta-tungstate, (5) analysis of the hexachloride, (6) analysis of iron tungstate, (7) analysis of silver tungstate, and (8) determination of the water in sodium tungstate. From the figures obtained by these various processes, Dr. Smith was led to conclude that the correct atomic weight for tungsten was not far from 184.05, a figure very close to the present official value of 184.0.

*Scandium.*—The mean value of the atomic weight of scandium, as determined by Lukens, by calcination of the sulphate to the oxide, was 44.33. The international tables give the preference to the value 45.1.

*Boron.*—The determination simultaneously of the atomic weight of fluorine and of boron by Smith and Van Haagen was based on the equivalent quantities of a number of different sodium salts formed by the conversion of anhydrous $Na_2B_4O_7$ through treatment with appropriate acids and repeated evaporation with methanol. From these data and the ratio $Na_2B_4O_7$: 2NaF, the atomic weight of fluorine was calculated as 19.005. The borax used was prepared from pure $Na_2CO_3$ and $H_3BO_3$, the latter obtained by saponification of a carefully rectified methyl borate. Complete dehydration of borax proved difficult, but was finally accomplished by prolonged fusion. The methanol used was secured by hydrolysis of distilled methyl oxalate. The direct conversion of borax into sodium fluoride was found to be impracticable, and was attained through the formate. The atomic weight thus deduced for boron was 10.900, which is about 1% lower than the older value, and it is believed that the previous figure was inaccurate because of the retention of some water by the borax glass. The figure accepted today is 10.82.

### C. Complex Inorganic Acids

Attracted by the brilliant pioneer work of Wolcott Gibbs, and in consequence of certain observations made in extracting large quantities of tungstic acid from its ores, Dr. Smith determined to investigate certain complex inorganic acids and their deriva-

tives. He succeeded in proving that many of those previously regarded as mixtures of isomorphs were actually distinct chemical individuals, and it was this study which caused him to announce that the great family of naturally occurring silicates was not made up of a series of salts of the several simple silicic acids, but really consisted of the alkali and alkaline earth salts of complex silicic acids, in which metallic oxides and silicic acid jointly formed the complex anion, a view which has been accepted quite generally by chemical mineralogists.

Many wholly new analytical separations and determinations were developed in the course of these studies, and a wealth of new chemical information gathered and carefully recorded.

The first of these studies was carried out by Smith and Exner and concerned itself with ammonium vanadico-phospho-tungstate. This was followed up by Rogers who prepared various ammonium salts of complex anions composed of the following oxides: $P_2O_5.V_2O_5.WO_3$, $P_2O_5.V_2O_3.WO_3$, $P_2O_3.V_2O_3.WO_3$, $As_2O_5.V_2O_5.WO_3$, $As_2O_5.V_2O_3.WO_3$, $As_2O_3.V_2O_3.WO_3$, $P_2O_5.V_2O_5.V_2O_3.WO_3$, $As_2O_5.V_2O_5.V_2O_3.WO_3$, $P_2O_5.As_2O_5.V_2O_3.WO_3$, and $P_2O_5.As_2O_5.V_2O_5.V_2O_3.WO_3$, with varying amounts of water. The complexity of such salts is obvious.

In later papers, Rogers and Smith prepared and described ammonium silicoso-, titanoso-, zirconoso-, thoroso-, and stannoso-vanadico-phosphotungstates; and also ammonium vanadico- and vanadoso-tungstates.

Paralleling these studies, Balke and Smith, by analogous methods, obtained ammonium and ammonium silver aluminico-tungstates, ammonium potassium and silicon bismuthico-tungstates.

Brubaker added to this list the ammonium manganico-tungstate; ammonium and barium platinoso-tungstates, platinoso-phospho-tungstates, platinoso-arseno-tungstates and platinoso-vanado-tungstates.

Daniels investigated the aluminico-tungstates of copper, barium, mercury and zinc; the aluminico-phospho-tungstates of ammonium, silver, barium and zinc; the aluminico-arseno-tungstates of ammonium, barium and cadmium; the aluminico-antimonio-tungstates of ammonium, silver and barium.

Further contributions were made by Blum by the preparation and investigation of various phospho-vanado-molybdates.

This brief outline will suffice to give some idea of the labyrinthic character of this chemical jungle into which he penetrated so boldly and the difficulties of blazing clear trails therein.

In addition to the elements studied in connection with these complex inorganic acids and atomic weight determinations, he conducted investigations of numerous others, notable among these being such rarer ones as Be, Cs, Ge, In, Rb, Rh, Ru and Tl.

The field of analytical chemistry was enriched by many new methods of separation and determination, as well as by critical studies of methods already in vogue.

## III. HISTORICAL CHEMISTRY

Great as have been Dr. Smith's contributions to electrochemistry and to the inorganic chemistry of the rarer elements, they are equalled or surpassed by the service he has rendered as historian of American chemistry, the field to which he devoted the riper years of his rich life.

No one has made so many or so important contributions to this field as he, or shown superior literary gifts in the presentation of his material; and in saying this I am not unappreciative of the admirable publications of Thomas Cooper, Venable, Moore, Stillman, and others. His facile pen and clever characterizations have made these chemists of previous years to live and breathe again, and their noteworthy accomplishments, as well as their foibles and fancies, are described in such a natural and interesting manner that the narrative flows on smoothly and delightfully. Many of the chemists portrayed so charmingly and so vividly by him had been "overshadowed, neglected, forgotten."

## ADMINISTRATIVE, EDUCATIONAL, CIVIC, HONORARY, SOCIETIES AND HUMAN ITEMS

There is no occasion to discuss here the truly astonishing *items* of the lists to be found in our adjoined *Biographical Summary* of Edgar Fahs Smith's works and honors. Those lists, being con-

sulted, will speak volumes for themselves. The world always has important service-need and due service-reward for such a man as he; and men who can exemplify his combination of world-service qualities are so rare that employment for them is always at hand.

It were idle to attempt herein, and seriatim, to do justice to Dr. Smith's accomplishments—space alone forbids; one shrinks from inadequacy for his memory; and the cited publications are available to those who will to go further. One may, however, touch upon certain of the high spots; and speak of the determinative human side which underlay Dr. Smith's effectiveness.

All who have written of him have stressed his extraordinary liking for those with whom he came into contact; of their responsive liking for him; and of the fine results flowing from such mutuality. He was no man for backslapping and over-promising. Dignity and conservatism abode with him; but his open, cheery smile and warm hand clasp were also everready, put each one, potent or humble, savant or simple, instantly at ease, autoconvinced him that here was real, spontaneous, kindly and unalloyed friendliness which it would be a pleasure, and privilege to reciprocate in kind—and to do so. It was a feeling akin to that of meeting Santa Claus and having a spontaneous desire to give Santa a present.

Why was this? Because it was no effort for Dr. Smith to be that way. That way was himself. It would have been difficult for him, indeed impossible, save in flashes, to have been any other way. It began with simple piety, a faith in God, and in man as God's chief work. When any one was the other way, Dr. Smith was tolerant, pained, puzzled. He could not understand why any man should be the other way, that surely he must return to the right way—or, if not, it must, like death, humbly be accepted from an inscrutable Providence.

He was a deeply religious man, but with little interest in churchly or creedly matters. It is true that in early life he grew in the Moravian faith, that he was always more of a Moravian than otherwise a sectarian; but it is also true that the United Brethren put their emphasis upon deeds rather than upon beliefs, except the belief in the Highest; and that was

his way. None may think that he wore his piety upon his coat-sleeve. The contrary is the truth. He was shy and retiring concerning himself in any particular. His amiable boldness appeared only for the things which he believed were his to accomplish; but even for them his method was labor and service, rather than controversy. Piety ruled him from within; but outwardly could only be inferred.

Dr. Smith always kept before him, in his office-desk drawer a Bible; a little manual entitled, "Daily Prayers for Moravian Households," (London. Moravian Prayer Union); and the current, yearly, Moravian manual of daily texts. He read daily from each of these books. While he was Vice Provost and Provost of the University of Pennsylvania he conducted, daily at noon, quarter-hour "chapel" services, for those of "his boys" who would attend, in the auditorium of the University's student club-house, Houston Hall, located across the street and lawn from his office. He had the constant and deep conviction that he could do nothing worthy by himself, that it could only occur with God's help. He was daily trying to do something worthy, and so he daily consulted, in seclusion, in his own way, with his Helper; and daylong he tried, still in his own way, to merit that help. There is nothing to show that he felt need for mediation by church or clergy—at least so our Sources tell us; but he had a thoroughgoing respect for the ways of all others in their approach to the Helper.

The University of Pennsylvania stems from the University of Edinburg; and it is due to that history that the University of Pennsylvania has its "Provost." In the years 1898-1911, as Vice Provost, and in the years 1911-1920, as Provost, Dr. Smith served the University administratively as well as academically. His Provostships brought him, inter alia, face to face with money matters. The University had many needs; that meant need for much money; and meant further that he must help to secure it. Perhaps he shrank, but he neither faltered nor failed. Still in his desk-drawer, in the (now) Smith Memorial Room at the University lies his little Moravian manual of daily prayer. Open it, and one finds his markings and notations for his daily chapel services for the students. But, inside the cover, one also finds several irregular slips of paper

with his handwriting upon them, beginning "To the Heavenly Father. Thanks for these." Then follows a memorandum list of many gifts to him for the University and its purposes, by named givers. Dates are not stated but apparently he added a notation of each gift, as it came, to this scraplike little prayer-book list, as his intimate token of thanks to his Helper. To know such revealing things is to know Dr. Smith. Whether the gifts came from Pennsylvania's legislators and executives, or from philanthropic foundations, or from the wealthy or the unwealthy, alive or by devise, they all came by God's help. One can almost see the good Doctor alone in his quiet study, adding a new item upon his little slips of paper, reading his daily prayer and believing his Helper to be there with him.

As Dr. Smith labored in it, and for it, the great University which came to him from Benjamin Franklin's seedling, waxed mightily; when he surrendered its headship to his successor, he had high reason to feel serene; and all who comprise the University, intramurally and extramurally, had high reason for their thankfulness and reverence that Edgar Fahs Smith had so loved and so nourished their academic arbor.

The Provost's home was a small housekeeping apartment in the "Avondale," a few squares from the Harrison Laboratory. Mrs. Smith still resides there. Occasionally there was a maid-servant. Breakfast there was customary. Luncheon was anywhere by the chance of the workday life—mayhap a sandwich which the goodman carried from the home in his pocket—mayhap excellent club luncheons for out-of-town or University-business guests. He was a member of several prominent Philadelphia clubs, so that he could meet there with persons of large affairs and play the rôle of host appropriate to one of his high office. He was a good host; and knew how to make his hospitality enthuse all degrees of his guests, from gourmet to blue-stocking. Himself, was abstemious, because he liked substantiality rather than luxury; but he knew, as host, just how to partake to his own best enjoyment and to that of his guests. Dinner was anywhere that was agreeable to Mrs. Smith or necessary in University affairs. This simple home, and mode of life, did not please the alumni, who held Dr. Smith and the University so dearly, and who believed that his comfort and

the dignities concerned called for an official Provost's mansion.

Consequently there was instituted a "drive," resulting in the mansion and in an endowment for its care. This did not please Dr. Smith; and he would not leave his simple apartment home to live in the dignified mansion provided for him—the Alumni could alter his opportunities, but could not alter the Provost.

The Doctor arrived at the Harrison Laboratory about eight o'clock in the morning, and departed at six o'clock in the evening, upon the days when his many duties did not require him to be elsewhere. This was a good example but not copied elsewhere in the University so far as yet reported. However, he did not intend his workday to be an example. He merely wanted to get the most out of his own time. It was no effort for him to do this. It would, to him, have been irksome to have done otherwise.

One of his great joys was "his boys." This was his name for all of his present and former students. His attitude toward them was that of a fond, but not too indulgent, academic father; and students and alumni responded in filial reverence. He greeted hundreds by their first names as soon as he saw their faces—even years after completion of their stays at the University. How he remembered was a mystery to all—including himself. When asked, he would say that he didn't know, that he made no effort to remember, but that remember he did.

He was a fine public speaker, daily addressed groups of his boys, and anywhere, anytime, on any occasion, his addresses were profitable, convincing and enjoyable to his auditors. His facility was a natural gift, which his excellent early training in the classics and the humanites culturally developed, and which his walk in life called into large practice. He probably could have been a success as a dramatic actor or writer. The celebrated Shakespearean scholar, Dr. Horace Howard Furness, characterized him as a "master of concise expression."

He had wide acquaintance with public and political personages and persons. They liked him thoroughly, and had complete confidence in him, as attested by the various important public commissions to which he became appointed. He liked them, as he liked all men; and, patriotically, liked to serve upon special-service "nonpolitical" public commissions. He was a Republican

as befitted a lad from York's Civil War period; but he disliked unreasoning, unholy, contentious, partisanship just as he disliked anything unreasonable, unholy or destructive. During the general time of that trend for the educator in politics which put Woodrow Wilson into New Jersey's Gubernatorial seat, and later into the White House, and put Martin G. Brumbaugh, Philadelphia's respected Superintendent of Schools into the Governorship of the Commonwealth of Pennsylvania, powerful political leaders, his friends, strongly urged Dr. Smith to accept their aid toward the Governorship of Pennsylvania, because they felt that the State needed his type of service. But he would have none of a kind of service which he believed would sever him from those peaceful and fruitful services which he loved, to plunge him into a turmoil which he heartily disliked. This incident is only another illustration of his simple devotion to his own well-chosen way of life.

Dr. Smith's labors and accomplishments loom so hugely, that there must arise the questions: how could he accomplish so much; and, had he no avocation or recreation? If those questions had been propounded to him, his answer to the first would have been, "By God's help"; and his answer to the second would have been "Plenty." Our answers are: to the first question, "He was fit, did not remit, and the very fact that he did it proved that it can be done"; to the second question, "Much that he did, of those doings we have listed, was play to him; and he did various other things, which we have not listed, all of which to him were recreative."

He ever spoke of his collection of memorabilia and of his researches and writings in historical chemistry as "play." The time, energy, study and thought which he gave to his historical collections and writings, could well be regarded as being quite as vocational as his educational and research activities; but to him all of this was avocational and restful.

He was also much interested in collecting early American stipple prints. His collection of stipple prints from plates by the esteemed engraver, David Edwin, is nearly complete, and is regarded by collectors as one of the best extant. It had nothing to do with chemistry; but only to do with art and with

well known personages of the past. This hobby constituted a favorite avocation, and probably an expensive one.

He had an active interest in Freemasonry; and attained to its thirty-third and last degree, which implies that he did much masonic "work." To him, Masonry's ancient, benign, reverent symbolism, discipline and orderliness appealed strongly; and became a recreative retreat.

His real labors were in and for education and research. All else to him was recreative—his activities in societies, conventions and whatnot had that quality for him.

"What!", it is asked, "did he have no downright relaxation, the kind for you and for me?" The answer is, "He did have that kind." He especially enjoyed professional baseball games; and his Kneipe in the companionship of a few select old academic comrades. He was always sturdy, and in his youth he was an ardent baseball player; and an able pitcher in his local sandlot league. He could tell his good friend, that Nestor of baseball, Connie Mack, a lot about baseball celebrities and statistics; and could listen eagerly to baseball lore new to himself. He often attended professional baseball games when he could find the time during his mature years; and when he got too busy for that, he read the baseball news like any other "fan." He kept so closely in touch with baseball doings, that Rogers, the faithful old diener of the Harrison Laboratory, especially during a "World Series," had to be careful to read the late afternoon papers before going near the beloved Doctor's door at quitting-time, for he was pretty sure to be called upon for the final scores. However, the diener was a "fan" too, which was the good reason for his summons, diverting alike to Vorstand and Hausmeister.

The Kneipe was, of course, of the sedate German university type, with a modicum of helles or dunkeles; with no smokes for Dr. Smith, who did not use tobacco; and with much random discussion, gentle banter and reminiscences of older chemists and of bygone but dearly remembered University days. Would that that select little group of scholar-boys still in session were; and that you and I might sit with those rare old comrades in that Wolfbräuhaus in the City of Brotherly Love.

The curtain was drawn upon this well-nigh perfect life of right-living and superservice to fellow-man, in the hospital of

the University of Pennsylvania, following a brief pneumonitis, May 3, 1928. As in mind's eye we see it drawn, we think of the words of the sixth Beatitude, "Blessed are the pure in heart, for they shall see God."

## BIOGRAPHIC SOURCES

### I.

*The Edgar Fahs Smith Memorial Collection in the History of Chemistry.* This collection, regarded as one of the most notable in the world, was begun early in Dr. Smith's professional life as his favorite, sustained, avocation; and by his fond and unremitting efforts and, for his limited means, heavy cost, had grown to unique excellence before his death. Thereafter it became endowed by Dr. Smith's widow. Located during Dr. Smith's lifetime in his offices in the Harrison Chemical Laboratory of the University of Pennsylvania, it has there, by the joint support of Mrs. Smith, of the University, and of a number of devoted chemical friends, become permanently and conveniently available to the scholarly world; is progressively becoming worthily augmented; and constitutes a singularly appropriate and useful memorial to its eminent founder. He was too modest a man ever to have dreamt of his collection as fated to become a living, permanent and waxing memorial of himself; but such was his affection for historical chemistry, and such his fatherly care and pride for his own collection of chemical memorabilia, that no other memorial to him could have been so suitable. To him it would loom as the enduring, useful, life of a loved child of an otherwise childless, but completely fatherly, man.

In addition to that entirely general, and impersonal, character with which Dr. Smith regarded and constructed his memorial collection, the collection since his death has been continuously enriched with all known or available memorabilia of his own venerated self.

The collection now comprises a cataloged collection of approximately one thousand volumes relating to alchemy and chemistry, dating from the fifteenth century; one thousand related portrait prints and engravings; six hundred related autograph letters and manuscripts; some apparatus used by noted chemists of the past (Joseph Priestley's balance having been one of Dr. Smith's most prized possessions); and memorabilia of the founder. The curator, Miss Eva Armstrong, who was Dr. Smith's private secretary and aide during the last nineteen years of his life, gives her undivided time and attention efficiently to the collection and to the assistance of those who consult it. Her assistance with material for this National Academy of Sciences Biographical Memoir of Dr. Smith is appreciatively acknowledged.

### II.

A volume of sixty-two pages, prepared and printed by friends of Dr. Smith, and entitled: *"Memorial Service for Edgar Fahs Smith";* "The

Provost of the University Presiding"; "William B. Irvine Auditorium, University of Pennsylvania"; "December 4, 1928."

This volume contains: "Biographical Summary"; Invocation by the Reverend Richard Montgomery, reading in part, "that the memory of our beloved Provost, our teacher, may long continue within these walls, to be an incentive to the men who teach, to be an inspiration to the men who study, and that out of his life still may come the influence which tends to Thy honor and glory and the good of mankind"; memorial address by the late Dr. Francis Xavier Dercum, then President of the American Philosophical Society, a scholarly, personal and broad, appreciation of Dr. Smith; memorial address by Dr. Marston Taylor Bogert, a masterly presentation of the personal character and general services of Dr. Smith, and details and analytic critique of the whole of Dr. Smith's chemical labors; memorial address by Dr. Josiah Harmer Penniman, Provost of the University of Pennsylvania, a graceful, felicitous and lettered appreciation by Dr. Smith's former associate in faculty and as Vice Provost, and successor as Provost; and nearly complete, chronologic, bibliographies of Dr. Smith's sixty-five single scientific papers, one hundred eleven coauthorship scientific papers, thirty-five brochures and volumes on American chemical history, thirteen original and translated chemical texts, and eighty-seven doctorate theses in chemistry, inspired, suggested and counseled by Dr. Smith. These bibliographies are presented below.

## III.

*"The Edgar Fahs Smith Memorial Number"* of the *Journal of Chemical Education*, IX, No. 4, April (1932). This number (pp. 607-750) contains various illustrations and one hundred forty-four pages relating directly or collaterally to Dr. Smith. Those pages relating directly to Dr. Smith contain bibliographies like those mentioned under Caption II; and thirty-one pages of biographic and memorial articles; partly reprinted in whole or part from other publications, partly quotations from Mrs. Smith, Dr. Allen J. Smith, and Miss Eva Armstrong, partly editorial by Dr. Lyman C. Newell and Dr. Harrison Hale, and articles by Dr. Walter T. Taggart, Dr. Josiah H. Penniman, Dr. C. A. Browne, Dr. Charles L. Parsons, Dr. Owen L. Shinn, Dr. Allen Rogers, Miss Eva Armstrong, Dr. Neil E. Gordon.

This *Memorial Number* also furnishes a Source list (p. 665) as follows:

### "BIOGRAPHICAL ACCOUNTS ON EDGAR FAHS SMITH, APPEARING SINCE 1928

BROWNE, C. A. "Edgar Fahs Smith, 1854-1928," J. CHEM. EDUC., **5**, 656-63 (June, 1928).

TAGGART, WALTER T., "Edgar Fahs Smith," *Science*, **68**, 6-8 (July 6, 1928).

BROWNE, C. A. "Edgar Fahs Smith, 1854-1928," *Isis*, **11**, 375-84 (Dec., 1928).

DERCUM, FRANCIS X., "Edgar Fahs Smith," *Ibid.* MARSTON T. BOGERT. *Ibid.* JOSIAH H. PENNIMAN, "Memorial Service for Edgar Fahs Smith," University of Pennsylvania, December 4, 1928.

"Some Experiences of Dr. Edgar Fahs Smith as a Student under Wöhler." (As recorded by W. MCPHERSON.) J. CHEM. EDUC., **5**, 1554-7 (Dec., 1928).

HILDEBRAND, J. H., "Edgar Fahs Smith," *Bull. soc. chim. ind.*, **1929**, 22-5.

BOGERT, MARSTON T., "Edgar Fahs Smith—Chemist," *Science*, **69**, 557-65 (1929)."

IV.

Another Source is an interesting typewritten brochure, *"Reminiscences of Professor Edgar Fahs Smith,"* unpublished, prepared by Dr. Charles Albert Browne from his private journals, for preservation with the other memorabilia of Dr. Smith. These reminiscences concern many personal meetings, 1920-1927, and conversations between two fellow-spirits in chemical-society and chemical-history activities. They are informal, intimate, frank and engaging; and furnish illuminating, "off-the-record," flashes of Dr. Smith.

V.

Still another, and intimate, Source is the author's many *Personal Contacts, and Correspondence,* with Dr. Smith, his kindred and friends—extending over the past sesquidecade.

## DEGREES

IN COURSE: Bachelor of Science—Pennsylvania College (Gettysburg), 1874; Master of Arts, Doctor of Philosophy—University of Göttingen, 1876 (reaffirmed as an honor, 1926).

HONORARY DOCTORATES: *Science*—University of Pennsylvania, 1899; University of Dublin, 1912; Yale University, 1914; Lafayette College, 1924; Wittenberg College, 1927. *Chemistry*—University of Pittsburgh, 1915. *Medicine*—University of Pennsylvania, 1920. *Humanities*—Muhlenberg College, 1911. *Literature*—Swarthmore College, 1918. *Laws*—University of Wisconsin, 1904; University of Pennsylvania, 1906; Pennsylvania College, 1906; Franklin and Marshall College, 1909; Rutgers University, 1911; University of Pittsburgh, 1912; University of North Carolina, 1912; Princeton University, 1913; Wittenberg College, 1914; Brown University, 1914; Allegheny College, 1915; Queen's College (Ontario), 1919; Temple University, 1922; Dickinson College, 1925.

## ACADEMIC OFFICES

Instructor in Chemistry, University of Pennsylvania, 1876-81; Professor of Chemistry, Muhlenberg College, 1881-83; Professor of Chemistry, Wittenberg College, 1883-88; Professor of Analytical Chemistry,

University of Pennsylvania, 1888-91; Professor of Chemistry, University of Pennsylvania, 1891-1920; Emeritus Professor of Chemistry, University of Pennsylvania, 1920-28; Vice-Provost, University of Pennsylvania, 1899-1910; Provost, University of Pennsylvania, 1910-20.

## ACADEMIC AND LEARNED SOCIETIES

Memberships, etc.: National Academy of Sciences; Society of Chemical Industry; American Philosophical Society (President 1902-08); American Chemical Society (President 1895, 1920-21); American Association for the Advancement of Science; History of Science Society (President 1928); Phi Beta Kappa; Sigma Xi; Phi Kappa Psi.

Honorary Memberships: Philadelphia College of Pharmacy and Science; American Electrochemical Society; American Chemical Society; Société de Chimie Industrielle (France); American Institute of Chemistry; Chemical, Mining, and Metallurgical Society of South Africa.

## MEDALS AND DECORATIONS

Elliott Cresson Medal, Franklin Institute (for distinguished contributions to chemistry), 1914; Chandler Medal, Columbia University (for contributions in the field of historical chemistry), 1922; Officer of the Legion of Honor of France (for distinguished services to chemistry), 1923; Priestley Medal, American Chemical Society, 1926.

## APPOINTMENTS

Jury of Awards, Chicago Exposition, 1893; United States Assay Commission, 1895, 1901-05; (by President Harding) Board of Technical Advisers, Disarmament Conference and (Chairman), International Committee on Poison Gas and High Explosives; Electoral College for Pennsylvania, 1917, 1925 (President 1925); Commission for Revision of Constitution of Pennsylvania, 1919; College and University Council of the State of Pennsylvania, 1911-20; State Council of Education, 1920-22; Carnegie Institution (Adviser in Chemistry, 1902; Research Associate, 1915, 1918-24); Carnegie Foundation (Trustee 1914-20); Wistar Institute of Anatomy and Biology (President 1911-22).

## BIBLIOGRAPHIES

The following abbreviations are used for journals listed several times:
*ACJ*—American Chemical Journal.
*AJS*—American Journal of Science.
*APSP*—American Philosophical Society Proceedings.
*ASS*—Archivio di Storia della Scienza (Italy).
*BdcG*—Bericht der deutschen chemischen Gesellschaft (Germany).
*CN*—Chemical News.
*JFI*—Journal of the Franklin Institute.
*JACS*—Journal of the American Chemical Society.

*JAAC*—Journal of Analytical and Applied Chemistry.
*JCE*—Journal of Chemical Education.
*JIEC*—Journal of Industrial and Engineering Chemistry.
*NASM*—National Academy of Sciences Memoirs.
*PM*—The Pennsylvania Magazine of History and Biography.
*PANS*—Proceedings of the Academy of Natural Sciences, Philadelphia.
*S*—Science.
*TAES*—Transactions of the American Electrochemical Society.
*ZaC*—Zeitschrift für anorganische Chemie (Germany).

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