(5) Sources of research material (1).
(6) Readings in literature of research.
(7) Orientation in the various sciences and fields of endeavor (9).
(8) Aptitude tests and personal problems (2).
(9) Elementary principles of statistical methods (4).
(10) Semantics (4).
(11) Logic—with particular reference to fallacies (2).
(12) Presentation of research reports (1).

Obviously, such a course could not be handled by any one instructor; it should be handled by the leaders or best speakers in the various fields. One of the by-products of this would be considerable vocational orientation or guidance.

The numbers in parenthesis cover, tentatively, the number of weeks' study that I would devote to each of the various general topics.

This course is not presented as a panacea or cure-all—but it can help do some of the things that James McKeen Cattell fought for for over fifty years—and which Dr. Carlson advocates to-day—extend the use of scientific methods.

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STARRING SUBJECTS IN "AMERICAN MEN OF SCIENCE"

IN view of the long service rendered by J. McKeen Cattell to science in our country it would seem appropriate to devote considerable space to his life work in SCIENCE. I would be especially interested in a discussion of the advantages of starring men in "American Men of Science." It seems to me that it is very important for the progress of science that the achievements of those working in this field should become known more widely and more reliably than is now customary.

If the methods adopted by J. McKeen Cattell can be replaced by better ones it is highly important that this should be done. I realize that it is very difficult to find methods of procedure which will be generally acceptable, but this does not seem to be a sufficient reason for not considering the possibility of improvement. I have heard many favorable comments on the success of J. McKeen Cattell along this line, and it seems to me that we could honor him mostly by considering the possibility of improvements of his methods.

G. A. MILLER

SCIENTIFIC BOOKS

WILLARD GIBBS

Willard Gibbs. By MURIEL RUKEYSER. xi + 465 pp. New York: Doubleday, Doran and Company, Inc. $3.50.

I HAVE always found it hard to write about Willard Gibbs. Neither my brief biographical sketch in the Dictionary of American Biography nor my Gibbs Lecture before the American Mathematical Society seems to me quite satisfactory. It may be a significant fact that in the forty years since his death none of his pupils, colleagues or friends have written so extensively about him as an English science writer, J. G. Crowther, or a native poet, Miss Rukeyser, whose whole background seems very remote from that of Gibbs.

There are two excellent biographical notices of Willard Gibbs. The one first published is by H. A. Bumstead, his pupil and colleague for the last decade of his life; it prints fifteen pages at the head of the first volume of "The Scientific Papers of Willard Gibbs." The second is by C. S. Hastings, who was his pupil during the first year of tenure of his professorship of mathematical physics, and who, except for a brief period of service away from Yale, was his colleague until the time of his death; it fills about twenty pages of volume 6 of the "Biographical Memoirs" of the National Academy of Sciences. These two notices represent Gibbs as I knew him better than I can; they deserve the most careful study by all who would know him as he appeared to his contemporaries, old or young.

The sixty-five pages Crowther devotes to Gibbs leave me rather cold. They constitute an interpretation rather than a biography, and much of the interpretation seems very dubious. The start is from: "The problem of Gibbs is the discovery of the explanations of his simultaneous greatness and obscurity, the nature of his own work, the influence of his personal psychology and social environment, and the social history of the United States."

One who sets himself such a task can hardly do otherwise than mold objective facts to his subjective philosophies. So far as I can see, Gibbs never suffered obscurity in matters that really counted—professor at 32, subject of Maxwell's praise at 35, elected to the National Academy at 40, called to Johns Hopkins a year later, recipient of the Rumford Medal within another year, he seems not at all to have suffered the fate of Gregor Mendel or Hermann Grassmann.

Later Crowther writes: "Is it possible that Maxwell's intelligibility was a reward for social conscience, and that Gibbs's unintelligibility was a penalty for the belief that he had no duty to ensure that his discoveries were understood and used?"

As to intelligibility or unintelligibility let me say that in the days when I was teaching Maxwell's electromagnetic theory and Gibb's thermodynamics I cer-

tainly did not find that the former's "Electricity and Magnetism" was any more intelligible than the latter's "Equilibrium of Heterogeneous Substances." It is likely that such great new syntheses can not well be entirely perspicuous. Was Newton's "Principia" quite intelligible to his immediate contemporaries?

The psychoanalytic interpretation which Crowther offers for some of Gibb's characteristics and the statement that his mouth has a petulant, disagreeable curl (in a reproduction from an early daguerreotype) seem to me not only highly speculative but extremely doubtful. I have examined the original daguerreotype with care but can see no petulance, and as to mother fixation, transference to an elder sister, symbols of persistence of his father's authority, and the disappointment of an unconscious psychological motive, I can only say that nothing I ever heard about Willard Gibbs gives me any inkling that Crowther is on sound ground.

The attention given to Crowther's essay is a necessary precursor to Miss Rukeyser's work because she leans so heavily upon him. In place of his sixty-five pages she gives us four hundred and fifty, diluted with more (and more exaggerated) interpretations and inflated with much matter alien to the story of Gibbs and his work—Melville, Whitman, Percival, J. Q. Adams, Henry Adams and William James figure at considerable length. The book is the author's interpretation, not only of Gibbs and his work, but of the sweep of American history from before his birth to the present time. It is different history from any I have read and a different Gibbs from him I knew. The author is a literary woman rather than a historian or scientist; she states as facts a great many things she can not possibly know, such as what some one felt or thought on a given occasion, even though there be no record to indicate it. As fictionalized biography has a great present vogue, many must like it and some may even consider this one "thrilling" in the places where it is best written, though I should think any one must consider a good deal of it as both badly written and boresome.

Miss Rukeyser starts her book with a frontispiece portrait of Gibbs which is new to me and which I should never have recognized. On the flyleaf she places a quotation from William James: " 'They laugh best who laugh last.' Wait until we are dead twenty years. Look at the way they're now treating poor Willard Gibbs, who during his lifetime can hardly have been considered any great shakes at New Haven!"

Whether it is fair to take this quotation out of its context, I doubt, but it surely fits the author's purpose of drawing Gibbs as a prophet without honor in his own university or country. For over forty years I have discussed this matter with many persons and find few who consider it a just judgment.

> In livery, driving
> his sister's coach in the city.

So wrote Miss Rukeyser in her poem on Gibbs. She now takes this back in the sentence: "And the legends grew, until people would come to say that Willard Gibbs wore livery driving his sister to market, which was not only a lie, but ridiculous to anyone who knew the circumstances of New Haven, or the family, or the gentle habits of these people."

Nevertheless, she does not take back the general implication of Gibb's subordination to his sisters and, as in other passages in her poem, she maintains *à l'outrance* the thesis that he avoided life and living:

> Silent, inhibited, remote [p. 4].
>
> Gibbs tore himself down until his life was nothing but self and science, and then he tore the self away [p. 6].
>
> . . . a careful withdrawal from personal life, a careful destruction of personal tokens [p. 12].
>
> Hesitation had come to be a deep current in his life [p. 220].
>
> That was the pale life,—whose letters were torn up, burned, anyway destroyed [p. 430].
>
> All the burden of withdrawal has been his [p. 433].
>
> He carried the tragedy of his own restraint, and it grew into an immense and jungle growth [p. 436].

May the author live to recant also this exaggeration, calling it lies and ridiculous!

So far as those who knew him could judge Gibbs was one of the most happy and serene of persons. I can not do better than to quote Hastings:

> Nothing is more difficult in a biographical memoir than to give the reader a definite impression of the personal characteristics of an eminent man, of those characteristics which make the man in the eyes of such of his contemporaries as are unable to estimate him by his works. On the other hand there is no more legitimate curiosity than that which prompts us to seek such information about a man who has impressed himself upon his times by his essential greatness. In many cases a mere accumulation of incidents in the life of one who has numerous points of contact with his fellow-men is all that is necessary for a discerning reader; but with one whose activities are chiefly intellectual this is often difficult, and particularly so with Professor Gibbs, who seems never to have sought or desired a wide circle of acquaintances. But we should greatly err if we concluded from this that Mr. Gibbs was of an unsocial nature. To me he always appeared quite the opposite—perfectly friendly and approachable, ready to talk on any subject, and always equable, he exhibited a flattering welcome to every friend. Effusiveness was as foreign to his nature as insincerity, but cordiality was never wanting. He laughed readily and possessed a lively sense of humor.

There is one thing I might add. Time was when we did not so much concern ourselves with superficial "personality" or behavior as with the substratum called character, and when we believed that the university,

the church and the courts, however so much they might profit by talent, served their essential social purposes chiefly through the integrity of character of their personnel, through uprightness, sincerity and faithfulness to principle. It was the high character of Willard Gibbs that impressed me even more than his great talent.

Miss Rukeyser says of him:

> His faith lay in a few often repeated words which come down through the memory of his friends, his friends' children, his students:
>
> "Mathematics *is* a language."
>
> "The whole is simpler than its parts."
>
> "Anyone having these desires will make these researches."

I can not recall that Gibbs was ever trite or hackneyed; if he repeated these or similar sayings often, it certainly was not in my hearing; indeed I never before heard any one suggest that he made the third of these statements.

Miss Rukeyser tries hard to give an intelligible account of Gibbs's contributions to science. It is a difficult task. I shall not attempt to assess failure and success of this effort at popularization; I should, however, like to refer to two items:

> 1. This was a man whose acceptance of his culture seemed to stop short only at the borders of his scientific labor.

I believe that Gibbs's "acceptance of his culture" was as clear in his scientific work as it could have been anywhere else—neither more nor less. His work was done in that great period of culmination of the victories of Newtonian mechanics. About two hundred years after the "Principia," we find among other important contributions that, in the decade 1870–1880, Lord Rayleigh published his elegant "Theory of Sound," Maxwell his "Electricity and Magnetism," Gibbs his "Equilibrium of Heterogeneous Substances." Gibbs applied, with great care and exceptional intuition and with very wide acquaintance with physicochemical facts, the concepts of equilibrium mechanics, particularly the technique of virtual work, to systems that were heterogeneous, specifying with precision the conditions that must hold for the great variety of infinitesimal displacements from a state of equilibrium which were possible when the substances were heterogeneous.

> 2. As the influence of Gibbs's work grew, the tragic waste, directly or indirectly traceable to ignorance of the laws he had stated, became more dramatic. The most heroic appearance is the story found in full detail in the heartbreaking record of Captain Scott's expedition to the South Pole during the iron winter of 1912. Crowther repeats the belief that Scott and his party died through ignorance of the phase rule.

Crowther's statement is:

> It is said that the lives of the English explorers, Captain Scott and his party, were lost in the Antarctic, owing to ignorance of the phase rule. When they started on their return from the South Pole, they found the fuel oil can in one of their depots was empty. The solder of the can contained tin, which may exist in different phases. At low temperatures block tin may fall into powder, and cans soldered with it become unsealed. This appears to have happened to the cans upon which Scott depended for survival.

I can find nothing in the writings of Gibbs, all of which I have reread since undertaking this review, which would serve to predict what new phases will occur. He states in several places that this sort of knowledge must come from observation. He says nothing about tin, let alone solder, which contains a good deal of lead. Moreover, he emphasizes the existence of passive resistances to change of phase which permit substances to exist in states far beyond the limit of absolute stability.

I can find no evidence in the literature or from private advices which I have sought widely that in fact solder in cans does degenerate in the cold. Moreover, the rather competent scientific observers of the expedition report in the official account that the tins at the depots awaiting the Southern Party had been opened and the due amount to be taken measured out by the supporting parties on their way back, and they attribute the lack of fuel to evaporation or leakage through the stoppers.

However, this "heart interest story" is now in the literature through the statements of Crowther and Rukeyser and may well remain in it a long time; so, too, I fear, will a lot of other errors about Gibbs and his work which Miss Rukeyser has incorporated in her fictionalized biography, and for which I can see no excuse even in her political or social or emotional ideas or ideals.

Without extending the review to quite impracticable length, it would be impossible for me to list the items which I believe to be wrong, and in many cases it would be entirely out of the question to determine whether they were wrong. For example, she writes in connection with Gibbs's death: "His digestion had always bothered him, and suddenly he suffered a violent and acute attack." What may be her authority I can not guess. So far as my information goes Gibbs's digestion had always been satisfactory. His fatal attack, diagnosed as intussusception, need not have been and I believe was not preceded by any considerable premonitory period of indigestion. It is certainly not true to claim that he was a weak and sickly person. Yet that impression is so much created by Miss Rukeyser that one reviewer says of him that he prob-

ably would have found it difficult to drive a nail straight or hang a picture. This is entirely untrue—Gibbs had useful hands, but we all have heard of the fable of the three black crows! Truth grows by the application of controlled imagination, and untruth by imagination uncontrolled.

It was my privilege as a young man to become acquainted with a considerable number of distinguished scholars of the generation of Willard Gibbs who seemed to me to be much alike in their simplicity, dignity and friendliness—gentleman of the old school we youngsters called them. They did not wish to be hero-worshipped, they were not patronizing, they did not proselytize, they were living examples of what the best in university life has been, is now, and will be so long as there are youth who are inspired by such examples to try to become in all simplicity worthy successors to them.

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REPORTS

WARTIME INVESTIGATIONS AT MELLON INSTITUTE

IN the industrial research proceedings of Mellon Institute during its fiscal year from March 1, 1943, to March 1, 1944, as set forth in the thirty-first annual report of the director, E. R. Weidlein, there are many facts of professional interest. As the following summary reveals, the emergency has raised the levels of investigational capacity and thereby has increased research usefulness.

OUTSTANDING CERAMIC RESEARCH RESULTS

The physical and chemical treatment of gypsum, for its improvement and for obtaining new products, has been given thoroughgoing study during the past five years, with especially valuable results in 1942–3. The use of gypsum in the manufacture of light-weight refractories has been extended. An investigation of mottled or colored silica brick has been described and definition has been made of the effect of furnace gas pressure on the life of refractories. A number of urgent wartime high-temperature problems have been solved by the use of "Carbofrax" and "Monofrax." A new apparatus has been contrived for aging dry cold-set mortars. "Garsand," a novel glass-making material, was introduced. The multiple industrial fellowship on ceramic chemicals has been devoting the full time of its enlarged staff to research on problems in wire-wound resistors. Eight fellowships in all are in the field of ceramics.

ACHIEVEMENTS IN METALLURGY

Many effectual war implements have been formed by metallurgical studies on thirteen fellowships of the institute. Fundamental relations within the foundry cupola have been examined critically. Iron compacts of improved physical properties are a contribution to powder metallurgy; in addition, a new grade of sponge-iron powder possessing excellent compressibility and uniformity has been developed, several original uses of importance have been devised for iron powder, and the commercial production of silicon powder has been worked out. Desirable physical properties have been imparted to arc-deposited low-alloy steel through the employment of novel slag compositions. The failure of restrained welds and the destructive testing of structural joints, involving special gaskets, have had much attention, and protective coatings for steel storage containers are being investigated. A new flux for silver soldering came into extensive use in war industries and a copper-brazing flux was introduced. Advances were made in chromium plating of tools and gages. Many improvements have been achieved in shell manufacture, mainly in the production and finishing of casings and components. Lock-nut technology has been benefited by fundamental mathematical and physical studies. These results have brought the institute close to the zones of military action. Announcement was made of a differential solubility process for treating waste pickle liquor, and basicity factors were interpreted as aids in evaluating limestones and limes as neutralizing agents.

MUCH IS BEING DONE ON COAL PRODUCTS

Methods have been investigated for improving heating efficiency and for conserving anthracite; better procedures of control and operation have been prescribed for house-heating equipment. Smoke-producing tendencies in coals of various ranks have been under inspection. A large program of research on the hydrogenation, dehydrogenation, oxidation and alkylation of coal products has been widened considerably, and several new catalytic processes are under development. The recovery of low-boiling compounds from coke-oven by-products is an allied project. Physical procedures are being applied experimentally to separating coke-oven gas constituents. A new process of making ethylbenzene has been put in large-scale operation. Another investigation has been concerned with the effect of paraffins on the nitration of toluene. Basic research on the production of phenols is well under way. Another group is working on the separation of cresols and xylenols from their mixtures. New