

WASTE IN SCIENTIFIC RESEARCH<sup>1</sup>

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For a number of years I have observed the trend toward mass production in the industrial field of our civilization, and it seemed to me that in scientific research one can also note an analogous trend in the prodigious activities sometimes made to solve some problem the solution of which was perhaps only within the grasp of some individual, that is, the individual effort of some synthesizer reviewing and generalizing the analytic work of many.

After preliminary orientation one begins to give thought to the various scientific research activities with which one has had some acquaintance, and the evidence of waste in some of these activities multiplies as one's thesis develops.

The waste in scientific research presents itself under two chief aspects: (a) waste of energy or effort; (b) waste of material or product.

Under the head of "Waste of Energy or Effort" one may more or less readily classify those efforts put forth in the mere preparation for the task of scientific research, which preparation seems to involve so little waste that this aspect of our thesis might appear to require very little attention; and yet this unsuspected source of waste might literally be teeming with a whole menagerie of useless embryonic workers.

The preparation for some great undertaking in the nature of scientific research has drawn from a layman the caustic observation that "The great laboratories that millionaires endow, though they multiply everywhere, seem to offer little effective competition to independent investigators. Many of them have produced nothing whatever save useless masses of scientific pedantry, and even those that have accomplished respectable work have scarcely justified their immense waste of money. . ."<sup>2</sup>

Also in the matter of securing research workers we must consider (a) the waste that occurs in giving proper education or training, and (b) the waste of effort in finding the particular field of work to which the student is adapted (where he finds a proper adjustment to conditions) and able to prove himself a success.

For some time the industries and large mercantile establishments have set the pace for efficiency in the use of labor and materials, and during the war the Federal Government found laboratories full of plans and formulas for the elimination or the utilization of the waste products in civil and in military life.

Therefore it is today a comparatively simple matter to make observations and advise and apply the remedy in purely mechanical lines and in the mercantile life of the nation. But in the case of the scientific worker, the man whose efforts can not be measured either in intensity or extent of time involved, it is quite alarming to note to what extremes the worker may go in striving to accomplish something, in overcoming obstacles, or in the face of adverse criticism.

If the scientific research worker could readily adjust himself to a machine pattern of existence, and react merely as an automaton to environmental conditions, he might find his way paved to a successful issue. But unfortunately the

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<sup>1</sup>Abstract.

<sup>2</sup>(Editorial by H. L. Mencken in *The American Mercury*, July, 1930).

scientist is usually an individual, a personality (fortunately for science itself) and not a unit of an efficiency group, not a cog in the wheel.

Generally speaking, men may be divided into two groups: those who can and are able to direct, and those who require directions or directing. The first is a small group, the other large.

Likewise, research workers form two groups: those working on their own initiative, and those working under direction. The mental attitude of these two groups may differ widely, especially when considered from an economic viewpoint. It may sound like a platitude to say that the worker who is being paid (working on a salary) does not have worries in regard to the means of subsistence, but this is nevertheless true when contrasted with the lot of the isolated research worker in original or neglected fields who has worries of all kinds and where it may truly be said that "Der Ausgang giebt den Thaten ihren Titel," and where the end results alone determine whether his work, if not his life work, was a success or a failure.

The man who is employed or hired most likely has his work outlined, and he may or may not carry his work home with him and into his dreams. The college teacher who takes up research work (probably in a laboratory not his own property) may not be worried in regard to ways and means to carry on, at least in work that is not too elaborate, and where the purpose or motive is a real contribution to knowledge, or perhaps merely the publication of a book, the ambition of many a college teacher. Contrast this with the condition of the isolated research worker in neglected fields, where he perhaps stands alone—his vision being the only stimulus to carry on.

One peculiar but very important aspect of carrying on individual scientific research is that of publishing the results of work done. Most of the larger educational institutions have a printing press, and the publication of professional research is usually taken for granted; sometimes it may have been a matter of discussion before the work was even undertaken. On the other hand, the original worker may have difficulty in finding a publisher, or he may be compelled to publish at great financial loss to himself.

In my complete paper there are considered in some detail the changes that have taken place in this matter of scientific research, from small scale to large scale investigations, and the facilities and the opportunities afforded for carrying on work. Various aspects of waste will be pointed out—at times enormous waste despite efforts for increased efficiency. This paper leads up to an aspect that is commonly overlooked or neglected in such inquiries, namely, the waste that results from a lack of appreciation of work already done—research that has perhaps been carried on for years, the results of which should be published more or less fully.

Work may be grouped under two heads: analytic and synthetic. Most any one who has the necessary patience can carry on analytic work—can observe and record; but, generally speaking, worth while work should be followed by publication; especially should this be done for the use of the synthesizer or generalizer, who draws the wider conclusions—conclusions based on the work of the many. Great synthesizers are few, we need only keep in mind a Darwin. It is well known that Darwin abstracted innumerable accounts given in the Proceedings and Transactions of scientific societies.

Incidentally, biographies tell of work that was carried on more or less satisfactorily—and also the reverse. Some of the biographic sketches in the Ency-

lopedia Britannica reveal how men had gathered much material, perhaps devoting a lifetime in a certain field or to a definite subject, but because they were unable to publish properly, for one reason or another, such men have very short biographic sketches. The man who does not publish at all likely gets no mention.

No research is ever fully completed. There is nothing that can be called absolute; all is an approximation. Often the solution of one problem leaves two new ones in its place. All this is trite to the experienced worker. But to the young one must tell the story of the student who applied to Linnacus, because he doubted finding a field for original research. The great naturalist placed his hand on a tuft of moss and said, "Here is work for a life time."

It should be emphasized that if research work is not published it is waste, and of no use to others—a waste of time and energy. If others do not know of the work done and the results accomplished, most likely there will be some to go over the same ground—meaning more waste—perhaps repeatedly, until some one does publish adequately, perhaps at the same time pointing out lines for future activities, for needed additional research.

Opportunities for "The Making of a Darwin," the title of a paper by the first president of our Academy, are still in a backward, if not chaotic condition in our country. If we compare and contrast the life of Darwin with the lives of Huxley and Spencer—all great generalizers, using the simple observations of others—we may see how difficult is the problem indicated by Spencer in the very title of his paper on "The difficulty of having too much material," it is equivalent to saying, "the lack of proper working facilities and trained assistants."

When Humboldt returned from his exploring expedition he assumed that he would be able to work up most of his material in two years. He actually required twenty. Today in our own country such a worker may find himself wholly unable to publish. The young man who is "a-going to do research work" may readily enough find backing—he can get a job.

Therefore, this paper is virtually a plea for the conservation of the energy and the labor of the isolated (individual) research worker who is not connected with any institution and whose work demands not merely the machinery of research, but the constant application of the very synthetic efforts for which no formula has yet been discovered, and whose work may be lost forever, perhaps, for want of mere mechanical assistance in clerical hire, etc., which he is unable financially to provide, and compared to which the expenditure of his time (time that might have been profitably invested in commercialized lines) would be a mere trifle.

#### ADDENDA

Since my own "collecting difficulties" have become acute (classifying, digesting and evaluating notes and items of all kinds that run into the hundreds of thousands) I have sought out others who have or have had difficulty in publishing. I found five men who have been collecting material (data), some for many years, and whose replies to my inquiries were in effect as follows:

One has now given up the idea of ever publishing. "I am getting too old, and I have lost the grasp over my material." He has no desire to merely publish scraps.

Another published a little, but complained that he was looked upon as a crank (insufficient publication accounts for it). He too has practically abandoned the idea of ever being able to publish.

"I still hope to publish," a third man replied. If he gets aid.

One published minor aspects of phases of his life work, and now on account of financial difficulties sees only gloom ahead.

Another has published practically in full, but at great financial loss to himself.

I may add that these five men except one were philosophic, took matters as they found them, but hoped conditions might be better in the future.

In discussion one gets all sorts of suggestions, for the paper proper, such as:

"Bring out the fact that the man who is too far ahead of his time is likely looked upon as a crank" (But this has always been the fate of the pioneer or the founder of any new science, theory or philosophy).

"It is your duty to act as spokesman for those who have difficulty in publishing." (It is? To do the subject justice requires much time. My own time, at near seventy, is limited. However, I promised to do my best).

"Take the case of Mendel. He carried on work along original lines. He published a little, buried his paper in an obscure journal—to be forgotten. Years later others worked in that field and the subject became one of great importance, and then the buried paper was found. The result—a new science was named after Mendel. Why not mention this to encourage the young worker to go ahead and publish. He may be looked upon as a crank, but if it is good work, good observations, he will find his reward later, perhaps long after he is dead. His work will receive recognition. Tell the young worker to publish, even if only in an 'obscure publication,' for most likely the generalizer, who comes later, will give him credit for being a pioneer worker." (All true scientists will agree with these statements).

"Consider the fact that a man working in some odd or neglected field has published a little, perhaps just enough to show his line of work. Others hesitate to enter his field, awaiting further publication. In time he gets the reputation of dawdling, because the difficulties in publishing more fully are not known. Shall one speak out, explain why—and offer his material to those who are able and willing to work it up." (In reply I had to tell of my own early collecting of natural history material, and that I had hoped some nephew might become interested and that I could turn the material over to him, including notes. Shall I too "speak out" and offer to turn material over to those interested? I should be pleased to hear from readers of this paper, both from those who have un-worked-up material, and those who might wish material; also from those who have "collating difficulties.")

Men who are vitally interested are the keenest critics.