

COPY

September 30, 1929.

My dear Dean Donham:-

Dr. Edsall asked me to send you the inclosed copy of the Memorandum. This is a carbon of the final form as it was sent off last week to Dr. Pearce and Mr. Day.

Dr. Edsall also wanted you to know that he asked these gentlemen to let him know as soon as possible when they could come up to Boston, and he will, of course, let you know just as soon as he hears from them.

Very sincerely yours,

Marian Dale,
Secretary to Dr. Edsall.

Dean W. B. Donham,
Harvard Business School,
Soldiers Field,
Mass.

RECEIVED JANUARY 1930

RECEIVED JANUARY 1930

RECEIVED JANUARY 1930

September 25, 1929.

Dear Pearce:-

I am sending you within a day or two the memorandum which I have prepared regarding the development here, which I hope it may be possible to carry out, in relation to the coordinated studies of psychiatric, industrial, and physiological background which I have discussed with you and Mr. Day before. I am also sending a copy of the memorandum to Mr. Day. It is long, but it is a complex group of things that cannot be briefly stated. My purpose has been to try to picture it to you and Mr. Day so that when you come up here, as I hope you will do early in October, you will come all ready with information that will aid you to observe understandingly, within a relatively short time, a very considerable group of activities that are, I think, of a good deal of force.

I shall be very much indebted if you will arrange with Mr. Day when you can come up, and let me know what dates, so that those particularly involved here may be available and ready to aid you in the observation of the things they are doing. I should, of course, expect at that time or at any other time, as would the other members of our Committee, to go over and deliberate upon the various details of the memorandum. It is stated now as appears to me, and to the Committee, to be the most reasonable and satisfactory way of putting it.

With best wishes, I am

Very sincerely yours,

David L. Misall, M.D.
Dean.

Mr. Richard M. Pearce,
The Rockefeller Foundation,
61 Broadway,
New York City, N.Y.

DLE:D

N41830.01

September 25, 1929.

Dear Mr. Day:-

I am sending both you and Dr. Pearce a long memorandum regarding the various subjects relating to industry and their physiological background that I discussed with you and Dr. Pearce last spring.

The memorandum is quite long, but it was purposed to give you something of a picture of what was going on in order that you may be able more quickly and more understandingly to observe the activities here if, as I hope will be the case, you and Dr. Pearce can come up to see them some time early in October.

As I have indicated to Dr. Pearce, I should be very pleased if you and he would discuss the dates that might be feasible for you and for him to come, and let me know so that I may make arrangements for the men particularly involved to be available and able to demonstrate their experiments and activities when you come. I should, of course, expect at that time or at another time, as would the other members of our Committee, to go over and deliberate upon the various details of the memorandum. It is stated now as appears to me and to the Committee to be the most reasonable and satisfactory way of putting it.

With best wishes, I am

Very sincerely yours,

David L. Edsall, M.D.,
Dean.

Mr. E. R. Day,
The Rockefeller Foundation,
61 Broadway,
New York City, N.Y.

DLE:D

N41830.02

MEMORANDUM

There have developed in recent years in several parts of the University a large group of research activities, which are in considerable part unique in character, that have already contributed in highly significant ways to three important lines of study:

1. To the problems of the handling of personnel and the maintenance of welfare and health in industry and the practical influence of these on the success of industry and upon general public health.
2. To neuropsychiatry and the vast economic and humane problems involved in it.
3. To general physiology and especially to those aspects of physiology that bear particularly upon phenomena of the nervous system and upon effort and fatigue; lines of research that are fundamental to understanding progress in the effectual use of human effort in industry and in the control of mental as well as physical disorders.

These studies are in striking degree under the guidance of men who have high reputation for achievement in research, and with what they have already accomplished in these lines there is much promise of important further progress. The individual lines of work were begun independently, but they have obvious relations and these have been emphasized by steps in progress so that the several activities have already been coordinated to a noteworthy degree.

They have been chiefly financed from University funds, but in some most important ways have been partly or entirely financed by temporary grants from the Laura Spelman Rockefeller Memorial, or the General Education Board.

the past seven years in industry in various parts of the United States - studies which I should term psychological although they relate themselves rather to certain observations of clinical medicine than to the academic psychological laboratory as it is usually at present constituted.

My object accordingly is to state, as succinctly as possible, the ideas which have influenced our work, the methods we have used, the results we have sometimes achieved in various factory situations. I trust that the following paragraphs will be sufficient for your purpose.

I. Our approach to the investigation of "industrial unrest" - that is, of morbid preoccupation in factory situations - was guided by certain empirical observations of Pierre Janet's with respect to the relation between concentration and reflection in any given individual. (These observations are to be found in his work on "Les Obsessions et la Psychasthénie" and in certain part of "Les Nevroses", rather than in his better known inquiries into hysteria). His observations, briefly put, were to the effect that morbid reflection diminished an individual's capacity for concentration at will upon any given question or object in his surroundings. He also observed that conditions of living which gave no opportunity of concentration, learning or social development to an individual tended to exaggerate in such individual a morbid preoccupation of an egocentric character. To this he added a brilliant description of the sequence of mental events leading up to an obsessive crisis. The technical importance of these observations for education and industry generally has never been rightly appreciated or understood. With general education we have not been concerned, but we have utilized to the full Janet's work in industrial inquiry.

Four years of work in Philadelphia factories showed us that in every instance where we were asked to investigate high labour turnover, insufficient

output or poor quality in production, we were invariably involved in a human situation the chief character of which was morbid preoccupation. In these instances where we could banish the morbid reflection, we reduced the high labor turnover (in one instance, the Continental Mills in Germantown, from 850% to a steady 5% over a five year period) and also increased the quality and quantity of production. We were forced nevertheless to consider a great variety of circumstances which led to morbid reflection and a poor morale. These circumstances might be:

A. Organic:

- a. Fatigue - two five hour work periods in the day with one interruption only in the lunch interval of 45 minutes - the Continental Mills, Philadelphia.
- b. Other causes such as poor ventilation in the gas burning room of a mercerized yarn department, with the consequence of sickness and absenteeism in approximately 80% of the workers.
- c. Indifferent diet, insufficient provision of toilets, and so on.

B. Mental:

- a. Monotony - repetitive work which requires no concentration of the individual, but which gradually develops boredom and morbid reflection.
- b. Social circumstances. Undue isolation of the individual and family (lack of group interest both in and out of the factory) must be regarded as contributing to morbid preoccupation.

II. The methods we have used have had to be devised usually in the midst of a factory situation of some difficulty. Our object has been to measure or at least observe, the changes that occur in the human organism during the working day. Our attempt to obtain precise observations has not as yet gone far, but the results obtained are sufficient to show the value of such an approach to the problem. In all our studies we have paid particular attention to

- a. changes in production
- b. bodily changes
- c. changes in mental attitude.

The continuation and development of these measurements (or observations) with the aid of the Fatigue Laboratory and the Medical School, is the central intention of the inquiry. In a given individual it is not difficult to demonstrate the relation of one type of change to the others; but we cannot yet demonstrate the general relation with precision.

a. Change in production can usually be obtained for the individual and the group from factory records. The importance of these changes is that when accurately recorded they provide an objective check for other experimental measurements of organic and mental change.

b. We have obtained some interesting results in the measurement of organic changes by taking numerous observations, in specially selected groups of sufficiently normal individuals, of changes in blood pressures and pulse rate during the working day. We have found that (in the Continental Mills, Philadelphia and in the Western Electric Co. plant in Chicago) a low and steady "pulse product" is usually associated with high production and mental content. This aspect of the inquiry is, however, insufficiently developed and we are, with the aid of our colleagues of the Fatigue Laboratory, revising our methods. It is nevertheless interesting that L. J. Henderson's observation (that "high production" (Dakar and Marathon running) is associated with a maintenance of organic equilibrium when the metabolic rate is lifted) seems to be capable of direct application to factory workers.

c. Changes in mental attitude are demonstrably closely related to organic changes and changes in production. Mental changes are however not easily measured directly and with precision. At present we have to rely upon interviews, conducted more or less in a clinical fashion, as a source of information as to mental attitude. The difficulty in a factory is that we cannot demand such

interviews as a clinician can in a hospital, we have to wait until the individual worker freely volunteers to talk to us. We have to some extent overcome this difficulty at the works of the Western Electric Co. in Chicago.

We have evidence nevertheless that

I. Emotional instability shows itself in low and irregular production:

- a. The nice-splitting group in the W. Elec. Co., Chicago.
- b. Inspection group in Wm. Carter Co., Massachusetts.
- c. Mule-spinners in Continental Mills, Philadelphia.

II. This is associated with heavy preoccupation with personal affairs, the preoccupation being of an unhappy type. This situation may arise, when the working conditions are bad, generally in a group - the mule-spinners. Or it may arise in individuals when the conditions of work are good, but the work monotonous - workers 1 and 5 in the nice-splitting group (W. Elec. Co., Chicago).

III. The morbid preoccupation is diminished by improved conditions of work -

- a. The mule-spinners in Philadelphia.
- b. The relay-assembling group in the W.E.Co. in Chicago.

IV. Increased personal content (i.e. diminished morbidity of preoccupation) is associated with increased efficiency of production. This statement applies to every inquiry we have undertaken - Massachusetts, Illinois, Pennsylvania, and Indiana.

V. The results we have obtained. We have had to rely upon industrial executives and the appropriate medical or engineering officers for the introduction of certain changes of an administrative or technical nature. Beyond this we have achieved our most striking practical results either by the introduction of rest-pauses or by a careful development of a method of interviewing.

A. Rest-pauses.

These may be used either to relieve physical tension or as interruptions to repetitive work of a monotonous character. The type of rest-period introduced, the use made of the leisure time and the number of interruptions, differs according to the situation.

1. Physical Fatigue.

In the Continental Mills, Crompton, there was much empirical evidence of physical fatigue. This has been recorded in the Journal of Personnel Research. In this instance the men worked ten hours daily - a five hour morning period, a forty-five minute interval for lunch and a five hour period again in the afternoon. With the consent of management, we introduced four ten-minute rest-pauses and persuaded the men to lie down and relax. They very soon formed the habit of sleeping through one morning and both afternoon rests. The five-hour work period was thus divided:

2 hours work	
10 minutes rest	
1 hr. 30 minutes work	The rests are so arranged
10 minutes rest	that the work periods de-
1 hr. 10 minutes work	crease in length.
5 hours	

This was made a general rule for the department for both morning and afternoon. The effect was so remarkable that we were not permitted to experiment further. The chronic labour turnover of 250% fell to 8% and remained at that low figure for the subsequent five years recorded. The production of the department increased by sixteen to twenty percent and the workers began to earn bonuses for the first time in the history of the Company. This bonus-earning also lasted for the five years recorded. "Wastage" was reduced and absenteeism diminished. There was also evidence, which I cannot record here, that the happiness and content in the private lives of the workers was increased.

2. Monotony.

The operation of relay assembling (small induction coils for telephones) is repetitive and monotonous in character. Two years ago the Western Electric Co. of Chicago, set apart five girl workers in a special room for the purpose of observing the effect on them of changes in the conditions of work. The various experiments have been carefully conducted and form the subject matter of a careful report, a copy of which is in my files at the Graduate Business School, Harvard; I think that this report should be placed in your hands as the most important single document which is explicatory of the investigations (of a practical order) which engage our attention.

Many types of change have been carefully observed in these girl workers. They have had medical examinations every month - and their health has unmistakably improved. For nine months, by means of an electrical device, a continuous check on the production of each worker was maintained. It was found that, as rest-pauses and other improvements of working conditions were introduced, the production of

increased but steadied (the variation was less). A specially selected supervisor was appointed who gained the girls' confidence and their mental attitude to their work and to the management improved. At the end of the first year measurements of their "pulse-products" (pulse pressure x pulse-rate = 100) made on two occasions by us and on another occasion by a member of the Western Electric medical staff showed that their pulse-products were lower and steadier than any others we have taken.

I have not set down here the series of experiments tried in two years because I think that the report I mentioned above should be submitted to you. The general result has been that the girls are better in health, unmistakably happier, and are earning more as a consequence of their increased production. The increase in production has been remarkable. At the beginning of the experiment, each girl was averaging about 3000 relays assembled weekly; at the present time each girl is assembling above 3000 relays weekly and the weekly "score" is still rising.

B. Interviewing.

The chief executives of the Company have for some time past been inclined to attribute the great practical success of this experiment very largely to the new relation of confidence that has been established between the five girls in the experimental room and the supervisor and the management. They have two rest-periods in the 8 3/4 hour day - a morning rest of 15 minutes and an afternoon rest of 10 minutes. In the morning rest of 15 minutes the Company gives each girl light refreshment - a bowl of soup or a cup of coffee and a sandwich. The executive officers feel that the improvements in mental attitude and in production have been due not merely to the interruption of any tendency to morbid preoccupation by rest-pauses - at best an indirect method - but perhaps rather to the development of a tendency to express anything that is "on their minds" (whether a factory or a private matter) to a sympathetic supervisor. To such an extent did they feel this that last year the Company adapted a method of "listening" which we had used in Philadelphia and began to "interview" the whole of the "inspection branch." This innovation proved extremely successful. It has a surprising effect on the personnel - for the mere express of grievances, whether morbid or real, seemed in large part to get rid of them. It also

provided the Company with excellent material (suitably disguised) to be used in the training of supervisors. The training courses for supervisory positions were formerly attended sparsely and without enthusiasm. They are now eagerly and fully attended. In addition to this, the Company has, as a result of the experiment, provided itself with an experienced staff of trained interviewers whose method is to "listen" rather than to "talk", and who are trained, at least in some degree, to listen to the expression of opinion with balanced judgment and without immediately "taking sides." This spring the Company determined to extend the interviews over the whole plant to 30,000 employees. This will take two years and will cost \$350,000; the work is already in progress.

I trust that this is enough to give some idea of the methods we are using and the small results that we begin to attain. It is much easier to achieve practically useful results in a factory than to know in any precise way the exact significance of what we do. This is one reason why we are so greatly in need of any help that the Medical School and the Fatigue Laboratory can give us.

I have made no mention at all of our technical work in psychology or of the relation of this to sociology and political theory. It has seemed to me better, in the interest of brevity and concise statement, to omit all technical discussion from this letter."

DAVID L. LORAN

DAVID L. LORAN
DAVID L. LORAN

The following comment by Dean Denham will also illuminate the past accomplishments and the purposes in view in the Business School in developing coordinately with Mayo's work the sociological, economic and ethical aspects of such studies.

The situation at the Business School is something as follows: Henderson and Mayo have been collaborating for two years in an effort to begin a careful investigation of the empirical facts with respect to the human situation in industry. Henderson's study of organic equilibrium is well known and needs no description here. Mayo's study of situations in industry has had to include studies of changes in production, studies of mental attitudes in workers, and studies of social situations. Two things have occurred recently which no one concerned in the work expected to happen within so short a period as two years.

I. The first is that the principles of organic equilibrium enunciated by Henderson have been found to possess high value as directive of industrial investigations of changed organic equilibrium in the worker. This must not be understood to mean that the laboratory methods of the Henderson group can be directly applied in industrial situations, for this cannot be done without considerable further elaboration of method. That is to say, one cannot arrange to collect a worker's expired air and to take blood samples while he is actively engaged upon some factory job. Furthermore, it seems improbable that the kind of work demanded of the average employee is of a character that involves heavy muscular effort. Direct investigations, therefore, of physiological muscular fatigue are not immediately relevant. Methods of making short cuts and getting rough and ready approximations of sufficient reliability must be worked out.

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JAN 10 1920
BUREAU OF LABOR
STATISTICS
WASHINGTON

These fatigue investigations will inevitably find their sphere of importance in the industrial situation. In the meantime the indirect value of the Henderson approach has been shown to be immensely significant for industry. This can be put in several ways. One might say that high production (De Mar in Marathon running) occurs in those individuals who can increase their muscular activity without any significant change in the character of their organic equilibrium. In the factory this implies that any measure, however unsatisfactory, of organic equilibrium, should show a significant difference to exist between the worker who is producing well and easily and the worker whose production is low and accomplished with difficulty. This has been found to be the case.

Those who work under specially suitable conditions in the "test rooms" of the Western Electric Company or elsewhere show a "pulse product" which is definitely lower and steadier than that of workers in other industrial situations. Their production, also, is from 30% to 50% higher than under former conditions. On the other hand, one might indicate the indirect value of Henderson's work by asserting that any factor that tends to disturb organic equilibrium will necessarily result in deteriorated morale and diminished production. The value of this assertion (or question) as a directive principle in industrial investigation has been demonstrated in the Philadelphia Mills and in the Western Electric Company's Works in Chicago many times over. Worker #5 in the mica-splitting rooms at the Western Electric Works for several months showed a low and exceedingly irregular production. Her home situation was unsatisfactory; she was constantly in difficulties with her foreign-born mother. Recently, she has left her home and gone to live with some other girls who are friends and fellow-workers. The emotional relief from constant preoccupation with her home situation has shown itself in a remarkable rise in her productive

capacity; at present this rise is well sustained and she makes far fewer mistakes and does less "poor work" than before.

II. The other event unanticipated after two years of work, that is of immediate importance is that the Western Electric Company's Works in Chicago with 40,000 employees has been thrown open to this department of the Business School as in industrial laboratory for human experiment. This is important because the executives of the company are well qualified by reason of their scientific training and unusual intelligence to collaborate with the investigators of this School. Within the last few months the company, feeling that it has already derived benefit from the researches of two years past, has instituted a new Division of Industrial Research whose sole duty will be to press forward and critically develop both the researches in the plant itself and the active collaboration with the researches of this School. This constitutes at once an opportunity of the first order of magnitude for industrial research here; it constitutes also a heavy demand upon the thinking and activity of this department.

So much for the situation as it is at this moment in the Graduate Business School. The question arises as to what should now be done in order to insure, first, the fullest development of these researches that is consistent with careful and critical work; second, the development of such subsidiary or complementary research as shall from time to time become obviously necessary; and, third, the communication of anything of value (in respect of inquiry instituted or results achieved) to the business world at large and to the students of this Graduate School in particular. It is the latter two of these questions that demand some consideration lest in the interest of developing existing inquiries, their importance and value should be lost sight of.

First, with respect to complementary researches. Mayo has already asked for the development of a sociological inquiry into the general conditions

of living, both in areas adjacent to the factory and in the modern city as a whole. This form of inquiry in addition to its direct sociological and anthropological interest possesses an undoubted relevance to psychiatric inquiry (see writings of Dr. J. S. Plant, in the American Journal of Psychiatry). It possesses also an unquestioned relevance to criminal investigation, (see the investigations of Dr. Clifford H. Shaw, Institute of Juvenile Delinquency, or Ruth Cavan, Department of Sociology, Chicago.) The interest and value of a sociological inquiry in these general directions is already in process of demonstration by the writers named above. This does not, however, guarantee that the industrial-sociological inquiry will be undertaken. There is no question that conditions of work in a particular department in a factory, or the general conditions of work within a factory, may do much to exaggerate or to mitigate the conditions described by the sociologists. In asking for sociological investigation Mayo (as a specialized worker) had this in mind. That is to say, he was thinking not merely of the general inquiry conducted by Plant or Shaw, but of its immediate relation to the conditions he is himself investigating within the factory. The sociological inquiry anticipated by this School is, therefore, already clearly specified and distinctive. It is to be an investigation of empirical facts no less than the work of the Fatigue Laboratory and the Industrial Research Department. It has, nevertheless, an aspect which might be described either as experimental or ethical. As ethical, it is bound to consider the responsibility of industry in this general regard. As experimental, it is committed to watching the effect of changed conditions of work within the factory upon the worker's life outside. In connection with industrial research such changes in the life of the worker outside the factory can be already demonstrated. A social inquiry such as this has a practical as well as a theoretical importance. It will demand careful economic as well as direct social investigation. In undertaking

such inquiries the School believes that they are important and necessary. It also realizes that its commitment in respect of development is large and, at present, indefinable. The need for carefully controlled investigation in an area of high importance and, at present, indefinable extent constitutes a grave responsibility for those who direct the fortunes of the School.

Secondly, with respect to the communication of the methods of inquiry pursued, and the significance of results obtained. It is clearly unwise to permit a major development of research to take place without providing in a relatively short time means of communication as between the inquiry itself, the workers in other fields, and the general public affected. If such channels of communication are not assured, then both the critical reconsideration of what is done and the perpetuation of the research are thereby imperiled. One obvious duty of the School in this respect is to insure that its students shall understand what is being done and why. If this is not assured then, for all one knows to the contrary, the inquiry itself might diminish with the retirement from the scene of various workers at present involved in it. The work might also fail to give rise to other such inquiries elsewhere. And in such event the community would remain ignorant of the interrelation and significance of certain industrial and social situations that are at present, to put it mildly, imperfectly understood.

Beyond this obligation to students, it is also clear from the attitude of significant groups of business men that the School must also undertake to follow and advise with reference to current practical applications and industrial extensions of its own work. The Western Electric case is in point. This will in the near future require considerable extension of our staff.

In asking for support for certain lines of inquiry which probably cannot be undertaken without endowment the School has to remember that its commitment in respect of the institution and maintenance of complementary research and of the communication of work done is at the moment incalculable. The School has

already appointed a professor of Economics and a professor of Business Ethics to work in their fields and allied fields. It must appoint shortly a professor to conduct social research. In so far as these men are to take part in the teaching work of the School their financial support will be provided out of our current budgets. These appointments have been and will be made, not only in order that these men may teach, but, in fact, principally, that they may begin the important work of seeing what can be done in respect of the complementary researches and the assurance of communication specified above. Research must precede effective instruction. While it is easy to state and to provide for the financial obligation involved in the work of giving certain classes in the School schedule, it is quite impossible at the moment to specify clearly what will be needed as the work of complementary inquiry and communication develops and without endowment the research organization cannot be built up.

Dr. Mayo's work has to date been mainly financed by the Rockefeller Foundations. It is hoped that this will continue to be covered by endowment with provision for very moderate expansion. The School has been spending substantial further sums on his work and expects to continue this. The School has just added two professors on its regular budget to work in this field. Counting Mayo's work, it needs critically an endowment equal to \$50,000 a year if it is to approach its future large obligations and opportunities with any assurance. Not even a beginning can be made with our present resources.

All of this work is directly allied to the most fundamental objects of this School. The attached article, reprinted from the Harvard Business Review, will by easy inference give the reader my own conception of the importance of this work.

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HARVARD BUSINESS SCHOOL
JAN 10 1924

APPENDIX II

The work in the Fatigue Laboratory is both new and abstract in conception to such degree that it is very difficult to gain an adequate understanding of it without rather considerable study of its methods and aims. That these are important may perhaps best be emphasized by saying that when A. V. Hill was here last, after observing the work for some time, he sought out University administration officers especially concerned and stated that he felt it was the most important work going on that he knew of - and Henderson, Boek and Hill the most extraordinary team, and he urged very strongly that everything possible be done to keep them operating jointly. It may also be said that the methods or the viewpoint and line of thought, or both, have influenced, and penetrated into, many physiological laboratories and well manned and equipped clinics already in this country, Canada and Europe, and their importance is thus widely recognized.

A bare statement of the kernel of the matter may perhaps be given as follows:

Years of biological, physiological and clinical studies have contributed a vast amount of data regarding individual functions of the organism, individual components of the body fluids, tissues, et cetera. Often several of these have been studied coincidentally. Much greater knowledge of the organism has been gained thereby, but the significance of much of the work has been very confused and uncertain; and while individual functions and organs are better understood, many fundamentally important things regarding the coordinately acting entire organism have remained as unsettled as ever. Some reasons for this have become apparent. If any one, (or more) of the numerous elements that take part in the functioning activity of the blood is altered the others alter in a way that may be either,

- (a) as an adjustment, (physiologically advantageous) to the changes in those elements that were primarily altered, or,

- (b) as a simple and inevitable physicochemical result of the primary alterations, but a result that may be physiologically disadvantageous or advantageous.

Viewing the organism more broadly the same is true. Changes in metabolism, respiration, circulation, excretion, other functions, or the blood, will affect the others mentioned. Simply multiplying data that individually may be accurately enough determined, will not tell whether the changes in any of the above are:

1. of primary pathological significance.
2. Pathological in influence but consequential to other changes.
3. A normal and satisfactory adjustment to other changes that have occurred.

Nor will it be clear what the summation of effect upon the function of the organism as a whole will be. A method of study, capable of gradually and increasingly approaching the solution of such problems in a reliable way, would obviously be of such value that the bounds of service it would render could scarcely be defined.

More than ten years ago Henderson, with his collaborators, began putting together data regarding the physical chemistry of that very complex fluid, the blood. Obviously the attack had to be by mathematical methods, and after much research and many mathematical difficulties it became possible, through use and elaboration of the principle of the nomogram, to present results in monographic form, with enough accuracy to represent all known important facts involved.

A monographic chart is enclosed - prepared five years ago after sufficient laboratory data had been obtained to permit of such expression of the normal of eighteen known important constituents of the blood. To represent what this single sheet shows would have required 108 ordinary curve charts. Analysis of the relations of 108 separate curves is a feat

that the mind is not capable of. Still less is it capable of coordinating accurately a description in words or tables of the individual data upon which such curves are built up. Furthermore, if two constituents in any case are determined, the nomogram permits at once of determining approximately what values the others must show if they are normal in relation to the values for those two that have been determined.

With the number of variables that must be dealt with in such problems, and the complexity that results, ordinary language and thought can not cope. The treatment must be mathematical, and it can be mathematical only when the facts have been expressed quantitatively. It should be emphasized that in all sciences that are concerned with organisms, (and this is the case with the natural and social sciences generally) if there is to be an approximation to a complete description of anything it involves the treatment of many variables and must be quantitative. The principles and methods of reaching such a description are applicable not to physiology alone but also to the other sciences, and in this way this work may prove to have its widest significance. The effect upon the social sciences may readily be especially great, and in some of the aspects of these sciences it is peculiarly needed.

In the course of this work as conducted now, every specimen of blood has to be described by its own nomogram; and comparative study of nomograms has necessarily, and successfully, been carried on. In the end a complicated nomogram descriptive of vertebrate blood in general will come.

From the blood the study has advanced to include also, simultaneously the circulation, respiration and metabolism. Nomographic handling of all this is extremely complicated and not yet satisfactory; but the understanding of the relations involved in such problems, that has come from the use of the nomogram, has immensely assisted the study of this difficult question.

A generalized conception of the total physiological state of individuals is aimed at and believed to be possible by these methods.

It has been shown that, as is well known for the basal state, the state of any person at any level of work or in any posture, when these can be maintained for a short period, tends to become constant, and when work or posture is varied transition occurs from one stationary state to another, (providing the load is not too great to permit of maintenance for a short period). The changes in going from one state to another, and the stationary state characteristic of a definite level of work, vary greatly in different individuals. These differences can be described with a good deal of accuracy.

The practical bearings of these results are very important, as are those of theoretical physiological interest, and further highly important problems come into view.

The significance of the relation to studies of human effort and fatigue appears to be fundamental. A vast amount of effort, all told, has heretofore been put into the study of fatigue in many laboratories, most of which is of but limited service. Much of it has sought to establish tests showing fatigue by studying a single factor, or a few factors, quite inadequately coordinated and without any real knowledge of the whole organism.

In clinical work this method of study has been employed in some cases, by this group of men, with seemingly very illuminating results, and when autopsy has occurred soon after, there were shown conditions wholly in keeping with the description of disorder of function that had been furnished during life. The nature of the disturbances in some obscure but important clinical conditions appears to be on the way toward elucidation.

Much of the method is as yet approximate and demands long further study, and the results that seem possible have but begun to materialize. It will require a long period of years to establish a suitable foundation even,

or to begin to furnish at all freely results of practical and theoretical value.

Work is in progress toward the establishment of simplified criteria and methods that will permit the wider use of the methods and experience of this laboratory in industry and the clinic. It now requires much time and labor by a considerable and highly trained group, and many determinations of the respiratory quotient, the level of carbonic acid in the blood, the lactic acid content of the blood, the stroke volume of the heart, the blood flow in liters per minute, et cetera, - all of which vary with different persons, with the level of metabolism, et cetera; and each varies in dependence upon all the others.

These elaborate and difficult methods must, however, go on for years. The simplified methods being sought for would be for practical use and would necessarily be too loosely approximate to be employed in theoretical problems and in further foundation work. Also a larger extent of correlation with the psychological work of Mayo and with Cannon's hormone work, two important aspects that have not been seriously included, are very important to be added.

Satisfactory comprehension of the theory and methods of the work and indications of its significance are, as has been stated, very difficult to obtain adequately without rather intensive consideration. Some reprints that help toward this are enclosed. Other articles by this group of men, and Dr. Henderson's book "Blood" are available for further illumination if desired.

RECEIVED
FEBRUARY 1941
NAVY DEPARTMENT
BUREAU OF MEDICAL RESEARCH

April 29, 1929.

President A. Lawrence Lowell,
Harvard University,
Cambridge, Massachusetts.

Dear Mr. Lowell:

In reply to your letter of April 19th, I would say that there is absolutely no objection to discussing with Mr. Day the matter of cutting diagonals across the various departments of knowledge. In fact, from that standpoint I think it would be perfectly all right to use the plan that I talked over with you the other day quite openly and freely as an example of the purposes that we have in view here in so far as that reinforces that argument in relation to the prize fellowships plan.

All that I meant in my previous letter was that I thought it would be undesirable to take up the plan that I was writing to Mr. Day about just yet in such a way as to seem to be asking for any money at the present moment in connection with that, as I do not think it matured up to the point yet where it seems wise to appear to be making even a tentative application for aid. But I would say again that, as an example of our point of view here and what we are attempting to do in bringing together the compartments of knowledge and integrating them in research as well as teaching, I should be perfectly ready to have you talk to Mr. Day about my plans, and in fact used in that way, I imagine it would rather aid than hinder subsequent possible requests for aid in it financially.

Very sincerely yours,

David L. Misall, M. D.
Dean.

DLM:H