THE MEASUREMENT OF SCIENTIFIC APTITUDE IN THE FIELD OF STUDENT PERSONNEL WORK.

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by

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Thesis submitted to the Department of Psychology in partial fulfillment of the requirements for the degree of Master of Arts.

McGILL UNIVERSITY

Montreal

September 1938

C O N T E N T S

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CHAPTER I

Student Personnel Work
Its history and principles

Personnel work is the means whereby the individual may be best guided in attaining the greatest possible satisfaction for his aptitudes and desires in his educational and vocational endeavors.

In both industry and education organized personnel work is a modern achievement. Galton laid the foundations for much of personnel work when he focused attention on the importance of individual differences. In 1894 when organizing a plan for testing Columbia students Cattell prophesied the use of measurement of individual differences in guiding students. He said at that time: 'Tests such as we are now making are of value both for the advancement of science and for the information of the student who is tested. It is of importance for science to learn how people differ and on what factors these difference depend. If we can disentangle the complex influences of heredity and environment we may be able to apply our knowledge to guide human development. Then it is well for each of us to know in what way he differs from others. We may thus in some cases correct defects and develop aptitudes which we might otherwise neglect!

About 1905 President Harper placed before the University of Chicago the ideal of individualized instruction. He asked for a regular diagnosis of each student comparable to the physical examination. This examination was to be made with reference to (1) the character of the student; (2) his intellectual capacity; (3) his mental habits; (4) his special capacities and tastes; and (5) the social side of his nature. The diagnosis was to serve as the basis for the student's choice of studies and a career. "This feature of twentieth-century college education will come to be regarded as of greatest importance, and fifty years hence will prevail as widely as it is now lacking." There followed a testing programme under the direction of Marshall and Kitson. They used sixteen psychological tests for the purpose of gaining reliable data concerning the students tested.

In 1908 Frank Parsons founded a vocational guidance bureau for young people in Boston. Although Parsons stressed the analytical side of personnel work as much as he did the giving of vocational information his immediate followers neglected the former and placed the emphasis on disseminating vocational and career information, much of which was inaccurate. This method of approach ruled the field of vocational guidance for several years.

The development of personnel work and testing techniques in the American armyduring the War gave an impetus to modern personnel work in industry and education. Gradually universities began to introduce various types and amounts of personnel work into their administrative policies.

In 1919 Scott introduced a personnel programme at Northwestern University and in 1922 a Director of Personnel for the University was appointed. Hopkins who had been appointed first Director of Personnel at Northwestern began in 1925, under the Rockefeller Benevolent Fund, a survey of personnel work then existent at fourteen universities. The report of this survey did much to clear up the haze surrounding the exact field of educational personnel work. Quoting from the report: "The concept that I have had before me has been that it (personnel work) means work having to do specifically with the individual. In education, one might question how this differs from the concept of education itself. I do not assume that it does differ. However, other factors constantly force themselves on the minds of those responsible for administration. In industry, it would be fair to say that management must concern itself with raw materials and output, with buildings and equipment, and with innumerable other items. So also in education, the administration is beset with many serious problems, and certain of these problems become so acute at times that there is danger that they may be met and solved without sufficient consideration for their ultimate effect upon the individual student. One of the functions, therefore, of personnel administration in education is to bring to bear upon any educational problem the point of view which concerns itself primarily with the individual. Thus, in this particular, as in all others, personnel work should remain consistent with the theory and purpose of education by tending constantly to emphasize the problem that underlies all other problems of education; namely, how the institution may best serve the individual.

In late years the advance in personnel work at American universities has been very rapid. The extent and detail of the programme at various universities differs but the progress has been in general along the same lines and based upon the same principles. Canadian universities have not kept abreast of their sister universities in the United States in developing student personnel work and even today this modern student personnel work is practically non-existent at most Canadian universities. Some have organized professor-student advisory systems, but these are not used a great deal and are usually found to be wholly inadequate both from the viewpoint of the staff and the students.

The backwardness of Canadian universities in developing educational personnel work may be accounted for in several ways. Education in Canada is known to be much more conservative than in the United States. Canadian universities are smaller than American, so in them it is easier to individualize education, and the older methods which have become so glaringly inadequate when applied in the large American university are more sufficient in the smaller more conservative universities of Canada. Also the Canadian University was much later in liberalizing the range and choice of courses hence, educational guidance was limited to a selection of students and to advising those selected as to the profession for which they should train.

It is to be expected that Canadian universities and colleges will soon begin to organize systems of student personnel work. In several cases this organization may depend upon the financing as well as upon the factors mentioned above. Various systems of personnel work have been in use in American colleges for some time and a survey of their fundamental principles seems pertinent.

The following outline is based largely on Williamson and Darley's divisions of personnel work functionally (43):-

1. Selection and prediction of student achievement.

Most authorities lay stress on the value of pre-college testing both as an aid to later guidance and to the administration of entrance regulations. In several of the States state-wide testing progammes have been instituted, the results being made available to the high schools and universities. An advance in technique has been the attempt to test for selection of students who are potential failures rather than potential successes.

2. Admissions.

The methods of admission are much more numerous in the United States than in Canada where provincial school leaving examinations are the rule. Lloyd-Jones lists the ten most common methods of admission in the United States:

a. Examination of the student in specified entrance subjects at the college.

b. Examination away from the college (College Entrance Examination Board, etc.).

c. Presentation of certificates from accredited schools.

d. Part certification and part examination.

e. Presentation of diploma from approved normal school.

f. Presentation of diploma from approved high school.

g. Presentation of state teacher's certificate.

h. "Comprehensive plan of examination."

i. Special or unclassed or adult students.

j. Partial use of intelligence tests, in conjunction with or as substitutes for other requirements.

These methods have been augmented in several universities by personal rating blanks, references, etc. The Committee of Personnel Methods of the American Council on Education has produced a cumulative record sheet to replace the static records which a student usually presents upon entrance into university. The latter usually consists merely of a record of the student's achievement in the last year of school with perhaps some hurried comments on the part of the teacher and principal. The cumulative record-sheet can progress with the student through high school and college and out into industry or business. In the university it becomes one of the most important items in personnel procedure.

3. Orientation.

This consists in helping the student fit himself to the new life both educational and social which he meets upon entering university. Many of the universities have freshman week programmes during which orientation courses are given and personal interviews take place between the staff and students. Some institutions give "How to Study" courses to improve the scholarship of students of high ability but poor working habits.

4. Testing.

Entrance test programmes are in use in various universities. These may include scholastic aptitude tests, special subject-matter achievement tests and achievement tests for placement within a subject, vocational aptitude tests and personality inventories. So far in most universities the use of test data has been restricted to statistical studies for the purpose of selecting students. Recently there has been a trend to use this data in personal counselling of the individual. This trend may best be seen in Universities such as Northwestern and Minnesota.

5. Improvement in criteria of scholarship.

The traditional criteria for a student's progress and achievement in academic work have been the marks given by the teacher. That these criteria were to a great extent, unreliable has long been known. Wood (44) has made a survey of the various studies which have been made upon the unreliability of the teacher's marks as criteria for scholarship.

The personnel movement has brought with it an attempt to improve the criteria of scholarship. One step has been the introduction and steady improvement of achievement tests. With the introduction of this type of tests there has also been an effort to change the attitude of the student towards the idea of a test. The test instead of being the "fly-paper" of the professor is becoming a "growth-measure", meaningful and useful to the student upon adequate interpretation by "guidance-minded" instructors.

6. Readjustment of curricula.

This falls into two sections, that for groups of students and that for the individual student. The necessity of readjustment is realized when one accepts the fact that individuals differ in amount and type of ability. This is most evident in the state supported university where adjustment to the needs and demands of the public is one of the main factors in directing policy. Williamson and Darley (43) point out the great advance made in readjusting curricula at Minnesota especially for students of low aptitude. Readjustment for the individual arises from personal counselling and involves for the most part little change in administrative policy.

7. Vocational information.

Following the older idea of guidance personnel work in education still retains as one of its functions the providing of information regarding the various vocations which are open to students. This is done at many universities which have as yet no organized personnel service. Several universities in Canada have made experiments in using this technique for the purpose of helping the student in choosing his career.

The Committee on Personnel Methods of the American Council on Education gives a description of the various procedures used in providing vocational information.

1. The lecture method
2. Summer employment
3. Inspection trips
4. Cooperative education (alternate periods of work and school)
5. Recruiting trips (by big companies' scouts)
6. Interviews with successful men and women in various occupations
7. Vocational monographs.

The use of these techniques as an aid to the student in orienting himself for future happiness has been tried and they have for the most part been found wanting, for without an analysis of the student the information provided fills in only half the picture.

8. Placement.

Finding jobs for students when they have finished their college training is, especially from the student's viewpoint, one of the most important and one of the most helpful extracurricular services the university can render. This service can be most adequately carried out by a well organized personnel department with its permanent staff and detailed records of the student, his abilities, and achievements.

9. Counselling.

For most this is the important function of a personnel organization and is the chief reason for the institution of the personnel plan as a major department of the university's activities. Counselling has been defined in almost as many ways as there are institutions using it as part of their programme. The chief method of counselling is through the interview; but before adequate counsel can be given the student much data must be gathered concerning him and the problems he faces. Thus the modern use of the term "counselling" has come to include the various means by which the student's individual problems may be met and solved.

Counselling may be divided into five major steps. These steps and the methods employed in each have been described by various authors (16,17,23,33,43). The next sections deal with counselling procedure based upon these descriptions.

A. Analysis.

This is chiefly the gathering of data concerning the individual seeking counsel. There are several traditional ways of doing this and some new ones have been introduced recently. They are:-

1. Academic record. This is one of the most available records of the student's achievement and is usually the sole measure used by the academic authorities to judge the individual's success in college. It is useful to show the academic weaknesses of a student and the post-counselling academic record is one means of measuring the efficiency

of the counsel.

2. The medical report. Often it has been found that poor academic work is due to some minor physical ailment which may easily be remedied. A physical analysis is also a great help in advising the student as to which occupation he is best fitted to enter.

3. Social and economic background. Information pertaining to the student's social behavior, his cultural background and the condition of his finances may be obtained from the student in interview, his application and registration forms; from his parents, relatives, teachers and fellow-students, and from social service agencies if he, or his family, have had any contact with them. The aid which such data gives in diagnosing the student's fundamental problems and in helping him solve them cannot be over-emphasized, especially if it is as objective and complete as possible. The check-up of statements made by the student by the various methods mentioned above has been found very helpful in some of the personnel organizations, for the individual is rarely able to give an objective account of his own experiences and conditions.

4. Work experiences. By relating the different aspects of his academic work to similar aspects in the various vocations the student is able more easily to come to a decision in the choice of his career. Summer work and any part-time employment also serve as a basis for such choice. The role of the personnel worker is to help the individual analyse these experiences so that he may reach

adequate and valid conclusions from them.

5. Psychiatric report. This is often unnecessary; and in cases where it is, the problems must be dealt with by a specialist. Lloyd Jones (17) gives a very good description of the mental Hygiene work done at Northwestern University. In addition to the individual work done for those who are already suffering from some mental ill-health there is possible a programme of preventive work through mental Hygiene lectures, and through early perception on the part of the personnel worker of possible causes of mental ill-health.

6. Tests. The new approach to an estimation of the individual through standardized objective tests is for the purpose of refining his impressions upon us. It permits the impression made to be more objectively comparable with similarly derived impressions made by others and also to be passed on in a definite form to others. A test is a sample measure of some aptitude, achievement, or characteristic procured under scientifically standardized conditions.

There is still a great deal of controversy over the value of the new psychological methods of measurement. It has been accepted in most universities as an aid if not a sole factor in diagnosing many conditions. Of course the acceptance of tests as useful aids does not always have as its corollary their organized use. Their acceptance and use grows with their refinement.

Testing is an integral part of all the more highly organized personnel systems. Test measurements have been used both in gross statistical selection and in personal work with the individual. The latter use of tests requires a great deal more training and experience on the part of the administrator than does the former. Another use of tests is for the purpose of research; this is most important from the point of view of improving the measuring tools in the hands of the personnel worker.

The more tests used in studying the individual, the more accurate will be the conclusion arrived at. The interpretation of the test must be arrived at cautiously and with due knowledge of the test's purpose and proven qualities. Much harm has been done to testing through inexperienced people attempting to use and interpret tests. More will be said in a later section regarding the various kinds of tests, their uses, and qualities.

7. <u>The interview.</u> Most of the counsellor's information regarding the individual's subjective attitude towards his problem and the effect of past experiences upon his outlook is gathered in the interview, although some information may be previously gleaned through the use of questionnaires etc. The interview is the personal contact between the personnel worker and the student and so is part of the method employed in nearly all the steps of counselling procedure. Emphasis may be laid on the necessity of complete recording of the details of each interview; as little as possible should be left to memory. A write-up of the interview immediately following its close has been found to be the most efficient method.

B. Synthesis.

This step is for the purpose of bringing together and co-ordinating all the information gained through the analysis. It will give the counsellor as complete and dynamic a picture of the individual as is possible and if properly carried out will simplify his work, and at the same time will make his diagnosis and decisions more accurate from having everything before him at the time of decision. Various forms for case histories have been produced.

Williamson and Darley (43) list the following details as necessary on a case record.

1. Full name of student. Names of both parents, (if divorced).
2. Age, date, and place of birth.
3. Religious preference.
4. Present and permanent address; telephone.
5. Parent's address and Father's occupation; and education of both parents.
6. Name, education, and occupation of brothers and sisters.
7. Name of high school; date of graduation; type of course taken; age at graduation; size of high-school senior class.
8. High-school subjects liked best, high-school subjects liked least.
9. Extra-curricular activities and offices in high school.

10. Other colleges or special schools attended: name of school or college, date attended, courses taken.
11. Listing of present interests, leisure-time or recreational activities and extra-curricular activities, such as athletics, dancing, bridge, movies, hunting, etc. Listing of church, clubs, fraternities, or organizations to which student belongs; types of books or articles of interest; favorite magazines; political and cultural interests, e. g. politics, art, drama, music, current affairs, etc.
12. Family's attitude toward college work; plans for financial support in college.
13. Employment experiences, jobs liked best.
14. Present vocational choice; year of making choice; reason for making choice; certainty of choice.
15. Student's classification of various occupations in terms of his general interests and abilities.
16. Words to be indicated by student as descriptive of general make-up, such as bashful, self-confident, nervous, etc.
17. Symptoms of physical condition to be indicated as present or absent; e. g., headache, backache, etc.
18. Physical disabilities (as reported by student).

19. Comments or remarks.

The case record form is not to be confused with the complete case file. This is stressed by both authors of the above, and the Sub-Committee on Personal Record Cards of the Committee on Personnel Methods of the American Council on Education. The latter body in a report (1) published in 1933 put forward a form for a cumulative record card which in as brief a manner as possible gives the complete life history of the student in anything pertinent to his personal guidance. Their criteria of a good cumulative record card on which to summarise the data contained in the case file are:

1. The record form must show trends of development of abilities and, in consequence, must be cumulative.
2. It must be based on accurate measures and concrete observations.
3. The record must provide a means for recording measures and observations in comparable and meaningful terms wherever such measures are available, but must, at the same time provide for convenient recording and clear differentiation of whatever measures, subjective and non-comparable, may be available.
4. The data should appear in a form and order capable of showing their inter-relations and thus presenting a coherant and integrated picture of the individual.
5. The record should be capable of quick reading. For many personnel officers this means that a part of

the data should be recorded graphically.

6. The record should be fairly complete for the large mass of "normal" individuals, requiring auxiliary cards only for extremely typical subjects, mental or physical.
7. The record should be accompanied by a carefully written and amply illustrated manual of directions.
8. It should be administratively convenient, showing all available information on one continuous record form and permitting the collection of further data by auxiliary cards and otherwise for current use and for periodic sifting and entering on the permanent record.
9. It must provide, so far as possible, for minimum expense in maintenance.

Following these principles the Sub-Committee produced a cumulative record card which should find large use among the university personnel departments. The card is amply described and explained in their report. The record will go with the student through lower school and so on out into vocational life. The manual provided for the card contains instructions for the gathering of the necessary material. Such record cards while being necessary for an adequate treatment of the student are at the same time invaluable for the personnel research worker.

C. Diagnosis.

This depends to a great extent on the ability and experience of the counsellor. The diagnosis consists of the correct and useful decision as to the fundamental problems of the individual and their causes. Students' problems with a few exceptions may be classified in six groups; health, educational, social-emotional-personal, vocational, financial,and family.

D. Prognosis.

Once the diagnosis has been accomplished the next step is prognosis. The evidence is summarized and presented to the student with all the possible alternatives of future action which the counsellor thinks possible and practical. Experienced personnel workers stress the importance of allowing the student to make the final decision himself. It is not the duty of the counsellor to make up the student's mind for him; but sometimes personnel workers forget that many students come to have the counsellor make them make up their minds, to encourage them to come to some decision so that all their energies may not continue to be wasted through doubt and indecision concerning the immediate and future goals. In this the watchword is not commands but guidance resulting in a definite decision.

E. Treatment.

Much treatment ends in making the student come to a decision; but there are many cases in which remedial treatment is necessary. This may consist of having the student change his aims or habits; as for instance,a change in curriculum to one more suited to his abilities and aptitudes, or it may be advice leading to new methods in finance matters or health. Many universities have remedial courses for students having educational problems, for example "How to Study" classes, special subject tutorial classes, etc. It must be remembered that treatment is not finished with the outline of what it should be, the counsellor must follow his case along until he is sure that as complete and permanent an adjustment as possible has been made.

This aspect coincides with follow-up work which also has as its purpose the wish of the counsellor to see the efficacy of his advice. Follow-up work also keeps an eye on the student to see if he is steering an even course, or if new problems have arisen. Then in the end there is the follow-up of the research worker who wishes to gather material in order that tests and techniques of the personnel worker may be improved.

The whole procedure in personnel work may be compared with medical practice. The analysis is the gathering of data regarding the symptoms; for example, test results may be likened to thermometer readings. Then follow the similar steps in both procedures, the synthesis of the symptoms in order that a correct diagnosis may be reached, the prognosis and treatment of the problem or disease, and the follow-up in order that the cure may be sure and permanent and as a check on the methods used. The necessity of a good case history is just as important in personnel work as in medicine. In fact some might consider personnel work a field of medicine in the larger sense.

We have reviewed the functions of the modern student personnel department. There are differences of opinion as to how these functions may be best carried out. Some believe that a personnel department should be centralized under a separate administrative head differing from the other administrative departments as staff and line departments differ in industry. Others hold that it should consist of an organization for the purpose of co-ordinating the various functional units of the university so that each may co-operate with the other in giving the student the best opportunity possible.

Williamson and Darley (43) are of the latter opinion, and although the majority of universities having personnel departments have organized them on the former principle, the co-ordination plan seems to be more feasible both for introducing the personnel idea into an institution unused to it and for the purpose of getting the greatest co-operation from the whole university. Co-ordination means using the agencies already present in the university, and supplementing them with whatever further bodies are needed to complete the needs of the personnel system, as, for instance, the need of a testing bureau in most colleges. The centralization system may have as its corollary, not an improvement in the student's lot, but a loss due to the jealousy and suspicion it arouses in the established system. The voluntary aspect of co-operation brings with it the willing coördination of the academic and administrative staff so that the whole university becomes the personnel department. Both from the viewpoint of the staff and of the student it is advisable to have professors especially interested in personnel work act as counsellors, for one of its results is that the student then thinks of the professorial staff as his teacher and guide rather than as an information machine from which the most is to be got through the advice of the personnel department. Of course it is necessary that there should be a personnel organization for the coordination of such a scheme and for the necessary clinical adminis-trative and clerical duties such as keeping case records, obtaining information,and making contacts.

"In discussing the development and organization of student personnel service in a university organization it is well at the outset to raise a fundamental question, namely: Who are the personnel officers in a university? The answer depends upon one's conception of the functions of personnel work and the way those functions can be discharged most effectively.

A page from the history of industrial personnel work may throw needed light on the question, since personnel work in industry has undergone an important change since the pre-war days of "centralization of personnel work in employment office." To quote, "Now, personnel administration is not, and cannot be, a departmentalized function. The personnel work of an organization cannot be housed within a certain department bearing that exalted name. Personnel administration is a leaven permeating all phases of management; the responsibility for it rests upon all executives and persons in supervisory positions. Personnel policies may be decided upon by the officers of the organization, but it is the executives, the foremen, and the supervisors who carry out those policies. They are the real personnel managers. Obviously a very great need exists for giving these executives, foremen, and supervisors the right point of view toward the administration of their subordinates. It is necessary that advice and consultation be made available to them in directing their workers. It is requisite, if the company's policies of personnel administration are to be uniformly and effectively carried out, that there should be an organization within the company, a department (if the reader will not allow the word to suggest separation and dettachment) which will be charged with the responsibility for seeing that the company's policies relating to personnel practices and procedure are carried out." (Scott 35). In other words personnel administration should be decentralized with centralized control.

If we may heed industrial experience in this field our answer to the original question is: The class-room laboratory instructors constitute the corps of personnel officers; they are the ones who are in constant, daily contact with the student body personnel and reliance must be placed upon them to put into practice whatever personnel policies and techniques may be developed." (43)

Thus we see the advantage of a personnel system not organized separately but as a function of the whole institution. The personnel counsellor while not an all-time personnel worker must not be an amateur at his work.

Colleges and universities should find suitable ways of decreasing their student mortality and student maladjustment. Scientific experimentation and individual study are necessary for the solution of these problems. The realization that individual differences exist and that through the organization of modern methods they may be directed to a more adequate self-determination making for the greatest possible happiness of the individual will help in solving educational and vocational adjustment. Personnel work is the organization of these modern methods of individual analysis, diagnosis, and direction.

CHAPTER II

Psychological Measurements
A brief review

The recognition of the traditional methods of educational examination and measurement as inadequate has encouraged the application of the scientific principles of psychological measurement to the task of measuring the aptitudes and achievements of the student. This has resulted in the development of various types of standardized objective tests. Cubberley wrote in 1917 (24a), "Still more recently, and wholly within the past decade, a still better method for the evaluation of the work which teachers and schools are doing has been evolved. This new method consists in the setting up, through the medium of a series of carefully devised "Standardized Tests", of standard measurements and units of accomplishments for the determination of the kind and the amount of work which a school or school system is doing. This new movement is as yet still young, but so important has it become in terms of the future of school administration that it already bids fair to change, in the course of time, the whole character of this professional service.

"The significance of these new standards of measurement for our educational service is indeed large. Their use means nothing less than the ultimate transformation of school work from guesswork to scientific accuracy; the elimination of favoritism and politics from the work; and the changing of school supervision from a temporary job to that of a highly skilled piece of social engineering."

The increase in the number of standardized psychological and educational measurements has been very rapid in the last few years. We have already seen some of the uses to which these measurements may be put in universities. The present section will deal with those measurements which are practical for the prediction and estimation of scholastic success in college. Before reviewing the different types of test in use let us look at some of the general conclusions regarding psychological tests that MacPhail (25) arrived at after directing a testing program at Brown.

Psychological tests, although by no means a perfect indication of what a student is likely to do in college, constitute one of the best available means for determining scholastic ability. About three-fourths of the students who receive high psychological scores in the psychological tests do satisfactory work in college. Only one-third of the students receiving low scores do satisfactory work. On the basis of what students have done in the past it is possible to state quite definitely what kind of academic work one has a right to expect on the average from a student who makes any given psychological score.

Nearly half of the students making high scores on psychological tests do B work or better. Nearly half of the students making low scores in both tests have academic averages below sixty-five per cent. Students who leave college for any and all reasons are as a group intellectually inferior to the rank and file of students. Those dismissed from college show a more marked inferiority. Among the students who make extremely poor academic records during the first semester there are from five to seven times as many with low psychological scores as with high.

Almost without exception the students who receive more than one academic honor are men with high psychological scores. Men receiving low psychological scores have practically no chance whatever of obtaining academic honors.

A student's rank in high school at graduation is not a reliable index of his intelligence as measured by the Brown and Thorndike test; nor does it indicate what he will do in college nearly so well as do his psychological scores. Three-fourths of the students from the two lowest fifths of their classes at the time of graduation have very little chance of succeeding in college.

Out of ten men with low high school ranks and also with low psychological scores, from seven to nine fail to succeed in college; and, coupled with poor academic work at the end of the first semester, a low psychological score is a reasonably just criterion for dismissing a man from college at that time. A student's general academic grade at the end of his first semester is a very accurate index of what he will do during his second semester; similarily there is a very close agreement between academic averages for the freshman and sophomore years.

Adaptation to the academic side of college life does not take place to any considerable extent until the junior year, and a surprisingly large proportion (nearly thirty per cent) of students who are superior academically, early in their college career, fail to maintain that standing.

These conclusions are drawn from research carried out at Brown using the Thorndike Psychological Test and the Brown University Test, but they may be taken as fairly representative of the findings on the use of general intelligence tests as predictive measures. In closing MacPhail points out that there is no single test or criterion that can accurately estimate a candidate's fitness to do the academic work required in college.

Psychological measurements may be classified according to function or structure; the following classification is primarily functional.

1. General intelligence tests. These may be divided into verbal and performance tests and may be constructed either for individual or group administration. The Stanford Revision of the Binet-Simon scale is an example of verbal and performance measures combined in the same scale for individual administration. The Kohs Block Test is an individual performance test, while the Otis Group Intelligence Test and the Army Beta Scale typify the group verbal test and the group performance test.
2. Achievement tests. These are intended to measure ability, that is natural aptitude, developed and increased by

education. The realization that the traditional examinations were inadequate as measures of accomplishment as well as predictive factors was the chief reason for the production of standardized achievement tests. The American Council on Education formed a committee in 1927 to supervise the construction of adequate achievement tests.

These tests are used as measures of accomplishment as well as for predictive measures in the selection of college students. When they are employed as predictive items, tests are given in subjects which appear in both the high school and college curricula. Examples of the newer achievement tests are the Iowa Placement Examinations and the series of college achievement tests of the American Council on Education.

3. <u>Personality measurements</u>. An attempt has been made to make the traditional measures of personality more objective, accurate, and complete, and to construct new measures having these qualities. A committee of the American Council ~~Committee~~ on Education was organized to survey the field of personality measurement and under their direction many new measures have been constructed. Personality measurements are not yet as good as those developed for the testing of aptitudes and achievement; but they are a decided improvement on the traditional measures and are being improved steadily.

Drake (6) does not find the present forms of interest and affectivity tests of much use in predicting college success. Flemming (10), however, concluded that there was a correlation between an emotional test score (Pressey-X-O) and scholarship. Ohmann (30) believes that emotional and motivational factors are extremely important in the maladjustment of the brilliant student and that these should be discovered and remedied. Ryder (33) found that personality tests were of help when used in conjunction with other predictive items in selecting potential college failures. Watson (41) reports that graduate students given highest rating by professors are those most in need of personality-emotional-social diagnosis and treatment.

The personality measurements while still in the early stages of construction and standardization seem to be filling a vacancy that has always existed. They should become excellent measures both for the selection of students and for the diagnosis of personality maladjustments of those already in the university. The clinical ability and experience of the administrator is most important in interpreting the results of these tests which are still in the experimental stage. Examples of this type of test are: the various free association tests, the personality and character rating scales, and the vocational interest tests such as Strong's.

4. Aptitude tests. The aptitude test is an attempt to measure the individual's specific potentialities, so that one may predict which individual should have a certain type of training and, on the other hand, so that one may advise the individual from what type of training he is likely to receive

the greatest returns. In education, aptitude tests are usually in specific scholastic subjects, although they may be broader in their scope. An example of the specific subject achievement test is the Aptitude section of the Iowa Placement Examinations, while the Stanford Scientific Aptitude Test is of the broader type, measuring a more general aptitude. This class of test is almost altogether for the purpose of measuring innate aptitude and of predicting the value of training, but insofar as aptitude and achievement cannot be separated these two types of tests overlap to some extent.

As MacPhail (26) and several other writers have pointed out that no single criterion is sufficient evidence upon which to predict a student's future performance, Segel (37) recommends the use of test batteries, points out the increase of tests to measure different traits is more important than increasing the length of tests already in use. He gives as an example of the efficiency of a broad test battery the successive editions of the American Council On Education Examination, which have increased their correlations with college success due to the careful selection of various tests rather than to the lengthening of tests. Segel recommends as an excellent basis for the prediction of college success the following criteria:

1) scholarship as shown by high school marks;
2) the results of a general mental test;
3) the results of objective test on common elements of high school achievement.

Further success in the use of tests will follow the more adequate understanding of statistical method by those who use the tests. The tests of intellectual aptitude and achievement are hampered by the influence of emotional and interest factors; thus a student of high aptitude and ability may be unable to do well due to personal problems or to lack of interest in the subject. Crawford found that the purpose of students attending college had an effect upon the correlation between their tests scores and their grades.

These few and random observations upon the various types of psychological measurements and their employment, while not at all adequate in describing the science of modern testing, will perhaps be helpful in understanding the choice and use of the Stanford Scientific Aptitude Test at McGill in 1932 as a probable predictive measure to aid in the selection of science students.

CHAPTER III

The Stanford Scientific Aptitude Test
History and description

During 1932 at the request of the Science Division of the Faculty of Arts and Science of McGill University the Department of Psychology undertook to administer to all members of the first, second and third years of the science course a Test of Scientific Aptitude which had just been developed and published by D. L. Zyve of Stanford University. This was done for the purpose of determining whether such a test would be of any value in predicting success in the academic course and more particularly in graduate study and research.

An immediate examination of the results was made but it was considered advisable to await the graduation of the students tested before coming to any final conclusions. The group in first year at the time of the test graduated in 1935. The present study was begun in the fall of 1937. In this way all the classes tested had an opportunity for at least two years graduate study and some four. The present report is based almost entirely on inter correlations of the test and the scholastic marks of the students tested. Before examining the results of this investigation let us review the history of the Stanford Scientific Aptitude Test.

In 1929 D. L. Zyve published in the Journal of Educational Psychology a paper entitled "A Test of Scientific Aptitude" (45). This was followed by the publication in 1930 of the "Stanford Scientific Aptitude Test" by Zyve (46) accompanied by a Manual of Directions and Scoring Key (47) and an Explanatory Booklet (48). In his article in 1929 Zyve set forth the reasons for undertaking the construction of the test, the methods employed and the results obtained in a preliminary application.

Modern industry and higher education have by their rapid growth made necessary the application of scientific principles of systemization, organization, and selection to their efficient development. The lack of scientific selection is evident when about 50 per cent of graduate engineers are found fifteen years after graduation in positions having little or nothing to do with the specialized training they have received. Some of the engineering profession have realized the necessity of better methods of selection in order that there may be fewer students enter the profession which later they will not follow.

One approach to the problem of selection is through the development of scientific tests which will give a more accurate idea of the individual's aptitudes. One trait which may be measured, and which when measured will be a basis for predicting an individual's success in science and engineering, is, according to Zyve, the aptitude for science or engineering.

Natural Science is defined as organized knowledge based upon experience and observation, and is the product of the interaction of two processes: the observational and the descriptive. There are, therefore, three types of natural scientist:

1. the observational group (Tycho Brahe);
2. the descriptive group (Maxwell); and
3. those who are equally proficient in both fields (Darwin, Faraday, Pasteur).

Zyve reviews some of the qualifications that great scientists have claimed as necessary for success in science. He concludes that the differences in aptitude between a biologist, chemist, physicist or engineer are, beside interest, secondary in nature and that they all have the aptitude for using the scientific method of approach in various problematic situations, characteristic of natural science. The essence of scientific method is described as wide-awake observation and reasoning, analogical thinking, and experimentation. It is scientific aptitude of this type that Zyve wished to measure.

"If scientific aptitude is a complex conglomerate of mental and character traits, as is probably the case, it ought to be analyzable into its components such as;

S A B C D E F G ...... etc.,

where A is, let us say, ability to reason (original, not routine reasoning); B, ability to form generalizations through the inductive method; C, accuracy of observation; D, discrimination of values in selecting and arranging experimental data; E, powers of suspended judgment; F, patience or sustained effort; G, imagination (including creative imagination) H, devotion to truth; I, muscular co-ordination; J, orderliness; K, sensory acuity, and so on." (45).

Zyve points out that all these components are not of equal importance. "Which of the elements should be incorporated into a scientific aptitude test?" An attempt is made to choose the most fundamental elements of scientific aptitude and those which are least the product of training. And although the choice of elements may not be exactly accurate either in number or nature yet this need not make impossible any measurement if it can be shown that a scientific measurement of those elements chosen has an acceptably high correlation with scientific aptitude as detected by some other method, such as actual performance in the field of science.

On this basis the following items were included in the Test of Scientific Aptitude, the description is based on the Explanatory Booklet and the Test.

Exercise I(Experimental Bent). - The test of this trait has been devised to detect, not the actual experimental ability due to training, but the first impulse which is actually symptomatic of a "bent". It does not matter whether the answers to various questions of this test are exactly applicable to real situations; that is, whether the individual would actually proceed in the way he indicated had he been placed in a corresponding life situation. What matters is that following his first impulse he would be inclined to proceed in the way indicated by him rather than in any other way. Once an experimental bent is detected, the degree of experimental ability is but a matter of training, other things being equal.

<u>EXPERIMENTAL BENT</u>.(Five Exercises).

(Suppose that you have plenty of leisure and the necessary means for meeting the situations described below. Check frankly the statement which comes nearest to the way in which your first impulse would lead you to handle the matter. (If you wish to be helped by this test you must be absolutely frank.)

You wish to get the lowest possible temperature from a mixture of ice and salt, but found contradictory statements in two books as to the accurate proportion of salt and ice.

(A) Take a proportion of ice and salt that is an average of those suggested in the books.

(B) Mix ice and salt in suggested proportions and check the information given in the books.

(C) Call up an ice-cream factory and secure the information needed.

The weight of this exercise is 3.

Exercise A (Clarity of Definition). - The purpose of this exercise is to see whether an individual is capable of differentiating better definitions from poorer ones and of appreciating their relative values. It matters little whether or not the best of the four definitions is the best possible one. What does matter is that it is the best of the given four.

These definitions were ranked by seven judges selected from among the faculty members in science and engineering departments at Stanford University. Only those definitions were adopted upon which unanimity of the judges was secured.

DEFINITION (Four Exercises).

Rank the following definitions of a bow according to merit, i. e. write 1 next to the best definition, write 2 next to the second best, etc. The poorest definition will receive the rank of 4.

A bow is a weapon used by primitive people, either in war or for hunting small and even large game by means of arrows.

A bow is a piece of wood which, after having been bent into an arc is used for shooting arrows.

A bow is a weapon well known in every country from time immemorial.

A bow is a weapon made of a strip of wood or other material, the two ends of which are connected by a cord, by means of which an arrow may be projected.

The weight of this exercise is 4.

Exercise E (Suspended Versus Snap Judgment). - The power of suspended judgment has been stressed by many scientists. Lack of suspended judgment, a consistent tendency of guessing at things, when data are utterly inadequate, is a decided handicap. Although such a short-coming may be found among men of science, it is a shortcoming nevertheless. It becomes a serious drawback when an individual makes a guess in cases where a simple computation would have given him the correct answer.

SUSPENDED VS. SNAP JUDGMENT (Five Exercises).

Write a check in the square next to the correct answer to the questions given below:

1. What will be the cost of living in this country in the year 3000?

About $50 per month per capita?

About $100 per month per capita?

About $200 per month per capita?

About $300 per month per capita?

Over $300 per month per capita?

If unable to answer check here.

The weight of this exercise was 4.

Exercise J (Reasoning). - The trouble with so many college students is that they "know" how to solve problems of a "known type", how to think in routine situations; yet as soon as the situation is unfamiliar to them, as soon as it does not fall within a given "type" of problem, they are baffled and often totally unable to follow simple, clear-cut reasoning in simple and unambiguous problematic situations.

The problems selected or devised in this exercise require concentration and straightforward reasoning. No special technical information of any kind is required.

REASONING.

2. There is a train leaving city A every hour (at the hour) and going to city B. At the same time another train leaves city B going to city A. The journey lasts exactly 20 hours. You took a train from A. How many trains did you meet on your way to B, counting the one that reaches A at the moment of your departure and the one that leaves B at your arrival?

Answer here.....

If you don't enjoy this type of problem check here.

The weight of this exercise is 7.

Exercise R (Inconsistencies). - The exercise consists in detecting inconsistencies or illogical conclusions.

INCONSISTENCIES.

Read the following five paragraphs. If a paragraph is consistent throughout, put an X in the square next to the top of each paragraph; if it is not, put a -a, and write in the two lower squares the numbers corresponding to the phrases or sentences which cause the inconsistency or lead to an illogical conclusion.

5. In stream or gas engines heat is changed into work. According to the laws of Thermodynamics, there will always be in steam or in gas engines a certain amount of heat besides that produced by friction, from which no work can be secured. Were it not for friction our steam and gas engines would be 100% efficient.

(The phrases were numbered).

The weight of this exercise is 3.

Exercise 0 (Fallacies). - The aptitude for detecting fallacies, for not being misled by their apparent plausibility is a trait of importance. The imaginative but not scientific minded have shown in this exercise a decided inferiority.

FALLACIES.

'1. The "Evening Star" correspondent writes from city A; "A plan was offered to X, located on the shore of Lake Ontario, by which it was proposed to generate at low cost electric light and power for the vicinity. The method consisted of digging a deep pit in the lowest part of the shore, at the bottom of which the plant was to be located. The cost of equipment for the plant would be relatively low, as it would consist only of generators run by turbines to which the lake water would be led through a large pipe."

At the meeting of the council various reasons were given either for or against this project. Put an X in the squares next to the statements which you would endorse, and a - next to those to which you would object.

1. I am in favour of this project, for the plant will be almost as advantageous as any using a natural waterfall.

2. I oppose this project, for the plan will never be practicable.

3. I am in favor of the project, for very cheap power would be generated by the proposed method.

4. I am opposed to the project, for such a plant would be very unsanitary.

The weight of this exercise is 5.

Exercise S (Induction, Deduction and Generalization. - The ability to draw correct inductions and deductions and to form lawful generalizations is a trait essential in any work requiring a scientific method of procedure. Simple situations, taken from the realm of physical phenomena and expressed numerically, are most susceptible to thie treatment.

Unfortunately in this connection, elementary physical laws are too well memorized by the high school student, and any simple problem falling under a physical law known to him could be easily recognized and automatically solved.

Such a solution would be for our purpose, of little significance. For what we intend to test, through this exercise, is not memory, not even intelligent information in physics, not training in philosophy, but the student's aptitude for forming correct inductions, deductions, and quantitative generalizations. For this reason, we have taken him on to a distant planet, in a world different from ours, where natural phenomena are made to follow laws different from those found in a textbook of physics.

One need not be alarmed by this apparent violation of the principle of uniformity. Under the circumstances such violence is harmless, and, moreover, it enables us to devise simple experimental situations the laws of which are not so thoroughly masticated in our high school textbooks.

INDUCTION, DEDUCTION, AND GENERALIZATION.

1. A scientist on a distant planet, in a world different from ours, was trying to discover the law governing the behavior of gases. He took a certain amount of gas, which occupied exactly 100 cubit feet, and with a pressure-gauge found the pressure of the gas was one pound per square inch. He then compressed that same amount of gas to a volume of 50 cubic feet. At that moment the pressure gauge indicated four pounds. He proceeded then compressing the gas more and more. Below are recorded the results of his experiment. (The temperature of the gas remained the same throughout the experiment).

Volume of Gas.	Pressure.
100 cu. ft.	1 lb. per sq. in.
50 cu. ft.	4 lbs. per sq. in.
25 cu. ft.	16 lbs. per sq. ft.
12.5 cu. ft.	64 lbs. per sq. ft.
2.0 cu. ft.	2,500 lbs. per sq. ft.

a. To what volume, probably, will the gas be reduced under the pressure of 1,600 lbs. per sq. in.? Answer here...........

b. If the gas occupies a volume of V cu. ft., when the pressure is P lbs. per sq. in., what formula will express the probable law governing the behavior of gases on that planet? (If you use a constant in your formula call it K.).
Answer here..............

The weight of this exercise is 7.

<u>Exercise F</u> (Caution and Thoroughness). - The exercises are, apparently, based upon well-known optical illusions; in reality, they have little to do with illusions, and were arranged with the purpose of meeting two ends: First, to determine whether or not the student is cautious enough to read the instructions carefully (as he is invited to do); Second, whether or not he is thorough enough to carry out these instructions without being influenced by the apparent ease of the task or by faulty inductions.
The weight of this exercise is 5.

<u>Exercise K</u> (Discrimination of Values in Selecting and Arranging Experimental Data). - The purpose of this exercise is to detect the aptitude of the individual in visualizing an experimental or statistical situation. What is essential in solving the exercises is the capacity for an analytical discrimination of values of various data presented. While on the surface the results seem mostly to depend on training,

the actual answers given by several students majoring either in science or in engineering disprove such a view to a very considerable extent.

DISCRIMINATION OF VALUES IN SELECTING AND ARRANGING EXPERIMENTAL DATA.

1. A physicist wanted to measure the length of a fine wire with precision; for this reason he measured it several times.

Below are given the results of his measuring:-

1st measure	... ...	13.63 cm.
2nd "	... ...	13.13 cm.
3rd "	... ...	13.12 cm.
4th "	... ...	13.14 cm.
5th "	... ...	13.15 cm.
6th "	... ...	13.16 cm.

What is the probable length of the wire?

Answer here.......

The weight of this exercise is 5.

Exercise M. (Accuracy of Interpretation). - The correctness of interpretation is tested by a multiple-choice set of questions based upon more or less technical material not requiring any special information.

ACCURACY OF INTERPRETATION.

The student is given a paragraph about the transference of light to read, he is then asked to designate which of many conclusions given below are correct.

The weight of this exercise is 2.

Exercise L (Accuracy of Observation). - The test consists in completing a geometric design so as to make it identical with another one. To those who have no acute sense of observation and are unable to analyze systemically a complex situation into its elements, the exercise appears decidedly complicated. In reality it is very simple for those who are accurate and systematic in their work.

ACCURACY OF OBSERVATION.

The two drawings in A and B are alike except that in B a certain number of lines is omitted. Fill in all the lines lacking in drawing B so as to make it practically identical with DrawingA. Use either black ink or pencil, and draw heavy, easily visible lines.

There follow two intricate, but symmetrical geometric designs side by side.

The weight of this exercise is 3.

The relative weights of the exercises were determined by comparing the responses of two groups of students, one composed of fifty research students in the Department of Physics, Chemistry and Electrical Engineering (Criterion or Scientific Group); the other composed of one hundred and twenty-one senior and graduate students in the departments of English, History, Languages, Economics, and Law (the Non-Scientific Group). The comparison was made by means of 2x2-fold tables, the line of dichotomy passing through the mean scores of the Scientific Group. The co-efficients or tetrachoric correlation (multiplied by ten) were then used as corresponding weights. These range from two to seven.' (43,44,46).

Each item of the test is scored individually, the highest possible score being 180.

We have ~~received~~ reviewed the purpose and construction of the Stanford Scientific Aptitude Test. The next chapter will deal with the statistical studies of the test at Stanford and at McGill.

CHAPTER IV

The Stanford Scientific Aptitude Test (cont'd.)

Statistical study and analysis

Zyve (45) administered the SAT to fifty research students in physics, chemistry and electrical engineering; these were used as the criterion group. The test was given to other groups as well and some of the results will be examined later.

At McGill, however, the test was given to the first, second and third years of the Science division, these were the classes which graduated in '35, '34, and '33 respectively. These groups contained both men and women and the main correlations included both sexes. Thus, while Zyve compared the scores on the SAT with contemporary rankings and grades of the subjects, at McGill it was possible to compare the subject's score on the test with his later accomplishment.

In the McGill administration of the SAT the scores and grade of the three classes were combined in computing the main correlations; that is, in finding the correlation between SAT ranks and first year science marks the population included, in all, three classes (33,34,35), and so the correlation contains scores of those ('35) who were taking first year science at the time of the testing and also of those (33) who had taken first year science three years before. This same principle applies to all the main correlations.

At Stanford the criterion used for estimating the validity of the test was the ranking given the fifty students of the criterion group by their professors, two professors ranking each student independently. The ranking was on the basis of aptitude for science rather than ability in research. The only criteria used at McGill were the scholastic grades of the subjects. It was found impractical to obtain ratings of the students by professors due either to the size of the elementary classes or to the fact that at the time of the final analysis so many of the subjects had been graduated for several years.

The subjects' scholastic marks in each year were divided into three groups;

Physical sciences	Biological sciences	Arts
Mathematics	Zoology	Languages
Chemistry	Physiology	Philosophy
Physics	Botany	Social sciences
Geology	Genetics	History
	Biochemistry	Classics
	Anatomy	Education
	Histology	
	Embryology	

In matriculation and first year there are very few biological sciences taken, and in second, third, and fourth years of the Science course the number of Arts subjects taken is negligible. The marks of each student in matriculation and the four years of college were obtained, grouped according to the above divisions and the average of each division taken as the representative mark to be used in estimating the correlations.

The correlations obtained by the method described above are shown in Table 1. These correlations were computed by the product-moment method on Otis Correlation Charts. Three correlations are missing from the table, this being due to the small populations (5 or under) having scores in both variables. Table II shows the correlations again with their P.E., the means and standard deviations of both variables, and the populations. The populations drop considerably from year to year due mostly to scholastic mortality. There are perhaps two important exceptions to this rule:

1, the class of 1935, who were in first year when the test was given, contains all the pre-engineering students who took their pre-engineering year of college work at McGill;
2, at the end of third year some students of high rank leave the science course to enter the medical school, and so what seems due altogether to mortality is, in some measure, due to selection.

There are also in Tables I and III correlations between the various measures and Otis Group Intelligence Test scores, about 40 of the subjects having taken the Otis at one time or another during their college career.

Table III shows the population taking the test of the three classes; what percentage of all the possible subjects took the tests (the test was not absolutely compulsory): the mean and median SAT scores of the various groups, the semi-interquartile range of each group; and the range of SAT scores for the various groups. Some computations are missing due to the fact that the data for these computations was available only at the time the test was given, and if not used then it was impossible to obtain five years later.

TABLE I.

LEGEND:

S	SAT scores	
O	Otis scores	
Ms	average	matriculation mark in physical science subjects
1s	"	first year " " " " "
2s	"	second year " " " " "
3s	"	third year " " " " "
4s	"	fourth year " " " " "
Ma	"	matriculation mark in arts subjects
1a	"	first year " " " "
2a	"	second year " " " "
2b	"	second year mark in biological science subjects
3b	"	third year " " " " "
4b	"	fourth year " " " " "
G	"	of marks in graduate school examinations, due to the few cases no distinction was made as to biological or physical science subjects; nor were these ratings, of which there are only three, taken into account.

This legend applies to all other tables following in which these symbols are used.

The mark x beside an individual correlation means that it is unreliable.

TABLE I.

INTER-CORRELATIONS OF SAT SCORES, OTIS SCORES AND SCHOLASTIC MARKS.

	S	O	Ms	Ma	1s	1a	2s	2b	3s	3b	4s	4b	G
S	-	.522	.535	.195	.475	.229	.317	.030	.365	.306	.322	.428	.407
O	.522	-	.544	.637	.448	.605	.303	(.058)	(.278)	(.200)	(.381)	(.074)	(-)x
Ms	.535	.544	-	.475	.658	.395	.544	.465	.568	.352	.624	.239	.607
Ma	.195	.637	.475	-	.416	.441	.464	(.301)	.383	(.173)	(.215)	.401	.556
1s	.475	.448	.658	.416	-	.637	.603	.832	.649	.713	.678	(.206)	.793
1a	.229	.605	.395	.441	.637	-	.406	.484	.628	(.238)	.454	(.067)	(.390)
2s	.317	.303	.554	.464	.603	.406	-	.752	.395	.375	.581	(.235)	.484
2b	.030	(.058)'	.465	(.301)'	.832	.484	.752	-	.436	.550	.589	.350	(.276)
3s	.365	(.278)'	.568	.383	.649	.628	.395	.436	-	.387	.620	.627	.548
3b	.306	(.200)'	.352	(.123)'	.713	(.238)	.375	.550	.381	-	(.149)	.570	(-)x
4s	.322	(.381)'	.624	(.215)'	.678	.454	.581	.589	.620	(.149)	-	(.193)	.603
4b	.428	(.074)'	.239	.401	(.206)'	(.067)	(.235)	.350	.627	.570	(.193)	-	(-)x
G	.407	(-)x	.607	.556	.793	(.390)	.484	(.276)	.548	(-)x	.603	(-)x	-

( ) The r's in brackets are not reliable as the r is less than four times its P.E.

(x) Insufficient number of cases.

....

TABLE II.

INTERCORRELATIONS OF SAT SCORES,
OTIS SCORES AND SCHOLASTIC MARKS. (with additional data.

Measures x	Measures y	r	P.E.r	N	Mean x	Mean y	Stand. dev. x	Stand. dev. y
S	O	.522	.063	61	100.77	60.88	28.6	8.4
	Ms	.535	.038	186	99.70	75.08	25.2	11.4
	Ma	.195	.047	189	100.09	67.22	25.2	7.5
	1s	.475	.036	214	98.76	61.39	25.2	15.0
	1a	.299	.043	217	98.74	54.74	24.3	13.5
	2s	.317	.054	126	102.93	59.10	25.2	18.0
	2b	.030	-	75	94.48	59.86	22.5	13.5
	3s	.365	.059	94	106.48	64.55	27.5	16.0
	3b	.306x	.087x	48	95.31	62.62	23.3	10.5
	4s	.322	.077	60	112.60	73.08	27.0	11.5
	4b	.428	.081	46	90.50	64.50	23.4	10.0
	G	.407	.129	19	123.05	80.58	22.5	8.1
O	Ms	.544	.074	41	59.61	76.80	6.1	12.0
	Ma	.637	.062	42	59.57	67.78	8.1	7.2
	1s	.448	.077	49	59.65	62.49	8.4	14.0
	1a	.605	.062	48	59.56	58.75	8.1	12.0
	2s	.303	.073	55	58.93	58.82	8.7	19.5
	2b	.058x	.112x	34	56.77	59.50	7.5	13.0
	3s	.278x	.103x	37	60.59	67.94	7.5	14.0
	3b	.200x	.174x	17	59.00	64.06	8.1	9.0
	4s	.381x	.114x	25	61.60	74.8	6.6	10.7
	4b	.074x	.196x	12	55.40	65.00	4.8	6.5
G								

TABLE II. (Cont'd)

Measures x	Measures y	r	P.E.r	N	Mean x	Mean y	Stand. dev. x	Stand. dev. y
Ms	Ma	.475	.038	186	75.10	66.30	11.4	7.5
	1s	.658	.028	186	75.06	62.70	11.1	15.0
	1a	.395	.041	185	75.95	55.75	11.1	12.5
	2s	.554	.046	101	82.60	65.20	11.5	18.5
	2b	.465	.072	54	75.22	60.15	10.8	13.0
	3s	.568	.054	70	78.70	67.92	11.1	15.0
	3b	.352	.097	36	77.08	52.97	11.1	10.7
	4s	.624	.057	51	78.94	74.25	11.7	9.0
	4b	.239	.047	35	76.26	66.14	11.4	9.0
	G	.607	.117	13	86.50	81.61	8.4	7.0
Ma	1s	.416	.041	185	66.50	62.92	7.3	15.5
	1a	.441	.039	186	79.46	55.89	7.2	12.6
	2s	.464	.051	103	77.88	60.39	7.5	18.5
	2b	.301[x]	.084[x]	53	67.88	60.39	7.2	13.0
	3s	.383	.067	72	69.17	67.48	7.0	15.4
	3b	.173	.098[x]	44	69.59	64.27	7.5	11.25
	4s	.215[x]	.087[x]	51	69.65	73.66	6.7	10.5
	4b	.401	.089	39	71.62	67.50	9.0	10.0
	G	.556	.122	15	69.60	82.00	8.4	7.0
Ls	1a	.637	.028	215	61.70	54.80	15.0	13.0
	2s	.603	.039	116	66.61	59.63	12.5	18.5
	2b	.832	.025	65	60.00	59.69	15.5	12.6
	3s	.649	.044	79	69.40	66.87	12.0	15.4
	3b	.713	.045	53	66.43	63.60	11.5	11.0
	4s	.678	.049	54	71.35	73.76	12.8	11.7
	4b	.206[x]	.101[x]	40	68.25	66.00	11.0	9.2
	G	.793	.062	16	78.87	81.37	14.0	7.5

TABLE II (Cont'd

Measures x	Measures y	r	P.E.r	N	Mean x	Mean y	Stand. dev. x	Stand. dev. y
1a	2s	.406	.051	117	61.06	60.00	10.5	17.0
	2b	.484	.062	65	61.07	60.00	10.4	12.5
	3s	.628	.045	80	63.30	66.40	7.5	15.5
	3b	.238	.087	52	62.09	63.93	11.0	11.30
	4s	.454	.071	55	63.36	73.45	9.0	11.5
	4b	.067[x]	.103[x]	40	64.25	65.75	14.5	14.0
	G	.390[x]	.142[x]	16	68.56	81.57	8.0	7.5
2s	2b	.753	.034	73	58.03	59.94	18.5	12.0
	3s	.395	.059	90	65.05	66.50	12.5	14.5
	3b	.375	.075	58	61.48	63.29	13.5	11.0
	4s	.581	.057	60	65.45	76.42	15.0	11.5
	4b	.235[x]	.097[x]	43	63.50	65.40	14.0	9.0
	G	.484	.117	19	74.63	80.16	13.0	8.0
2b	3s	.436	.082	44	61.88	62.68	8.0	13.5
	3b	.550	.075	39	61.48	63.92	8.3	10.4
	4s	.589	.095	21	61.05	67.24	9.5	11.5
	4b	.350	.098	36	64.22	66.30	9.0	7.5
	G	.276[x]	.281[x]	5	75.00	76.00	8.0	2.0
3s	3b	.387	.081	49	62.71	62.41	16.0	11.2
	4s	.620	.053	60	68.33	73.33	13.0	11.5
	4b	.627	.066	38	63.84	64.50	15.3	10.3
	G	.548	.111	18	72.28	80.33	14.0	9.0

TABLE II (Cont'd

Measures		r	P.E.	N	Mean		Stand. dev.	
x	y				x	y	x	y
3b	4s	.149x	.142x	22	63.36	68.36	10.0	9.5
	4b	.570	.070	42	64.14	64.42	11.0	10.0
4s	4b	.193x	.140x	21	68.19	64.86	9.0	10.0
	G	.603	.103		81.70	80.53	7.5	8.5

TABLE III.

TEST GROUPS DIVIDED IN VARIOUS WAYS COMPARING PROPERTIES OF DIFFERENT DIVISIONS.

	N	% Tested	Mean Score	Median Score	Q	P.E.	Range
Women (33,34,35)	37	90.5	85.6	86.0	24.5	5.0	46-122
Men (33,34,35)	198	89.7	101.6	100.0	18.1	1.6	33-166
1st Year (all) (35)	139	91.4	97.4	97.0	16.5	1.8	45-157
2nd Year (all) (34)	62	88.6	104.4	105.5	16.3	2.6	43-157
3rd Year (all) (33)	33	84.6	96.6	87.0	26.0	5.6	33-166
Women I (35)	15	93.8	80.9	74.0	26.3	8.6	46-122
Men I (35)	124	91.2	99.4	98.5	15.0	1.7	45-157
Women II (34)	14	93.5	92.8	92.5	12.5	4.2	64-116
Men II (34)	48	87.3	107.8	107.5	18.0	3.3	43-157
Women III (33)	7	77-8	81.1	73.0	13.5	6.4	58-122
Men III (33)	26	86.7	100.8	95.5	24.0	5.9	33-166
					S.D.	P.E.	
Men, Honour ('33,34)	27	-	129.6	-	22.3	2.9	
Men, General ('33,'34)	47	-	91.4	-	23.5	2.3	
Men, Unconditioned, ('33),'34)	53	-	112.7	-	28.0	2.6	
Men, Conditioned or Limited ('33, '34)	21	-	86.9	86.0	25.7	3.8	
Graduates	19	-	123	-	-	-	85-157
Entire Group	234	89.7	99.1	94	200	-	33-166.

....

In Table IV are shown the distributions of the SAT scores for the three year groups ('33, '34, '35) and for the total population. Several other similar distributions are shown which will be referred to later. Table V gives the comparisons of the medians of the different groups, separating the populations for several different ways for comparison. The median of the group in question is given beside the group name,

a) is the difference between the medians of the two groups crossing at that point,

b) is the probable error of that difference,

c) is the ratio of the probable error to the difference, and

d) is the chances out of a hundred that the difference is a true difference.

In all these tables, unless otherwise designated, men and women are included in the population. The numbers '33, '34, '35 in brackets beside the various group names are for ease in distinguishing the graduating years of the three classes.

TABLE IV.

Showing the various distributions of SAT scores at McGill and Stanford with an Otis score distribution and a traditional type examination marks distribution.

. . .

In the following histograms the test or examination scores are represented on the horizontal axis and the population is represented on the vertical axis. On the horizontal axis two squares equal one unit (that is, a class interval of 12 points). On the vertical axis each square equals one unit(that is, one subject).

The description of the vertical axis holds for all the histograms, but in the Otis distribution on the horizontal axis two squares equal one unit (that is, a class interval of 2 points), and in the examination distribution on the horizontal axis two squares equal one unit (that is, a class interval of 12 points).

Fig. 1

Distribution of SAT scores for entire McGill group.

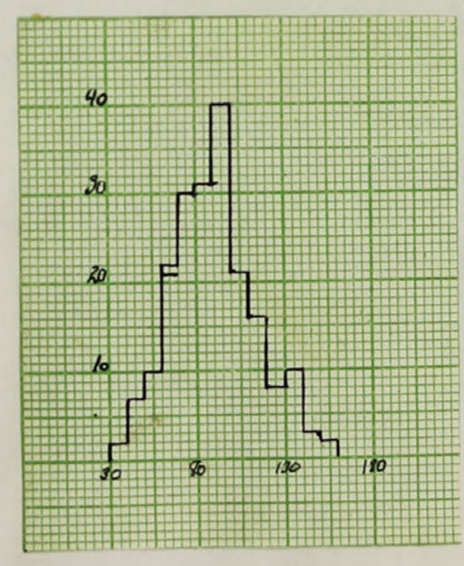


TABLE IV (cont'd.)

Fig. 6

Distribution of SAT scores for those of McGill group who became graduate students.

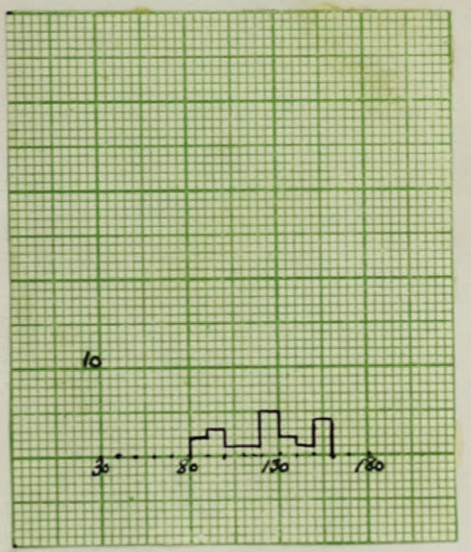


Fig. 7

Distribution of SAT scores for Stanford Criterion Group. (Graduates)

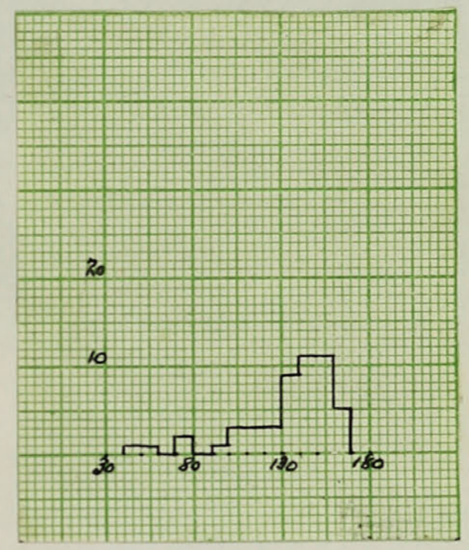


Fig. 8

Distribution of SAT scores for Stanford unselected freshmen group.

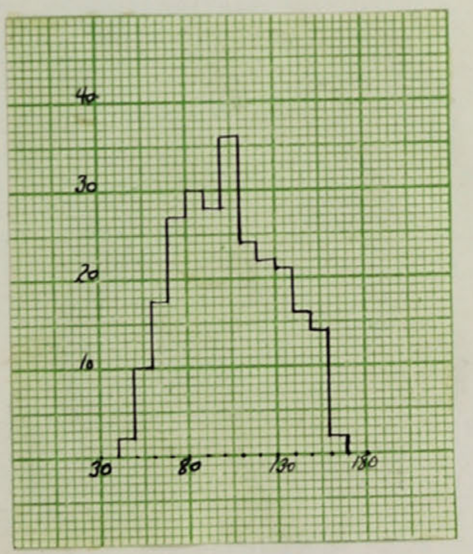


Fig. 9

Distribution of Otis scores for those of the McGill group who took the Otis.

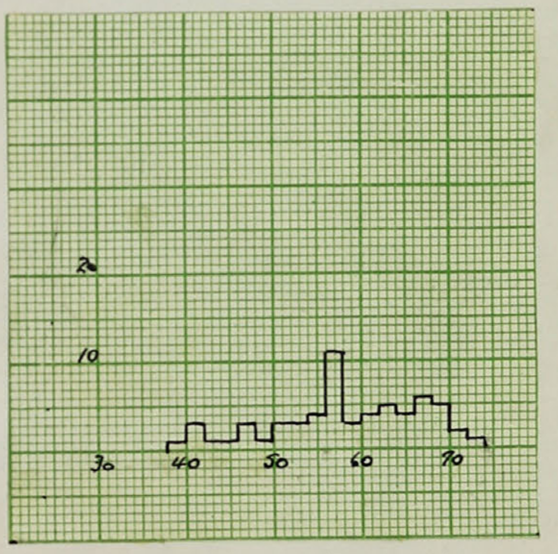
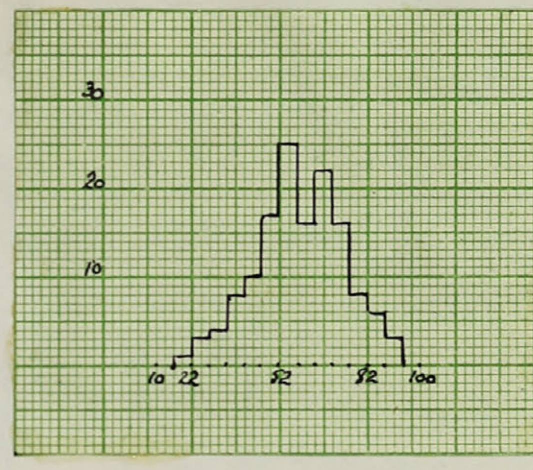


Fig. 10

Distribution of marks from traditional type group of examinations (the physical science group for the freshmen class).



It is seen that the distributions of SAT scores are quite similar for the corresponding groups at McGill and Stanford, the McGill graduate group being not skewed as negatively as the Stanford.

TABLE V.

RELIABILITIES OF THE DIFFERENCES BETWEEN MEDIAN SCORES.

(Compare with Table III)

A

		Women I, ('35) 74.2.	Men I ('35) 98.5	Women II ('34) 92.5	Men II ('34) 107.5	Women III ('33) 73.0
Men III, ('33) 95.5	(a)	21.5	3.0	3.0	12.0	22.5
	(b)	10.3	6.1	7.2	6.7	8.7
	(c)	1.1	.5	.4	1.8	2.6
	(d)	77	63	61	89	96
Women III, ('33) 73.0	(a)	2.4	25.5	19.5	34.9	
	(b)	10.7	6.6	7.6	7.1	
	(c)	.1	3.9	2.6	4.9	
	(d)	53	100	96	100	
Men II, ('34) 107.5	(a)	33.5	9.0	15.0		
	(b)	9.1	3.7	5.3		
	(c)	3.7	2.4	2.8		
	(d)	99	95	97		
Women II, ('34) 92.5	(a)	18.5	6.0			
	(b)	9.5	4.5			
	(c)	1.9	1.3			
	(d)	91	82			
Men I ('35) 98.5	(a)	24.5				
	(b)	8.7				
	(c)	2.8				
	(d)	97				

TABLE V (Cont'd)

RELIABILITIES OF THE DIFFERENCES BETWEEN MEDIAN SCORES.

(Compare with Table 111.)

B.

		First Year	Second Year
		97.0	105.5
Third	(a)	10.0	18.5
year	(b)	5.9	6.2
87.0	(c)	1.7	3.0
	(d)	87	98
Second	(a)	8.5	
year	(b)	3.11	
105.5	(c)	2.7	
	(d)		

....

C.

Men ('33,34'35.	Women ('33,'34,'35)			Men
100-0	86. 0		(a)	14.0
		Women	(b)	5.3
			(c)	2.6
			(d)	96

....

TABLE V. (Cont'd)

RELIABILITIES OF THE DIFFERENCES BETWEEN MEDIAN SCORES.

D.

Men, Honour 129-6		
Men, General 91.4	(a)	38.2
	(b)	3.7
	(c)	10.3
	(d)	100
Men, Uncond. 112.7		
Men, Cond, & Limited	(a)	25-8
	(b)	4.6
	(c)	5.6
	(d)	100

....

Table VI shows the correlations between SAT scores and two other possible predictive measures and final year grades in engineering. The group, from whose records the data for these correlations were obtained, was the pre-engineering students who were in first year science with the class of Science '35, and so took the SAT. The group took the first year science course in 1931-32, when they also took the SAT, and after four years in engineering graduated in 1936.

TABLE VI.

Correlation of three predictive measures with final year engineering grades.

Predictive measure	N	r	PE r
SAT	21	.340	.137
Ms '35	19	.761	.065
1s '36	22	.681	.076

Since the correlations between graduate achievement (G) and the other measures if not unreliable were so small in relation to their PEs and the same thing being true of fourth year biological science achievement (4b), the fourth year physical science achievement (4s) was taken as the criterion of all possible predictive measures. As pointed out before achievement was measured by scholastic grades.

Multiple correlation coefficients were obtained where it was thought that they would be of use and where inspection did not show the procedure useless as far as seeking a more reliable predictive measure was concerned. The multiple correlations are listed in Table VII.

TABLE VII.

Criterion	Combined Predictive measures	R
4s	SAT AND Ms	.675
4s	SAT and 1s	.322
4s	1s and Ms	.797
4s	SAT Ms and 1s	.723

COMPARISON OF McGILL RESULTS AND ZYVE'S R E S U L T S.

The Criterion and Validity of the SAT.

No analysis accompanied the above presentation of the findings of the study made at McGill for the most interesting aspect seems to be the comparison between the results of the two studies, one at McGill and the other at Stanford.

As pointed out Zyve's main group consisted of fifty students in research in the departments of Physics, Chemistry, and Electrical Engineering. The criterion of the validity of the SAT in measuring scientific aptitude and predicting scientific achievement was the ratings given to each of the fifty by two judges chosen from their professors. These ratings were considered reliable and valid due to the quality of the judges and their intimate knowledge of the students they rated.

Table VIII gives the results of Zyve's investigation for his Criterion Group. Included in the table proper are the results of the SAT when given to an unselected freshman group, to a group of the Science faculty, to a group of Non-science faculty, to a group of science freshmen, and to a group of seniors and graduates in non-science subjects. Appended at the bottom of the table is an extract from Table III for ease in comparison.

TABLE VIII

Group	N	Minimum Score	Maximum Score	Mean	Stand. Dev.	Correlation of SAT Scores with Av. Scores of Judges. r	PEr.
Chemistry	21	45	159	134	30.2	.77	.06
Physics	10	50	154	125	27.2	.95	.02
Electrical engineering	19	76	166	138	23.2	.89	.03
Whole criterion	50	45	166	134	27.3	.74	.04
Unselected freshmen	246	47	166	105	28.3		
Science faculty	21	133	177	153	13		
Non-science faculty	14	95	167	118	24		
Science freshmen	79	45	156	113	27.9		
Seniors & graduates non-science	47	30	155	90	29.3		
Extract from Table III:							
Entire Group	234	33	166	99.1	25		

Group	N	Minimum Score	Maximum Score	Mean	Stand.D.	Cor.of SAT etc.
Freshmen ('35) (Science)	124	45	157	99.4		
Graduate group from '35'33'34	19	85	157	123	22.5	

....

Of his results Zyve says: "When the SAT was given to a group of Stanford Faculty Members in various departments of science and engineering; and their scores were compared with those of the science freshmen group (those intending to major either in science or engineering), the standard deviation of the science faculty group was found to be 13.0 with a maximum score of 177 and a mean of 153, while the SD, maximum score, and the mean of the freshmen group were 27.9, 156, and 113 respectively; the main differences between the two groups become obvious when we compare the minimum scores and the means. It is rather significant that the standard deviation of the faculty group is relatively high, which may be taken as an indication that the test is capable of differentiating aptitudes among men of even so highly a picked group.".........

"It may be noted that the standard deviation of the criterion group is 27.3, while the standard deviation of an unselected group of 246 Stanford freshmen is 28.3, which suggests that the SAT is capable of differentiating aptitudes for science even among highly selected and relatively homogenous groups."

The results of the McGill science freshmen ('35) and the Stanford science freshmen are very similar, the range being almost identical (4 Table IV). The mean of the former group is nearly fourteen points below that of the latter, but this difference in means is seen throughout the comparison. The McGill Entire Group mean is also almost fourteen points below the Stanford science freshmen mean, the only group to which it is comparable; similarly the McGill graduate group mean is eleven points below the Stanford Whole Criterion group mean, while its range is less, especially on the lower end.

What do these differences in the means imply? Has the McGill group as scientifically apt individuals as the Stanford, but a lower level of aptitude for the group as a whole, is it that the Stanford population is much more used to the idea of psychological tests of this nature and so do better, due to general experience in test techniques, or is it due to the overlapping of ability and achievement?

The range and standard deviation of McGill Entire Group when compared with the ranges and standard deviation of the various Stanford groups suggest that the SAT is just as discriminating in the McGill population as in the Stanford.

The SAT gave a correlation of .74 with the criterion of professors' ratings for the Whole Criterion group at Stanford. At McGill the SAT gave a correlation of .322 with the criterion fourth year physical science marks, a correlation of .407 with the graduate marks, and a correlation of .340 with final year engineering marks. The criteria are not really comparable. While the judges' ratings may more nearly estimate the individual's true scientific aptitude than do the scholastic marks, nevertheless, it is scholastic marks and similar criteria by which the individual is judged in all practical branches of science. It is probably only in research that pure scientific aptitude shows up as the most important item in success.

Statistically determined the validity of the SAT according to Zyve's results is:

$$r_{\infty\infty} = \frac{r_{12}}{\sqrt{r_{11}}\ \sqrt{r_{2}r_{2}}} = \frac{.74}{.93 \quad .90} = 82 \pm 07$$

Then according to the criterion Zyve used the SAT is a valid and good predictive item of scientific aptitudes. According to the McGill criterion, which was scientific scholastic achievement as measured by examinations, the SAT is not of much aid in predicting scholastic success, as measured by the examinations, in science either in the graduate school or in the undergraduate years. It must be remembered that at Stanford the criterion was obtained at the same time as the test scores while at McGill the criterion was obtained anywhere from one to three years after the test scores.

SAT and Intelligence Tests.

Zyve shows the relationship between the SAT and several intelligence tests to determine whether or not the SAT overlaps appreciably the use of the intelligence test. His results are shown inTable IX, with some comparable results from the McGill Study.

TABLE IX.

Correlation between SAT and other tests.

Name of test	Number tested	r	
Thorndike intelligence examination	324	.51	.02
ditto	53	.44	.07
ditto	31	.33	
Terman group test	38	.13	.10

Otis Group Test (McGill)	61	.522	.063

These correlations are low enough Zyve considers to infer that the SAT measures to a considerable extent different attributes than do the intelligence tests. The McGill results are very similar to those obtained by him, but even though the SAT and Otis may intercorrelate little enough to be considered as measuring different abilities still the Otis has just as high a correlation as the SAT with the first three sets of science marks, that is Ms, Ls and 2s, these having correlations with the Otis of ....544, .448 and .303 respectively and with the SAT of .535, .475 and .317 respectively. May we conclude from this that success in the physical sciences academic examinations is just as much dependent upon general intelligence as upon scientifia aptitude. It is impossible to compare the SAT and Otis for the Upper years as the Otis correlations with these are unreliable. It is quite true that the Otis correlates more highly with Arts subjects than with science subjects, the correlations between the Otis and Ma and la being .637 and .605. (See Table I).

In Table X is shown the comparison between the correlation of the SAT and the Thorndike intelligence test and scholarship both for scientific and non-scientific groups. (Zyve 43,46).

TABLE X.

Group	r SAT and scholarship	r Thorndike examination and scholarship
Scientific (i.e.Criterion)	.50 .07 (a)	.27 .06 (c)
Non-scientific (law, econ.,languages)	.02 .09 (b)	.53 .04 (econ.) (d)
		.38 .04 (law) (e)
		.41 .07 (general(f)

From these results Zyve believes that a comparison of (a) with (f) or of (a) with (c) indicates the difference between the nature of the SAT and the Thorndike intelligence examination. No comparison of these results with similar ones at McGill is possible since the SAT was only given to science students.

In this table Zyve gives us a correlation which he might have, but did not use at all, when estimating the validity of the test. This is the correlation between the SAT scores and the scholarship of the criterion group, which is .50. This correlation compares with but is higher than correlations of the SAT scores with physical science scholarship for the McGill group (see Table I). The difference may be due to the training, that the graduate student in scientific research must have in many of the traits which the SAT claims to measure (e.g. suspended vs. snap judgment, induction, deduction and generalization, etc.). Or it may be that graduate work lays more stress upon the qualities which the SAT measures, indeed the rating of graduate students by their teachers would certainly seem to have more emphasis upon the traits common to the SAT.

The coefficient of correlation under discussion reaffirms our opinion that the SAT is not a useful predictive measure of scholastic examination success in the sciences.

Diagnosis, Prognosis and Norms.

Zyve (45) cites several cases in which the SAT score has been helpful in discovering misfits in scientific research. For the purpose of prognosis of scientific aptitude on the basis of a SAT score Kelley's method of determining the corresponding true score is recommended. The probable error of estimate of a true score by means of single SAT score is:

$$PE_{est.x} = 6745 \text{ S.D.} = \text{approximately } 4.$$

"We may then infer that the chances are even that a score, say of 115 or SAT will correspond to a true score lying somewhere between 111 and 119; while we may say with fair certitude that the true score will lie between 115 SPE, i.e., between 103 and 127." (Zyve, 45).

Zyve recommends that the norm if the SAT be used might tentatively be placed at about 115. The following Table XI shows what proportion of successfully graduating students would have been dismissed upon the basis of their SAT scores both for a norm of 115 and 100. The norm of 100 is considered because we found that the mean SAT score at McGill was about 15 points lower than the mean SAT score at Stanford for corresponding groups. (See Table VIII).

TABLE XI.

Effect of selection by SAT scores using recommended norms. Proportion of eventually successful students who would have been dismissed on SAT score.

Class	Norm 115	Norm 100
Fourth year science	1/2	1/3
" " engineering	2/3	1/2
Graduate degrees	1/3	1/4

Inspection would indicate that the norm used would be no better in keeping out failures than they were in selecting potential successes. The conclusion seems to be that the SAT scores do not provide a measure in which the use of a critical score will increase the efficiency of selection.

FURTHER CONCLUSIONS FROM THE McGILL STUDY.

Sex differences in SAT scores.

From Tables III and V we can see that there is a significant difference between the mean scores of the men and of the women. For the whole group the difference in mean scores is fourteen points. The difference between any year group of women and any year group of men as well as of the men and women divided in the entire group is significant. Does this mean that there is a sex difference in scientific aptitude? (It must be remembered that in these tables the three years have been combined).

Year differences in SAT scores.

There is a significant rise in SAT scores between Year I ('35) and Year II ('34) and there is a significant drop from Year II to Year III ('35). The rise can be understood as probably due to some type of selection. What factors govern this selection is difficult to discover, perhaps it is a selection affecting the SAT scores but not the grades.

Scholarship differences in SAT scores.

The median of the SAT scores of the men taking an Honours course in science is thirty eight points above the SAT score median of the men taking a General course in science. This is a very significant difference. Similarly the median of the unconditioned men is twenty-six points above the median of the conditioned men.

The present best means of predicting success in the B.Sc. course and in graduate work in science.

Science matriculation (Ms) and first year physical science (1s) seem to be the best available predictive measures having correlations with graduation marks of .624 and .678 (Table I). When these two measures are combined into one predictive measure in multiple correlation we have an R of .797 which if used as a basis of predicting achievement in fourth year physical science would increase the forecasting-efficiency 40% above that of chance as compared with 25% above chance given by the highest of the two simple ones.

The SAT was combined with the two best predictive measures, that is the above two, to see if it would appreciably increase the forecasting efficiency of either. It was found that it did not, giving R's of .675 and .322 compared with r's of .624 and .678 respectively (see above paragraph and Tables I and VII).

The best predictive items for fourth year physical science were also the best for graduate work in science. Physical science matriculation (Ms) gave a correlation of .607 with graduate achievement, while first year physical science gave a correlation of .793 with it. This latter relationship gives a forecasting-efficiency of 40% above that of chance.

It is interesting to note that the correlations between the Otis scores and scholastic marks in first year are much higher than the correlations found by Kellogg (19) between Alpha test scores and scholarship at McGill in 1929. This may be due to the differences in reliability of the correlations.

SUMMARY.

The Stanford Scientific Aptitude Test(SAT) was administered to the B. Sc. classes of 1933, 1934, and 1935 in 1932. The intercorrelations of the SAT scores and scholastic achievement, measured by examinations, were found.

A positive correlation was found between the SAT and science achievement, but it is not high enough to warrant using the SAT as a predictive measure of science achievement as shown in graduation and post-graduation examinations. The correlations found (.317-407) were comparable to a corresponding correlation (.50) found by the author of the SAT at Stanford.

Corollative findings of the SAT-science achievement were shown. According to the results obtained matriculation science marks and first year science marks either singly or combined are the best predictive measures found of graduation or post-graduation achievement in science.

The corresponding Stanford and McGill distributions of SAT scores were compared and found to be quite similar with one exception, the means of the McGill distributions are on the average 15 points lower than the means of the corresponding Stanford distributions.

Scholarship and sex differences in SAT scores were examined and the employment of Zyve's recommended norm (115) as a selection basis for potentially successful B. Sc. and Engineering students is shown to be useless at McGill.

The SAT is as poor a predictive measure for engineering scholastic achievement as for science scholastic achievement, science matriculation giving the best prediction.

CHAPTER V

Summary and Conclusions

We have traced the growth of Student Personnel Work in American universities. Its connection with the recognition of individual differences and the advance in their measurement by modern psychological methods has been shown. A survey of the functional divisions of student personnel work has been made. The place of this work in the university activities has been examined. The idea of coordinating and supplementing the existing agencies into a personnel system is thought to be better than that of organizing the personnel department as a separate unit, co-ordination rather than centralization, so that the whole institution may become active in carrying on the personnel work.

Four types of psychological measurements; general intelligence tests, achievement tests, personality tests, and aptitude tests have been described and examined.

The Scientific Aptitude Test by D.L.Zyve of Stanford University has been described and a statistical study of it at McGill has been reported. The test was developed not to measure scientific achievement but aptitude. Zyve used as a criterion of aptitude the ratings, by judges, of a tested group of research students in science, and decided that the test was a valid measure of such scientific aptitude.

The purpose of the McGill Study of the test was to determine its usefulness as a predictive measure of undergraduate and graduate scientific achievement as measured by examinations. The conclusion reached was that the Scientific Aptitude Test is not a useful predictive measure of college science achievement for the selection of potential successes or failures. No attempt was made to examine the usefulness of the test in measuring the type of scientific aptitude that Zyve used, for this was impossible at the time.

Matriculation science marks and first year science marks ~~has~~ have been found to be the best of the measures examined for prediction of graduation and post-graduation physical science achievement.

The Scientific Aptitude Test was found to have a fairly low correlation with the Otis Group Intelligence Test indicating that they did not measure the same thing.

In conclusion the Test studied has been shown to be rather unpredictive of science examination marks in university, but it is still quite possible that it may measure a much more specific type of scientific aptitude which is only evident in the higher types of scientific work such as research, an aptitude more separated from general ability than college science achievment is.

Further study of the test from the approach used by Zyve would seem to be desirable. He showed very little evidence of the reliability of his criterion (the judges' ratings) other than the size of the correlations obtained; the size of these necessarily indicate a rather high reliability of both variables. It would be interesting to see the relationship between examination marks like those used at McGill as criteria and ratings by judges, similar to those obtained by Zyve. If in such a study it was found that there was a higher correlation between the test scores and the judges' ratings, which had been shown to be reliable, than there was between ordinary science examinations and the judges' ratings it would probably be correct to conclude that the Scientific Aptitude Test was measuring a trait important in scientific work and not measured by the existing criteria.

APPENDIX I

TABLE SHOWING THE AVERAGE PHYSICAL SCIENCE MARKS

OF VARIOUS GROUPS FROM YEAR TO YEAR.

A.

Group	Year	Mean	Stan. Dev.
'33, '34, '35	Matric	75.1	11.4
'33, '34, '35	1	61.7	15.0
'33, '34	2	56.5	19.0
'33	3	61.0	17.5

B. Year II.

'34	Matric	74.7	-
"	1	64.1	-
"	2	52.7	-

C. Year III.

'33	Matric	74.7	12.3
"	1	67.5	14.5
"	2	64.5	12.6
"	3	61.0	17.5

D. Year II & III

'33, '34	Matric	74.7	12.6

E. Year I.

'35	Matric	75.7	-
"	1	59.7	-

The table shown above brings to light one interesting fact. At first it would seem that the means dropped for each group from year to year, in other words that there was adverse selection. But if the Matric means are examined it will be seen that they are practically the same for all the groups. Now if there were an adverse selection in force Group E should have the highest Matric mean, group B should have the next highest and Group C thelowest Matric mean for those whose marks are averaged to give group C mean are only those who have reached third year and so group B representing second year. Now since the Matric means do not drop as the class progresses through the Faculty then there does not seem to be adverse selection. The explanation of the drop in the means for each group from one year to the next would seem to be an increase in difficulty of the examinations in the upper years or else more severe marking. The more select the group becomes through other causes the more severe the criterion of scholastic success.

APPENDIX II

STANFORD SCIENTIFIC APTITUDE TEST

T	
S	

For High School and College Students

By D. L. Zyve, M.Sci., Ph.D.

PRELIMINARY

Read the following few lines carefully: This is not an intelligence test, or even an information test. Its purpose is to help you in selecting the line of work for which you are best fitted. If you wish to get intelligent advice, you must be **as frank and as fair as possible** in answering the various questions included in this test.

After the starting signal is given ("Everybody ready? Go!") you will not be timed; that is, you will proceed with each next exercise as soon as you have completed the preceding one to the best of your ability.

To complete the test you will be given two hours. Do not hurry too much, but work steadily and without interruption. If in any part of the test you need a ruler, you may use one, or anything that will take its place. **Do not spend more than about ten minutes** on any one problem. **Reserve for the end** any problem the solution of which may require twenty minutes or more. **There are no "catch questions" in this test.**

DO NOT TURN THIS PAGE UNTIL YOU ARE ASKED TO DO SO. FILL OUT THIS PAGE.

1. Your name: .... Your age: .... years, ... months

2. If you do not know what line of work you would be most interested in or would enjoy most, put a cross (×) in this square: ☐

3. You are most interested in: ....

4. Your other interests are: 1. ....
   2. ....

5. You are a freshman, a sophomore, a junior, a senior at ....
   (underline the right term)

6. While in high school, did you take:
   General Science? .... How many months? ....
   Physics? .... How many months? ....
   Chemistry? .... How many months? ....
   Biology? .... How many months? ....

7. **Do not answer** questions 7 and 8, **unless** you are a college student.
   Your major department is (or will be): ....
   Your minor department is (or will be): ....

8. If you are not majoring in science or engineering, answer whether or not you took any college courses in:
   Physics? .... How many months? ....
   General Chemistry? .... How many months? ....
   Biology? .... How many months? ....
   Other science courses and how many months each:
   .... months
   .... months

9. Are you feeling well today? Fine? Well? Not so well as usual?
   (underline the right answer)

DO NOT TURN THE PAGE UNTIL YOU ARE ASKED TO DO SO.

Published by Stanford University Press, Stanford University, California

DO NOT WRITE ON THIS PAGE

PROFILE

Exercise	Score	Remarks and Later Observations
I		
A		
E		
J		
R		
O		
F		
S		
K		
M		
L		
Total Score:		

Remarks:

EXERCISE I

Suppose that you have **plenty of leisure and the necessary means** for meeting the situations described below. Check (X) frankly the statement which comes nearest to the way in which **your first impulse** would lead you to handle the matter. **(If you wish to be helped by this test, you must be absolutely frank.)**

I. Suppose that your alarm clock suddenly stopped because of some trouble.

1. ☐ Try to determine how serious the trouble is, and then take it to a watchmaker.
2. ☐ Instead of tampering with the clock and making matters worse, take it to the watchmaker.
3. ☐ Locate the cause of the trouble and try to correct it.

II. Suppose that you are interested in radio.

1. ☐ Get diagrams and necessary information, and try to build a simple radio set.
2. ☐ Instead of wasting time and possibly ruining costly material, have an expert help you build it.
3. ☐ Buy a neat radio set ready-made.

III. You wish to know whether the assertion that there are spots on the sun's surface is correct.

1. ☐ Look up the matter in a textbook on Astronomy.
2. ☐ Ask a competent person to give you the information desired.
3. ☐ Observe the sun through a telescope.

IV While freezing some ice cream you became interested in obtaining the lowest possible temperature from a mixture of ice and salt, but found contradictory statements in two books as to the proportion of salt and ice.

1. ☐ Take a proportion of ice and salt that is an average of those suggested by the books.
2. ☐ Mix ice and salt in suggested proportions and check the information given in the books.
3. ☐ Call up an ice cream factory and secure the information needed.

V Suppose that you are very much interested in the behavior of metallic potassium in water. To get the information desired:

1. ☐ Look up in the **Encyclopaedia Britannica** the word "potassium."
2. ☐ Look it up in a good chemistry textbook.
3. ☐ Drop a piece of metallic potassium into water.
4. ☐ Ask a competent person to give you the information desired.

Remarks:

EXERCISE A

Rank the following definitions of "a table," "a bow," "an automobile" according to their merit; that is, write 1 in t square next to the best definition, 2 next to the second best, 3 next to the following best, and 4 next to the poorest de nition.

I.

☐ A table is an article of furniture variously used, as in eating, writing, reading, or working.

☐ A table is an article used in homes, offices, stores, restaurants, and other public places for various purposes, such eating or working.

☐ A table is a piece of furniture consisting of a flat top fixed horizontally on three or four legs and variously used, as eating, playing, or working.

☐ A table is an article of furniture consisting of a flat top fixed horizontally on legs.

II.

☐ An automobile is a mechanical vehicle which is gradually supplanting vehicles drawn by horses.

☐ An automobile is a self-propelling carriage driven by a gas engine.

☐ An automobile is a self-propelling vehicle, ordinarily on four wheels, not directed by tracks, and traveling on roa ways or streets.

☐ An automobile is a self-propelling carriage, ordinarily on four wheels, driven by a gas or steam engine, or by an ele tric motor.

III.

☐ A bow is a weapon used by primitive people, either in war or for hunting small and even large game by means arrows.

☐ A bow is a weapon well known in every country from time immemorial and used by adults either in war or huntin it is also used by children in their play.

☐ A bow is a piece of wood which, after having been bent into an arc, is used for shooting arrows.

☐ A bow is a weapon made of a strip of wood or other material, the two ends of which are connected by a cord, means of which an arrow may be projected.

EXERCISE E

Write a check (X) in the square next to the correct answer to the questions given below:

I. What will be the average cost of living in this country in the year 3000?

☐ 1. About $50 per month per capita.
☐ 2. About $100 per month per capita.
☐ 3. About $200 per month per capita.
☐ 4. About $300 per month per capita.
☐ 5. Over $300 per month per capita.

If unable to answer, put a check here: ☐ 6.

II. If you stack nickels in one pile 10 feet high, it will contain:

☐ 1. About $100.
☐ 2. About $200.
☐ 3. About $225.
☐ 4. Over $250.

If unable to answer, put a check here: ☐ 5.

III. A certain government, selling land, offered it on the following terms:

☐ 1. If the buyer is an immigrant, he may pay $1,000 every year for 20 years.

☐ 2. If the buyer is a native born, he may pay
$100 the first year,
$300 the second year,
$500 the third year, and so on, the annual payment being increased by $200 each year for 20 years.

☐ 3. If he is a war veteran, he may pay
$1 the first year,
$2 the second year,
$4 the third year, etc., the annual payment being doubled each year for 16 years.

Which terms are the most advantageous? Put a check in the corresponding square.

If unable to answer, put a check here: ☐ 4.

IV With the general use of highly perfected machinery, the length of the working day in this country will be in the year 3000:

☐ 1. 6 hours.
☐ 2. 5 hours
☐ 3. 4 hours.
☐ 4. 3 hours.
☐ 5. 2 hours.
☐ 6. less than 2 hours.

If unable to answer, put a check here: ☐ 7

V There will be in the year 3000 on the average in the whole world, one automobile

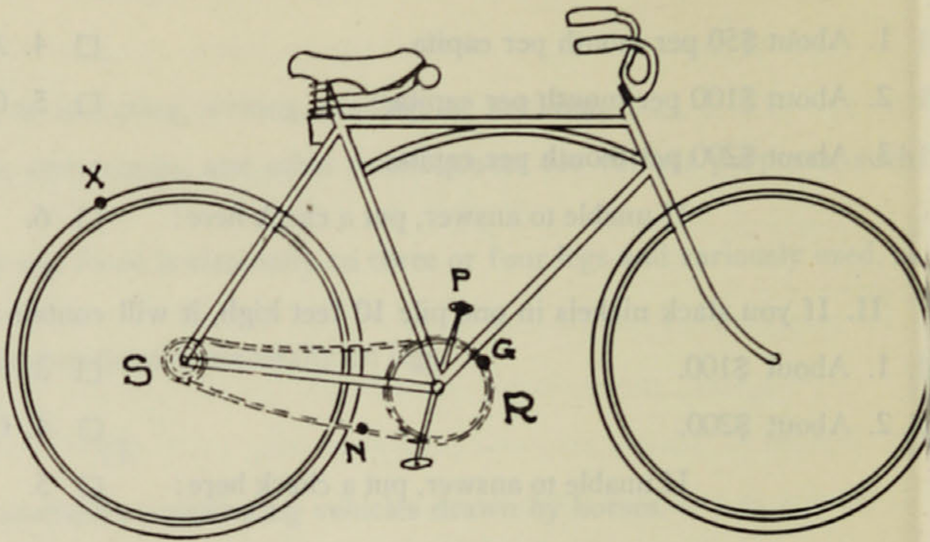
☐ 1. for every 50 people.
☐ 2. for every 25 people.
☐ 3. for every 10 people.
☐ 4. for every 5 people.

If unable to answer, put a check here: ☐ 5.

EXERCISE J

I. In a given bicycle the large gear R has 30 teeth, while the small one S has ten (10). The rear wheel has a circu ference of 6 feet. There are four spots marked: one, X on the rear tire; one, G, on one of the teeth of the gear R; o P, on the pedal; and one, N, on the chain. The length of the chain is 4 feet.

A boy took a 3-mile ride from town A to town B. Complete the statements given below so as to make them correct, by putting a check in one of the squares.



1. The path traveled in space from A to B by the spot X is

   ☐ greater than 3 miles.

   ☐ equal to 3 miles.

   ☐ less than 3 miles.

2. The path traveled in space from A to B by the spot G is

   ☐ greater than that traveled by X.

   ☐ less than that traveled by X.

   ☐ equal to that traveled by X.

3. The path traveled in space from A to B by the spot N is

   ☐ greater than that traveled by G.

   ☐ less than that traveled by G.

   ☐ equal to that traveled by G.

4. The path traveled in space from A to B by the spot P is

   ☐ greater than that traveled by N.

   ☐ less than that traveled by N.

   ☐ equal to that traveled by N.

Remarks: If you don't enjoy this type of problem, put a check here: ☐

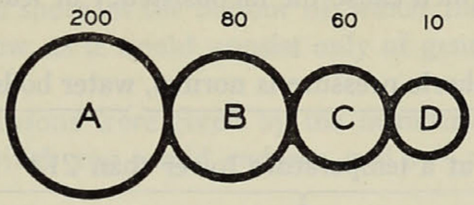
II. There is a train leaving city A every hour (at the hour) and going to city B. At the same time another tra leaves city B going to A. The journey lasts exactly 20 hours. You took a train from A. How many trains did you me on your way to B, counting the one that reaches A at the moment of your departure and the one that leaves B at yo arrival?

Answer here: ☐

If you don't enjoy this type of problem, put a check here: ☐

EXERCISE J (Continued)

III. Four gears are connected as shown in the drawing. A has 200 teeth, B has 80 teeth, C has 60 teeth, and D has 10 teeth.



1. a. How many turns will A make when D makes one complete turn?

Answer here: ☐

b. How many turns will A make when C makes one complete turn?

Answer here: ☐

Complete the following statements so as to make them correct, by placing a check in one of the squares:

2. If we connect D to B without using C, A will rotate

☐ more slowly than in case 1a.

☐ faster than in case 1a.

☐ as fast as in case 1a.

3. If we place between C and D a fifth gear, A will rotate

☐ more slowly than in case 1a.

☐ faster than in case 1a.

☐ as fast as in case 1a.

☐ more slowly or faster or as fast, according to the number of teeth in the fifth gear.

4. If, in this arrangement of five gears, we take off the gear A, how many turns will be made by D when B makes one complete turn?

Answer here: ☐ ; or check below:

☐ depends on the number of teeth of the fifth gear.

If you don't enjoy this kind of problem, put a check here: ☐

EXERCISE R

Read the following five paragraphs. If a paragraph is consistent throughout, put an X in the square next to the top of each paragraph; if it is not, put a —, and write in the two lower squares the numbers corresponding to the phrases or sentences which cause the inconsistency or lead to an illogical conclusion.

I. $\underbrace{\text{At sea level,}}_{1}$ $\underbrace{\text{when atmospheric pressure is normal,}}_{2}$ $\underbrace{\text{water boils at }212^\circ\text{ F.}}_{3}$ $\underbrace{\text{When the atmospheric pressure drops below normal,}}_{4}$ $\underbrace{\text{water boils at a temperature lower than }212^\circ\text{ F.}}_{5}$ $\underbrace{\text{In localities situated above the sea level}}_{6}$ $\underbrace{\text{the atmospheric pressure}}_{7}$ $\underbrace{\text{is often below normal.}}_{8}$ $\underbrace{\text{In such localities}}_{9}$ $\underbrace{\text{water always boils}}_{10}$ $\underbrace{\text{at a temperature below }212^\circ\text{ F.}}_{11}$

II. $\underbrace{\text{When a body is heavier than its volume of water, it sinks;}}_{1}$ $\underbrace{\text{otherwise, it floats.}}_{2}$ $\underbrace{\text{Cork is lighter than water;}}_{3}$ $\underbrace{\text{therefore, it floats.}}_{4}$ $\underbrace{\text{Sodium is lighter than water.}}_{5}$ $\underbrace{\text{Sodium is a metal.}}_{6}$ $\underbrace{\text{Metals usually sink in water.}}_{7}$ $\underbrace{\text{A chunk of metallic sodium thrown into water will float.}}_{8}$

III. $\underbrace{\text{White light is a mixture of various rays,}}_{1}$ $\underbrace{\text{the "wave-lengths" of which decrease}}_{2}$ $\underbrace{\text{as we proceed from red to violet.}}_{3}$ $\underbrace{\text{Rays of still smaller wave-lengths}}_{4}$ $\underbrace{\text{are not visible to the eye.}}_{5}$ $\underbrace{\text{Among them some rays, such as the ultra-violet and the X rays,}}_{6}$ $\underbrace{\text{find many applications in medicine.}}_{7}$ $\underbrace{\text{The X-rays,}}_{8}$ $\underbrace{\text{the wave-length of which is approximately double that of the violet rays,}}_{9}$ $\underbrace{\text{are used in surgery.}}_{10}$

IV. $\underbrace{\text{Extremely small particles of matter,}}_{1}$ $\underbrace{\text{when seen through an ultra-microscope,}}_{2}$ $\underbrace{\text{always appear surrounded by rings.}}_{3}$ $\underbrace{\text{These rings are produced by the diffraction of light.}}_{4}$ $\underbrace{\text{The smaller the particles observed are,}}_{5}$ $\underbrace{\text{the more pronounced are the rings.}}_{6}$ $\underbrace{\text{These rings always conceal the shape of the particle observed.}}_{7}$ $\underbrace{\text{The smallest particle of matter is an electron.}}_{8}$ $\underbrace{\text{Only through the discovery of extremely powerful microscopes shall we ever be able to examine its actual shape.}}_{9}$

V. $\underbrace{\text{In steam or gas engines}}_{1}$ $\underbrace{\text{heat is changed into work.}}_{2}$ $\underbrace{\text{According to the laws of Thermodynamics,}}_{3}$ $\underbrace{\text{there will always be}}_{4}$ $\underbrace{\text{in steam or gas engines}}_{5}$ $\underbrace{\text{a certain amount of heat,}}_{6}$ $\underbrace{\text{besides that produced by friction,}}_{7}$ $\underbrace{\text{from which no work can be secured.}}_{8}$ $\underbrace{\text{Were it not for friction}}_{9}$ $\underbrace{\text{our steam and gas engines}}_{10}$ $\underbrace{\text{would be 100\% efficient.}}_{11}$

EXERCISE O

I. The "Evening Star" correspondent writes from city X: "A plan was offered to X, located on the shore of Lake Ontario, by which it was proposed to generate at low cost electric light and power for the vicinity. The method consisted of digging a deep pit in the lowest part of the shore, at the bottom of which the plant was to be located. The cost of equipment for the plant would be relatively low, as it would consist only of generators run by turbines to which the lake water would be led through a large pipe."

At the meeting of the council various reasons were given by the members either for or against this project. Put an X in the squares next to the statements which you would endorse, and a — next to those to which you would object.

1. ☐ I am in favor of this project, for the plant will be almost as advantageous as any using a natural waterfall.

2. ☐ I oppose this project, for the plan will never be practicable.

3. ☐ I am in favor of the project, for very cheap power would be generated by the proposed method.

4. ☐ I am opposed to the project, for such a plant would be very unsanitary.

II. At a recent meeting of the American Association of Mechanical Engineers the following project received thorough consideration: With the future development of extremely light gas engines it will be possible to build dirigible balloons much lighter than those built today. It might be then possible, by the use of air tanks, provided for breathing, to attempt a flight to the moon. Supposing that the distance to the moon is 200,000 miles, and that the average velocity of such a dirigible would be 100 miles per hour, it would be possible to complete the journey in about 2,000 hours.

The following reasons either for or against the project were given by various members. Put an X in the squares next to the reasons which you would endorse, and a — next to those to which you would object.

1. ☐ Less than 25 years ago almost everybody believed that flying, as we have it today, was rank impossibility. Therefore, the above project is worth trying.

2. ☐ The above project is worthless, for it is well known that air in the upper layers of the atmosphere does not contain oxygen and therefore is not suitable for breathing.

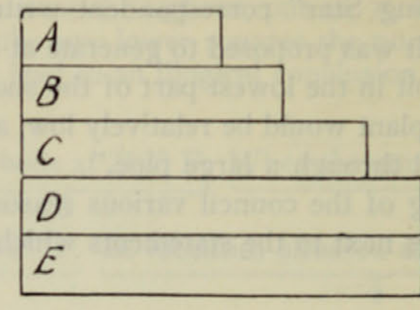
3. ☐ The above project is worthless, for it is definitely known that the atmosphere does not extend beyond a few hundred miles from the earth.

4. ☐ The above project is worth trying, for the advance in engineering is more rapid than ever and it is unwise to set any definite limit to it.

EXERCISE F

Sample Exercise:

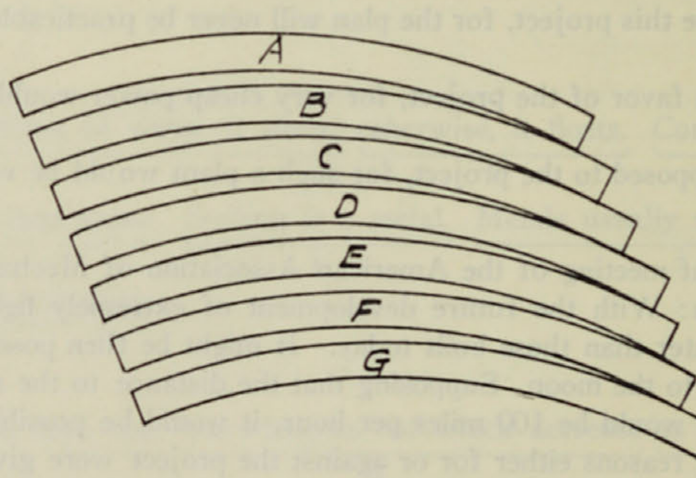
Rank the rectangles A, B, C, D, E according to their lengths; that is, write 1 in the square next to the letter corresponding to the longest rectangle, 2 in the square next to the letter corresponding to the next longest, and so on. Rectangles of practically equal length should bear the same rank. The correct answer is given to the right in this figure.



A	4
B	3
C	2
D	1
E	1

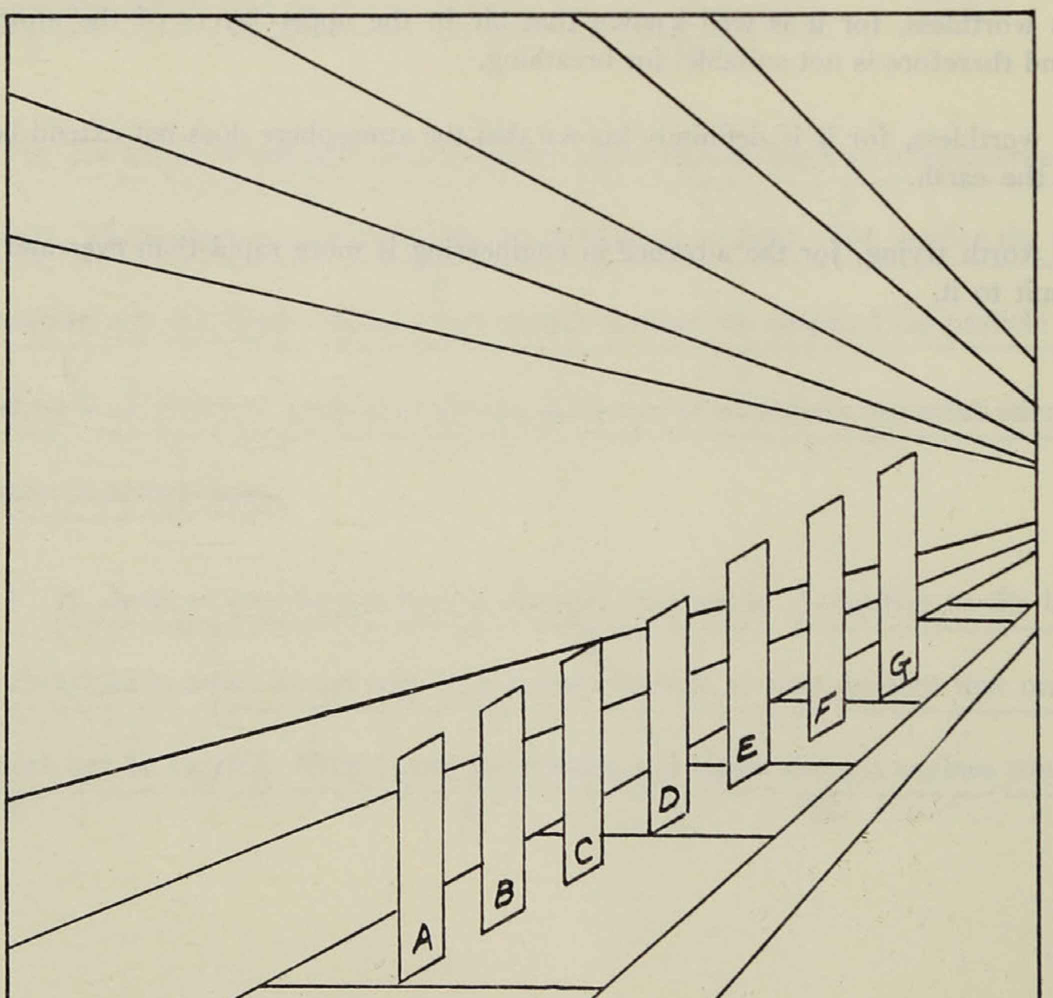
I

I. Rank the figures A, B, C, D, E, F, G according to the length of the chords of their upper arcs; that is, write 1 in the square next to the letter corresponding to the longest chord, 2 in the square next to the letter corresponding to the next longest chord, and so on.



A	
B	
C	
D	
E	
F	
G	

II. Rank rectangles A, B, C, D, E, F, G in order of their height; that is, write 1 in the small square next to letter corresponding to the highest rectangle, 2 next to the letter corresponding to the next highest, etc.



II

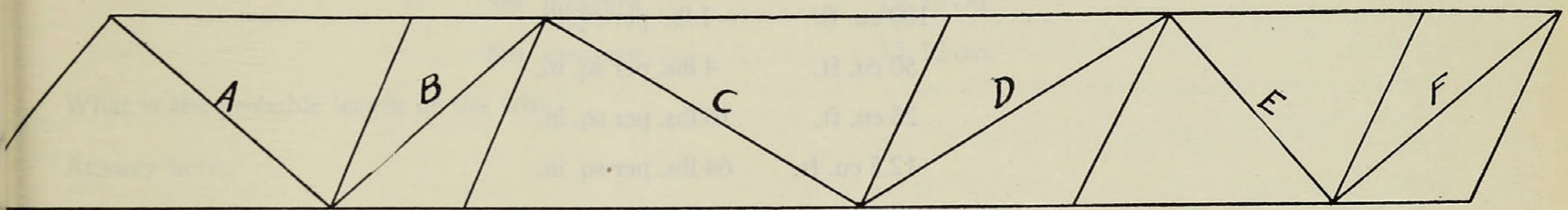
A	
B	
C	
D	
E	
F	
G	

EXERCISE F (Continued)

III

A	
B	
C	
D	
E	
F	

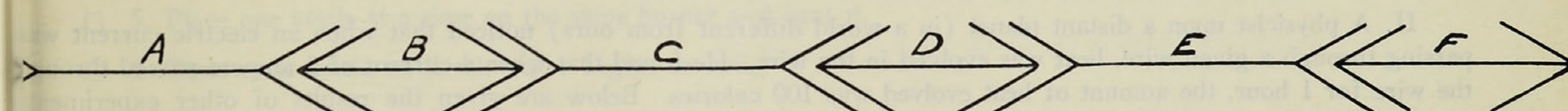
III. Rank the diagonals A, B, C, D, E, F according to their length; that is, write 1 in the square corresponding to the longest diagonal, 2 in that corresponding to next longest, and so on.



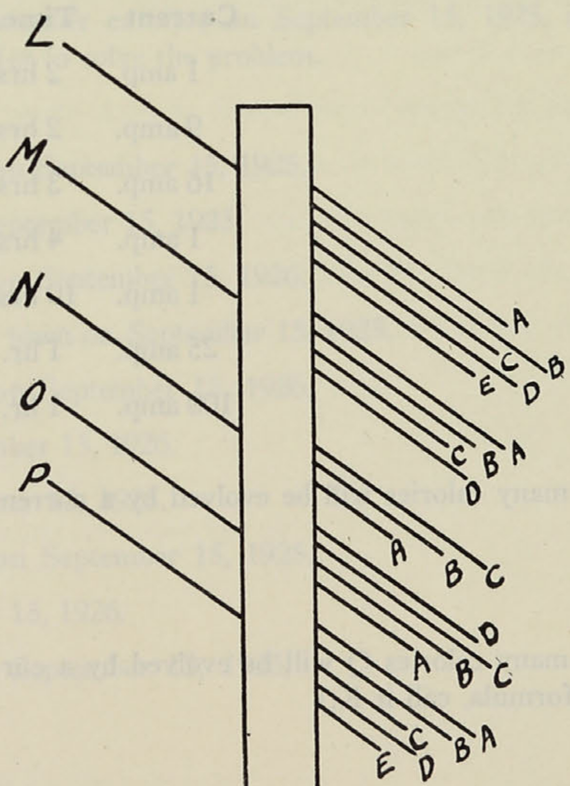
IV

A	
B	
C	
D	
E	
F	

IV Rank the lines A, B, C, D, E, F between the arrowheads according to their lengths; that is, write 1 in the square corresponding to the longest line, 2 in that corresponding to the next longest, and so on.



V Which of the lines A, B, C, etc., are prolongations of the lines L, M, N, O, and P, respectively? Write in the square next to each of the letters L, M, N, etc., the letter denoting the prolongation of the line indicated.



V

L	
M	
N	
O	
P	

EXERCISE S

I. A scientist on a distant planet, in a world different from ours, was trying to discover the law governing t behavior of gases. He took a certain amount of gas, which occupied exactly 100 cubic feet, and with a pressure-gau found the pressure of the gas was one pound per square inch. He then compressed that same amount of gas to volume of 50 cubic feet. At that moment the pressure-gauge indicated four pounds. He proceeded then compressi the gas more and more. Below are recorded the results of his experiment. (The temperature of the gas remained t same throughout the experiment.)

Volume of Gas	Pressure
100 cu. ft.	1 lb. per sq. in.
50 cu. ft.	4 lbs. per sq. in.
25 cu. ft.	16 lbs. per sq. in.
12.5 cu. ft.	64 lbs. per-sq. in.
2.0 cu. ft.	2,500 lbs. per sq. in.

1. To what volume, probably, will the gas be reduced under the pressure of 1,600 lbs. per sq. in.?

Answer here: [ ]

2. If the gas occupies a volume of V cu. ft., when the pressure is P lbs. per sq. in., what formula will expre the probable law governing the behavior of gases on that planet? (If you use a constant in your formul call it K.)

Answer here: V =

II. A physicist upon a distant planet (in a world different from ours) noticed that when an electric current w passing through a given wire, heat was evolved in the wire. He found that when a current of 1 ampere passed throu the wire for 1 hour, the amount of heat evolved was 100 calories. Below are given the results of other experimen performed by the physicist:

Current	Time	Heat Evolved
1 amp.	2 hrs.	400 calories
9 amp.	2 hrs.	1,200 calories
16 amp.	3 hrs.	3,600 calories
1 amp.	4 hrs.	1,600 calories
1 amp.	10 hrs.	10,000 calories
25 amp.	1 hr.	500 calories
100 amp.	1 hr.	1,000 calories

1. How many calories will be evolved by a current of 64 amperes in 5 hours?

Answer here: [ ]

2. How many calories Q will be evolved by a current, of A amperes in T hours? (If you use a constant your formula, call it K.)

Answer here: Q =

EXERCISE K

I. A physicist wanted to measure the length of a fine wire with precision; for this reason he measured it several times. Below are given the results of his measuring.

1st measure.	13.63 cm.
2nd measure.	13.13 cm.
3rd measure.	13.12 cm.
4th measure.	13.14 cm.
5th measure.	13.15 cm.
6th measure.	13.16 cm.

What is the probable length of the wire?

Answer here:

☐

II. A housewife uses 2 quarts of boiling water for her coffee and wishes to find out which of her three kettles: a 4-quart aluminum, a 5-quart copper, and a 3-quart granite one, consumes the least gas for boiling water. Check those statements only which will enable her to get the right answer.

☐ 1. Fill all three kettles with water.

☐ 2. Pour into each kettle 2 quarts of water.

☐ 3. Place all three kettles on the gas range, heat them at the same time, and time each kettle until the water begins to boil.

☐ 4. Place all three kettles on the three different burners on the gas range and heat them one after another.

☐ 5. Place one kettle at a time on the same burner and heat it.

☐ 6. Time each kettle until the water begins to boil.

III. You wish to determine the increase of the total number of children enrolled on September 15, 1926, in all private and public schools in a certain town, over the total number enrolled on September 15, 1925, in the same town. Check only those facts given below, which you need in order to solve the problem.

☐ 1. Number of children in town.

☐ 2. Number of children enrolled in private schools on September 15, 1925.

☐ 3. Number of children enrolled who were ill on September 15, 1925.

☐ 4. Number of children enrolled in private schools on September 15, 1926.

☐ 5. Number of children enrolled who moved out of town on September 15, 1925.

☐ 6. Number of children enrolled in public schools on September 15, 1926.

☐ 7. Number of children arrived in town on September 15, 1926.

☐ 8. Number of children arrived in town on September 15, 1925.

☐ 9. Number of children enrolled in public schools on September 15, 1925.

☐ 10. Number of children who were ill on September 15, 1926.

☐ 11. Number of children who moved out of town on September 15, 1926.

IV. A biologist wanted to determine the effect of alcoholized water upon the weight of rats by adding 10% c alcohol to their drinking water. Below are given a few suggestions which he might follow. Check those which wi enable him to solve the problem.

☐ 1. Take two young rats of the same litter.

☐ 2. Take four young rats of the same litter.

☐ 3. Take two dozen young rats of approximately the same health and age.

☐ 4. Keep them in the same large cage provided with drinking bottles, containing both pure and alcoholized wate

☐ 5. Divide the rats into two equal groups.

☐ 6. Keep each group in a separate cage.

☐ 7. Keep the two cages in the same room.

☐ 8. Keep the two cages in different rooms.

☐ 9. Provide one group with pure water and the other with alcoholized water.

☐ 10. Give to each group different food, although in the same quantity.

☐ 11. Give the same quantity of the same food to both groups.

☐ 12. Weigh every rat every day.

☐ 13. Weigh every rat every week.

☐ 14. Record carefully the weights.

☐ 15. Proceed with the experiment for fifteen days.

☐ 16. Proceed with the experiment for several months.

☐ 17. Compare the health and vigor of the rats in the two groups.

☐ 18. Compare the weights of the rats in the two groups.

V. You wish to determine which of two metallic alloys, of which you have two samples, is heavier. The samples ar irregular lumps. Check the statements which will enable you to secure the information in the simplest possible way.

☐ 1. Weigh each lump.

☐ 2. Estimate the approximate volume of each lump.

☐ 3. File down each lump so as to get a regular block and measure its volume.

☐ 4. Determine the volume of each lump by dropping it into a measuring cylinder partly filled with water.

☐ 5. Divide the weight of each lump by its volume.

☐ 6. Multiply the weight of each lump by its volume.

EXERCISE M

"The foundations of the wave theory of light were laid by Huyghens, the great Dutch philosopher, contemporary ·ith Newton, but its construction advanced very slowly, being opposed by the great authority of Newton, who favored ıe corpuscular or emission theory, and regarded light as consisting of particles emitted with excessive velocity from ıining bodies. Although there were facts, such as those connected with double refraction, easily accounted for by the ystem of undulations of waves, but inexplicable on the emission theory, these were put aside, in the expectation that ıey would in the course of time be successfully dealt with. It was not until the publication of a course of lectures n natural and experimental philosophy by Young in 1802, in which he announced the great discovery of the inter- erence of light, that the undulatory theory could no longer be overlooked. In 1819, a memoir by Fresnel was crowned y the French Academy of Sciences. He discovered that the vibratory movements in the ether constituting light are ansverse to the course of the ray. His views are embodied in what is now known as the theory of transverse vibra- ons. The conflict between the rival theories was eventually settled by the experiments of Fizeau and Foucault. On ewton's principles the particles of light should move faster through water than through air; on the theory of Huy- hens, waves of light must move slower in water than in air. The experiments of the French physicists proved that the tter is the case. This may, then, be considered as the successful establishment of one of the two theories. It has, more- ver, given that striking proof of its truth which may be considered as the criterion of any theory—the ability to foretell esults. This it did in the case of the discovery of conical refraction. Light, therefore, consists in the transference of ıergy, not in the transference of matter."

After having read the above paragraph on light, check with an X only those statements which complete correctly ıd in as many ways as possible the sentences given below:

I. According to the emission theory, light consists of

- ☐ 1. energy transferred through ether from a shining body.
- ☐ 2. transverse waves spreading from the illuminated or shining body.
- ☐ 3. tiny particles of matter shot off by a source of light.

II. Fresnel was the first to discover that

- ☐ 1. the wave theory was right.
- ☐ 2. the emission theory was wrong.
- ☐ 3. the corpuscular theory was wrong.
- ☐ 4. the ether vibrations in a ray of light were perpendicular to the ray.

III. Light travels slower in water than in air according to

- ☐ 1. the wave theory.
- ☐ 2. the emission theory.
- ☐ 3. Newton's theory.

IV. Fizeau and Foucault proved experimentally

- ☐ 1. the correctness of the emission theory of light.
- ☐ 2. the correctness of the undulatory theory of light.
- ☐ 3. that particles of light move faster through water than through air.

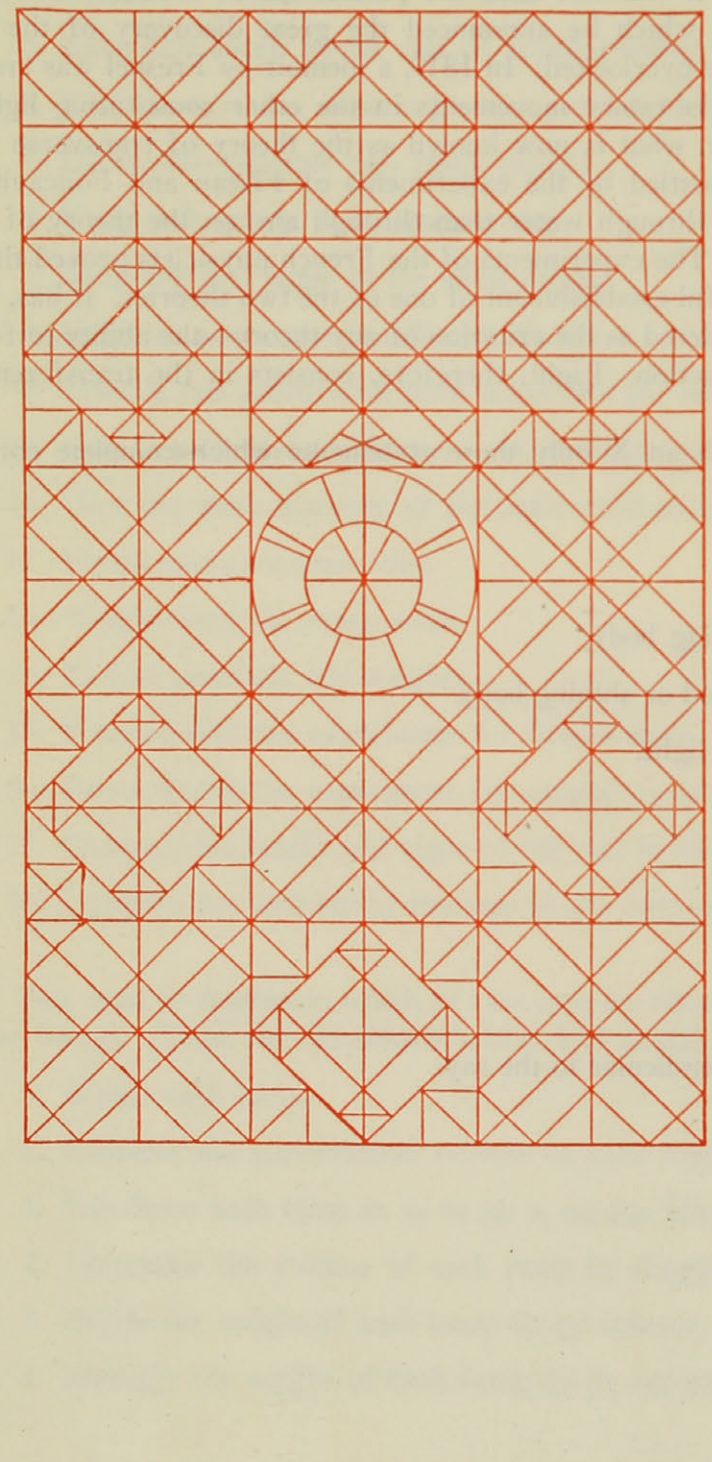
V. Huyghens' theory of light was definitely established

- ☐ 1. when Young discovered the interference of light.
- ☐ 2. when Fresnel made his discovery.
- ☐ 3. after it was proved that light travels faster in air than in water.

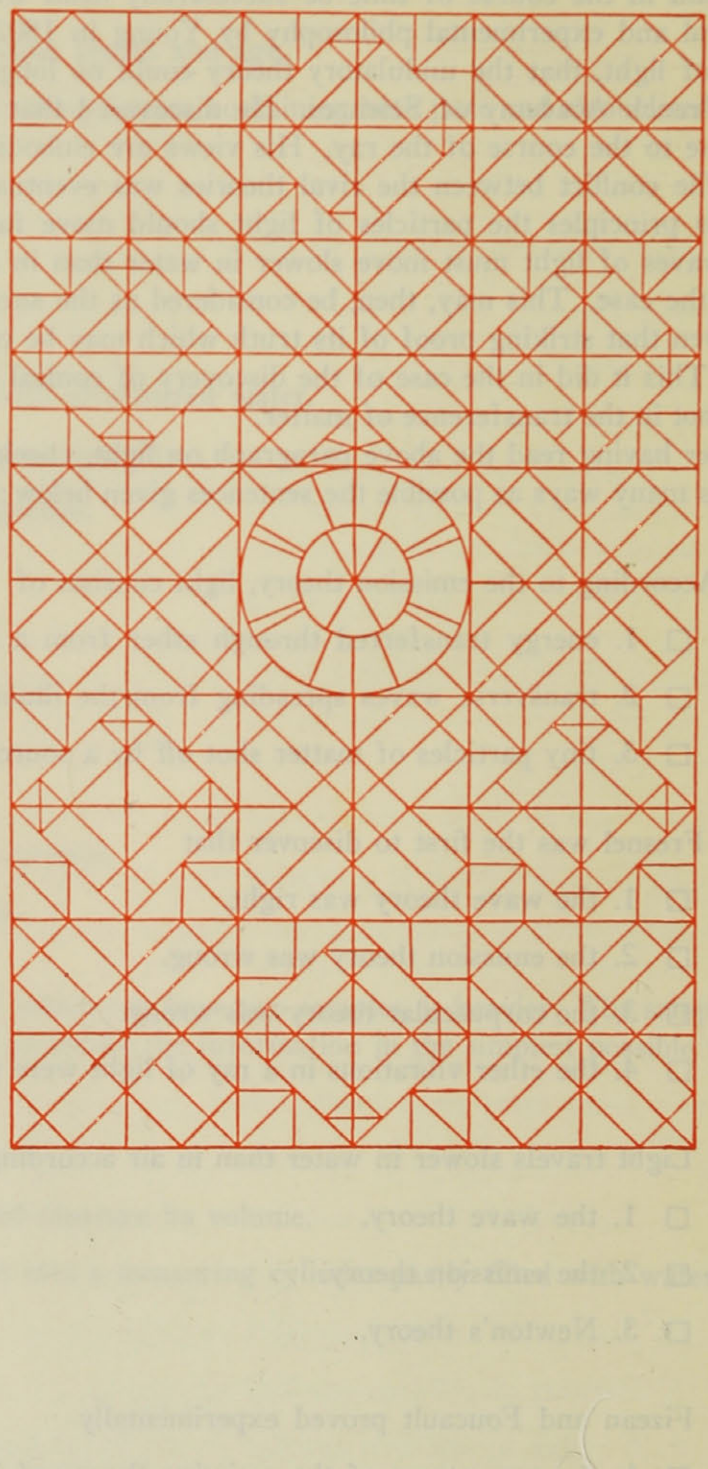
EXERCISE L

The two drawings A and B are alike except that in B a certain number of lines are omitted. Fill in all the lin[es] lacking in drawing B so as to make it practically identical with drawing A. Use either *black* ink or pencil, and dr[aw] heavy, easily visible lines.

A



B



Second Printing, December 19
Third Printing, November 19

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