A Psychological Laboratory

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It is now twenty years since Prof. Wundt instituted the first psychological laboratory in the University of Leipsic. A revolution, radical and far-reaching, was thus quietly inaugurated; the range and character of the psychological work of the last two decades differ in essential respects from those of the work that preceded it. There is probably no psychologist of note at the present day who does not confess to the influence exerted on his systematic thinking by the results of the experimental method, while there are not a few biologists, moralists and metaphysicians who acknowledge a similar indebtedness to laboratory psychology. Laboratories have been established in most of the principal universities of Germany and in all the principal universities of the United States, while there is, I think, no country now contributing to the general stock of scientific knowledge that does not possess at least one such foundation. It follows from all this that to carry on the psychological work of a modern university the psychological professor must have acquired a body of what one may call 'technical' knowledge, knowledge of applied mechanics and applied electricity, which a generation ago would have been as unnecessary for him as it still is for the professor of philosophy. For all laboratories are alike in their main features: there must, be a power supply, special kinds of furniture and fixtures, and a collection of special appliances; and if physics, the mother [p. 312] of the sciences, does not preside at the installation, the provision of an equipment, however elaborate, will be in vain.

But although psychologists require from one another, and although universities require from their professors of psychology, some measure of familiarity with the principles of physics, and therefore with mathematics and applied physics, the kind and amount of this familiarity have never, so far as I know, been illustrated in the concrete by a description of the actual working of a psychological laboratory. Accounts of certain American laboratories have been published, one at least with a diagram of ground-plan and a statement of the dimensions of its rooms; there are papers dealing statistically with endowment, equipment, student attendance, etc.;[1] [p. 313] and the output of the Leipsic laboratory has twice been summarised in the pages of MIND.[2] But I know of no article which describes the 'running,' the daily working, of a psychological laboratory. This is the topic with which I propose here to deal, making the

arrangements of my own laboratory the peg upon which to hang my account. I hope that the results of my experience may be of some use to my colleagues, and especially to those whose laboratories are still in the planning; and I hope, further, that what I have to say may call out comment and criticism, and so lead to a general formulation of the necessities of an adequately equipped laboratory.

First of all, however, and by way of preface to the whole discussion, I would remind the reader of the dual character of the American psychological laboratory. The German laboratories are essentially research laboratories; drill-courses are practically unknown. 'Einführungscursus ' are given at some universities; but the 'Einführungscursus ' at Leipsic, *e.g.*, consists simply of a series of lectures upon the psychophysical measurement-methods, photometric methods, and reaction methods, with occasional exercises and demonstrations. The student gets his training by serving as 'Versuchsobject' for his seniors, and the training varies as the investigations in progress vary. If he desires to repeat the classical experiments in any particular field, he must do so on his own account. The American laboratory, on the other hand, has to serve the purpose of instruction as well as that of research. Any scheme of arrangement and equipment must, therefore, keep the drill-course steadily in view.

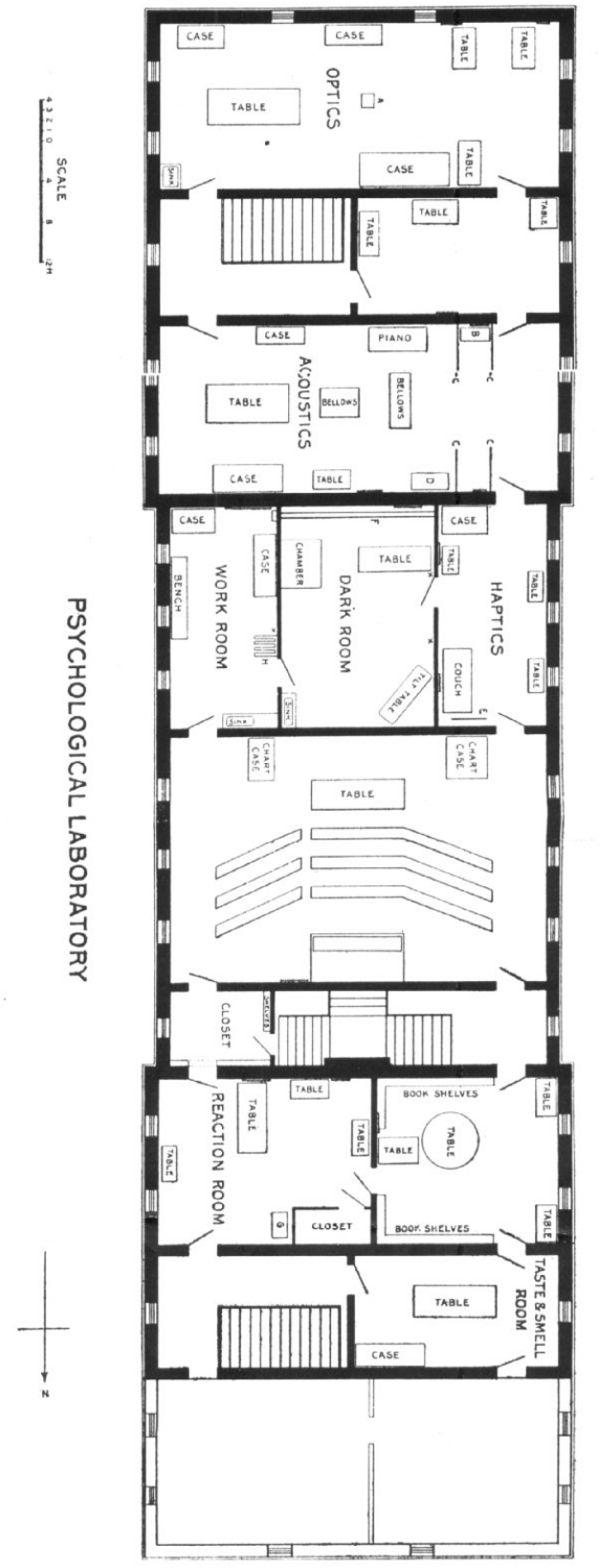
This difference in educational purpose and conditions can be, brought out most clearly by a description of the psychological curriculum at a typical American university. At Cornell, *e.g.*, -- I select the course with which I am most familiar, -- the full curriculum extends over a period of six years. In his second undergraduate year the student can take a course in General Psychology (lectures and demonstrations); in the following year, a drill-course in Experimental [p. 314] Psychology (laboratory work and occasional lectures); in the fourth year, a course in Systematic Psychology (lectures, demonstrations, exercises). No lecture courses need be taken in the graduate years, though some special course or seminary is usually attended. The work done after the obtaining of the B.A. degree is, therefore, almost exclusively, research work. At the end of one year of graduate study, the M.A. degree may be taken; two years later, the degree of Ph.D. The gap between the undergraduate and graduate curricula, is bridged by the requirement of a thesis for the first degree. Here, then, are three years of instruction and three years of investigation. And -- what is the important point in the present connexion -- all students, from those of the third undergraduate year inclusive, are handled not in a general lecture-room, but in the laboratory.

The consequences of this twofold demand upon the laboratory will appear in detail as we proceed; it is sufficient here to have called attention to the fact. I pass on, therefore, to a description of the Cornell laboratory itself.

1. Ge*neral Plan of the Laboratory*. -- I do not know that any psychologist has hitherto succeeded in persuading his university to provide him with a special building, constructed after his own designs. The directors of the new laboratories at the University of Leipsic and at Columbia University were, I believe, allowed complete freedom as regards arrangement and equipment; but, none the less, these laboratories form parts of large buildings, so that their plan is necessarily determined, to some extent, by the plan of the whole. At Yale a private house has been converted to laboratory uses; at Toronto the laboratory occupies two widely separated sets of rooms in the main university building; everywhere, indeed, psychology has come late to the feast, and been obliged to content Itself with what it can get.

The Cornell laboratory was opened in 1891. From that date until 1896 it consisted of a continuous suite of six not very large rooms. Extension then became urgently necessary, and it migrated to its present quarters, -- the upper floor of one of the university lecture halls. It now consists, as the Figure shows, of ten rooms, to which, I hope, the two remaining rooms of the floor will soon be added. These two rooms are shown in the Figure, as the laboratory has been planned -- partitions erected, doors cut, etc. -- upon the twelve-room basis. It is accessible from three corridors; those to the north and south are used principally by graduate students, while the central stairway, opening upon the: lecture-room, is the way of public entrance. [p. 315]

Room 1, the 'optics room,' is a large room, lighted from three sides, with walls and ceiling painted a cream. Room 2, intended for the private room of the laboratory assistants, now serves the purposes to which room 12 will ultimately be put. Room 3 is the 'acoustics,' room 4 the 'haptics room.' Room 5 is a dark room employed for drill-work, demonstration and photography. Room 6 is the 'work,' and room 7 the 'lecture-room'. Room 8 is the director's private room ; room 9 the 'reaction,' and room 10 the 'taste and smell room'. Room 11, which faces north, will be fitted up as a research dark



EXPLANATON OF FIGURE.

The letters A to H of the Figure stand for the following instruments, etc. :—

A. Hering indirect-vision colour mixer.
B. Fall phonometer.
C. Curtains for screening phonometer and subject, to avoid echo.
D. Ellis-Helmholtz harmonical.
E. Münsterberg arm-movement apparatus.
F. Photometry bar.
G. Zimmermann chronograph.
H. Nichols rheostat.

The arrangement of tables, apparatus, etc., is largely arbitrary.

room; room 12 will be furnished with the instruments used in the investigation of the physiological processes underlying affective consciousness, ---pulse, respiration, volume and muscular tone. Between rooms 7 and 9 is a large store-closet, spacious enough to allow of the building up of apparatus previously to its actual use in the appropriate room. It will be noticed that the work-room is entirely cut off from the acoustics room, and opens only into rooms 5 and 7. The reaction room contains the time-measuring instruments end their controls; it is paired with the optics, acoustics, haptics or lecture-room for the performance of reaction-time experiments.

It may be said at once that the above arrangement has proved quite satisfactory; I do not know how the space could be more usefully apportioned. The haptics room is too small but it could not have been made larger without very considerable outlay, and crowding is avoided by pairing it with the work-room, especially for temperature work. We are suffering just now for lack of a few more small rooms, but the pressure will be relieved when the full plan of the laboratory is realised.[3]

2. *Furniture*. -- Rooms 1, 3, 4, 9, and 10 each contain one or more large wall-cases, for the storage of the optical, acoustical, haptical, reaction and taste-and-smell apparatus, respectively. It need hardly be said that the instruments thus grouped under various sense-names are by no means exclusively sensation instruments. The optical apparatus, *e.g.*, includes instruments for the investigation of visual sensation, visual space perception, visual memory, visual recognition, visual attention, imagination, etc., and for the giving of visual stimuli, simple and compound, in reaction work; the acoustical [p. 316] apparatus includes the instruments necessary for the investigation of tonal fusion, of clang analysis, of auditory rhythm, of auditory memory, attention and recognition, of the localisation of sounds, etc., and for the giving of auditory stimuli in reaction work. The distribution of the various appliances to their appropriate rooms has some convenience, as saving the labour of transportation from one part of the laboratory to another. But I am quite clear upon the point that the ideal laboratory must have a central 'museum room,' for the storage of all pieces not actually in use.

Small, solid, low tables are necessary for haptical work, and convenient for olfactometry. They are found in rooms 4 and 10. Where mercury is used (I shall return to this question presently) the tables must be edged with a raised bead, end a shallow well sunk in one or more corners, to prevent spilling. Tables of this sort have been placed in rooms 1, 3 and 9. It is advisable to have a lounge and a couple of swing-back, revolving chairs in the laboratory; very much depends in research work, and particularly in haptics, upon the bodily comfort of the subject.

The work-room has two wall-cases, the one for batteries, the other for general laboratory supplies, and a carpenter's bench with the usual appliances. The south end of the lecture-room is taken up with two cases for wall-diagrams and along draughting table. The nine desks or benches shown in the Figure -- each of which accommodates four students, separately seated -- are low end extremely solid, so that class experiments can, if need arise, be performed upon them.

Besides tables and chairs and cases, which are 'furniture' in the strict sense of the word, the laboratory possesses certain pieces which lie upon the border-line between furniture and apparatus, and which may therefore be mentioned in this place. In the optics room, *e.g.*, we have a wall-campimeter, 4.25 x 1.80 m., made by slinging a wooden frame upon ordinary copper window-springs between up-rights that reach from floor to ceiling. The frame is easily reversible, and is covered on the one side with black, on the other with white cloth, the meridians being marked out with grey and black threads respectively. This whole apparatus cost only £2, and has proved eminently serviceable.[4] In the acoustics room, again, we have the Appunn and Koenig [p. 317] bellows tables, a strong, portable foot-bellows, and an arrangement whereby a section of the room may be curtained off for phonometrical work. The fittings of the dark room are almost wholly of this mid-way character. Along the south well runs a photometric bar, ending to the west in a dark box within the dark room, and to the east in a similar box opening into the work-room. Parallel with this bar extends the association apparatus, consisting of a long black table that carries the lantern and ground-glass screen

(west), and a small, black, curtained chamber, within which the subject sits during experimentation (east). The centre of the room is free. To the north of the two doors we have the combined tilt-table and rotation-chair (west), and the photographic sink and ruby-window (east). The future research dark room, number 11, will have a Hering window, and heliostat arrangements for solar work.

3. *Gas, Water and Electric Service and Fixtures.* -- Water is laid on in rooms 1, 5 and 6; gas in rooms 1, 3, 5, 6 and 7. Both services can easily be extended, if need arises. We have made no trial of water as a source of power.

The laboratory possesses three sets of electric fixtures. (*a*) It is furnished throughout with incandescent lamps for illuminating purposes. These lamps are, at present, run upon a night circuit only. Hence we have not employed the alternating current as a source of power. (*b*) Each of the rooms 1 to 9 is connected with every other room by a thirty-fold system of overhead wires. These are of varying sizes, the smallest capable of carrying a six-ampère current without undue heating, and mounted and insulated for a pressure of twenty-five volts. The wires come down to switch-boards at the places indicated in the Figure by a dotted line. The two half-systems -- the groups of thirty wires running to the north and south ends of the laboratory -- are brought together at a double (sixty-wire) switch-board in room 6. We are thus able to lose twenty simple circuits at the same time.

There are three things for which a laboratory is disquieted: primary batteries, smoked paper and mercury.[5] The ideal [p. 318] laboratory will be able to dispense with them; I am sorry to say that we have still some need of all three. Primary batteries we employ only for the ringing of signal bells end for our telephone circuit; the Hipp chronoscope can be worked satisfactorily by a storage battery. Of course, a primary cell may be useful for some occasional purpose; but as a general rule it is more troublesome than serviceable. Mercury we employ on our small switch-boards. These are constructed after the Leipsic model. The wires descend to a wooden shelf in which is bored a series of wells. Over against these, in the length of the shelf, a counter-series is sunk, from which wires run to the apparatus. The wells are filled with mercury, and connected according to requirement by wire bridges. All shelves are edged with a raised bead, so that there is no lateral escape of mercury drops; and each is furnished with a close-fitting lid, which is kept always in place except for the brief intervals during which connexions are made or shifted. Our central switch-board has only dry contacts; and I should now prefer to have all wet contacts, whether on switch-boards, keys, or instruments, replaced by hard metal.

(*c*) The direct current supplied by the university power plant enters the laboratory at the haptics room, and is available for use at two points in the dark room and in the work-room (see **x** in the Figure). We draw upon it to charge storage batteries, to run the arc-light of our lantern, and in general to actuate instruments (colour wheels, pendulums, kymographs) throughout the laboratory. The necessary reduction of current and pressure can be effected either by the arrangement of lamp resistances to which Dr. Scripture has given the name of 'lamp batteries,' or by aid of a Nichols tinned iron rheostat.[6] I have no hesitation in recommending the latter in preference to the lamp batteries. The initial cost of the rheostat is very small ; it is not liable to be broken, as lamps are; and the required amount of pressure and current can he obtained very easily and very accurately. As many pairs of wires as are needed can be taken from the rheostat to the central switch-board, and instruments supplied simultaneously in the different rooms of the laboratory. There is, naturally, some waste of power in the use of a heavy current for laboratory ends; but this is more than counter-balanced by the saving of time, trouble and expense that follows from the elimination of the primary battery. [p. 319]

So far, we have not found it necessary to have the current 'on tap' at more than the three places indicated. The main lead can be extended to other rooms at any time. Next year I intend to cut in the north wall of the dark room a square opening for the reception of a sheet of ground glass. Behind this a projection lantern will be placed. It will thus be possible, by arranging the audience with their faces to the south, to show slide diagrams in the lecture-room without darkening the room itself.

4. *Books*. -- Books are necessary adjuncts to laboratory work; but it is difficult to give anything like a precise estimate of the library required. We are fortunate, at Cornell, in this regard: Morrill Hall, in which the laboratory situated, lies within a stone's throw of the University Library. The psychological department has a yearly grant of £15 for the purchase of books for the library, and another of some £2 or £3 for the placing of books in the Philosophical Seminary Room. These grants are distinct from the library periodical fund. As for the laboratory: room 8 contains my private library, which has a fair working collection of psychological books end pamphlets, and files of the more Important neurological and psychological periodicals. It is, of course, at the disposal of students who are working in the laboratory. I should say, giving a very rough estimate, that an initial sum of £20 and a yearly expenditure of £10 would provide a moderate technical library for laboratory purposes, inclusive of periodicals.

There is, however, one class of books which the head of the laboratory must collect for himself, -- catalogues. Catalogues may usually be had for the asking; and all sorts and kinds, chemical, electrical, physiological, physical, bacteriological, photographic, zoological, are apt to 'come in useful' at one time or another. An apparatus should never be ordered after consultation of a single catalogue; it may quite well be that the tenth or eleventh that one consults will advertise a more serviceable form of the same device. And no apparatus that is at all costly should be ordered without previous consultation with the director of a large laboratory. Almost every firm has its weaknesses and its excellences, which can be discovered only by experience. The older laboratories have bought this experience, and it is needless for their successors to pay the same price. I may add a word of advice to inquireres: that they make their questions as *definite* as possible. Scientific men are, as a rule, only too glad to help one another; but to require your correspondent to formulate your problem, [p. 320] as well as appreciate your instrument, is to demand too much.[7]

5. *Instruments*. -- It is not my intention here to give a catalogue of our own instruments. A year or two hence, when the laboratory is completed, I hope to publish a pamphlet containing a full list of the pieces that we possess, with makers and prices, and stating briefly the results of our experience with them. At present we are concerned, however, not with a particular laboratory, but with the working of the laboratory in general, and have to consider psychological appliances from a general standpoint. Looked at in this way, the instruments fall into four, unequal but distinct, groups: We have (*a*) the apparatus needed for research in experimental psychology; (*b*) that required for drill-work in experimental psychology ; (*c*) that required for class experiments in experimental psychology; and (*d*) that employed in the study of individual psychology.

(*a*) A large proportion of the pieces listed as serviceable for research in psychology and the physiology of the senses are pieces that have been employed in a special investigation for a special end. I suppose that all original work, in whatever science, is likely to require newly constructed apparatus. But the older sciences are at this advantage, that they have a large store of designs to draw upon; so that the new appliance may take shape, at least in large measure, from the recombination and readjustment of older devices. Experimental psychology is still so young that each new problem must be faced independently, and instruments contrived to meet its peculiar exigencies. The consequence is that a laboratory which is to keep abreast of scientific progress must have a skilled mechanic attached to it. It is of little use to have ideas, if you have no means of realising them in brass and steel. This is the weak point of the Cornell laboratory: we have no mechanic of our own, and no skilled workman to whom we can have recourse in the city. A laboratory so situated is very severely handicapped. For successful work we should have a workshop, fitted up at a cost of £150 or £200, and a mechanic working at least half-time for the laboratory.

But it is not only necessary to devise apparatus for the solving of new problems; even the standard pieces usually require a thorough overhauling on their arrival in the laboratory. [p. 321] Mr. J. D·Brown points out in his catalogue[8] that the old-established Hipp chronoscope generally demands a readjustment after it has left; the factory. And if this is true of the dry tree, what may be expected of the green? A clever carpenter will go a long way in a laboratory, as I can, gratefully affirm from personal experience; but what is needed is a skilled metal-worker

who is something of an electrician and does not disdain to work in wood when wood-work is desirable.

(*b*) I mean by 'drill' instruments the appliances needed for such a course as is offered at Cornell in the third undergraduate year. The first term in this course is devoted to qualitative work, the repetition of classics experiments in optics, acoustics and haptics. The work of the second term is quantitative, work with the psychophysical measurement-methods. That of the third term is both qualitative and quantitative; it includes experiments upon action, attention and the affective processes.

The apparatus used in such a course is almost wholly American, just as the research apparatus is preponderantly German in origin. There are two or three American firms from which one can procure the instruments needed for Prof. Sanford's *Laboratory Course in Experimental Psychology.* Individual pieces are, however, by no means always satisfactory; and no firm, as far as I am aware, has received Prof. Sanford's authorisation. For optical work we have the very useful collection of material put together recently by Prof. Münsterberg.[9] For haptical, there are a number of pieces upon the market bearing Dr. Scripture's name.[10] Some of these are quite good others (I speak from three years' experience) are practically valueless. I have no doubt that, with revision, this set could he made both more efficient and less expensive than it is. For acoustical work we have, as yet, hardly any drill material. I am now trying to make up a fairly cheap and reliable acoustical outfit for class purposes, though, I shall be very glad if some other psychologist anticipates me.

The method work presents little difficulty. There are plenty of pieces lying on the border-line between this and the previous group that can be put into the hands of careful students and give good results. I need only mention colour wheels, [p. 322] eye-measurement screens, weights, movement apparatus, forks slid temperature tubes.

The reaction work has hitherto offered considerable difficulties. I believe (though this is not the place to enter into technical reasons) that the Hipp chronoscope arrangement is the most satisfactory of any yet proposed. And it has the advantage, for drill work, that the student need not know anything about the special mechanism of the clock; be may receive a useful training, both as subject and as experimenter, although he has but the vaguest knowledge of the technicalities of the apparatus. On the other hand, the chronoscope is expensive; I do not suppose that any laboratory possesses more than two clocks. Hence, while four students may be engaged at any one time upon reaction experiments, the rest of the class must occupy themselves with other matters until their turn comes round. The difficulties seem happily surmounted by the introduction of Prof. Sanford's vernier chronoscope. This instrument costs only £1, and is well adapted for drill work.[11]

(*c*) Class experiments are very different from the drill experiments just described. In drill work the students are paired off, two and two, precisely as they would be in research work; the only distinction is that the experiments are repetitions of experiments already performed, and that they are repeated with somewhat rough instruments, -- instruments that are cheap enough to be bought by the half-dozen. The class experiment is an experiment in which ten or a dozen students take part at the same time. It is necessitated by an overcrowded laboratory and a small teaching staff.

We have succeeded in keeping the numbers of our third year's class down to twenty; the course is a hard one, not to be taken except by those seriously interested in psychology. The reason is -- and this may be taken as an axiom of psychological pedagogy --- that the instructor cannot handle more than ten, and cannot well handle more than eight students during a two-hour laboratory period. To let more into the laboratory without a corresponding increase of the teaching force would be unfair both to teacher and to learner.

But there are many teachers who shrink from any system of rigorous exclusion. To them two alternatives are open. The one is to repeat their work, giving the course six days in the week instead of three; the other is to have recourse to class experiments. It seems to me that the first

plan is [p. 323] objectionable from the point of view of the director of the laboratory: it curtails unduly the opportunities for research work, and brings teaching too much to the front; while the second is objectionable from the point of view of the student: he receives no individual instruction, and has to perform his experiments in a disturbing environment, and without any of that freedom of speech and movement which is one of the great charms of true laboratory work. Hence I can say nothing, from personal experience, of class experiments. One such arrangement would be a 'chain reaction ' taken by the help of Wundt's demonstration chronoscope; another would be a test of the range of attention by means of the large fall chronometer. At the Christmas meeting of the American Psychological Association a paper on this subject, written by Dr. Kirschmann of the University of Toronto, was read by title. When it is published we shall know more about the possibilities of the class experiment and of the appliances that it requires. In the meantime there can be no doubt that many laboratories already possess appliances of the sort, and that they will play an increasing pert in the work of those that are poorly endowed or much cramped for space.

(*d*) It is through individual psychology that experimental psychology joins hands with anthropometry. 'Mental tests' are beginning to loom large in psychological literature, and every test requires its own apparatus. The instruments must be strong, cheap, and of simple construction. A good many of those devised by Mr. Galton would answer the purposes of individual psychology were they less expensive. The best pieces to be had at present, so far as I am acquainted with them are of Prof. Jastrow's contriving. A full set would include the ordinary sense tests (tests of keenness of vision and of audition, of colour blindness, of æsthesiometric discrimination, of power of smell, etc.), instruments for the taking of the simple and association reaction-times, tests of muscular strength, steadiness, fatigue, etc., as well as tests of the 'higher' mental processes: quickness of apprehension, ingenuity, accuracy, fidelity of memory, power of co-ordination, keenness of observation, type of memory and imagination, control of attention, temperament, mental disposition and furniture, etc. The materials for these last cover a wide range, extending from ink-blots upon paper squares to the crowning triumphs of 'parlour magic'. Whether mental tests, as at present performed, will yield a real insight into the tangle of the individual consciousness is a question that can hardly be answered for some time to [p. 324] come. The significant thing is that many psychologists are seriously interested in them, and that this interest has brought to birth a fourth category of psychological apparatus.

The ideal laboratory will possess, in its museum room, a collection of instruments of all these four classes. The working laboratory does not need to possess them all. As I have indicated, we have ourselves no pieces of class *c*, which is a substitute for class *b*. We are now getting together some amount of the material that comes under class *d*, but rather with a view to testing its general psychological value than of carrying out any investigation into individual psychology as such. Experimental psychology must legislate for individual psychology, but the aims of the two are different.

6. *Endowment*. -- A laboratory can be equipped, one may, say, at any cost, from a final £10 upwards. I have several times been called upon to lay out sums of £10, £20 or £30 for the less fortunate of my colleagues; and something of value can be obtained even for the smallest of these amounts. Hence my advice to the as yet unendowed would be that they take what they can get, but get all that they can. If I were compelled to name a definite limiting sum, I should, I think, make it £30. For £10 you can get one or two good pieces: the Ellis-Helmholtz harmonical, or the Marbe colour mixer, or a Zwaardemaker double olfactometer with solutions, or a triad of colour wheels and a reliable æsthesiometer, or a Stumpf interval apparatus, or a set of Appunn forks; and the remaining £20 will go some distance towards a series of instruments for drill work, more especially if you have a carpenter at hand and make your memory-drops and fall chronometers and so forth at home. Still, a psychologist thus endowed could scarcely be called happy during his lifetime.[12]

The Cornell figures may be used to give the reader an idea of endowment upon the university settle. In 1891 the Professor of Psychology was granted a sum of £400; this was spent upon standard pieces and sets, not upon furniture and [p. 325] fixtures. The laboratory is permanently endowed with an income of £120, the annual payments of which began with the

academic year 1891-2. This £120 is supposed to cover fixtures, running expenses, etc., as well as apparatus. Two grants have, however, been made in addition to it: one of £53 for installation of the equipment in Morrill Hall in 1895, and another of £21 for the taste and smell room in 1897. At the end of the present academic year, 1897-8, the expenditure upon the laboratory will therefore amount to £1194, irrespective of minor gifts of instruments from students and from the director.[13]

Arguing from our own experience, then, I offer the following sums as roughly representing the upper end lower limits of requirement for a university laboratory, on the assumption that rooms, light, heat and power are free:--

Initial expenditure ; workshop	£175,	£100
Initial expenditure; apparatus	£600,	£400
Annual income; apparatus	£150,	£100
Annual income; books	£20,	£10
Annual income; mechanic's salary,	?	

The latter item will depend upon the facilities offered the mechanic for putting the pieces invented in the laboratory on the general psychological market, and the vogue that these pieces obtain, as well as upon the number of hours a day that he devotes to the laboratory.

Where does all this money go to? It goes, first of all, for research apparatus. Every autumn we purchase, at Cornell, some few good instruments, choosing them, so far as possible, with a view to our own future investigations, attempting, at the same time, to give equal attention to all the different fields of work. This year, *e.g.*, we bought the Koenig bellows table and differential sonometer, the new Griesbach æsthesiometer, a Dove siren, and the Hering indirect-vision colour mixer and colour-blindness instrument. The total cost of these, delivered in the laboratory, was rather more than £50: no small slice from the year's income. Indeed, all research apparatus is costly. Our chronograph, with accessory instruments, cost us over £60, transportation not included. The acoustics room contains no less than eighty-three forks, of varying sizes all of them used in the course of a year's work for one purpose or another; and forks are not cheap. The large Helmholtz colour-mixing apparatus, which, I believe, [p. 326] the Leipsic Institute alone of psychological laboratories possess, is listed at Mk. 3000: and so on.

Secondly, the money is spent upon drill instruments. The expense here is not large, after the first initial outlay, although repairs amount to something every year. The only considerable items in our 1897-8 sheet are two, of £4 10s. for six Sanford chronoscopes, and of £3 for two Roux regulators (temperature work). I do not expect to spend upon drill appliances more than £10 a year at the outside, for some time to come.

There remains of our £120 a sum of, say, £60. This is accounted for under the very elastic heading -of 'running expenses'. The items very almost indefinitely from year to year. A laboratory is constantly needing glassware, photographic supplies, rubber tubing, the commoner carpenter's tools and materials, the minor electrical fittings (binding posts, switches, fuse plugs), drawing materials (pens, paper scales, drawing inks, crayons), black and white cardboard, clock oil and chamois leather, clamps and supports -- a thousand and one things, from beeswax and burners and burettes to T-ways and thermometers and twine. These 'mount up' to a higher total than might be supposed. Next in importance, perhaps, stand the payments for carpenter's labour. There is hardly a week in the year that we have not something for the carpenter to do; he must alter fixtures, make frames and screens and shutters, overhaul the woodwork of foreign instruments (we find that all imported wood, however paraffin-soaked, warps and splits in time), cut windows in partitions, construct models and demonstration pieces to design,[14] stop leaks in the dark room, make up resistances, turn weight-holders, mend bellows, etc. I said above that a clever carpenter is capable of rendering essential aid in the laboratory. Besides the wall-campimeter, of which I have already spoken, we have a reading

apparatus, an artificial waterfall, Lambert colour mixer, a Listing's Law screen, a telestereoscope and several other useful pieces, all carpenter made. Thirdly, there are the expenses incident to investigation ; the renewal of damaged parts, the supply of kymograph paper, of gelatine sheets, of taste and smell solutions, of the materials required for work in individual psychology, -- alphabets and numerals, ruled cards end printed sheets, [p. 327] photographs and plaster casts. And lastly come the purely sporadic expenditures, for occasional anatomical specimens or microscope slides, for preliminary models of instruments to be made in metal, for drawings of instruments or wall-charts, and so forth. Anything that remains at the end of the year goes towards the purchase of research instruments.

The reader must not imagine that the line between 'instruments' and 'running expenses' can be very sharply drawn; still less that a hard and fast division can be made between the various kinds of 'running expenses'. I have had recourse to a rough classification for purposes of survey, but that is all. In reality, a good part of our 'running expenditure' inures to the benefit of the laboratory; many of the items on the list are not perishable. The laboratory has just now to pay the penalty of its youth. Later on, when the sundries are no longer all to get, the running expenses will diminish, even if the general demands upon our resources should considerably increase. It is the first few years that cost.

7. *Conduct of the Laboratory*. -- The laboratory is opened at 8 A.M. It usually closes at (6 P.M., although it may be kept open until 11 P.M., if necessary. All lectures, except those intermixed with the drill work of the third undergraduate year, are given in the forenoon. I have not found that particular hours are preferred for research work; though, indeed, the student's day is generally so full that hours are apt to be arranged rather by necessity than from convenience. Every student who works an hour as 'Versuchsobject' for his friend, takes it for granted that the friend will do him a like favour; and so the groups constitute themselves, very amicably. Every leader of a research group has a weekly meeting with the director, to report progress and discuss methods. The number and character of investigations differ considerably from year to year; at present three major and six minor studies are in course.

But the conduct of a laboratory is a personal matter. Whet I have written so far has, I hope, something of an objective ring about it. When a science is so young as experimental psychology still is, there must, of course, be differences of opinion as regards the indispensable parts of an equipment, the best method of reaching a proposed result, the proportioning of instruction and research. But these are all questions of degree. The question of the conduct of the laboratory at large, as envisaged by the one man responsible for it, is much more important; not only does much more hinge on it, but our answers to it may differ [p. 328] in kind. I offer my own personal view here with some diffidence, because the subject is not one that lends itself easily to any but conversational and quasi-confidential treatment. I believe, however, that if each of us will state his own conviction, and give reasons for it, we may attain to a far better co-ordination and correlation of our university and college laboratories than at present exists.

For my own part, then, I have always felt that it is very necessary to conduct a laboratory upon the lines of a determinate psychological system. This is one of the chief lessons that I learned, without realising at the time what I was learning, at the Leipsic Institute. In my German student days we all knew whereabouts in Wundt's system we were working, and that our results would reinforce or modify this or that statement of the *Physiologische Psychologie*. The consequence was that we all knew the system; we had a standard of reference for every new investigation. I believe that this is the way to make one's students psychologise, and I have followed it to the utmost of my power. Even in the drill-course, I do not allow the experiments to remain wholly detached and self-sufficient, as they are, *e.g.*, in Prof. Sanford's *Laboratory Course*; I try always to hang upon them some suggestion of further problems in a systematic psychology. Still more do the graduates, who have already taken my systematic course, approach their work with a keen eye for general relations. I can see objections to the plan: the laboratory tends to become the expression of a single man's ideas, and the demands upon the time of the director are such as almost entirely to preclude his own accomplishment of original work. But I see much more objection to the opposite plan, of complete freedom in choice of problem and of method; and compromise is difficult. I may add that, in my experience, the American student is on the

average --t here are many exceptions -- quicker in generalisation end less patient of minute and laborious search for facts than are the English and the German; and that I have found my plan of work to produce good effects in the way of training and discipline, quite apart from its scientific results. The details of the 'system' may be right or wrong; that is really a minor matter, provided that the system itself be clear and self-consistent. It is of the nature of a system to be modified under stress of new facts. Advance in scientific thinking always implies an unlearning of old beliefs; and I do not see that it matters how many things we unlearn, if only we have never to unlearn our method. [p. 329]

I know that these opinions are not generally held; and I should not have intruded them as a part of the *vie intime* of my laboratory did I not hope that their expression will evoke criticism, and so lead to results of practical value. Nothing need be said, in a psychological journal, as to the nature of psychological problems. Students of psychology who are unfamiliar with the laboratory may take it for granted that our problems are the same as theirs. The difficulties that they try to resolve by observant introspection, by the genetic method, by the collection of statistics, we are trying to resolve by an introspection held under experimental control, -- to secure which we levy tax upon physics or physiology or chemistry or any other wealthy science that may come our way. That is the only difference.

8. *Student Attendance*. -- The times are hardly ripe for a discussion of the function which a department of psychology discharges in the general economy of the university. Laboratory psychology has not yet grown to its full stature; and its youth has been vexed by the interference, friendly and hostile, of older disciplines. Nevertheless, it can do no harm to set down the facts that we have at our disposal, whether they are final or not.

As regards the place of psychology in the undergraduate curriculum, I think we call speak pretty positively. I see no reason at all why, under a system of free election, a course in psychology should not compete on even terms with courses in literature and history, and laboratory work in psychology with laboratory work in physiology or physics or zoology. There can be no doubt of the intrinsic interest of the topics with which psychology deals.

On the other hand, the question of the attractiveness of psychology to the graduate student is much more difficult of decision. It is probable that the graduate attendance at the American laboratories is now at its lowest ebb. A few years ago, when several important laboratories were in course of founding, and instructors were in great demand, the attraction of the new study was, naturally, very considerable. To-day, the places are filled; there is little likelihood of more establishments on a large scale; and the increased number of laboratories means an increased severity of competition. A man who has been fitted by undergraduate courses in history, languages, sociology and psychology to undertake (let us say) either literary work or the research work that shall prepare him for a psychological chair, may therefore very well prefer literature to psychology.

So much on the debit side. As a set-off, we may notice [p. 330] the following facts. First, the training that can now be obtained in the American laboratories is at least as good a fitting for work in an American university as can be gained in Germany. Hence, while a large percentage of students will doubtless continue to spend a year in Germany, for the sake of acquiring the language and seeing the German equipments[*sic*], the number of Americans who take the German doctorate will probably decrease, and the number who take the American degree correspondingly increase. Secondly, the establishment of laboratories, while it increases competition, guarantees a psychological career, if only one is capable. Livelihood and reputation are there, to be grasped by the competent. Thirdly, I regard it as probable that the requirements laid upon teachers, in normal and high schools, will in the near future become heavier rather than lighter, and that a good proportion of those who intend to devote their lives to teaching will find it useful to have the psychological degree. Of course, the relation of the teacher to laboratory psychology is extremely complicated. It has been taken as an axiom that pedagogy must be based upon psychology, and teachers and psychologists alike have lost sight both of the difficulty of 'application,' of the translation of theory into practice, and of the immaturity of psychology itself. There has thus been, in the recent past, a provision of crude

psychological literature, on the one hand, and on the other a rush for books and keen disappointment at their contents, -- a swing of the educational pendulum towards psychology and a reactive swing away from it. But it is surely undeniable that, in the long run, the teacher will gain a great deal from the laboratory: what one may call the psychology of function, -- the psychology of attention, of memory-type, of action, of invention, -- all this does bear upon teaching. As child-study passes from the unschooled to the schooled, as the bridge is built from anthropometry across individual psychology to experimental psychology, as laboratory psychology ceases to be either an educational fashion or a scape-goat for the sins of past educators: in a word, as the public comes to see things psychological and educational in their right perspective, we may expect that the teachers' colleges and the pedagogical departments will keep a steady stream of students circulating through the psychological laboratory. On the whole, then, I look for a slow but constant increase in the number of our graduate students.

My sketch is now finished. Doubtless, there are many omissions; one is apt not to see the obvious. But the [p. 331] reader will be able, I hope, to form some notion of the activity of a psychological laboratory, of the nature of a psychological course that is surrounded from beginning to end by the laboratory atmosphere, of the duties that devolve upon the director, -- in general, of the 'running' of the whole machine. And he will probably ask: What comes out of it all? It would be hardly fair to conclude my paper without returning some sort of answer to this question.

In the first place, then, training comes out of it. Education, discipline, method come out of it; and that they are of a kind worth paying for is attested by the bare fact that in America they are paid for, that a laboratory equipment is a thing of course at the universities, and is coming to be a thing of course in the colleges. In the second place, contributions to knowledge come out of it. During my six years at Cornell the department has published three major[15] and eighteen minor studies; it has three major[16] and three minor practically ready for publication; and six minor studies are in progress. There is nothing epoch-making about current laboratory work: psychologists have not yet discovered their argon or their Röntgen rays: but it is none the less work, work whose methods get discussed and assimilated, and whose results gradually alter the face of the science. In brief, the two things that come out of the physical or chemical laboratory, precisely those two things come out of the psychological,-trained workers and original work. And when one thinks how great a part of the world of knowledge rests upon psychological foundations, one sees how great is the import of these two things for knowledge, compare them with whatsoever else one will.

Footnotes

[1]The following are, I believe, the most important references:--

(1) J. M. Baldwin, "The Psychological Laboratory in the University of Toronto". *Science,* O.S., vol. xix., 1892, p. 143.

(2) M. Baudouin, "La psychologie expérimentale en Amérique. Le laboratoire et les cours de Clark University à Worcester." *Archives de neurologie*, vol. xxviii., no. 89. "Les laboratoires et les cours à Yale, Harvard, Cornell, Pennsylvania, ... etc." *Ibid.*, vol, xxviii., no. 93.

(3) W. Bechterew, "Le laboratoire psychophysique de l'université impérialle de Kazan". *Cong. de Zool. de 1892*. vol. iii.

(4) E. Bérillon, "Notice sur l'institut psychophysiologique de Paris". Paris, 1897.

(5) M. W. Calkins, "Experimental Psychology at Wellesley College". *Am. J. of Psych.,* vol. v., p. 260.

(6) E. Casslant, "Le laboratoire de physiologie des sensations de la Sorbonne Paris, 1897.

(7) E. B. Delabarre, "Les laboratoires de psychologie en Amérique". *L'année psychologique*, vol. i., p. 209.

(8) T. Flournoy, "Notice sur le laboratoire de psychologie de l'université de Genève". Geneva, 1896.

(9) V. Henri, "Les laboratoires de la psychologie expérimentale en Allemagne" *Rev. phil.,* vol, xxxvi., Dec., 1893.

(10) .J. Jastrow, "The Section of Psychology". *World's Columbian Exposition Official* Catalogue, pt xii., p. 50

(11) W. O. Krohn, "Facilities in Experimental Psychology in the Colleges of the U. S.". *Report of the Commissioner of Education for 1890-1*, vol. ii., p. 1139. "Experimental Psychology at the Various German Universities." *Am. J. of Psych.,* vol. iv., p. 585. "The Laboratory of the Psychological Institute at the University of Göttingen." *Ibid.*, vol. v., p. 282.

(12) "Psychological Laboratory of Harvard University." Cambridge, Mass., 1893.

(13) E. C. Sanford, "Some Practical Suggestions on the Equipment of a Psychological Laboratory ". *Am. J. of Psych.*, vol. v., p. 429.

(14) G. M. Stratton, "The new Psychological Laboratory at Leipzig". *Science*, N.S., vol. iv., 1896, p. 867.

(15) H. de Varigny, "Le laboratoire de Madison, Wis." *Revue scient.*, 1894, p. 624.

Of these papers (all of which, except nos. 3, 4 end 6, are known to me) nos. 5 and 13 come nearest the intention of the present article. I omit a few papers of merely local interest or popular character. Information as to laboratory furnishings can be gleaned from many other sources; thus there are accounts of a 'silent room' and of a photographic room in the *Yale Studies*, of a dark room in the *Phil. Stud.*, the *Arch. f. Ophth.*, etc.; Prof. Sanford's *Course* has a chapter entitled "Suggestions on Apparatus"; the fourth ed. of Wundt's *Phys. Psych.* devotes much space to the description of instruments; and so on.

[2] By Prof. Cattell, in O.S., vol, xiii., p. 37; by myself, in N.S., vol. i., p. 206.

[3] The 'when' here and elsewhere in the article should perhaps be written 'if'. M. Flournoy, whose original account of the Geneva laboratory proved to be too sanguine, remarks sorrowfully that "il ne faut jamais vendre la peau de l'ours avant de l'avoir tué". The fact that I annex rooms 11 end 12 solely for the reader's benefit may, I hope, suffice to propitiate the Fates.

[4] Throughout this article I take £l as the equivalent of $5.00. -- It would, of course, be easy to replace the thread-meridians by a revolving arm of the same brightness as the background. But the apparatus would then be a good deal more expensive, and I do not think that any real advantage would be gained.

[5] At the Christmas, 1897, meeting of the American Psychological Association, Prof. Cattell remarked: "We have tried to banish mercury and smoked paper from our [the new Columbia] laboratory; and we think we have succeeded" I have not get succeeded in finding the perfect substitute for smoked paper in chronographic work; but there are so many writing devices upon the market that a systematic search will probably reveal (or at least suggest) something that can advantageously replace it. Where a current can be passed through the writing point to some part of the writing surface, tinsel paper (' silver' paper) may be employed.

[6] E. W. Scripture, *The New Psychology*, 1897, pp. 483, 484; E. L. Nichols, *The Outlines of Physics*, 1897, pp. 442, 443.

[7] A useful preliminary list of firms will be found in the pamphlet issued by the Harvard Psychological Laboratory, to which I have referred in a previous note.

[8] "Catalogue of Phil. Instr. devised by J. McK. Cattell," Camden, N.J.· *Cf.* Prof. Cattell, in *Mem. Nat. Acad. Sci.*, vol. vii., no. ii., 1896.

[9] "Pseudoptics," Milton Bradley Co., Springfield, Mass., £l.

[10] *Cf.* Catalogue of E.G. Willyoung & Co., Philadelphia, Pa.

[11] *Am. Journ. of Psych.*, vol. ix., p. 191.

[12] Professor Sanford has made out a liminal list of apparatus -- the amount that is lust noticeably better than nothing -- as follows: "Weights for pressure and lifting, including those of equal weight but unequal size; a sonometer; ten or a dozen ordinary tuning-forks of a' and c'' pitches for special tuning; a resonance bottle; a pair of bottle whistles; a yard of small rubber tubing; Bradley's Pseudoptics; some small pieces of coloured gelatine; a 60° prism; a dark box; and a couple of yards of metric cross-section paper". *Course*, p. 419. The approximate cost of such a set mould be £5.

[13] To the psychologist, £1000 seems a large sum. What would it seem to the physicist or the physiologist? The comparison shows very prettily the working of the law of the *fortune morale.*

[14] I made no fifth class of apparatus, for 'demonstration' instruments, because the pieces used for lecture demonstrations will always, I think, fall within some one of my four classes, or be simply models; models of brain or sense organs or sensori-motor connexions, or models illustrative of the course of association, of feeling, etc.

[15] M. F. Washhurn, "Ueber den Einfluss von Gesichtsassociationen auf die Raumwahrnehmungen der Haut," *Phil. Stud.*, xi. A. J. Hamlin, "Attention and Distraction," *Amer. Journ. of Psych.*, vi. W. B. Pillsbury, " The Reading of Words: a Study in Apperception," *ibid.*, viii.

[16] E. A. Gamble, "The Validity of Weber's Law for Smell Intensities". S. E. Sharp, "The Relation of Individual to Experimental Psychology". I. M. Bentley, "The Qualitative Fidelity of the Memory Image".

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