effect he uses positives printed on glass and moderately illuminated before a specially arranged background. The details are set forth in a small pamphlet* which may be advantageously studied by any one who cares to employ the new method.

It will be observed that the stereoscopic method gives the shapes of lunar features in terms altogether independent of those afforded by telescopic observation. The data furnished by the telescope serve through the principle of shadows; the data of the spectroscope serve through the principle of optical parallax. In the stereoscopic view light and shadow join with local color in defining points and spots, and all points are thrown into proper relation through their parallaxes.

G. K. GILBERT.

A FURTHER STUDY OF THE UNIT SYSTEM OF LABORATORY CONSTRUCTION.

IT is desired to present a series of drawings with the necessary explanations to illustrate the practicability of designing a laboratory on a unit system. These drawings are the outcome of a somewhat careful study of the problem and of discussions with a number of experienced laboratory administrators. They seem to me to demonstrate the entire possibility of constructing a laboratory upon the unit system.

In a previous article, which was published in the *Philadelphia Medical Journal*,† it was maintained that the unit system of Laboratory construction offers real and very great advantages. The advantages are architectural, administrative and for the work of instruction.

The architectural advantages are those of facility and flexibility of design, and those of convenience and economy of construction. It is evident that if the essential requirement is to provide a number of rooms of uniform and moderate size, abundantly lighted and conveniently accessible, then an architect has a comparatively simple problem, which may be carried out in a great variety of designs, and may be readily adapted to special situations and conditions. Such a requirement leaves an architect great freedom as to the exterior of the building, which generally seems as important to the architect as the interior arrangements are important to the owners and users of a building. One indispensable exception to the exclusive adoption of the unit rooms will recur, in probably every case —namely, that of lecture rooms. As regards the construction, I am informed that it would cost less for a building on the unit plan than for one of equal capacity but with rooms of the customary irregularity of size.

The advantages of administration are manifold. Most valuable will prove, I think, the possibility of changing the uses to which the rooms may be put, for not only may the use of a given room for one object or another of a given department be changed, but it may be transferred wholly to a different department, for a unit room as proposed will be equally adapted to the needs of, for example, chemistry, botany, anatomy or physiology—its adaptation to the special needs of any of these sciences depending only upon the furniture put into it. Within a single department a unit room may be applied to many different uses. It will be of convenient dimensions for a class of elementary study, a smaller class of advanced students, or a still smaller number of research men, or of assistants. It can be subdivided into two smaller rooms by temporary partitions. It will be convenient for collections, for a library or reading room, or for a small lecture room. The particular use of any room can be changed

* De l'emploi des photographies stéréoscopiques en sélenénologie. Extrait de l'annuaire de l'Observatoire royal de Belgique pour 1901. 27 pages.

† Vol. VI., p. 390, Sept. 1, 1900.

at any time by moving the furniture from one room to another. Another administrative advantage will be the ease with which the laboratory may be enlarged by adding a few more unit rooms, each of which will be as perfectly suited to all the varied requirements of the laboratory as the rooms already in use. Such enlargements may be indefinitely repeated as long as the building space holds out.

The advantages of instruction are those which ensue from having the students divided into small sections. These were considered in the previous article, reference to which has been made above. I venture to repeat what was there said. There are two principal alternatives between which we may choose—the adoption of large laboratories or of a series of small laboratories. The choice is between keeping the students in large classes and dividing them into small sections. Personally I can advocate only the latter choice and must plead for it very strongly. In a large laboratory with 75 or 100 or more students, the noise and confusion are necessarily great, and the detailed supervision of the work is extremely difficult. If the students are subdivided into small sections, these and other difficulties at once vanish, and if each section can be assigned a separate room it may be put under the charge of a special instructor, who shall be personally responsible for the work of that section. Thus each assistant can be given a certain independence. The sense of opportunity with the accompanying responsibility will tend to improve the quality of his teaching. He can be directed to carry his section over a certain part of the subject in a given time and left free to accomplish the result. If the section is small enough the work can be interrupted for an explanation, a direction or a quiz, and the students will ask more and better questions than in the large laboratory, where the many listeners embarrass them, and where they may not find always the same instructor at hand. Finally, the instructor can learn the personal qualities and needs of the men in a small section and establish personal relations with the individuals. It should never be forgotten that such personal relations are most important factors in efficient teaching. It might be urged against the position here taken that the class could be divided into sections in a large room, but my experience convinces me that such a scheme is utterly impracticable. The advantages of moderate sized rooms for all advanced work and for investigations of every kind are so commonly admitted, that their justification by argument is uncalled for. The unit rooms should be therefore of suitable size for these purposes also.

Assuming now that the unit system is desirable, we pass on to the consideration of what may be the best dimensions. The problem resolves itself into three questions :

First, What is the best unit space to allow for each student?

Second, What is the most convenient maximum number of students to assign to a single room?

Third, What additional space must be provided in each room for passages, sinks, shelves, etc., so as to permit it to be fully equipped for the class work?

Let us now consider these questions in the order given.

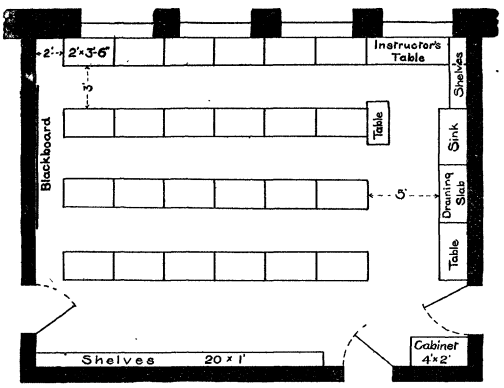
First. The unit space required for each student. In the previous article twenty square feet was suggested as a preliminary estimate, or an area four by five feet. Since then a number of laboratories have been measured, and the relative advantages of various unit areas considered. It is of course desirable on the one hand to reduce the space reserved for each student in order to reduce the total size of the building required, and on the other hand to give each student ample room to carry on the prac-

tical laboratory work under favorable conditions and without interference from his neighbors. These somewhat contradictory requirements may, it seems to me, be reconciled. The study of the subject has led to the final proposition that we accept as the *unit space three feet six inches by five feet* (3 ft. 6 x 5 ft. 0).

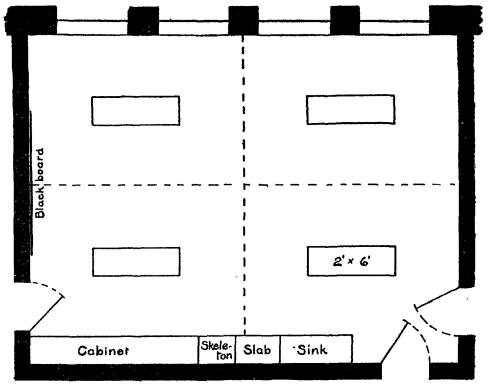
By the metric system such a space would measure 1.067 x 1.524 m., or roughly 1.01 x 1.50 m. These values suggest the possibility of adopting one meter by one and one-half as the unit space. In our space there can be put a table measuring 3 ft. 6 x 2 ft., leaving 3 ft. 6 x 3 ft. clear space for the student to sit or stand at his work, and for the instructor or others to pass behind him. The table will be long enough to permit having, say, two drawers and a locker below them, making on one side a tier about a foot wide, and still leaving space for the student to sit comfortably at the table. There are doubtless many laboratories in this country in which less space is assigned to the individual student than is here advocated, but it seems to me that such crowding and cramping immediately lowers the quality of the teaching and the quality of the studying done. The bad result is due in part to the sheer discomfort of the conditions, but is chiefly due to the inferior opportunities which such crowding entails. When students are close together there can be but little room for laboratory apparatus, consequently the practical work for the students must be to a large extent made ready for them beforehand, so that what should be a laboratory exercise at once becomes barely more than a demonstration. If the students are not crowded, then each one may be supplied with a set of apparatus and be afforded an opportunity to perform himself the complete series of operations necessary to obtain and render available the material or phenomena he is to study. A true laboratory experience is thus placed within his reach, and the instruction is changed from the lower to the higher type. It may be said, therefore, that a fundamental pedagogical principle is involved in refusing to adopt a smaller unit area than above proposed.

Second. The convenient maximum number of students in a single room. This number it is very difficult to determine. It is essentially a question of experience and judgment, and as such, the question is inherently impossible to answer in a conclusive scientific manner. I can therefore only express my opinion that twenty-four is such a convenient maximum number. This opinion is based partly upon general considerations, partly upon an examination of the special requirements of medical instruction. Apparently the common American practise, where large elementary classes are taught, is to provide instructors about in the proportion of one to every twenty-five students more or less. In some universities, where the endowments are ample and the classes moderate in size, the proportion of students to each instructor is less, even in a few cases considerably less. In many universities, on the contrary, the opposite is true. A thorough study of the proportion as it actually exists in the various American institutions of higher instruction would be a valuable contribution to the discussion.

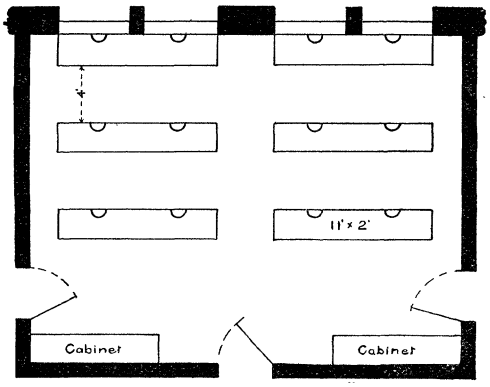
So far as I am aware this study has, unfortunately, still to be made. As regards the particular needs of medical instruction—and it is with this that I am personally most directly concerned—there are special conditions, which greatly facilitate the determination of our convenient maximum. The special conditions, alluded to, are furnished by the work of the dissecting room, because six students are assigned commonly to each subject, hence six forms a natural group in medical studies, and the number put in one room should be a multiple of



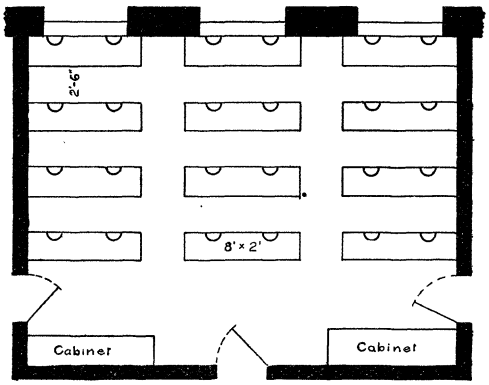
Histology



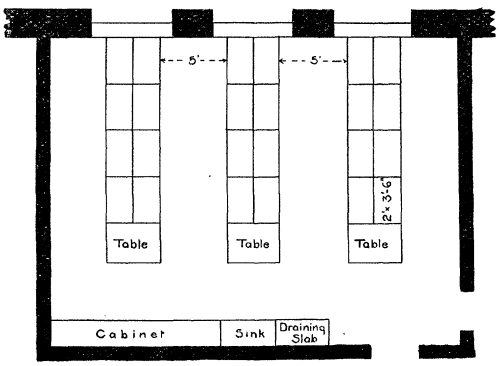
Anatomy



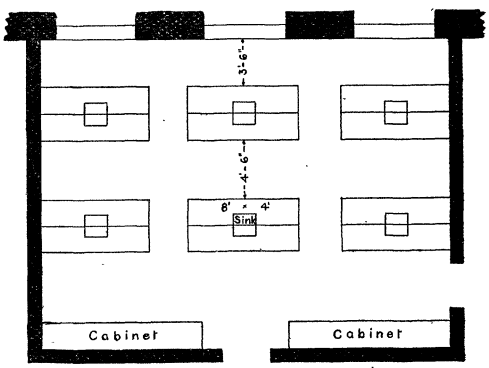
Physiology



Chemistry



Zoology



General Chemistry

six. This leads at once to the number twenty-four, four subjects in one room being convenient and having the advantage of allowing the room to approximate to the square form, which would not be practicable if the number of subjects be fixed at three or five. Twenty-four is close to twenty-five, the approximate number first determined, and being an even number it permits the formation of pairs, which has been found advantageous for certain kinds of laboratory experimental instruction. It appears also that this number commends itself to various professors, who have been consulted as heads of laboratories for histology, physiology, chemistry and pathology. While, therefore, no number can be asserted to be best, it is probably safe to accept twenty-four.

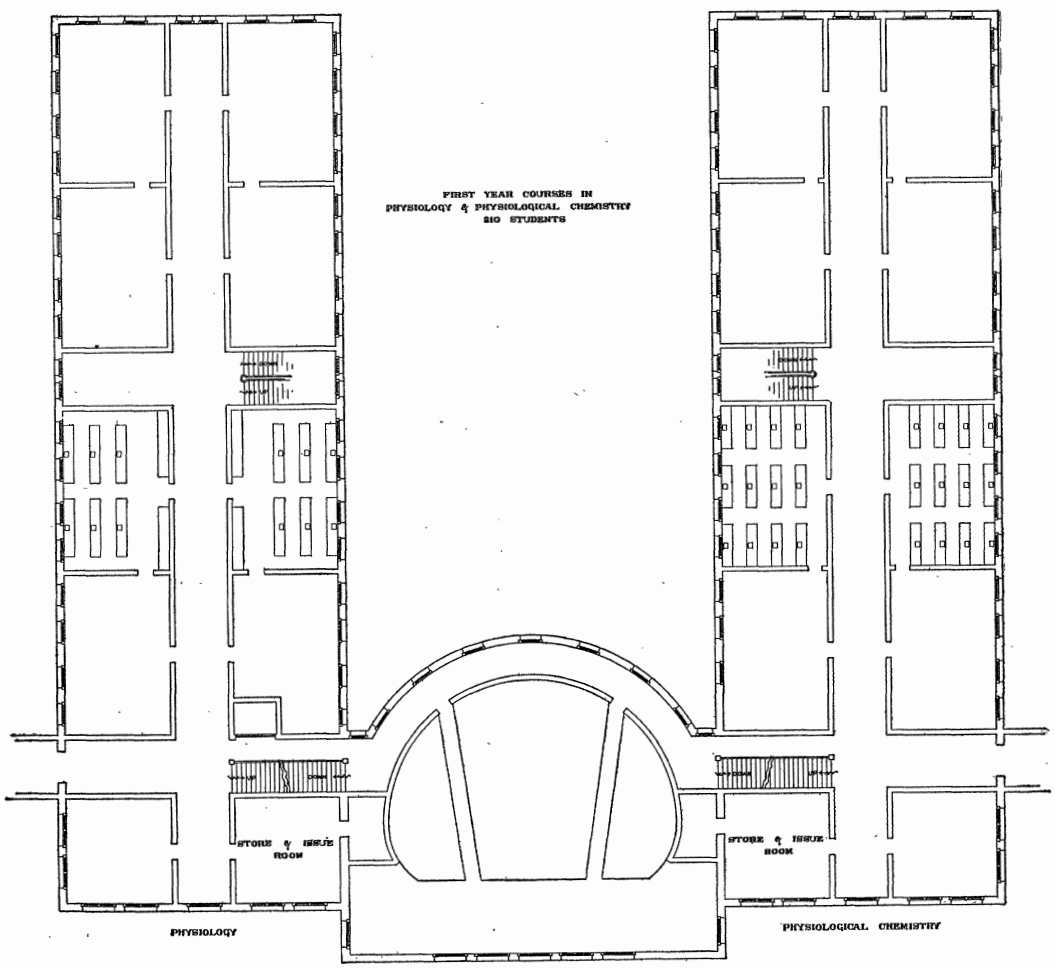
Third. The additional space to be allowed for passages, sinks, cabinets, etc., on the assumption that each room is to have an independent equipment, so that classwork in it can be carried along independently of the work in the other rooms. Measurements of several laboratories led to the supposition that for each student some ten or twelve square feet additional should be allowed. The supposition was then tested by drawing out several rooms, with varying dimensions, with detail plans of the arrangement of the furniture and fittings, until finally eleven square feet was fixed as a desirable allowance.

We are now in a position to calculate the desirable floor area on the following basis: There are to be twenty-four students in each room. Each student is to be allowed for his own use a space 3 ft. 6 by 5 ft., or $17\frac{1}{2}$ square feet, or in all 420 square feet, each student also should be reckoned to require eleven square feet additional for the general use, or in all 264 square feet. Thence $420 + 264 = 684$ square feet required for a room.

A room measuring 30 feet by 23 contains a floor area of 690 square feet (about 10.67 meters by 5.20 m.), which is almost exactly the area desired, exceeding it only by six feet. Rooms of other dimensions have been drawn, but the propositions adopted seemed the best. The thirty-foot side should of course have the windows, and the narrower dimensions, twenty-three feet, correspond therefore to the depth of the room.

I offer herewith six studies of possible arrangements of the *unit room* which the preceding discussion establishes. The six plans are for convenience, though somewhat arbitrarily, named *Histology*, *Anatomy*, *Physiology*, *Chemistry*, *General Chemistry* and *Zoology*. Little need be said about these plans, because they are in the main self-explanatory. Various dispositions of the windows are indicated, but possibly three pairs of double windows would be better than any of the arrangements on the plans. Experience has led many scientific men to doubt whether any architect knows the meaning of the term 'a sufficiently lighted laboratory.' We have all seen inadequately lighted laboratories, but if an over-lighted laboratory exists anywhere in the world, I have yet to hear of it. As to the doors, it may be suggested that, in order to provide for a future possible subdivision of the room, the wall should be so built as to allow two doors, one towards each end of the room; one door space might be built up until needed. Doors are indicated by which adjacent rooms are directly connected. It might be preferable to arrange the rooms in pairs, as indicated by the distribution of the doors in the plans for *general chemistry* and *zoology*.

In *histology* the students are placed in four rows of six each, and a special table is provided for the instructor; a large blackboard is called for on one wall, where it can be easily seen by all the students from their seats. The front edge of a table



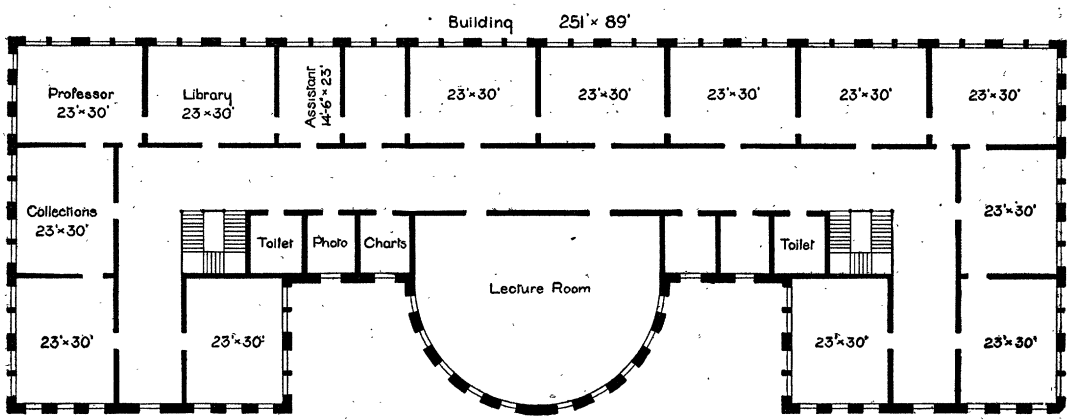
STUDY FOR FIRST FLOOR PLAN
OF PHYSIOLOGICAL INSTITUTE BY
W. T. PORTER.

in the fourth row is only fifteen feet from the windows. Every student will be able to obtain unobstructed light for his microscope, especially if the windows are high enough. In *anatomy* there are four dissecting tables, a blackboard, cabinet, sink, etc. In *physiology* the students are assumed to work in pairs, two pairs at each table; hence the design shows six long tables, with a separate sink for each pair of workers. In *chemistry* the tables are eight feet by two, with a separate sink for each student; as the men usually work standing, the tables are placed closer together, and since two students are calculated to a table, twelve tables are provided. The whole or part of one of the spaces marked 'Cabinet' in this plan, as in *general chemistry* may be made into a hood. *General chemistry* shows the more usual grouping of the chemical desks. back to back, with one sink for four desks. Finally *zoology* shows an arrangement which is preferred by many, the tables forming rows at right angles to the line of windows. In many respects this arrangement is favorable. A special advantage is that, without overcrowding, it permits the addition of three tables, upon which appa-

ratus may be placed which is rather for general and common than for personal use.

A candid examination of these six plans will, I hope, convince the reader that the proposed unit-room provides thoroughly convenient, but not excessive, accommodations for twenty-four students, and that the students may be distributed in many differing ways, according to special needs. It has not seemed worth while to pursue these plans further, with a view of showing how a smaller number of advanced workers could be disposed. The solution of such a problem is so simple as not to require illustration. If such a room is to be used for a collection, two cases could be arranged along the side wall, and if there are three windows, two sets of double cases could be placed against the space between the windows and run into the room as do the double rows of tables in the *zoology* plan.

In conclusion, attention is asked to the two studies for a floor plan. The first study is by Professor W. T. Porter, of the Harvard Medical School, to whose generous courtesy I am indebted for the opportunity to publish the plan for the first time. In this study the unit size adopted is 20 x 30 feet, but I have Dr. Porter's permission to state that he considers 23 x 30 feet preferable. In this study there is a central large lecture room connected with the main building, and there are two symmetrically placed wings, which, building space permitting, can be indefinitely extended, whenever enlargement shall become necessary. The second study, by myself, is merely a modification of the first: the size of the unit room is 23 x 30 feet, one room being drawn subdivided for assistant's use; the main building has been lengthened in order to provide small rooms near the lecture hall, and to increase the distance between the wings so as to secure better light; in order not to increase the floor space the wings are drawn shorter. Neither of these studies is to be regarded as more than a preliminary sketch, which needs competent revision and modification by a professional architect before it can become practically available. They suffice, however, for the purposes of this article and to illustrate the construction of a laboratory upon the unit system.



CHARLES S. MINOT.

HARVARD MEDICAL SCHOOL, BOSTON,
February 18, 1901.

THE NEW YORK STATE SCIENCE TEACHERS' ASSOCIATION.

THE fifth annual meeting of the Association was held at the University of Rochester, on Friday and Saturday, December 28 and 29, 1900, about two hundred members and others being in attendance. The