SCIENCE

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LABORATORY ORGANIZATION[1]

PROBLEMS incident to a complete reorganization of a growing department, construction and equipment of a laboratory with adequate provision for a thousand students, and the laying out of suitable courses of instruction for a college proper, have so engrossed my time during the past two or three years, that I have had to forego in a large part the pleasure of the pursuit of research in my special field of inorganic chemistry and offering the results for your consideration. Such is the price the teacher, who loves his work, must and does pay. As the coming half year promises a consummation of the work in this direction to a fair degree and as it is the purpose of the authorities of the college to formally dedicate the new buildings in May next, to which ceremony it will be our pleasure in due time to request your attendance, it has appeared appropriate, in preparation for your visit, to present to you this evening and at the two succeeding meetings of the section, a series of three short papers under the titles "Laboratory Organization," "Principles of Laboratory Construction" and "Courses in Chemistry for Colleges." That such hackneyed titles offer little that is attractive is recognized, yet I am constrained to believe that what I shall have to say will serve as an incentive for discussion. In this connection allow me to remind you of the fact that the institution to which I shall refer more particu-

[1] Read before the New York Section of the American Chemical Society, February 7, 1908.

larly, belongs to you, to me, to every man, woman or child in this great city, who pays taxes or rent. I am merely one of the instruments for making it most effective. Having centralized my efforts, for the time at least, upon it, I shall welcome every suggestion by which the ideal may be more nearly approached. Human nature prompts a desire for helpful advice and sympathetic criticism. I may add, what is presented this evening will likely provoke an amused smile on the part of those of you who are associated with large well-organized corporations.

Every department of an educational institution requires some form of organization. A chemical department is more acutely affected by lack of organization than any other of the various subdivisions of an educational plant. The nature of the work classes a chemical laboratory under the head of department stores. Every chemical department has some style of organization. Much consideration of the subject has resulted in settling upon the plan here outlined as most suitable to an institution as the College of the City of New York, which is of collegiate grade only, not offering graduate or technical courses of study. Perhaps with slight variations parts of the plan may commend themselves to other institutions.

The pedagogic phase of the subject, first in importance, is to be considered as the last of the three topics. The material arrangements for securing the best results will be taken up next time. This evening I desire to direct your attention to the consideration of the executive phase, which involves the selection of a staff, the proper care for a large plant, its upkeep and control over current expenses, whereby the largest output and the greatest use may result with the least expenditure.

Complaint is frequently made in this country on the part of directors of laboratories and teachers of chemistry, that they are overcome with detail work. This complaint is, as a rule, well founded, but it is my belief that a system of organization can be adopted which will relieve the directors of much of the detail work, subdividing it in such a manner that it does not become too great a burden for any one individual.

CLERICAL HELP

In the first place it is uneconomical to require the head of the department to do much of the clerical work, which may be done by one who has not had to spend so much time in preparation for the duties of a directorship. In short, fuller return is made to the institution by the employment of a clerk or secretary, or both.

SELECTION OF A STAFF

As the head is held responsible for the department, his advice in the selection of subordinates should carry great weight. This is a principle generally recognized in all reputable institutions of learning, although not always lived up to. Many factors are involved in the selection of a staff. I shall limit myself in this connection to two pertinent remarks. Naturally we know our own graduates better than those who come from other institutions, and whom we have met incidentally. Our own graduates are more familiar with the local problems and it is easier to meet the difficulties with sympathetic help. In not a few institutions, however, in-breeding has resulted, if not in stagnation, at least in bringing about a state of affairs which has prevented the department from producing its best results. It is desirable, therefore, to hold enough of the men who know the inside life of the institution to preserve its traditions, yet new blood should be brought in continually to show the best of other

places and act as a stimulus for the whole. Withal it is better to have a man two years whom other people want, than to have a man twenty years whom nobody wants.

TIME FOR RESEARCH

It does not follow that the investigator is the best teacher, but a man of research at least has had a taste of the sweets of discovering the unknown, and consequently, with rare exceptions, is more capable of imparting some of that spirit to students than he who knows nothing of such experience. Research must be the prime means by which the young teacher can hope to attract such attention as may bring him preferment elsewhere. Yet he may not be wanted elsewhere, if he neglects the work at hand, namely, his teaching.

The controlling powers are often unfair to the young men who occupy the inferior positions in placing heavy teaching burdens upon them. Time for research, for by it advancement is hoped, is secured often only at the sacrifice of hours of needed rest and recreation, or by neglect of the little but important things of their teaching. I regard it really better business, if I may assume to speak from that point of view, to require less teaching hours for these young men, and to assign them certain times to be used for research, which may or may not be in cooperation with a colleague.[2] The freshness and vigor of his instruction will be improved and the responsibility for advancement will in a greater degree rest upon the man himself. A staff of ambitious young men secured under the same title and compensation gives an opportunity for competition for preference.

[2] We have provided one room where twelve tutors may have each a private place. Ten private laboratories are provided for those of higher grade.

STAFF ASSIGNMENTS

When a staff, or a nucleus of a staff, has been secured, it is advisable to organize the department into divisions. The extent of the subdivision and the duties assigned to the chief of each division will depend upon the number of men available and their qualifications. We have found it convenient so far to divide our department into divisions of general, analytical, organic and physical chemistry, and supplies. Each chief is held responsible not only for the instruction in his division, all details of equipment, etc., going first to him also, but for certain other matters, for example, the chief of the analytical division has general superintendence of the upkeep of the department; the chief of the physical division supervises the electrical equipment; the chief of the organic division oversees the museum and library, etc. A weekly conference of the whole staff gives an opportunity for suggestions and their discussion.

CONTROL OF NUMBERS

In a separate building given to any one subject in the curriculum of a college, there must be a fairly large assemblage of students at some time or other, particularly when a portion of the instruction is given by lectures to several hundred at once. Not only must the building be so constructed, but the organization so effected, that there may be rapid assembly and quick dispersion of people. Counter currents of the throng are avoided by having one stairway for going up and another for descending. Inevitable friction in the passages caused by discharging several groups of students into the corridors at once is avoided by a little foresight in arranging the schedule of recitations and laboratory practise. After three o'clock in the afternoon, after which hour no new class now begins, or in times of emergency, all means of exit

are used. They are so arranged that there is no converging of currents, the upstairs leading out one way, and the downstairs leading another. The exemplary conduct of the children in our public schools of New York at times of alarms of fire have often demonstrated the wisdom of such precautions.

STUDENTS' SUPPLIES

The problem of supplies is an ever vexing one with every chemical department. The College of the City is unique in requiring no fees, and by law we must provide sufficient apparatus and chemicals for each student to complete a first-class course in chemistry without cost to him. The cost for the average student, therefore, must be determined for each course. The student has that amount, in terms of supplies, to his credit upon which he may draft as his requirements arise. At the point of overdrawing on the part of an extravagant or careless student, his credit ceases and he must make good any excesses.

CARD CATALOGUE SYSTEM

Satisfactory bookkeeping is therefore a necessity. We have adopted the card catalogue system. The system for the division of supplies, including four auxiliary supply rooms, provides requisitions for immediate or temporary use, import orders, desk equipment and private laboratories; shipping instructions, inventory, labels, tags, etc.

A budget is prepared. The amount of the appropriation is known to the director. All requisitions are recorded with the estimated cost opposite in one column. When the bill for that particular requisition is presented the actual expenditure is placed in an adjoining column. By this means we live within our means, whether they be meager or extravagant. The Board of Estimate usually avoids the latter, even if we were inclined to extravagance.

The executive side of the system cares for students' registration, division registration, advancement, admission to advanced standing, record cards, requests for permit to work out of hours, notices of poor work and regular students' reports, etc. The cards are colored, which facilitates classification, as yellow for analytical, red for organic, etc. The selection of any designating color once decided upon is adhered to.[3]

In elaborating this system I have received hearty aid from my colleagues, Associate Professor H. R. Moody in particular.

PLACING RESPONSIBILITY ON THE STAFF

The use of a time stamp to indicate the receipt of invoices, date of approval of bills, for stamping of notebooks, etc., has proved of great value in our department in serving to place the responsibilities. In this connection it may be stated in anticipation of a subsequent discussion of certain pedagogic problems that we have the "section system" for laboratory instruction. We do not have large laboratories, but small ones, accommodating, as a rule, not more than twenty-five students at one time. The reasons for this will be discussed in a later communication. The instruction in each laboratory is given by one instructor. He is held absolutely responsible for the conduct of that room, including its physical condition. Instructors are human and when the responsibility is divided, one usually bears the brunt of the work and the filthy condition of a laboratory is always attributed to the "other fellow." This is a principle and one of fundamental importance. Its application

[3] Samples of the cards in use were exhibited. They may be had on request to the author.

discloses the slipshod clock-watcher, while it rewards the earnest and worthy.

UNIFORM REAGENTS

To bring about uniformity in the use of chemicals throughout the laboratory, where it is possible, reagents are made up in bulk according to a standard, which has a normal basis. These reagents, on requisition to the main stores, are distributed in proper vessels and charged to the respective laboratories to which they are issued. As the instruction in one laboratory is as a rule limited to a particular kind, and as several laboratories are carrying on the same kind of instruction, it is comparatively easy at the end of the semester to determine the consideration given to economy by the instructor in charge. Parsimony may not be a desirable quality in a man, but economy is not a bad habit.

REAGENT BOTTLES

The missing reagent bottle has been the source of unending worry to instructors and the cause for much useless delay to the student in his work. When the number of reagent bottles goes beyond ten thousand, the problem is serious and the exasperation resulting is likely to be beyond words. It may be solved in large part by burning numbers indicating the floor, room and desk in with the label. The number of the stopper and bottle is cut by a diamond or etched. A glance shows the completeness of a set of reagents or the location of a misplaced bottle, for bottles will be misplaced as long as human beings use laboratories. There is only one system which will prevent that, and it is not allowed by the law. I mean the shotgun system.

LOCK SYSTEM

In order to hold a student responsible for the apparatus with which he is charged, he must be provided with locked cupboards and drawers. These in some laboratories have combination locks. They get out of order and are wasteful of the instructor's time in the semestral cleaning up and refitting. Therefore, we adopted the separate key system, the instructor being supplied with a master-key. To avoid the frequent excuse of leaving keys at home, they are kept upon numbered hooks within a cupboard, provided with a clear glass front, next the bulletin board, which is conveniently placed in each laboratory by the entrance door. The cupboard is opened only by the instructor's master-key. A glance indicates absences and prevents the use of the laboratory by students out of hours without a special permit.

The key system adopted for the entire department may be of interest. The stock-room system (six rooms) are under one key. Each stock-keeper has one. All students' laboratories, lecture and quiz rooms, the key cupboards, students' desks, toilets, janitor's closets, switch boxes for lighting, library and doors to the building are opened by one master key. Each member of the staff has one of these. The toilets, janitor's closets, and laboratories are under one key for the cleaners. The suite of executive rooms, including the private laboratory of the director, is under one key. The director's secretary, private and lecture assistants have one. Each private laboratory is under a separate key, that of the chief of the division of physical chemistry controlling the switchboard, storage battery and electric furnace rooms. The director is provided with a grand master key which opens every lock in the building except the private desk of each member of the staff.

ELECTRIC CURRENT SYSTEM

In pursuing the pedagogic policy to which reference has been made, it is neces-

sary to provide students with electric current from storage batteries. These delicate sources of energy require systematic and intelligent supervision. The instructor in charge of a particular laboratory makes requisition upon the chief of the division of physical chemistry for current of definite voltage and an outside limit of amperage. The cells are connected with plugs carrying fuses with the limit of amperage wanted. A careful record of the condition of the cells, when put in service and when disconnected, is made. Communication among the offices, private laboratories (for a staff of thirty), stock rooms, preparation rooms, etc., is facilitated by an intercommunicating telephone system, whereby eight different conversations may be carried on simultaneously and without interference.

SEMI-ANNUAL CLEANING UP

The semi-annual cleaning of movable ironware like files, tripods, etc., may best be accomplished by dumping the pieces into an electrolytic tank containing water to which salt has been added. After the passage of the current for a few minutes, the cleaned metal is washed with tapwater and placed in a drying oven. Those articles requiring painting are then dipped in a tank of acid-proof paint and allowed to drain on an incline which leads the excess of paint back to the tank.

CONTROL OF PLATINUM

We have found it advisable to mark all our platinum ware by a special stamp and register it with each dealer in platinum with the request that any of that metal bearing the "Sign" presented for sale without an accompanying letter of the director, be held pending communication with the department. We have met with gratifying cooperation on the part of the dealers.

FIRE PRECAUTIONS

It goes without saying that precautionary measures must be taken against the inevitable fires often recurring in laboratories. In each laboratory, depending upon the size of the room, we decided to place tube powder fire extinguishers. The larger rooms have a tube at each end. In the corridors on each floor and in the organic laboratory is an improved Babcock machine. That failing, recourse is had to the fire hose conveniently placed. Each laboratory is connected directly by enunciator bells with the office of the assistant to the director, who is chief of the division of supplies and *ex-officio* chief of our voluntary fire brigade.

In the event that an accident has resulted in setting fire to an individual, recourse is had to the shower which extends over the exit door of each laboratory for students, and the fire-proof blanket hung nearby. Emergency medical closets are in the corridors of each floor. An accurate detailed statement of each accident, however small, is filed with the director by the responsible instructor within twenty-four hours. These records are kept open for court or medical inspection.

By the system outlined the head professor secures some time for service on many important committees involving general problems concerning the welfare of the institution. The division of labor has not resulted in any complaints about having placed too heavy a burden upon any one of my associates. Each member of the staff not only earns his salary legitimately, but secures some hours for investigation. The city gets a constant rich return for the investment, for the service is not only good, but fuller, when the work of the individual is stimulated by a happy ambition.

Charles Baskerville
College of the City of New York