effort to follow his dictum. I have purposely left out of this description of the fellowship any detailed mention of the very active departments of research at the Universities of Oxford, Cambridge, and London, because these are usually better known; the fact that there are other very active scientific research centers in the United Kingdom is perhaps not as well appreciated in other countries as it might be.

The Royal Society seeks to recognize and encourage scientific research wherever it is carried out. Through its award of medals, the invitations it issues to scientists to lecture or to read papers before it, and by its maintenance of the highest standard in its publications, it will continue to exert a not inconsiderable influence on the course of research in the natural sciences.

Graduate Students in Britain

H. N. V. Temperley

Graduate students in Britain vary enormously. They range from the strictly "dedicated" person to the man who merely regards the Ph.D. as an additional qualification for getting a good job. In personality, they range from the carefree, sometimes almost childish, individual to the serious and earnest seeker after truth. Sometimes they seem to be working under continuous strain; the worried face and the tic that goes with it (often coupled with brilliant work) is probably represented in any research group of any size. As in the United States, it has been found that a research director cannot look after more than about six students with any efficiency, so that the head of a group of any size has to delegate a great deal of this work to others.

The success or failure of a student depends very much on the stimulus he gets from his director of research, who is a far more important influence than is the graduate student adviser in the United States, for reasons that will be explained in a subsequent paragraph. There can be no question that the student who has a really good research director at the beginning of his career has an immense advantage, and such an experience is quite unforgettable, as many of the former students of Rutherford and R. H. Fowler will testify.

The problems facing a director, such as that of guiding a student into profitable channels and yet avoiding bullying, of telling him tactfully that his cherished idea is unsound or not new, of striking the happy mean between "spoon-feeding" and unduly neglecting his students, of advising them about their personal problems and future plans, and of seeing that they all get proper credit for their work, have probably always existed, but a further complication is becoming evident today on account of the trend of research itself, the tendency being more and more toward work in large teams on big projects. The attempt to expand a flourishing team can lead to disaster. It by no means follows that a first-rate individual researcher can lead a team of six with any success: the relationship between a student and his director is always rather delicate, and it is almost impossible to repair the damage once a real "blow-up" has occurred. Still less does it follow that such a man can successfully run a department of 30 or more; he may resent the inevitable load of administration, which he considers to be "waste of time," he may find that its problems fascinate him as much as his now neglected research and students once did, or he may make a heroic effort to do both parts of the job at high pressure and end up with an ulcer. Thus, the personality of the director influences the students enormously. It is possible to inspire better work in others than one can do oneself, as Barrow inspired Newton.

Beginning Graduate Work

The main differences between a British graduate student and his American cousin arise from their different educational backgrounds. In the first place, a British boy has to be fairly bright to get into a university at all, the percentage of population being far smaller than in the United States. No one has any prescriptive *right* to a place in a college, each of which has its own special system of selecting candidates. Secondly, he will already have done at school most of the work that is usually done during the freshman year in the United States, and, at the end of his 3 undergraduate years, he will be in about the same position as is a second-year graduate student in the United States. His chance of becoming a graduate student depends mainly on his undergraduate degree.

Nearly everyone at college *passes* his final examinations, but he would not usually be considered to be graduate student material unless he finished up with a "First Class." The type of man who would be elected to Phi Beta Kappa in the United States would probably get a good "First Class" in England. Quite a few of the research grants also go to those who are fairly high in the "Second Class." (This probably corresponds to a minimum grade average of about 6.5 out of 9.)

Having attained this standard, he will probably be awarded some research grant or scholarship. The system for handing these out is complicated, and is administered partly by the Government and partly by the universities themselves, the money coming partly from taxes and partly from private endowments of many kinds. In practice, a man without private means gets enough to pay his fees as a graduate student and to enable him to live in a fairly simple style. Unlike his American cousin, he is not specifically required to do any work outside his research program in return for this money; indeed, the outside work he may do is usually limited to a little teaching or laboratory demonstration during termtime. Some students earn a little extra money during the summer vacation, but control on the type and length of job is often exercised here too. Most of our graduate students are unmarried, our convention being that a man lines up a safe job before considering marriage.

The third main difference is that the British graduate student is given a great deal more freedom to organize his own program than his American cousin is

The author, who resides at Riversdale, Grantchester, Cambridge, England, has had about 10 years' experience in directing the research of others at the British Admiralty and at Cambridge University. He has spent a total of about 2 years in the United States, where he has held various visiting appointments at Yale University, the University of Nebraska, and the National Bureau of Standards. In addition, he has made short visits to about 15 other universities. His experience has been with mathematics and the physical sciences, but he feels that the situation of students in the other subjects is not very different.

given. He very often stays on at his original university. If he moves to another, there is usually some specific reason—for example, he may have quite decided about the field in which he wishes to work, and there may be no suitable supervisor available at his original university. Once he has been accepted by a university and has found a supervisor, the actual requirements imposed on him are relatively light. The university does not usually *force* him to attend specific courses of lectures, although there are always plenty of courses *available* at an advanced level, nor is he usually required to take any more examinations until the time comes to present his thesis. In fact, the *formal* requirements amount to little more than "residing" for a certain number of days each year, our system thus resembling the German one, from which it is said to have been copied.

As we have seen, the British student will probably have done as an undergraduate some of the work that is left until the graduate student stage in the United States, but it is nevertheless true that our system throws very much more responsibility both on the supervisor, who is really the only person who can speak with any authority on the student's progress and prospects, and also on the head of the laboratory or department, who may have to step in for many reasons—for example, if the first research problem turns out to be a "dud," or to be a bigger job than was at first thought, or if "supervisor trouble" develops. If a student is obviously not the research type after all, he is usually told so tactfully after a year or so, and he takes the hint; it is very seldom necessary to force him to go by withdrawing his grant. A supervisor who let a weak student "drift" for any length of time would be considered to have failed in his duty.

Thesis

So we come to the final stage when the student presents his thesis. The arrangements for evaluating the thesis are very similar to those in the United States, the award of the degree depending partly on the thesis itself and partly on a fairly formidable oral examination in which the student is required both to defend his thesis and also to show a sound general grasp of his field of work. It is fair to say that the volume of original work expected is distinctly higher than it is in the United States, but this is reasonable in view of the fact that the student has been working on his problem almost full time for 3 years. The American Ph.D. degree may represent more than 3 years of time, but much of this will have been taken up with graduate courses and examinations, and probably also with earning enough money to keep going, so that the time actually spent on the problem may well be a good deal less.

Research Careers

We need say little more about the person who regards his British Ph.D. merely as a qualification for a job, which he chooses and takes up in exactly the same way that a person with a bachelor's degree would do. The fun is only just starting for the person who wishes to make a *career* in pure research.

Elsewhere, I have reviewed the many problems [*Nature* **177**, 455 (1956)], that seem to me to face such a person in the United States, and I have, as a result, had a number of kind letters from people with many more years of experience who have reached similar conclusions. I therefore feel justified in putting on record my impressions of the same problems in Britain, which seem to me to be very similar. Although the problem of giving the research man a living, and yet securing that he does a reasonable job of work for society in return, has been with us for hundreds of years, we have not yet found a satisfactory solution. (The life fellowships of the Oxford and Cambridge colleges were abolished, for various reasons, in the 1920's.) The difficulty is, of course, that a research career that begins well may, in a minority of cases, degenerate into an output of philosophic trash, "science fiction," and wild suggestions, or may even come to an end through sheer laziness. The hard fact is one that has often been stressed, namely, that society must be prepared to give a researcher a very free hand if it wants research to be done effectively, and it is inevitable that society will be occasionally let down.

What of the researcher who thinks that the universities are the true home of fundamental research and wishes to work there? There are quite a number of postdoctoral fellowships of various types so that the first few years are not really a serious problem to a good man, while anyone who does not secure something of this kind would be well advised to drop out.

At the end of such a fellowship, a researcher is likely to run into fierce competition with his contemporaries for staff jobs at the universities. These are always in short supply, in marked contrast to the number of vacancies in industry, our situation in this respect being very similar to what I found in the United States. Even if he gets such a post, his troubles are still not over. He will, nearly always, be expected to carry quite a heavy teaching load, although he may have no real aptitude for teaching, and the fact that he has proved himself capable of creating new knowledge is no guarantee at all that he has the ability to pass elementary knowledge on to others, or to direct laboratory classes. In addition, he faces the fact that it will probably be several years (at Cambridge it can be eight in an extreme case) before he is appointed permanently to the staff and is able to plan ahead with some confidence. It seems hardly right that such a man should be burdened with this uncertainty, and be afraid to disagree even on minor points with the head of his department, and that he should be weighed down with a heavy teaching load at the very time when he has plenty of research experience behind him and yet is not too old to use it to the best advantage. A few university posts do specify research and the direction of research as the main duties, but there is an undoubted tendency on the part of many of the teaching staff to look on such appointments with suspicion, claiming that teaching is the primary function of any university, and sometimes even hinting that research is something that young people do until they are old enough to know better! With the present expansion of demand for scientists and engineers, it is indeed true that the teaching must somehow be done, even if the staffs are overworked, and even if some of their research is crowded out. It then becomes difficult to create posts with no teaching duties at all, or to employ staff who are poor teachers.

From the practical point of view, the research scientist in industry or in government service is probably better off than his university colleague, both financially and from the point of view of the time that he actually has available for research. Again, this is in line with what I found in the United States. The fact that his boss will usually call for some "bread and butter" work in return for the money that is spent on him is no more than just, provided that the researcher is also allowed to plan some of his work for himself. Although more and more industrial firms seem to be expanding, or creating, research departments, the queues for staff appointments at the universities seem to be as long as ever; "the lure of the ivory tower" seems to be at least as strong in Britain as it is in the United States. It is not easy to explain this fascination in concrete terms. As a race, we have an innate respect for learning and scholarship for its own sake, so prestige probably plays its part. The love of teaching is *not* the complete explanation, for many people who are interested in university posts would not even consider a school job—indeed, we face a serious shortage of science teachers in the schools. The basic ambition is probably to build up a flourishing group of young workers whose reputation shall attract others. It is difficult to do this anywhere except at a university, but this may change in the course of time, when research institutes of other types have had time to build up reputations.