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BOTANY—TEACHING AND RESEARCH[1, 2]

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At the outset I wish to thank the fellow members of the Indian Botanical Society for giving me the privilege of addressing the society as its President this year. I am deeply conscious of this honour. I take this opportunity to extend a hearty welcome to all members who have gathered here, and specially to new ones who joined the society during this year, and are attending its meeting for the first time.

It is befitting that this meeting of the society is being held in the Department of Botany, University of Delhi. Late Professor Panchanan Maheshwari guided the destinies of this department for about two decades during which he not only placed this department on the map of the botanical world, but did everything to increase the prestige of botanists in the country. The only regret is, that he is no longer with us today, but I am sure his spirit must be hovering in the precincts of this department.

To-day is a special occasion—our society has completed 50 years of its existence—this year we begin our second 50 years as a society and I tried to look back. In looking over the record of addresses of my distinguished predecessors who had been privileged to occupy this position, I find the following :

1921—Professor Winfield Dudgeon—'The Botanical opportunity in India'.

1926—Professor S.L. Ajrekar—'Difficulties of Botanical research in India'.

1939—Professor K. C. Mehta—'Some more items of work for the third decade'.

1940—Professor H. Chaudhuri—'A plea for better coordination of Botanical work in India'.

1948—Professor A. C. Joshi—'Indian Botany—Present position and prospects'.

1951—Professor P. Maheshwari—'Teaching and examination of Botany in India'.

Among other things, each one of them expressed concern for botany teaching and research, for students and teachers, for colleges, universities and research institutions. The last was two decades ago.

During this intervening period there has been an enormous growth in plant sciences along with animal sciences which led Dr Alexander King of the Organisation of Economic Cooperation and

1. Received for publication on March 1, 1971.

2. Presidential address delivered before the 50th annual general meeting of the Indian Botanical Society held, during the Golden Jubilee Session at the University of Delhi on December 25, 1970.

Development to remark, that "While chemistry was perhaps the science of 1920's and physics that of the 1940's, and 1950's, I am convinced that biology will be the fashionable science of the 1970's and 1980's." According to him, biology is one of the subjects that contributes to economic and social growth. This is amply reflected by the gain in popularity of biology in recent years throughout the world. Earlier maturity of physics and chemistry has been attributed by Stebbins (1967) to each having grown outward from a single focal point, while central focus of life sciences could not be approached until the middle of the present century. He has rightly pointed out that there are no basic concepts in Botany as such, apart from those which govern biology as a whole.

Nobody knows, if there was any clear purpose when biological teaching developed in the universities in 19th century. Whatever the reasons, botany and zoology were always separated from one another. Those who studied plants were in separate departments from those who studied animals, and the study of man was excluded from both. When agricultural teaching developed, new institutions were created, where plants and animals were discussed in a useful way. The study of life had been broken up into smaller and smaller fragments with no connections in theory and in practice. Because of this as Darlington (1963) pointed out, "the teaching of biology has gone to pieces, and by a paradox, the teaching has gone to pieces at the very time when researches on living things and living processes were putting the pieces together...they have been exposing the inadequacy of the methods of teaching the subject and the institutions available for it".

The present day concept of fundamental biology is essentially a creation of the present century and is different from the mixture of old classical descriptive botany and zoology with some chemistry. It demands a new approach to teaching based on latest discoveries and ignores the division between old subjects. The old artificially circumscribed subjects of botany and zoology are being brought together again in a department of biological sciences. To quote Stebbins (1967) again, "If the discoveries which biologists and biochemists have made during the past 20 years have taught us anything, they have shown us with crystal clarity that biology is a unified science. If it is to be divided into compartments at all, its vertical, taxonomic division into botany, zoology and microbiology is not necessarily any more desirable than a horizontal division into molecular, cellular, developmental, organismal, environmental and evolutionary biology." Along with this, natural sciences have developed branches extending in many new directions giving rise to several hybrid sciences like biochemistry, biometrics, biophysics and molecular biology. Fears have been expressed, and rightly too, that the new departments of biological sciences in their enthusiasm for cellular and molecular biology, may be so fascinated, as to relegate plants and animals to a secondary position. Nevertheless, if instead of maintaining the divided state of Biology, we achieve such unification, future of biologists including botanists will be brighter.

Educationists in U. S. A. were quick to seize the problem, and commendable work is being done in this direction by the Commission on Undergraduate Education in the Biological Sciences (CUEBS) who hold regular conferences on courses and

curricula in the biological sciences. American Institute of Biological Sciences (AIBS), as far back as 1959, organised the Biological Sciences Curriculum Study, which was instrumental in producing BSCS texts for secondary school students. In United Kingdom also, the Nuffield Foundation Science Teaching Project became active in 1950's, and in collaboration with Biological Education Committee have been studying the teaching of biology for early age group. In other countries like Sweden, West Germany and U. S. S. R. more emphasis is being laid on the cultural role of Biology in education and efforts are being made for its development in a direction that will produce a biology conscious generation. National Council of Educational Research and Training (NCERT) in our country has also been actively considering this situation, and a series of good books have been brought out by it for students in lower classes. These books are in use by schools in limited areas of the country.

So far as our country is concerned, the so called 'progressives' and 'traditionalists' have not been able to bridge the gap, with the result that there is a mixed, or rather confused position. It is, however, heartening that some concern has been shown regarding reorientation of teaching and research programmes, and a number of group discussions and symposia have been organised for this purpose. As early as 1957, University of Delhi organised a symposium on 'Modern trends in Plant Physiology' where suggestions for improving courses in plant physiology were made. In 1960 Indian Council of Agricultural Research (ICAR) discussed 'Improvements in the teaching of plant physiology in Indian Universities'. In 1959 University Grants Commission appointed a review committee in Botany which submitted its report in 1963 embodying suggestions for improvement in the pattern of botanical teaching and research in the country. In the recent past a seminar on teaching of mycology and plant pathology was arranged at Agra College, Agra in 1967 and teaching of Botany was discussed by the Botany Section of the Indian Science Congress in 1967 at Hyderabad and again at Kharagpur in 1970.

Having agreed that there is much common to plants, animals and micro-organisms, spectrum of biological knowledge is to be made continuous. This can be done by bringing out such changes in botanical studies which infuse a spirit of continued enquiry and study. Courses will have to be framed so that biologists may understand the newer biochemical and biophysical knowledge. But this alone will not be sufficient, and adjustments will have to be made so that biochemists and biophysicists get a broad and fundamental view of biology. The problem has to be approached with an open and flexible mind.

Let us first see the state of students taking admission in our undergraduate classes. What stage have they reached, not merely in biology but in other subjects ?

About thirty years ago, none entering intermediate classes had any formal training in biology in high schools. Later on a change had begun and biology gradually established itself as one of the subjects on the same level as physics, chemistry and mathematics (as the students had no earlier biology training the courses in botany and zoology were of an elementary character, so as to give a general picture of plants and animals). Those who were aiming at being [illegible] mists

physicists or engineers would go on to take mathematics, physics and chemistry. The other group which included the future biologists, medical doctors or agriculturists took up a course which comprised biology with physics and chemistry. Generally the subject dropped was mathematics. The almost invariable result was that the biology student was inadequately grounded in physical sciences which was not due to his fault or his inability to cope with the subject and he was never able to repair the loss.

In our country this situation is not only confined to intermediate classes but to undergraduate classes also. Barring a few newer Universities and couple of older ones, the combinations provided at B.Sc. level for botany students are Botany, Zoology and Chemistry or Botany, Zoology and Military science (Defence studies). Here the scope of learning physics or even chemistry is eliminated. This can be changed either to 'central core pattern' or the 'American credit system' with its wider choice of options. The emphasis in older Universities is still on the integrated degree pattern and the American system is being tried at newly started Agricultural Universities. Ideal thing will be a system in which students wanting to study botany must have special courses in chemistry, physics, mathematics specially designed for them.

It is generally agreed that students of botany or biological sciences should have knowledge which will enable them to follow the implication of advances and impact which researches in life sciences are making. There seem to be two ways to impart more scientific knowledge to students. Either we lengthen the undergraduate curriculum or stengthen the science taught at lower stages. Much can be said for this, but their incorporation in introductory courses is beset with many difficulties, including that of the teachers trained in traditional disciplines who are ill equipped to undertake it.

As mentioned above NCERT has produced some texts with revised syllabi which are under trial in institutions in certain areas of the country. The results will be eagerly awaited by all. We have to watch and not be complacent because reports from some other countries indicate that students in high schools undergoing recently developed modern courses are apt to have superficial background of the subject. They become familiar with the terminology in one or more areas of the advanced subjects, but have no real understanding of them. But this is not universally true and at most selective institutions, the quality of those students has increased but not at other places. Let us at this stage not forget the words of Robert Graves, the poet and novelist on the effect of present day science and technology. He said ".....you might say they (scientists) are shooting at the moon and evading the human ties of earth (students)".

It would, therefore, be wise to take a long hard look at the undergraduate courses and curricula. The introduction of so much teaching of the related scientific disciplines into the training of a botanist presents a very serious problem to those responsible for its teaching. Some check should be applied on the material which must be packed into lectures, read in text books and committed to memory by the students. The weight of knowledge poured on them does not allow them to think for themselves and devoids them of imagination and enthusiasm. Time for instruction is also limited and to cover a reasonable

syllabus enough time is required. Increased time given to other subjects will force the teachers in Botany to select from existing syllabi the most essential items and to discard the rest. In selecting the items for exclusion, those of factual information may be dropped, as these are neither necessary for understanding the basic principles of botany nor for the training of the students' brains and eyes. A student can acquire the particular factual knowledge in his immediate post-graduate period. The facts that are taught to an undergraduate and over which considerable time is spent, can only be a minute fraction of the basic knowledge of botany. These facts should be so selected as to use them for mental training. He must learn to observe, to have imagination, to reason, to plan experiments and to carry them out with patience. A review of various discussions held in the past and mentioned above would show that usually we over-emphasize the importance of branches of our specialisation, altogether forgetting that Botany cannot develop in case we run after individual branches. Some branches like plant physiology, cytogenetics, microbiology, community physiology (behavioural and production ecology), cell biology which have made tremendous progress during the last few years along with applied botany undoubtedly deserve more recognition than in the past. The tendency to include new knowledge because it is new and to exclude old knowledge because it is old is also dangerous. Inclusion or exclusion of a particular material should depend on significance and not on recency.

More important than the factual knowledge is the training required to be given in the principles of mathematics, physics and chemistry which are specially relevant to biological systems and such techniques as are required in understanding them. The position will be easier, if teaching of these disciplines is specially designed for botanists and the whole course is fully integrated. I am giving below some topics in physics and chemistry which I have attempted to collect in the hope that they may form the nucleus for discussion while framing courses in these and other branches like organic chemistry, biochemistry and mathematics.

Suggested Topics of Physical Chemistry

1. Solutions, suspensions and colloids (mass flow osmosis).
2. Chemical equilibrium in heterogeneous and homogeneous systems (colligative properties of solutions, Gibbs Donnan effect, dialysis).
3. Solution of electrolytes (biologically important consequences of ionic environment).
4. Electro chemical cells, (determination of pH, oxidation and reduction in biological systems).
5. Kinetics (energy of activation, ideas about theory of root pressure and enzyme catalyzed reactions).
6. Surface chemistry (phenomenon of adsorption and contact catalysis).
7. Macromolecular solutions and colloidal dispersions (electrophoresis, viscosity, flow birefrigence).
8. Principles of nuclear chemistry and some biological application (tracer studies, biological research applications).
9. Structure of molecules (protein-biophysics).
10. Molecules, atoms and isotopes (tracers).

Suggested Topics of Physics

1. The gas laws; the kinetic the

Van der Waals equation (laws governing osmotic pressure, basic understanding of several simple laws).

2. Laws of thermodynamics and an introduction to free energy concept (biochemical energetics and kinetics).

3. Membranes (physical properties in relation to plants, membrane biophysics).

4. Physical force and chemical bonds (Osmotic force, gravitation force).

5. Electricity and other radiations (X-rays crystallography, electron microscopy).

6. Light (wavelengths, frequency, spectrum with special reference to wavelength, phosphorescence, fluorescence, optical microscopes).

7. Radioactivity (Biological effects, mutations, ultra violet light and X-ray mutagenesis).

8. X-ray diffraction.

9. Environmental biophysics.

Unfortunately the practical work in Botany apart from being antiquated is very much neglected in our country. In some branches hardly any work is done even at the M. Sc. level. Most of the exercises in vogue were designed about thirty years ago and not enough has been added since. Periods of practical work, specially in undergraduate classes are isolated and are of short duration. Thus very little continuous practical work is done with the result that the study of plant as a living organism is precluded. Curricula and syllabi should be framed in a way that it may be possible to carry out fairly elaborate experiments involving a connected series of observations. Experiments should work to a reasonable degree and achieve completion. Maximum use of living material be aimed at and the laboratory sessions should be co-ordinated with the lectures. Tendency of students to waste time on elaborate drawings be discouraged. They should use a drawing as a personal thing to make their own recall easier.

In the study of old type of botany, microscope was the basic tool with slide and the dissecting equipment. Knowledge about other equipment, if and when used, was inadequate. But now familiarity with the tools and techniques was more important than ever. It is necessary that the principles, procedures and precautions in working of equipments used in performing experiments be familiar to the students at different levels. Some such instruments include dendrograph, dendrometer, infiltrometer, lysimeter, tensiometer, anemometer, psychometer, centrifuge, pH meter, autoclave, microtome, phase contrast microscope, interference microscope, ultra violet microscope, spectrophotometer, colorimeter, densitometer, gas liquid chromatography, scintillation counter, incubator, cool incubator and refrigerator, ultra centrifuge, etc.

Increased mass of information poses severe problems in teaching also. A larger number of teachers, specially freshers know very little about these topics and they entirely depend upon what is given in available text books. In many cases source material is not available. They merely act as transmission lines and at times have cut a sorry figure in not being able to explain properly in the classes.

Apart from the subject matter, teaching of botany itself upto undergraduate classes is regarded as a second rate activity not only by the teachers but also by the administrators. The situation is worse when these courses are taught in higher secondary schools, intermediate or degree colleges situated in remote places. The conditions present in these institutions and the treatment the subject receives is

least conducive to its growth and development. The management is concerned only to give birth to the subject and expects it to take care of itself later. The laboratories are ill-equipped and poorly provided, the staff is generally inadequate and teaching is generally done by fresh graduates or part-time teachers, who lack experience and enthusiasm. Many professors and senior teachers also shirk from taking these classes. They do not regard it as an intellectual or scholarly activity and do not come in contact with their students. It is also partly because teaching as such does not bring any glorification.

Advancement of any branch of science including botany is either by research or by dissemination of scientific knowledge *i.e.* by teaching. Research is variously defined as "a diligent, protracted investigation"; "studious enquiry or a systematic investigation of some phenomenon or series of phenomena by experimental method". A purist defines it as a "continual experience in asking questions about natural phenomenon and the developing and testing of answers", while a broader view takes it as "any scholarly activity which can and probably does lead to the maintenance of an active and inquiring mind". Usual scientific research is typified by laboratory investigation or field experimentation, but some people are able to carry out what is called 'historical research'. They are able to produce a monograph or some scholarly treatise. If a person does plenty of reading about other people's research and new findings or about history of science and keeps himself up with the current investigations, he is doing research. In fact any creative activity can substitute for research.

The research out-look which is expected of a botanist (biologist) is different from that of a chemist or a physicist working on a biological material. The botanist should remember that he is working with a living organism which is in a state of continuous change. Methods used by him involve destruction of life. While a chemist or a physicist working on such a material will interpret his data from the dead material, the biologist will have to assess the composition of the living organism from the analytical data on the dead material before it was killed. A biologist with the necessary training in chemistry and physics is better suited to understand this implication than a biochemist or a biophysicist, many of whom have a tendency to regard biochemistry or biophysics as no more than a branch of organic chemistry or physics respectively.

We are in an era of explosive growth of science. We may be familiar how the number of scientific journals increases exponentially. According to Derek Price (1961) there were 1000 scientific journals in the world in 1850, 10,000 in 1900 and 100,000 in 1950. He expected that with the continuing trend, there may be a million journals in science by the year 2000. Though such statistics are not separately available for botany or life sciences, a proportionate figure will be largely true for these also. In order that this expanding knowledge be interpreted to the students, who are the potential biologists of the future, it is necessary that opportunities be offered and expanded for exchange of ideas and information between research scientists and the teachers.

When one thinks of modifications in a curriculum, he should take into account the effectiveness of the teacher also and in many institutions a teacher implies a researcher. The main concern there

fore, should be 'the necessity to put research in the proper place in the academic structure while at the same time upgrading the status of teaching to an equal or greater position.' In a survey by the Commission on Under graduate Education in the Biological Sciences in U.S.A. one respondent wrote about teaching-research as follows : "The total system of teaching-research may be depicted as a pyramid with a number of levels. The base of the pyramid represents the great mass of students of heterogeneous backgrounds and abilities and the place where good teaching is essential (two-year college). I define good teaching here primarily as the ability to structure a course and to fire the imagination of young people so that they become personally and emotionally involved in the learning process. As one moves towards the apex of the pyramid, the students become more and more homogeneous in abilities and motivations and, therefore, the urgency for 'good-teaching' is lessened."

The relation between teaching and research has been debated by so many people on different occasions. Some persons believe that active research participation is a contributing factor to good teaching and insist that a college professor must do research and that lack of research leads to deterioration in teaching. Others maintain that a teacher need not do any research, while a third category is of the opinion that research work conflicts with teaching and is detrimental. In fact teacher researcher is the ideal, argument if any, is always on degree and emphasis. Indications are that at a certain level, research is a complement and help to teaching, but it could, if continued to grow unwieldy become a distraction and a rival.

Research no doubt helps one to have deeper insight and appreciation for the subject and helps to keep him abreast of new discoveries. In many instances, if the students know that their teacher is engaged in outstanding research, they listen to him more carefully and come nearer to him. If research of a teacher has a direct link with the subject taught, it will have a direct bearing on the quality of teaching, otherwise it might interfere with it. Here one may draw a distinction between research—the discovery of new knowledge or the development of new intellectual ideas, and scholarship—the exhaustive study of everything already written about a subject. A researcher confined to a narrow field is not a scholar. It is not uncommon to hear from a person engaged in research that he does not remember what he learnt in M.Sc. class or is unaware of recent discoveries as he had been devoting his time to his immediate research problem.

There may be few geniuses who may be able to do both good research and good teaching. Such are the exceptions rather than the rule. In most cases it results in poor teaching and second rate research. Individual average teacher is in a dilemma as he is unable to fulfil the dual role of a teacher and a researcher at the same time. Within the University or Colleges there should be a clear division of the research and the teaching functions.

Good teaching demands time for preparation with extensive reading in general areas. It takes so much time of a conscientious teacher that researches of consequence are impossible. Teachers should be judged by their teaching. As long as they keep it alive and exciting, we should not bother whether they do it by research

or by wide reading, but if a person joins a teaching profession, he should take responsibility for teaching students. There are occasions where a poor researcher scores over good teachers. A researcher having a detailed knowledge of the techniques in a narrow field can publish a large number of papers, without keeping up with current work outside his speciality i.e., without being a scholar but a teacher who keeps his lectures in constant repairs is in fact doing research which is not publishable as it is not original. Such a person interested in teaching is sometimes at a disadvantage because criteria for selection for appointments and promotions constitute a strong and continuous pressure to devote time to research. University administrators often deny that promotions depend on research alone and claim that teaching capacity is given due weight as well. But in practice promotion is hard for any one with no record of published work simply because there are no means to measure the excellence of teaching but a publication can be read and assessed. There are times, however, where no-good teachers score over research workers. One can get away with doing a poor job of teaching for years, as there is no yardstick to evaluate teaching but one cannot get away with doing poor research as his papers will not be published. Because of this we find a high proportion of mediocrity amongst the teachers who confine themselves to minimum obligations of a university post and take advantage of comparatively leisurely life.

A couple of years back a chemistry teacher facing his class for the first time asked each student to write out a paragraph stating what he hoped to attain from the course. One student wrote the following : "I hope to discover what it is you and other Chemists have learned that can enrich my life, help me with my work or improve the society of which we are a part". In my humble opinion it equally applies to a teacher of Botany.

I am afraid I have not painted a very bright picture of the situation. What I have said above holds good for most parts of our country which is regarded as developing or undeveloped in the world. Moreover many of its areas are regarded as backward. The conditions in some more effluent areas limited to big cities may be different, but there too in smaller institutions the condition of botany education is far from satisfactory. Such institutions deserve more attention than given hitherto.

Advances in Botany in recent years have been to such an extent that no one man can master it. The problems are so complex that it is only through cooperative effort that we can hope to achieve anything. Team work should replace the gifted individual till now working single handed.

In 1949 Professor Joshi emphasised before this august body the necessity of a standing committee to constantly look into the question of botanical teaching in right earnest. It seems that such a committee could not function because of financial stringency as was pointed out in the annual meeting two years later. I beg to reinforce the plea and emphasize that the Indian Botanical Society has both an obligation and opportunity to help solve the problems of teaching Botany in India. We, as members by our cooperative efforts, should see what specialists are needed to solve particular problems and extract money from the financial authorities for a righteous cause.

At this moment I am reminded of an old Sanskrit saying :

संगच्छध्वं संवदध्वं संवोमनांसि जानतां ।।

"Let us wend our way together ; let us speak with one voice ; let our minds be in unison."

Fellow members, I have now come to the end of my address. Of necessity I chose a general topic because interests of Botany will be served only by improving the public understanding and appreciation of Botany through broadening the botanical education of our students, to make them aware of the role and scope of Botany in Society and to make them receptive to the ways by which Botany can contribute to society's needs. It is my earnest hope that as the Indian Botanical Society moves forward to round out its first century of activity, the hope cherished by its first President in 1921 'that it may in very deed be a society for uniting the botanists and promoting the botanical interests of India' may not only be fulfilled but even surpassed and the rising curve of these 50 years may continue steadily upwards. I thank you once again for the patient hearing.