Physics – Uspekhi **42** (12) 1219 – 1222 (1999)

FROM THE "USPEKHI FIZICHESKIKH NAUK" ARCHIVE PACS numbers: **01.65.+g**, **01.75.+m**

The speech delivered upon assuming the position of Rector of Berlin University on October 15, 1873

K Weierstrass

Preface to the Russian translation. **While it became proverbial after the 1870 – 1871 war that it was a German school teacher who defeated France, the present war is demonstrating what the German professor has since achieved. Finding themselves a unified nation and one of the world's leading powers as a result of the French war, Germans realised that to maintain this position, continuous efforts and persistent concern were needed. They were quick to understand that only well developed and properly organised industry may provide a sound basis for the country's might; that industrial development requires a wide dissemination of technical knowledge; and that this knowledge, in turn, relies on science, from which necessary methods and principles can be derived. Germany has long recognised that those performing and developing science appear if the higher education policy (in the broadest sense of the word) is efficient. A magnificent edifice needs a stable foundation; Germans saw science to be the guarantee of their might — and they were right. Russia now lies in ruins and has a long way to go before its past is restored and its entire life is reconstructed on new principles. In this creative process priority should be given to science, which alone can provide means for assessing the future while at the same time providing proper foundations for the present. Without a well organised higher school, serious progress in science is not possible. The above considerations led us to believe that it would be of some use for Russian readers to acquaint themselves with the spectacular address the great mathematician and thinker Karl Weierstrass delivered when assuming the position of Rector of Berlin University on October 15, 1873. In this clear and carefully argued speech the great scientist describes what the German philosophical tradition regards as the proper organisation of both the higher school and the ordinary schooling systems, of which the former should raise the latter to its own level rather than levelling down to win in number at the expense of quality.**

Academician A N Krylov

All the addresses given in this lecture hall over the last three years, excepting purely business messages, bear the deep imprint of that great time which inspired the speakers. They had nothing to do with routine academic presentations intended for a narrow circle of listeners. In fact, they were 'appeals to the nation' invariably penetrated with a buoyant spirit and alive with the issues of the present, regardless of whether the orator wrathfully and indignantly showed the true character of the enemy that had rudely broken the peace and expressed confidence in the victory of his country, greeted with profound veneration the majestic leader of German troops as the caesar of the restored empire or looked back, in a politico-historical review, over the years bygone in an attempt to bridge the gap between the past and the present and anticipate the vital tasks that need to be accomplished in the future.

Historians of the succeeding centuries will undoubtedly consider these speeches to be the most valued monuments of our time. For us, they are the primary source materials of which this University is a depository and which retain a clear memory of three other landmark years when the sons of the new times proved themselves worthy to stand with the sons of the past.

Dear gentlemen,

Members of the University who spoke from this stand in the recent past were not only permitted but indeed often compelled to leave untouched certain issues of immediate relevance to the general welfare of us all as compatriots and sons of our common fatherland. Those times have now gone. The enemy has been defeated, the true foundation for the national recovery and glory laid in the form of a new state, and the splendid epoch completed in the face of the world by the unveiling, a few weeks ago, of a magnificent monument with an inscription engraved on its pedestal reading, "To the Victorious Host from the Grateful Fatherland". This, however, does not mean that we, the Germans, will enjoy a period of peace and tranquility. Far from it, the struggle provoked by the clash of incompatible interests is forthcoming. Indeed, controversies are beginning to take form as an inevitable result of our achievements, but none of us living today is destined to see how the strife will end; a successful outcome is possible only through the full exertion of the inner spiritual strengths of the nation.

Pondering on the coming future and the serious demands which it makes on the rising generation, I feel it opportune, in accord with a long-standing tradition, to address my speech first and foremost to those young people who take a keen interest in being engaged intensely in research activity and are set to unselfishly dedicate their lives to a scientific career which, in our troubled time, requires great spiritual freedom and moral fortitude. To prepare you for the life-long unwavering devotion and loyalty to science is the primary goal and sacred duty of our higher school. I heartily welcome you, dear comrades, especially those of you who are happy to exercise for the first time the newly acquired right to join the academic community. You will soon embark upon a new period in your life and are sure to be full of great expectations and noble intentions. I wish these expectations to be eventually fulfilled and intentions materialised so that you can enjoy in full measure the fruits of your endeavours. But it is not my purpose to confine this address to good wishes. I

Article first published in "Uspekhi fizicheskikh nauk"" **1** (2) 85 (1918)

Uspekhi Fizicheskikh Nauk **169** (12) 1325 – 1328 (1999)
Translated by Yu V Morozov; edited by S D Danilov

would like to tell you something which you must know in the very beginning to distinguish yourself academically and be able to consciously and unhesitatingly pursue the predetermined goal avoiding a bitter disillusion with the prospects of the selected career devoted to the service of science which now seems so attractive to you. Let your present hopes not be deceived, after you have completed the course of academic study, into lamentations over '*the passing of old ideals which overfilled the delighted heart in bygone days*'.

Those whose spirit and character have been shaped by higher education are accustomed to call their university "*alma mater*" when they meet to celebrate traditional festive occasions and recall their school days. However, the university is not a mother who blindly gives her love wasting it on the weak and unworthy to indulge their vain desires. He who enters a university with a genuine and firm resolution to enjoy the advantage of the highest intellectual and spiritual development provided at such an institution alongside the best possible training for a future professional career should not cherish the idea of only acquiring. Nor should he expect to receive for nothing the wide and deep knowledge painstakingly accumulated in the course of the spiritual activity of many generations. He must be prepared to add to this tremendous wealth by working hard and to the limits of his will and strength, certainly under the supervision and expert tutelage of experienced and learned teachers. Also, he should not consider his primary objective to be the achievement of academic excellence by acquiring practical knowledge and skills applicable either immediately or in the near future; rather he must seek to depart from traditional attitudes and learn, in the first place, how such knowledge can be obtained. In striving after this goal, the student must be aware that the inner structure of our higher educational institutions is neither arbitrary nor subject to deliberate modification but naturally and logically ensues from the very idea of the higher school mission, i.e. to educate well-trained young specialists for the continuity and promotion of scientific progress and for the benefit of the nation. Such inner structure does not tolerate any unjustified interference from the outside. That is why, each must decide for himself whether the character and the volume of his previous training are sufficient to enable him to obtain a wider understanding in the field of interest covered by the academic curriculum. In other words, one should not expect the university to neglect its main purposes and adjust its activity in favour of one's personal needs.

My dear comrades,

These and other equally important truths you could better learn if you familiarised yourself with what was said to the same effect in the opening addresses of many of my predecessors when they entered upon their duties at this University or on other occasions. I consider those statements to be models of lucidity so thoroughly comprehensive and instructive that one can hardly add something new to them to elucidate more clearly the essentials and imponderables of a university education. To tell you the truth, I believe it would be useful if someone, knowing and experienced, collected these speeches (or at least the most important ones) and commented on them in a small volume which would make an excellent guide to pilot students through academic life. Such a book handed out to a freshman upon his enrollment in the University together with a copy of its Statutes would impart additional vigour and spirit to the latter and brighten them with the ideal light in which a young student sees the University and its standing rules. Indeed, let us imagine that we have this volume before us and are browsing through it. I shall quote just a few passages which might catch the eye upon random reading to show you what sort of most useful and encouraging knowledge could be drawn from this book.

Would you like to shape a clear idea of the purposes and essentials of higher education ? This is how J Fichte, the first elected rector of this University, enlightens you:

"*The higher school exists to provide the continuity and reliability of education. It is through the higher school that each generation passes its greatest intellectual achievements to the next one, in conformity with strictly fixed rules, hoping that the latter will enrich and pass them to subsequent generations throughout all succeeding ages, to the end of time*"

If you think about the specific features of academic teaching which is said to be impossible to substitute by studying even with the best written manuals and books of reference, there is an explanation proposed in a most appropriate address by our greatly missed Rudorf from which we learn that:

"*An essential and indispensable attribute of the higher school and academic teaching is that the science itself becomes virtually personified through direct intercourse of a lucid and enthusiastic teacher with his keen and determined pupils, encouraging them to work independently. The true objective of university education is not so much to directly communicate knowledge as to show students the ways to obtain it and acquire the relevant facts necessary for the purpose.*"

In the meantime, there are ceaseless attempts to prevail on you to have misgivings that such an ideal view of the aims and methods of higher learning tends to turn the University into a bizarre ivory tower where it will be actually impossible to train specialists capable of imparting schemes and translating them into action for the benefit of the state and further technical progress leading to miraculous achievements and allowing the nation to keep fully abreast of all current affairs of the time.

'*This is sheer delusion*', says Beck whose cherished memory we still carry with deepest sorrow in our hearts. "*Nothing can be more practical than a thought coined into an ideal and an urge to approximate it, even though such an ideal can never and nowhere be really attained. This is the way in which to prepare young people for a practical life instead of teaching them to act mechanically following an established routine. In other words, they must be instructed so as to be able to turn away from well-trodden paths and motivated to develop the critical faculty required for the prosecution of their own designs to the best of their knowledge and capabilities.*"

Today, you can frequently hear talk about intellectual stagnation in our universities, their inability to adapt education to the rapidly changing course of ideas and formulate fundamental questions to be answered. But Beck denies this fear in the following remarkable statement:

"*A scientific institution must not and can not remain as it was when it first came into being. Nevertheless, there is nothing more useful for it than the lasting consistency in the general spirit and basic principles provided they were carefully and explicitly formulated from the very beginning as they actually were with respect to this University. Such steadfastness is in itself a guarantee for further successful development.*"

I could easily enlarge the number of relevant quotations, but I choose instead to draw your attention to the neatly turned comments of Fichte and Trendelenburg on the concept and necessity of academic freedom in teaching and

learning as well as to the insistently urgent appeals of the latter to university students to pursue the most serious studies of primary source materials starting from the early period of their education.

To conclude, I would like to make a few remarks of my own although I am afraid they may sound as truisms after what was said to the same effect by my predecessors.

It has been mentioned above that the success of academic teaching largely depends on how deeply the teacher instills in his students the habit of asking the right questions pertaining to the problem to be resolved. However, this problem-solving approach cannot be successfully realised by simply instructing students to do what they must. Much more important, they must see their teacher reducing the facts to their essentials and marshalling them towards the practical issues to which they are relevant. This is the way to motivate students to embark on a course following which a mature and experienced scholar, weighing probabilities and openly stating his judgment, gradually and in an orderly regulated manner comes to obtain new findings or better verify previously available data.

The teacher must not fail to show frontiers beyond which the science of his time has not yet expanded and to indicate starting points from which new developments may be expected to proceed in the near future. Nor should he refuse his students a story of his own studies with all the wanderings and disappointments that he might have suffered. In this case, however, his lectures are likely to be lacking in beauty and elegance and not as readily understandable to mentally dull listeners as, for instance, the lectures which used to be given by the majority of French professors who frequently read them having a standard lithographed text at the desk and sometimes even entrusting the reading to their assistants.[1] Such lectures probably contain more real facts, but they are sure to be much less stimulating in terms of arousing and encouraging the creative activity of the students.

After having been properly trained, each student must proceed to work for himself. Unfortunately, the overwhelming majority of students appear to be unable to choose a feasible and scientifically interesting object of research within their terms of reference.

Here is some advice given to his listeners by the outstanding mathematician K Jacobi whose lectures, to my utmost disappointment, I have never had a chance to attend.

"*To be sitting idly pending a discovery is not the truest way to contribute to science. It is the meticulous care with which one carries out the work, alongside the ability to absorb all known facts and set one's sight on resolving any problem whatever, that opens the road for discoveries and thus ensures that the ultimate goals of science are attained.*"

True, only those naturally endowed with an unusually high degree of mental ability show a drive to achieve these goals in such a way. Others can be recommended an alternative approach following which even such a notable figure as Jacobi himself is said to have designed and conducted many of his studies. Old volumes of collected works issued by research institutions as well as extensive correspondence between scientists of the past contain an enormous body of eminently useful data from which an intelligent reader can derive both much inspiration for his own studies and thought-provoking information necessary for the purpose.

Two more issues need to be briefly discussed. The urge to explore the surrounding world reflects an innate impulse that drives man to investigate the order and regularity in the coexistence of natural phenomena or their succession through time. Separate scientific disciplines come to acquire significance so far as they promote the accomplishment of this goal either singly or in concert as links in the chain of natural and social sciences, in a broad sense, having mathematics at one end and philosophy at the other. Mathematics and natural sciences examine manifestations of various forms of matter in space and time. The subject matter of mathematics concerns ideal entities, such as mental images and assumed concepts, while natural sciences deal with objects actually existing in the real world. Therefore, mathematics is an indispensable prerequisite for natural sciences rather than an ancillary discipline in the general sense of the term. On the other hand, a naturalist making observations or obtaining experimental results offers mathematicians something more than a mere set of problems for solution. Social sciences, e.g. history, linguistics, etc., have the objective to study driving forces and laws that govern the evolution of man and society. There are concrete links between social and natural sciences conditioned by the dependence of the individual and the social development of human beings as much on the relations between themselves as on the interaction with the environment. Finally, philosophy summarises the information procured by all sciences, elucidates it more clearly, inspires researchers with confidence, and seeks to work out and achieve a scientific ideal which consists in the description and explanation of the absolute unity in the infinite variety of natural phenomena and manifestations of intellectual life. In this sense, it can be argued that the knowledge of the nature of things is the ultimate objective of any research. Moreover, the advancement in understanding their essential features achieved by a society serves as a measure of the educational level of mankind at different stages of civilisation.

It is not easy to say in what particular way and how significantly an individual can contribute to the general education of his age. Suffice it to say in this context that there is nothing as fruitless as to be involved in many various endeavours at a time without cutting to the heart of the matter. Firstly, you will never come to learn the focal point of scientific activity unless you concentrate all your efforts and attention on an in-depth study of one key subject. Secondly, given a tremendous body of facts accumulated in different branches of knowledge some of which undergo rapid development, nobody can be expected to digest the entire stock of available scientific data after the manner of a few exceptionally gifted and hard-working scholars of the past. Nevertheless, it is not altogether impossible for a well-educated and diligent young person of today to acquire a profound knowledge of the major subject of interest and concomitantly familiarise himself with the methods and contents of other disciplines, including those unrelated directly to the main area of his research (at least to the extent that he has a clear idea about their place in the system of sciences). More than that, such knowledge seems to be absolutely indispensable for a young student if he does not want to see his early enthusiasm later turning to bitter disappointment or suffer defeat in the battle of life having no strong foothold for further advance, a stranger to the ways

[1] It must be remembered that K Weierstrass is refering to the situation in France in the 1870s. Before that time, France was ahead of all other nations as regards the organization of academic education (*note by the editor, 1918*).

of others swinging constantly from one situation to another and back. Therefore, no student must leave the University without listening to a course of lectures on political history and general history of culture with special reference to the history of philosophy. None of the students who studied classical literature in a gymnasium should give it up during his stay at the University. Lectures on mathematics and natural sciences could be given in such a form as to be understandable and instructive in the stated sense to students studying law or philology. Lessons received in a gymnasium appear to be sufficient to enable students to assimilate this new intelligence. I can hardly resist the temptation to dwell on this subject in greater detail.

Therefore, I shall conclude with a note which I ask you, dear comrades, to take as seriously as can be expected.

There is every justification for asserting that scientific progress, especially recent advances in natural sciences, is instrumental in bringing about benefit for all. There are equally good reasons to expect new discoveries. Try, if you can, to imbue your mind with noble aspirations leading to this purpose. Remember that scholars whose names came to be immortalised in great scientific discoveries enriched the lives of many millions. I hope that what I told you before about the interaction between different branches of science convinced you that the true happiness of mankind lies in their mutually beneficial arrangement and close cooperation. No individual science, notwithstanding its importance and achievements, can alone guarantee the people's freedom from intellectual slavery, maintain and improve moral standards, and at the same time provide the material security necessary to ensure a blessed life.

Above all, you should know that only he who, in poet's words, seeks to have in science neither wife nor bondmaid but looks on her as a heavenly goddess will enjoy merited recognition of his efforts.

It is true that knowledge yields great returns in the form of fame and power. It is a wand with which to hunt buried treasure, the philosopher's stone which alchemists of old times vainly sought on a false path. Young Athenians are said to have applied to Socrates for instructions in the art of 'governing people'. Even today the University's class-rooms are crowded with equally self-seeking young folk who appear to need wisdom only to further their own ends. Let them know that they are trying to grasp the shadow of science instead of pursuing the true scientific quest.

All these people are doomed to stay forever in the courtyard of the temple, to employ an old phrase, having no access to its inner sanctuary reserved for the worship of the truth, not for offering sacrifice to evil forces of the time. Those striving to be admitted into the shrine must be driven by an insatiable thirst for knowledge, have a pure heart and genuine inspiration for all the great works of the human spirit and all the noble and lofty qualities with which the human soul is endowed.