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## THE NEWER DEMANDS ON PHYSICS AND PHYSICS TEACHERS DUE TO THE WAR[1]

At this time when the daily press all over the world is filled with statements and exciting accounts, proving beyond all doubt that the present war is a war of science, we, who pose as champions of so basic a branch of science as physics, would be guilty of gross carelessness should we not in some way take advantage of this unprecedented world-wide advertising. As expressed recently by the president of The American Institute of Electrical Engineers, "a flood of scientific and technical accomplishment has swept over the face of the earth."[1a] and it is just such a description of our world war that the physicit must consider if he is to aid in bringing about the end—or assist in its indefinite continuation, if need be—or if as a teacher he is to prepare his pupils for the new wartime and peaceful duties sure to fall to the lot of every citizen in the newer civilization now passing through the agonies of its birth.

What are some of the points where immediate attack by physics teachers may be expected to result in compensatory results to the nation? What are the demands on these apostles and on their science? If any, what are the opportunities for the promulgation of this science, accompanying, or growing out of this opportunity for service?

There are two general aspects to the whole inquiry. One is that of the imme-

[1] Read before the Ohio Academy of Science, Columbus meeting, May 31, 1918.

[1a] *Electrical World,* July 7, 1917, p. 5.

diate service to the nation that the information or ability of the physicist may afford. Of this I need say nothing. The other, and one which is not clearly separable from the first, is the question of our opportunity to take advantage of the world's awakening to the realization of the value of fundamental science, and establish as never before an interest in that broad domain closely analyzed only in the study of physics. Though the utilitarian motive may always be one of the chief recruiting agencies for any fundamental science, there is now every reason to believe that in the immediate future it will be glorified by an accompanying inspiration—for this world-wide "flood of scientific and technical accomplishment" which is now identified with the war, and which will attain to even loftier heights in ending the war—this upheaval is accompanied by one of no less importance for the future—the sudden unrest and dissatisfaction of the average individual with his own scientific appreciation. To keep pace with events even now makes an effort toward progress along this line imperative. Survival hereafter may be synonymous with successful competition in a new world where scientific method based upon ever-increasing scientific information is the dominating factor in existence. Hence it is that we, simple teachers of physics, have now an opportunity and a duty, probably unique.

Even against the advice of the President and other government authorities, our students, though below draft age, are rushing into the war because there have come to them ever louder the echoes of a larger life now centered in the great struggle, which have brought with them to the youthful mind the sudden realization of the fact that his academic world is not the most actual one, that he is not learning in the most direct manner of the things that count, and he is truly justified in answering the call to enter that world where his interest may be focused on things felt to be real.

What can be done that will help him when he goes, or to strengthen him in the most efficient manner while he stays? Those who leave must go with all possible preparation; those who remain behind must be well armed for the equally important struggle here—and the beginning steps for the teacher, for example, the teacher of physics, are clearly indicated by the sudden development of a host of new questions of interest in themselves, and which may serve to entice the beginner through uninviting portals into a new storehouse of endless benefits for him and all with whom he may come in contact

Let us consider some of the more common questions specifically, in approximately the general order in which we have been accustomed to classify their kind.

To begin with, we may take aviation. Here we have ample material for the discussion of such good physics that even the most conservative text-book-repeating pedagogue can not object. To the student it affords a most impressive illustration of the relation of action to reaction, also of the omnipresence of friction, and at the same time of its indispensable utility—and again, of the universality of gravitational attraction. There is also the question of the non-ricocheting shell[2] that will dive and not glance from the surface of the water when directed toward a more-or-less submerged submarine. Such devices can not be explained to the ordinary class completely, but the nature of the solution of the problem can be indicated with sufficient detail to increase rather than chill the student's interest. He asks about the various types of unsinkable ships, and even

[2] *Scientific American*, February 9, 1918, p. 125.

though he may not now know the actual details of the construction of such a craft, he soon sees the general requirements to be satisfied. Archimedes's principle acquires a new interest. The laws of fluid pressure become more than text-book formulations of rare phenomena. His knowledge of the fact that water is practically incompressible enables him to criticize constructively such a story as told by the preacher who pictured to his horrified audience the wrecked *Lusitania* coursing the ocean ways at some far-down level below which no ship can ever sink. He sees new light when it dawns on him that even "the whys and why-nots of deep sea diving"[3] come well within the field of discussion of an ordinary course in physics. Then again, the nation-wide interest in the conservation of ammonia for the manufacture of explosives lends new color to the whole subjects of heat and of gas phenomena, from the simple laws of Boyle, of thermal expansion, of heat exchanges, to the applied side of refrigeration. Perhaps for the first time he sees the reason for having a kinetic theory of gases.

Next, perhaps, may come the field of sound, commonly considered as one of the minor branches of physics, a judgment somewhat justified, for in the more elementary texts such as used in the high schools, this subject is allowed only from six to nine per cent. of the space in the book. And why? Surely not because its phenomena are fewer than those of the other phases of our science, not because they are of less importance, but rather, let us say, because they are less understood. After the United States entered the war and a census of our scientific abilities was taken, American physicists had to admit that after all no one knew very much about sound. The great sources of information were the works of Helmholtz and Rayleigh, treasure stores, to be sure, but limited in their applicability to practical problems, and containing little that could be recast into any form digestible by either practical workers or students. And then came real problems, thick and fast. Methods were sorely needed for locating the enemy in the sea and in the air. In all of these directions some success has been attained, but until details are made public the physics teacher will have to supply what he can by way of suggesting the probable solutions of the problems. He knows something of the possibilities, something of the conditions that must be satisfied, and he is, or at least should be, free from the danger of the illogical reasoning of which others may be guilty. For example, he can assist his pupils in understanding how it is that successful methods can be devised for insulating a whole region against air-sounds and earth-sounds.[4] Doppler's principle finds a new illustration in the phenomena produced by a near-by projectile.[5] Then there are those other questions, not so easily explained, such as those about the causes of distinct sound areas separated by a zone of silence which may be several miles in width, although the disturbance has originated at a single source, as in the case of some of the explosions in East London.[6] Such questions surely make new demands on the investigator and teacher, but at the same time they afford unequalled opportunities for enlisting the interests of many to whom the subject has been wholly foreign.

For the first time artificially produced sounds are observed to have traveled as

3 *Scientific American,* January 12, 1918, p. 60.

4 *Elekt. Zeits.,* 38, pp. 410–441. Also *Science Abstracts, A,* No. 180, February, 1918.

5 *Science Abstracts, A,* No. 528, 1917.

6 *Science Abstracts A,* No. 1295, 1917. *Phys. Zeit.,* 18, pp. 501–504. *Science Abstracts, A,* No. 183, February, 1918.

much as two or three hundred kilometers[7]—how, we can not say, but probably in no manner different from that in which lesser disturbances are propagated. And this is typical of a fact the teacher should not overlook. Scientific progress is the discovery of more truth, rather than the contradiction of laws already clearly established.

No one who has had the pleasure of seeing some of the beautiful slides, such as those from photographs by Professor Foley, showing sound waves in all stages of development—birth, growth, reflection, refraction—can question their interest, or their instructiveness. And yet, what are the emotions that stir one as he reads of the visible sound waves described by several observers after moments of extra violent cannonading along the battle line.[8] Distinct bands were actually seen moving across the clouds with the known velocity of sound, or again, equally distinct against a clear sky. Such points of interest should escape no teacher of physics, for nothing can be more legitimate than enlisting the pupil's interest with illustrations of this kind.

Other problems in other fields are fully as numerous and as fascinating as those we have noted, but we will have to content ourselves with mere reference to some of them. What of the application of optical principles? At home we have protective lighting[9] based upon an ever-improving appreciation of the correct principles of illuminating engineering. Then again, American manufacturers have struggled heroically and with incomplete success to produce good optical glass. The student wants to know the reason for this endeavor—the reason for the failure—the necessity for such glass anyway. And who is to enlighten him if not the physics teacher. When he seeks to learn something about the submarine camera, he comes upon the stabilizing gyroscope.[10] He also finds that the search lamp is an optical instrument of high design, and that the manufacture and operation of the portable gasoline-motor-electric-generator search-lamp outfits embraces a wide field of activity and many physical principles.[11]

Even the teacher must be alert to keep up with only such phases of physical development due to the war as are published. There are new methods for testing mirrors for signalling purposes and special apparatus for measuring magnifying powers and the angle between the axes of binoculars. The Michelson interferometer finds use in finishing prisms, lenses and combinations. There are weathering tests for glass, new tests for parallax in the telescopic sights for rifles, new methods for determining the illumination and field of view of field glasses, special parallelism tests, micrometers for measuring prism angles before polishing, and new surface testing methods.[12] The refractometry and identification of glass requires special equipment and training.[13] Range finders have multiplied, even the prismatic binocular having joined the list by the simple addition of a calibrated disk by means of which the distance to an object of known dimensions can be determined.[14] Unfortunately all of these

[7] *Science Abstracts A*, No. 657, 1917. *Science Abstracts, A*, No. 658, 1917.

[8] *L'Astronomie*, July, 1917. *Scientific American*, November 10, 1917, p. 343.

[9] *Electrical World*, May 18, 1918, p. 1049.

[10] *Scientific American*, May 19, 1917, p. 483. *Trans. Illum. Eng. Soc.*, XII., 8, November 20, 1917, p. 396.

[11] *Trans. Illum. Eng. Soc.*, XII., 8, November 20, 1917, p. 357. *Elect. World*, December 9, 1916, p. 1169.

[12] *Science Abstracts, A*, 379, 1917.

[13] *Scientific American Supp.*, No. 2178, September 29, 1917, p. 198.

[14] *Scientific American*, January 12, 1918, p. 60.

latter devices are far too scarce. The industry concerned in their manufacture as well as the youth who may be called upon to use them, must be encouraged to the fullest possible extent, not only to win in the present war, but for the sake of the future. The recent condition has been aptly described by Professor Southall. Last December he pointed out that the British navy was almost without range finders at the opening of the war—that almost the entire optical industry had to be built up both in France and in England since that time. But what is of especial interest to the physics teacher is his statement that, "if the optical industries are to be encouraged and developed among us, not only now but in the years to come after the war, there will be an increasing need of trained and experienced men with more or less extensive acquaintance with the whole range of optics, both theoretical and applied."[15] Here is a demand and also an opportunity. Only recently has there been organized anything like a comprehensive series of courses in the various branches of geometrical and physical optics. For the first time an American university now offers complete courses in the "Theory of Modern Optical Instruments, Lens Design and Lens Testing, Manufacture of Optical Glass, Refractometry, Polarimetry, Physiological Optics, Photometry, Spectrophotometry, Colorimetry, Optometry, etc."[16] There is a new interest in the optics of vision due to the physical examination for military service, and at the same time we have corrective surgery of the eye, again based on physical principles.[17]

But to hasten on. Smoke screens on the sea had no sooner begun to shut out ordinary vision than there came the suggestion that the use of infra-red and ultra-violet lenses would make photography perfectly possible.[18] Surely this involves physical principles of interest to the student because of their increasing utility, if for no other reason.

New methods of photometry have had to be developed because of the growing military use of fluorescent and phosphorescent compounds.[19] Here the Purkinje effect again appears. Then again, the selenium cell has received such study that its sensitiveness has been increased a thousand fold.[20] Can the student escape the charming influence of such ideas as these developments afford? Can the teacher do less than encourage this interest to the fullest extent possible?

The war is responsible to a great extent for the fact that more attention was paid to illuminating engineering than to any other branch in the leading articles in the most important technical periodicals in 1917.[21] Here is a great field of applied physics just opening up. Its demands on the present-day teachers are evident. Its opportunities need not be discussed.

And so we could go on through the various divisions of physics. Under electricity, we meet our old acquaintance, the Hughes induction balance, now equally serviceable for locating shells buried in the earth and fragments embedded in the muscles of the human body. Coal shortage has pushed hydro-electric development. Food scarcity has aroused new interest in the electro-culture of crops. Magnetic surveys similar to

15 *Scientific American*, December 15, 1917, p. 455.

16 *Scientific American*, December 15, 1917, p. 455.

17 *Scientific American*, January 12, 1918, p. 53.

18 *Scientific American*, September 22, 1917, p. 207.

19 *Trans. Illum. Eng. Soc.*, November 20, 1917, p. 394. *Illum. Eng.* (Lond.), March 1917, p. 76. *Rep. Nat. Phys. Lab.*, 1915–16, p. 33.

20 *Trans. Illum. Eng. Soc.*, XII., 8, November 20, 1917, p. 395.

21 *Trans. Illum. Eng. Soc.*, XII., 8, November 20, 1917, p. 117.

those made for land and sea are now needed for the air.[22] Wireless telegraphy and telephony have advanced by leaps and bounds, and simple inductive telephony has reached a high degree of development in the very front lines of the opposing armies.[23] Electrical schools have opened up for the training of war-made cripples.[24] The radiodynamics of torpedo and boat control offers a field for study almost new. The use of the X-rays requires constructors, operators and doctors who have acquired the requisite fundamental principles in good courses in physics. Electrochemical processes in general are becoming American for the first time, and every citizen is continually being reminded in one way or another of the fact that the war is one of science, and that the reconstruction must likewise be one based on a knowledge of natural laws.

There is still another phase of our new development which makes a definite demand on the physics teacher. It is the part that women are to take in the life of the nation in the years to come. Whatever may be one's idea of equal suffrage, he must recognize the fact that a large portion of the burden of the world war is being borne by women. They are entering the industries; they are becoming electricians, machinists, chemists, in fact everything that man has wished to be solely. And with this awakening will undoubtedly come wide interest in the sciences fundamental to industrial activity. New economies have required more detailed explanations of the scientific methods of obtaining them. Household physics, though a comparatively recent term, has now for the first time come to have a real meaning. Surely the present war, however unpleasant it may be otherwise, will serve above all other things to hasten the happy era of better ideals, when the joys and burdens of the world will be more equally shared by its men and its women. Hence, the instruction of the girl as well as of the boy makes new demands on the teacher, and affords him widening opportunities for developing his subject as an integral part of the school curriculum, and thereby better himself by bettering every one else.

To enumerate additional problems brought to the physicist as a result of the war would be useless, but with the necessary increase in vocational education[25] will come the necessity for a more practical type of physics as presented to the elementary class. This suggestion is not meant in any way to disparage the more advanced type of research work, for it will be in greater demand than ever before, but, as always, the teacher must be the interpreter who shall spread abroad truths and thus justify the effort made in their discovery.

You well know that to include in such an attempt as the present one a comprehensive statement of such advances in physics as those which we are hoping may aid in winning the war, is futile. We do know, however, that advances are being made. We know something of the results. Those of us who are fortunate enough to have some knowledge of the details must remain silent because of military necessity. As recently expressed,

> Whatever startling developments have taken place during the year of 1917 are hidden behind the veil of the censor, and it remains for us to wait for the end of the war before a complete review can be undertaken.[26]

That the effect on physical research resulting from the present governmental co-

[22] *Scientific American*, April 20, 1918, p. 355.

[23] *Scientific American*, April 6, 1918, p. 305.

[24] *Elec. World*, November 17, 1917, p. 955.

[25] *Scientific American Supp.*, No. 2201, March 9, 1918, p. 149.

[26] *Scientific American*, January 5, 1918, p. 7.

operation will be inestimable, can not be questioned. The great British National Physical Laboratory, which is the equivalent of our own Bureau of Standards, has been taken over from the Royal Society for government work alone.[27] In our own country among numerous organizations may be mentioned the expanding Engineering Council, which now proposes an affiliation with all of the national engineering bodies and technical societies in the United States, thus bringing to physics and allied branches applications of unprecedented scope.[28] Our Council of National Defense, together with the Bureau of Education and the States Relations Service of the Department of Agriculture have considered the mistakes of the Allies and have emphasized the fact that the people now receiving any scientific training will have special advantages after the war. As Dr. Claxton, Commissioner of Education, has said,

> When the war is over, whether within a few months or after many years, there will be demands upon this country for men and women of scientific knowledge, technical skill and general culture as have never before come to any country.[29]

We must supply men and women familiar with fundamental science not only for our own development but to replace the hordes from European countries now going down on the fields of battle.

Again, President Wilson has asked that the National Research Council be perpetuated "to stimulate research in the mathematical, physical and biological sciences."[30] An Inventions Section as an agency within the General Staff of the War Department has been organized, and it is not without great import to the whole field of physics teaching that the Science and Research division is headed by Professor Millikan.

Still another probable development, that can not but bring joy to the heart of every physicist, is the more or less universal adoption of the metric system with the readjustment succeeding the war. England has already admitted that Germany has gained in industrial efficiency by the use of this system.[31]

> So many hundreds of young Englishmen have gone to somewhere in France that Englishmen have seen a great light in the simple workings of the decimal and metric systems. They are urging the abolition of the needless, brain-wasting multiplication of units at home.[32]

To date twenty-eight of the greatest public bodies in the United Kingdom have advocated the adoption of decimal systems of coinage, weights and measures. It can be no different in this country. We are now manufacturing some of our munitions of war to metric measurements, and surely this is a movement in which physics teachers should be the leaders. Knowing its value, they have advocated it in a half-hearted sort of a way for many years, but now, unbidden, comes a demand and an opportunity. No single development could go further to establish in the mind of the public the idea that physics is a science of practical value—that its ways are the ways of efficiency. And hand in hand with this movement comes the proposal from Dr. Klotz for universal scientific symbols.[33]

We have already gone further than was necessary to draw the conclusion of the whole argument. What has been said of physics is applicable in many ways to other branches of science. But the tacit assumption throughout has been that physics is one of the most if not the most basic of sciences. This may be a doctrine not universally accepted, but we who advocate it

27 *Scientific American*, October 20, 1917, p. 283.

28 *Scientific American*, April 20, 1918, p. 355.

29 *Scientific American*, September 1, 1917, p. 153.

30 SCIENCE, May 24, 1918, p. 511.

31 *Scientific American Supp.*, No. 2175, September 8, 1917, p. 149.

32 *Elec. World*, July 7, 1917, p. 3.

33 *Scientific American*, December 8, 1917, p. 435.

on the basis of something more than a superficial knowledge of its content, can do so with all sincerity. It is legitimate that we should struggle to make it as popular a science as may be without discarding its essentially rigorous methods, for, as Dr. Nutting has said, the typical product of slack methods is a slacker.[34] But difficulties will only serve to heighten its estimated value, once it becomes generally known that physics is good for something. In meeting the demand for such evidence, the physics teacher will find the greatest opportunity for his own development and that of his beloved science.

E. H. Johnson

## THE IRWIN EXPEDITION OF INDIANA UNIVERSITY TO PERU AND BOLIVIA

In 1909 I summarized the knowledge of the distribution of South American fresh-water fishes in general. I dealt with the origin of the Pacific slope fish fauna in part in the following words:[1]

There are four distinct faunas on the Pacific slope of America between Cape Horn and the Tropic of Cancer. One of these is of common origin with that on the Atlantic slope, one is autochthonus and the other two are derivative from the Atlantic slope faunas opposed to them.

1. The fauna of southern Chili is essentially like that of Patagonia, and inasmuch as it is largely made up of marine forms entering fresh water, and fresh-water forms entering the ocean, it seems very probable that the species migrated from river to river along the coast from Patagonia to Chili or from Chili to Patagonia.

2. At the other extreme in the Rio Mezquital of the Transition Region and the Yaqui just to the north of it there is a fauna essentially like that of the Rio Grande east of them. As Meek has pointed out, the Yaqui and Mezquital have captured tributaries of the Rio Grande togther with the fishes in them, and the migration of Atlantic slope northern forms to the Pacific slope has been a passive one. Thus, types which in America north of Mexico have not succeeded in reaching the Pacific slope, have, within the Tropics, crossed the divide. . . .

3. The third fauna is the Mexican of the Rio de Santiago. This is undoubtedly the relict of an old fauna reenforced by a few immigrants from the north. It is here not a question of the origin of the fauna from an eastern one, but of an autochthonus development that has, on its part, contributed elements to the surrounding rivers. It passively contributed to the Atlantic slope fauna by having one of its small rivers captured by the Rio Panuco.

4. Of more particular interest is the origin of the fauna of western Peru and Ecuador and that of western Central America. Not enough is known of the fauna of the western part of Central America to attempt an explanation of its origin.

Concerning the Andean fauna I said in part, page 305:

The Andean region includes the high Andes on both slopes from Venezuela and Colombia to Chili.

It is poor in species at any given point, but some of the genera have a large number of local adaptations or species. This region is distinctly marked off into three provinces.

1. The Northern includes the highlands of northern Peru, Ecuador, Colombia and Venezuela. This is the richest in species and distinguished by the genera *Arges, Cyclopium, Prenadilla* and the high development of *Chætostomus.* Its fauna is largely an ancient derivative from the lowland fresh-water fauna of Archiguiana.

2. The Titicacan, including the basin of Titicaca and neighboring streams, and possibly the land-locked basins of Bolivia, concerning which nothing is known, is distinguished by the genus *Orestias* and the absence of the genera distinguishing the northern province. Its fauna is largely an ancient derivative from the ocean.

3. The Southern is the poorest in species, characterized by the absence of everything but a few species of *Pygidium,* a genus which extends the entire length of the Andean region.

Further, p. 373, I said:

The points of strategic importance for ichthyic chorology in South America are, therefore, western Colombia and Panama, Guayaquil and Peru to the Amazon, across the Andes. . . .

Most of my time since the publication of the monograph quoted, in fact, since its preparation several years earlier, has been de-

[34] *Scientific Monthly,* May, 1918, p. 406.

[1] Reports of the Princeton University Expeditions to Patagonia, III., 1909, p. 352.