

PHYSICS as a SCIENCE

THE charge of speaking after five such orators as have preceded me is not a light one, and yet is an assignment which should be treated lightly. The hands of the clock are joyously advancing toward the cocktail hour, and they advise me to pervert the famous words beneath a clock in San Francisco and say to myself, "Son, observe the time and fly from wisdom." The organizers of this meeting actually proposed that I should speak under the title "The Whole of Physics". Apart of course from my predecessors on this platform, the last man who could probably have done this was Hermann von Helmholtz. It interests me to realize that there are people still living who studied under Helmholtz; they are the last of our contacts with the era of omniscience. The wishes of the organizers will be formally fulfilled if I succeed in saying nothing that is more irrelevant to any one field of physics than to any other. This condition I will attempt to meet.

I ought to begin with a definition of physics. The American Institute of Physics has provided one, and it would be unseemly to use another in this place. Actually it is a definition of a physicist, but we can easily translate it into a definition of physics. Harken to it. "A physicist is one whose training and experience lie in the study and applications of the interactions between matter and energy in the fields of mechanics, acoustics, optics, heat, electricity, magnetism, radiation, atomic structure, and nuclear phenomena."

Clearly this is addressed to people who have a clear-cut notion of energy, and therefore not to the general public. But even with respect to its intended audience it has a certain rashness. People who have a clear-cut notion of energy are likely to remember the equation $E = mc^2$. This equation operates like a nuclear bomb on the definition, for the definition implies that matter is cleanly and neatly distinguishable from energy, and the equation says it is not so at all. The equation in fact invites us to alter the wording, and say that the physicist is one who concerns himself with the interactions between energy and energy. This has a silly sound, but it is not a silly thought, and I can clothe it in appropriately formal garb by saying that the physicist concerns himself with the interactions between various types of energy. But I will not tamper further with the head of the definition, for it is just the sauce, and the meat is in the tail. Oddly enough, the meat is disguised as a limitation.

There are two limitations here, and one of them is

not in Nature and I think that it was not in the minds of the definers. It is implied that in respect of magnetism, for instance, there is one part of magnetism that involves interactions between matter and energy and another that does not. The first part is physics and the second part is not. But there is no second part, and the whole affair reduces itself to a plain and simple definition by enumeration. Physics is a grouping of nine fields like the nine Muses, and the names of the Muses are mechanics, acoustics, optics, heat, electricity, magnetism, radiation, atomic structure and nuclear phenomena. This is what the definers really say and this is the meat of the definition, and all the rest is a valiant attempt to express in a very few words something that slowly dawns on the physicist as he progresses in his science. When in this manner we get down to brass tacks, the only people who can rightly complain are those who would like to have their tacks removed from the list and transferred to some other science than physics, and those others who do not find their tacks in the list and yet would like to be considered physicists. I will not be their spokesman; let them enter their own objections.

The definition also speaks of "study and applications". This sounds like the classic antithesis between pure and applied physics. Let us examine into this distinction, which as will soon appear I deem a necessary evil.

As our science expands, its journals become so huge that they are insupportable in all senses of the word, and the meetings of its cultivators so congested that they defeat their purpose. These are only symptoms: the malady is the finiteness of the human brain, which can absorb only a finite amount of knowledge before old age sets in. But although the malady is incurable the symptoms can be controlled, and this is done by the same technique as prevailed in the cities of ancient Greece and prevails to this day in the beehive. Some of the bees get tired of the congestion and swarm off to another hive. This is the reason and the only reason why the American Physical Society cannot deprecate the newer hives of the Optical Society of America and the Acoustical Society of America, each of which has taken a large piece of physics unto itself. The engineering societies swarmed away a long time ago and they have even larger segments of our domain, but we could not force them back into our hive if we would and we would not if we could. The distinctions are evil in principle, but we cannot get along without them.

nd an ART

By K. K. Darrow

LET us try to contrive a definition. One begins by saying that a pure physicist is interested in a device because it illustrates the laws of physics, an applied physicist is interested in the laws of physics because they explain a device. The teacher of physics teaches the dynamo because it exemplifies Faraday's laws, the teacher of engineering teaches Faraday's laws because they show how the dynamo works. This definition implies a static science and a static technology. We try to put evolution into it. A pure physicist is one who discovers new laws of Nature, an applied physicist is one who improves an old device or invents a new one. But many experimental physicists of uncontested purity spend a large part of their time in improving their devices. We must introduce more motive into the definition. A pure physicist is one who improves his devices for *no* other purpose than to extend his understanding of Nature, an applied physicist is one who improves his devices for *any* other purpose than to extend his understanding of Nature. On this basis Rutherford was an applied physicist at the start of his career when he was trying to make a radio, purified himself when he abandoned the attempt; Lawrence was a pure physicist until his cyclotrons started to make isotopes which are useful to medical men, then he lost his caste. It is evident that our definition is one of extremes, and it takes a rather single-minded person to hold a position at either extreme. Let us see whether we can discover any analogies in the practice of the arts.

A composer who produces a symphony is presumably a pure musician, one who writes for a dance-orchestra is presumably applied. Yet any conductor knows that the subscribers will not object and will in fact be very pleased if he plays some of the works of Johann Strauss and Manuel de Falla. We are meeting in an opera house. Richard Wagner himself said that the only purpose of his music was to enhance his libretto; he is accordingly an applied musician. Even more singular is the case of Tchaikowsky, who remained a pure musician until he had been in his grave for fifty-odd years, whereupon the sonorous opening theme of his piano concerto in B flat minor was converted into a dance entitled "This Night We Love". I shall leave to people more expert than myself the question whether in the Gilbert-Sullivan team Sullivan was an applied musician or Gilbert an applied poet.

Take painting and sculpture. The pure painter, let us say, is the one whose paintings hang in a museum; the

The following is the text of the last of six invited papers presented on October 25th during the symposium on "physics today" which keynoted the 20th Anniversary Meeting of the American Institute of Physics in Chicago. Other papers presented during the symposium will appear in subsequent issues.

applied painter is the one whose paintings are fitted into the decorative scheme of a house. On this basis Monet and Renoir are applied painters for those who can afford to pay twenty thousand dollars for a picture, pure painters for the rest of us. I do not know quite where to put the portrait painter, except that he is probably pure when his work is hung in a museum with a label "Portrait of a man". I am reasonably sure that there are many modern painters who, in the inconceivable event that they were present, would wish me to say that the pure painter is the one whose pictures look like nothing on earth, and all the others are applied. There is an analogy to physics in this; we will take another glance at it later.

Architecture ought to be the perfect example of an applied art. Yet I note that there is a doctrine called "functionalism", the exponents of which profess that every part of a building ought to be requisite for its purpose and essential to its structure. The existence of such a doctrine implies that there are buildings with details that are not required by their purpose or their structure, and indeed this is obvious to anybody who has seen a cornice. A drawback of this doctrine is that it forbids you to enjoy a cornice, and indeed in principle it forbids you to enjoy a Gothic cathedral until a civil engineer has proved to you by calculation that if any flying buttress, any pinnacle or any crocket were removed the building would fall down. Then there arises the question of the stained-glass windows: these are functional if they stir a mystical emotion, decorative if they please the tourist, anti-functional if they just impair the light. The first of these views was that of the artists who created the windows of Chartres, the second is that of the guides, the third was that of the eighteenth-century people who improved the lighting by smashing some of the windows and throwing the precious fragments onto the rubbish-heap. It is not easy after all to distinguish what is functional and what is decorative in the totality of a cathedral. A cathedral is a texture of purposeful construction, purposeful decoration, decoration for the sake of decoration, and symbolic instruction. So also is a science. And if some of the sublimest features of a Gothic church derive from the fact that the builders did not have steel beams avail-

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able, and if the modern builders with steel beams produce a structure that in spite of all its competence is mysteriously lacking in something that we like, these are perhaps analogies with the classical physics and the theories of today.

I might suggest at this point that the names of pure and applied physics be changed into decorative and functional physics; but this also would be bad. I suggest instead that the distinction be recognized as an irrational one which is required by imperious practical necessity. A piece of applied physics is either physics or it is not; in the former case the adjective should be dropped, and in the latter case the noun should be dropped. Architecture is architecture whether it is exemplified in the United Nations Building or in the Sainte-Chapelle. Music is music whether it is a Viennese waltz or the B minor mass. Painting is painting whether it results in a landscape, a portrait, or an abstraction. Physics is physics whether it explains the television set or the helium spectrum. If some of physics is now called acoustics and another part is called radio engineering, that has no more and no less significance than the breakup of the Roman Empire. The empire broke up because the administrators at the capital could no longer hold the sprawling thing together; but France and Spain and Italy went along on the basis of the Roman culture.

HOWEVER there really ought to be more of a distinction than I have admitted, since people are always talking about fundamental research and therefore implying the existence of a nameless opposite. A good definition of fundamental research would certainly be welcomed: let us see whether we can contrive one. We have to begin, of course, by defining research. Unfortunately the concept of research contains a negative element. Research is searching without knowing what you are going to find; if you know what you are going to find you have already found it, and your activity is not research. Now since the outcome of your research is unknown, how can you know whether it will be fundamental or not?

At this point we switch the adjective "fundamental" from the outcome of the enterprise to the enterprise itself, and say for instance that fundamental research is that which you undertake without caring whether the results will be of practical value or not. It would be imprudent to go further, and say that fundamental research is that which you will abandon as soon as it shows a sign of leading to results of practical value. By saying this you may limit your own achievement and even antagonize your sponsors. The way to please even the most difficult of sponsors is to say that fundamental research is that which may have no *immediate* practical value, but can be counted upon to lead to practical value sooner or later. There is no truer statement and there is no safer gamble. The extension of knowledge will always be profitable in the long run if not in the short. The only question is one which I will phrase in the language of Wall Street. Will the profits

be paid out in immediate cash dividends, or will they be plowed back into plant?

This is a very powerful argument for fundamental research and it is a completely unassailable one; and yet there are people who will not like it. This in fact leads to one of the best definitions I can contrive for a pure physicist. A pure physicist is one who does not quite like to have his activities condoned on the ground that they may be useful some day—not even if the expected use is something as noble as the cure of a disease or the more nearly perfect reproduction of a symphony. Let us seek a definition which will give to fundamental research a value of its own, not contingent upon other uses appearing soon or late. We say that fundamental research is that which extends the theory of physics. Now we have to theorize about theory.

There have been several viewpoints about theory. One is, that theory discerns the underlying simplicity of the universe. The non-theorist sees a crazy welter of phenomena; when he becomes a theorist they fuse into a simple and dignified structure. But now that quantum mechanics has become so intricate, there is an increasing number of people who would rather take the welter of the phenomena than the welter of the theory. A different idea is the one lately proposed by Condon, who says that the office of theory is to enable one to calculate the result of an experiment in shorter time than it takes to perform the experiment. It is dangerous to disagree with Condon, who is generally right; but I cannot think that this definition is very pleasing to the theorists, who are thus entered in a race which they are foredoomed to lose when the problem is that of ascertaining the resistance of a silver wire or the wave length of a line in the spectrum of germanium. Another viewpoint is that theory serves to suggest new experiments. This is sound; but it makes the theorist the handmaid of the experimenter, and he may not like this ancillary role. Still another viewpoint is that theory serves to discourage the waste of time on useless experiments. I presume it is true that some attempts to design impossible heat engines have been prevented by a study of the laws of thermodynamics. On the other hand it is a matter of record that some good experiments have been delayed, and quite possibly others have not been performed even yet, because the experimenters who might have done them were scared away by too much faith in a fallacious theory which pronounced them vain. I do not know how the balance can be struck.

Let us try to flatter theory by giving it a definition that shall not describe it as a mere handmaid of experiment or a mere device for saving time. I suggest that theory is an intellectual cathedral, erected if you will to the glory of God, granting a deep and indescribable contentment to the architect and to the onlooker—and incidentally able to help quite a number of people who have no concern whatever with the faith in which it was raised. I shall not describe it as an image of reality. The word "reality" frightens me, because I have a notion that philosophers know exactly what it means and I do not, and anything that I might say

about it would offend them. I do not mind describing it as a beautiful thing, for beauty is a matter of taste, and I am not afraid of what the philosophers may say about it. Let me develop further this simile of the cathedral.

MEDIAEVAL cathedrals were never quite finished, and no more is theory. Sometimes the money ran out, and sometimes there was a change of architectural fashion. When a change of fashion arrived, the early part of the cathedral was sometimes pulled down, in other cases coupled with the newer part. You may find a severe and solid Romanesque choir built with an enormous factor of safety, and an airily soaring Gothic nave built very near to the verge of the dangerously unstable. The Romanesque choir is classical physics and the Gothic nave is quantum mechanics. I remind you in this connection that the nave of Beauvais cathedral fell down twice, or perhaps it was three times, before the architects reconciled themselves to building something that would stand. A cathedral is also a congeries of chapels. The chapel of solid-state physics has only a remote relation with the chapel of relativity, and the chapel of acoustics has no connection whatever with the chapel of elementary particles. Those who habitually worship in one of the chapels can get along without the rest of the cathedral, and the chapel itself can survive if the rest of the building falls down. The cathedral may be very magnificent to those who do not share the faith in which it was reared, and even to those who spurn the faith in which it was reared, and even to those who would build an entirely different building if they could make a fresh start.

You are all worshippers in this cathedral, and you have already heard five speeches about the chapel of acoustics and the chapel of optics and the chapel of solid-state physics and the chapels of the atom and the nucleus. Unless some one of the previous speakers has wandered away from his title, you have not heard about the choir in which the quantum-mechanicists are presumably singing Alleluia but are more likely trying to figure out how they can fix the cracks in the pillars and get the nave roofed in. I am not going to try to fill this gap; the rest of my talk will be devoted to a different question, which is: how are we going to communicate to the layman some of our passion for the cathedral? This is a more important question than it is sometimes made to seem, for everyone is a layman, or at any rate a lay child, until he becomes a student of physics. If we can solve the problem of interesting the mature, we might be able to do better at the job of seducing the potential Condons, Fermis, Slaters, Lands, and Fletchers of the future into the field of physics. Nothing could be more desirable.

A frequent technique is that of surprise. The trouble with this is, that one cannot be surprised if one is not accustomed to the situation which is nullified by the surprise. Not long ago I read that someone had swum 100 yards in 49 seconds. This did not surprise me, for I had no idea whether the previous record was 39 or

59 or 99 seconds. But I did read further, and discovered that the previous record had been 51 seconds and had stood for several years. The original statement now evoked a very mild interest, hardly distinguishable from zero—but still, no surprise. Surprise is not retroactive. Now imagine a physicist, myself for instance, trying to amaze an audience of the laity by telling them that there are a dozen elementary particles instead of two or three, or that lead has no resistance at all below a certain temperature, or that the newest cyclotron imparts an energy of 500 Mev to protons. It simply will not work; and if I load my discourse with extravagant statements and similes, I shall produce much the same effect as a lecturer who is shouting and waving his hands in order to impress a man who is stone deaf. A certain degree of amazement can be produced by telling the audience that there are temperatures four-hundred-odd degrees below Fahrenheit zero, pressures of the order of thousands of atmospheres, velocities of almost two hundred thousand miles per second, particles weighing less than a billionth of a billionth of a billionth of a gram. We are entitled to derive all the benefit we can in this way, but it will not be much. The astronomers can really produce an awe-inspired amazement, but we cannot rival them.

Fallacious also is the notion that we can excite an audience by solving a mystery for them. The trouble here is that practically no one is interested in the answer to a question which he never thought of asking. Relativity had a wonderful build-up in the decade before 1905, for the physicists of that era were acquainted with the sequence of experiments which were designed to show that the earth moves relatively to the aether and which obstinately showed the opposite. Each stage in the unfolding of quantum mechanics was exciting to the physicists who knew the earlier stages, because they knew the problems which the earlier stages left unsolved. The writer of a detective story creates the mystery before he solves it; but the mystery usually begins with the discovery of a murdered man, and this is considerably more gripping than a murdered theory. The corresponding technique in physics consists in trying to create a particular brand of out-of-dateness in the mind of the public, in the expectation of bringing them up-to-date at the end of the lecture or article. There is too much danger of leaving the audience in the out-of-date condition, and I cannot recommend the technique.

Another mistake, in my opinion at least, is that of stressing a paradox. Try telling an audience that if you know the exact position of a particle you cannot know its momentum, and vice versa—the effect is unpredictable, but is not likely to be what you wanted. Perplexities like this are best reserved for the student. Another mistake is that of springing an isolated fact upon the audience. An isolated fact is not physics and it is not interesting. The statement that tritium is radioactive, the statement that the magnetic moment of the neutron is so-and-so-many nuclear magnetons, the statement that germanium is a semi-conductor—these are of no inter-

est by themselves, and anyone who thinks that they are is ignoring the vast amount of background that he himself possesses. They are of interest only as parts of a texture, or, to return to my first metaphor, as parts of a chapel. It is in the texture or the chapel that we must strive to interest the layman.

ONE device for this purpose is to tell the layman that if he enters the cathedral he will be on the highroad to omniscience. Omniscience is a grand concept and it has a certain inspiring power. In this respect our situation differs from that of our forerunners. Laplace said something to the effect that if there were a being who knew the positions and the velocities of all the particles in the universe at a given instant, and who had in addition the needful mathematical powers, he would be able to calculate the whole of the past and the whole of the future of the universe. Strictly this is a meaningless statement, since it can never be verified; but it does give one a curious feeling of omniscience. You somehow feel that once you realize that force is mass times acceleration and that particles act on each other with forces varying as functions of the distance, you know it all, and you can either work out the details or contentedly leave them for others to work out as you may choose. Now it appears from the principle of uncertainty that even the hypothetical being of Laplace doesn't know as much as Laplace thought that he did, and the highroad to omniscience seems to end in a haze. On the other hand we are undoubtedly farther along the highroad of knowledge than our ancestors were, and the fact that it may terminate short of omniscience ought not to discourage the travelers.

Another device is to promise that he who enters the cathedral will gratify his deep desire to find the changeless, the abiding, the eternal and the immortal. This must really be a fundamental desire, for it recurs again and again in the writings of mystics, poets, philosophers, and scientists. Lucretius thought that he had satisfied it by saying that atoms are eternal. This was a nice idea, but unfortunately Lucretius did not know anything about atoms. What correspond most nearly to the atoms of the ancients are not our atoms, but our elementary particles. By a singular piece of bad luck, not one member of this weird and distracting flock is immortal, with the possible exception of the proton. Either they are radioactive, which is the case of the neutrons and the mesons; or they are liable to perish in suicide-pacts with one another, which is the case of the electrons; or they vanish into another form of energy, which is the case of the photons. The proton itself is hanging onto immortality only by a hair, for as soon as somebody discovers a negative proton it will entice some positive proton into a suicide-pact with itself. Our ancestors delved for centuries to find the eternal atom, and now that we think that we have got to bed-rock we learn that it is quicksand. With the invaluable assistance of the hypothetical neutrino, we can still manage to hold onto the conservation of mass and energy, the conservation of momentum and angular mo-

mentum, and the conservation of electric charge. The totality of mass, the totality of energy, the totality of momentum and the totality of electric charge—these are quite possibly the immortals, even though we do have to take our stand on such an unsubstantial footing as the neutrino in order to defend them. But they are not associated with individual particles, and therefore they are less agreeable than the vanished atom of Lucretius. This highroad also may be ending in the haze.

Shall we then fall back upon the grandeur and simplicity of our picture of the world? The grandeur is there indeed; but the simplicity that was apparent to Newton and Laplace has gone to join the atom of Lucretius. Simplicity has been drowned in the waves of quantum mechanics; the dream of omniscience and the dream of the eternal atom have been blotted out by an uneasy wakefulness; the stimuli of paradox and mystery and surprise are transient where they are not misleading—so where do we go from here?

The cathedral is far too grand to be apprehended as a whole by others than the mathematically-trained elite, and these are precisely the people who are most conscious of its unfinished state. But the chapels of the nine Muses of the definition of the Institute are not so overpowering, and there are subordinate chapels opening out of them which are harmonious and relatively simple. We can guide the listener into them, and point out the design and the vaulting and the pinnacles and the traceries and the stained-glass windows. It is possible to tell a good story of the conduction of electricity in metals and the escape of electrons from metals; we are not forced to talk about bands or the paradoxes of the Fermi-Dirac statistics. Quite an excellent story can be made of optics and its innumerable proofs of the wave theory of light; we do not have to confuse the listener by talking about photons. Acoustics affords a wonderful opportunity, for here there need be no confusion at all. It is possible to expound the periodic table of the elements and the arrangement of the electrons in the atoms without rehashing our ancient tribulations arising from the fact that classical theory says that an accelerated electron ought to radiate. It is feasible to give quite a good account of the taxonomy of nuclei by representing them as clusters of little globules hanging together by virtue of a strong cohesive force, contending against the repulsion between the charges of the protons; we do not have to lead the audience into the bogs of exchange-interactions and meson-theory. I suspect that of every field of physics it is possible to give a good and an instructive and enticing story, *provided only that one does not try to go too deep*. But there remains a question, and this is the very last with which I will torment your weary minds.

SUPPOSE that I am lecturing on the hydrogen atom, not to a sophisticated audience like yourselves, but to the student body of a college or the members of a club. I will say that the hydrogen atom consists of a proton and an electron, and that these are particles of matter possessing definite masses and definite charges.

I will say that they attract one another with a force e^2/r^2 , and to this point I shall continue in agreement with the theorists, though they would doubtless prefer to hear me speak of a Coulomb interaction. I will say something about the normal state and the excited states of the atom, and I shall doubtless be able to convey some notion of the reasons for believing in these states. Now the problem is near at hand. Shall I talk for a while about the elliptical orbits of the planets around the sun, and then assert that each of the states corresponds to one particular elliptical orbit of the electron? Or shall I say that each state corresponds to a certain eigenvalue of a differential equation of the second order, and that the product of the eigenfunction by its conjugate gives a measure of the probability that the electron shall be at the place for which this product is evaluated?

Well, these are purely rhetorical questions, for I know the answers and so do you. If I follow the first policy, I have at least a slender chance of holding my audience. If I follow the second policy the audience is lost immediately and permanently, and the chairman is muttering to himself, "I ought to have known better than to invite a physicist." I shall therefore follow the first policy. But shall I then be lying to my audience, and if I am, is it a white lie or a black lie?

The question is whether it is mendacious to use a comprehensible theory which goes only a smaller part of the way, instead of an incomprehensible theory which goes a larger part of the way. It is not a rhetorical question at all, for I am not sure of the answer. I know, however, that it is a question which recurs again and again on all of the levels of physics, and we are obliged to postulate an answer. The fact that it does recur on all of the levels of physics suggests to me that if my policy amounts to telling a lie, the lie is no more than a white one. Moreover I am told that even on the highest levels of theory the people do not yet know all the answers, and this implies to me that if lying is going on, even the pioneers are telling white lies to one another. However, I much prefer to believe that there is no lying at all, but instead there are various forms of truth, each of which is good as far as it goes. Bohr's original theory of the atom does not go as far as some of the others; but it is true as far as it goes, and it is better to climb to its summit than to stand helplessly staring at the side of a mountain which only a mountaineer can ascend.

Now if this is at all a proper way of looking at things, it suggests that physics partakes of the nature of an art. The purpose of an art is to produce a peculiar form of satisfaction, indescribable to those who cannot feel it but very real to those who can. I have chosen the word "satisfaction" because it is a neutral sort of a word. A physicist of the nineteenth century might have used words of greater glamor, might have spoken of the glory and passion of understanding; a physicist of the twentieth century would be more likely to indulge in the ostentation of understatement, and say that it is great fun. The adjective to be applied to a successful work

of art is "beautiful". Bohr's original theory of the atom was a beautiful thing, and so is Newton's mechanics and so were some at least of the forgotten theories of the aether. These have an abiding beauty, even though in part or in the whole they may be superseded by another and a more competent fashion.

There are indeed people who feel that Bohr's original theory is no longer beautiful because it is outdated, and there are also people who think that the contents of the National Gallery are outdated and who prefer to wander in the Museum of Abstract Art, where almost nothing looks like anything that you have ever seen. Moreover these people tend to sneer at those who wander in the National Gallery, and try to cover them with shame by saying that all they like are pictures that tell a story. However, there are also disadvantages of abstract art, and these I will illustrate by telling an ancient joke. There was a Scot who decided to economize by training his horse to eat less. Week by week he reduced the diet of the horse, and eventually he got the poor beast down to a ration of one straw per day. At this point the experiment unfortunately had to be suspended, because the horse died. I cannot but feel that something important will die out of physics if it continues too far on the road to abstraction. If the time ever comes when all theoretical problems are solved by feeding a prescription into a calculating machine, whom shall we find who will care enough to learn to run the machine?

I have been presenting a sort of an argument for the study and cultivation of physics; and there are certainly people to whom it will not appeal. It is, however, a remarkable and indeed a wonderful quality of physics, that no matter whom you may want to convince of its importance there is some argument that will convince him. Music is of no interest to the deaf, and painting cannot appeal to the blind; but there is nobody who is blind or deaf to every attribute of physics, unless it be some hermit who has forsworn the world. Do you want to speak more clearly or travel more swiftly and safely to the ends of the earth? physics will achieve it for you if it can be achieved at all. Do you want to stay at home and enjoy the amenities of life? you have physics to thank for many of these. Do you wish to preserve your amenities by strengthening the defenses of your country? it is on physics that you must rely. Do you wish to give full play to the deftness of your hands? go into the laboratory and make an experiment. Do you wish to extend your mind to the utmost of its powers? try to extend the range of theoretical physics, or even to catch up with those who are now on the frontiers. Do you wish to travel along the highroad toward omniscience? physics is the portal, though no one can tell you how far the road extends. Do you wish to roam around the cathedral, enjoying the elegance and harmony and aptness of its structure, the beauty of its vaultings and traceries and decorations? it is there for your enjoyment. All these and more are offered to you by the science which now for twenty years has been ministered to by the American Institute of Physics.