The X-Rays

Helmholtz, Hertz and Kundt, the three greatest physicists of modern Germany, have died within two years, and the friends of German science feared that this loss would be followed by a standstill in physics, or at least by a lack of really important discoveries. But now we have Professor W. Röntgen's investigations in the physical laboratory of the University of Würzburg, the importance of which does not stand behind the famous electrical discoveries of Hertz in Bonn. Röntgen has found a new kind of rays—he calls them X-rays—which, though invisible to the eye, affect the photographic plate; which produce fluorescent phenomena; which pass through wood, metal and the human body; which are neither broken by prism and lenses nor reflected.

The chief facts about the X-rays are the following: It is well known that the discharges of a large Ruhmkorff induction coil produce in a vacuum tube, such as Crookes' or Hittorf's, colored rays which go in straight lines from the cathode to the glass of the tube. These cathode rays, which have been much studied, are visible to the eye and are well characterized by the fact that the magnet changes their direction; they do not pass thick cardboard, wood, etc. The place where these cathode rays reach the glass of the tube is the centre of Röntgen's X-rays. They are not visible and are not turned aside by a magnet; in short, they are not cathode rays, but are produced by them. If in a dark room we cover the tube by thin, black cardboard, nothing can be seen at all, even if we bring the eye in the direct neighborhood of the tube during the electric discharges. But if we now bring a card covered with barium platinocyanide near it the paper flashes up with every discharge, and this fluorescent effect is visible even if the paper is distant 2 meters from the tube, and it does not matter whether the varnished or the other side of the paper is directed towards the tube. The X-rays thus go through the black cardboard which is opaque to sunlight, and the same effect follows when a bound volume of a thousand printed pages is put between the tube and the fluorescent paper. We can measure the perviousness of the different substances to the new rays by the intensity of the light on the paper, comparing the effect with and without objects between the tube and the fluorescent surface. But there is also an objective way possible to study the perviousness, as the rays produce an effect upon photographic dry plates, which, of course, remains and allows us to control the subjective comparisons. Both methods show that wood is not much less pervious than paper; boards 3 cm. thick absorb very little. Hard rubber disks several centimeters thick do not stop the rays, and even aluminum plates 15 mm. thick do not make the fluorescence entirely disappear. Glass plates vary with the lead in them, those containing lead being less pervious. Platinum is slightly pervious, if the plate is not thicker than 0.2 mm., silver and copper can be a little thicker; lead plates 1.5 mm. thick are no longer pervious. All substances become less pervious with increasing thickness, a fact which is nicely demonstrated by photographs taken through tinfoils of gradually increasing number. The perviousness of substances of equal thickness seems chiefly dependent on the density, but special experiments showed that different metals are not equally pervious if the product of thickness and density is equal; the perviousness of platinum 0.018 mm. thick and a density of 2.15 equals that of lead 0.05 mm. thick, density 11.3 and that of tin 0.1 mm. thick, density 7.1, and that of aluminium 3.5 mm. thick and a density of 2.6. Aluminium may thus be 200 times thicker than platinum, while its density is one-tenth. . . .

. . . One practical result . . . is already clear, as the new rays pass boards but not thick metal plates, so they pass the organic substances of the human body, such as skin, muscles, etc., but not the bones. As the metal weights in the wooden box can be photographed, so can photographs of the human bones be taken. Röntgen has put his hand between the tube and the dry plate in the closed camera; the photograph shows clearly all the bones of the hand without the flesh and skin, and the gold rings seem to hang in the air. The value of such a method for medical diagnosis is clear. Fractures and diseases of bones can be examined by photographic plates and metal pieces in the body, for example, needles, bullets, etc., can be found by this method. It will be a matter of the future to learn whether the rays have psycho-physiological effects.

Hugo Münsterberg, Harvard University
Freiburg, Baden, January 15, 1896

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SCIENTIFIC LITERATURE

The Florentine Painters of the Renaissance with an Index to their Works. BERNHARD BERENSON. New York, G. P. Putnam's Sons. 1896. Pp. 141.

This little handbook, by an accomplished student of art history, deserves notice in these pages because it is the first attempt we have seen to apply elementary psychological categories to the interpretation of higher works of art. A painting, says the author, is of only two dimensions and yet must suggest the third dimension to the spectator's mind. The artist to do this, must give *tactile values* to retinal impressions. "It follows that the essential in the art of painting * * * is somehow to stimulate our consciousness of tactile values, so that the picture shall have at least as much power as the object represented, to appeal to our tactile imagination." From Giotto onwards, the Florentine painters pre-eminently did this, so that the phrase 'tactile value,' instead of the more familiar word 'form,' appears on every page of Mr. Berenson's account of their characteristics. The high pleasure derived from tactile values artfully portrayed would seem to be due to the rapidity and intensity with which they are suggested. The tactile aspect of reality is actually 'heightened' by the picture, and thereupon ensues the secondary enjoyment of our own capacity for the enhanced experience. The rendering of movement is a step farther in the same direction; we feel the motor life of the figure in ourselves and a heightened sense of our own capacity results. To say that pictures have a 'life-communicating value' is thus to sum up the explanation of their effect on us from this point of view.

William James, Harvard University

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Scientific Investigation and Progress

by President Ira Remsen

Address of the retiring president of the American Association for the Advancement of Science, St. Louis meeting, December 28, 1903.

. . . What does the world gain by scientific investigation? . . . In general it may be said that the results of scientific investigation fall under three heads—the material, the intellectual and the ethical.

The material results are the most obvious and they naturally receive the most attention. . . . [Man] must have food and clothing, the means of combating disease, the means of transportation, the means of producing heat and a great variety of things that contribute to his bodily comfort and gratify his esthetic desires. It is not my purpose to attempt to deal with all of these and to show how science is helping to work out the problems suggested. I shall have to content myself by pointing out a few of the more important problems the solution of which depends upon the prosecution of scientific research.

First, the food problem. . . . [I]t is certain that the population of the world is increasing rapidly. The desirable places have been occupied. In some parts of the earth there is such a surplus of population that famines occur from time to time. . . . Here is the field for the work of the agricultural chemist who is showing us how to increase the yield from a given area and, in case of poor and worn-out soils, how to preserve and increase their fertility. . . .

But enough on the purely material side. Let us turn to the intellectual results of scientific investigation. . . . It is so obvious that the intellectual condition of mankind is a direct result of scientific investigation that one hesitates to make the statement. The mind of man can not carry him much in advance of his knowledge of the facts. Intellectual gains can be made only by discoveries, and discoveries can be made only by investigation. One generation differs from another in the way it looks at the world. A generation that thinks the earth is the center of the universe differs intellectually from one that has learned the true position of the earth in the solar system, and the general relations of the solar system to other similar systems that make up the universe. A generation that sees in every species of animal and plant evidence of a special creative act differs from one that has recognized the general truth of the conception of evolution. And so in every department of knowledge the great generalizations that have been reached through the persistent efforts of scientific investigators are the intellectual gains that have resulted. These great generalizations measure the intellectual wealth of mankind. . . .

What are the ethical results of scientific investigation? . . . The fundamental characteristic of the scientific method is honesty. In dealing with any question science asks no favors. The sole object is to learn the truth, and to be guided by the truth. Absolute accuracy, absolute fidelity, absolute honesty are the prime conditions of scientific progress. I believe that the constant use of the scientific method must in the end leave its impress upon him who uses it. The results will not be satisfactory in all cases, but the tendency will be in the right direction. A life spent in accordance with scientific teachings would be of a high order. It would practically conform to the teachings of the highest types of religion. The motives would be different, but so far as conduct is concerned the results would be practically identical. . . . Unfortunately, abstract truth and knowledge of facts and of the conclusions to be drawn from them do not at present furnish a sufficient basis for right living in the case of the great majority of mankind, and science can not now, and I do not believe it ever can, take the place of religion in some form. When the feeling that the two are antagonistic wears away, as it is wearing away, it will no doubt be seen that one supplements the other, in so far as they have to do with the conduct of man. . . .

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