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Multi-author Reviews

Development and consequences of the discovery of X-rays by W. C. Roentgen in 1895

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The centenary of W. C. Roentgen's discovery: a look at developments in science, clinical radiologic practice and environmental problems

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Introduction

In December 1945 the first volume of the journal EXPERIENTIA brought several contributions in memory of the 50th anniversary of W. C. Roentgen's discovery. They described the development and state of roentgenology at that time, with respect to X-ray equipment and tube constructions, the main problems in radiobiology and methods in medical practice, as well as the international character of the discipline.

P. Niggli and E. Brandenberger, Zürich, saw the main results of radiation physics in an extended knowledge of the structure of matter, especially since the discovery of X-ray diffraction in crystals. A. Lacassagne, Paris, described the principle of statistical methods inquiring into radiolesions and W. Minder and A. Liechti, Bern, analysed more accurate details of radiation effects on biological objects. As a pioneer of the early Roentgen technique, the victim of X-rays and refugee from Nazism, F. Dessauer, Fribourg (Switzerland), deserves special attention in the history of radiology for his contribution to EXPERIENTIA and other publications on the philosophy and importance of the technique. From our point of view the survey of clinical roentgenology by E. A. Zimmer, Basel, demonstrates the very conventional methods used in radiological diagnostics and therapy compared with the early decades. Immediately after World War II a single radiology specialist could act for the whole field of clinical roentgenology. No special examinations such as in bronchography, arthrography, angiography or myelography existed in clinical practice. These working methods fundamentally changed in the second half of the century.

Radiology with its subdisciplines is now characterized by several great strides in the last 50 years. No expert foresaw this. The progress is partly founded on further stepwise developments of basic approaches, but mainly on revolutionary new ideas, technologies and pathological knowledge. Thus radiation physics and radiobiology are fundamentals of measurement techniques, quality control, estimating radiation risks and optimizing radiation protection in Roentgen diagnostics, nuclear medicine or treatment planning. Molecular structures and mechanisms, especially the Watson and Crick model of the DNA double helix with the base-pairs sequence, gave a more profound idea of genetics. The role of the gene is dominant in understanding radiation lesions and repair. Interpretations of effects of regional radiooncologic treatment are also based upon such ideas. The observed stimulatory or beneficial effects of radiation in the low dose range, the so-called 'hormesis', is explicable.

Nuclear medicine, in clinical use after 1945, presents new information about metabolic pathways at the molecular level, and therapeutic possibilities with artificial shortlived radionuclides. Distribution studies by noninvasive tracer substances of 'radiant markers' are functions of time. Watching with interest the increasing combinations of positron emission tomography (PET) with computerized tomography (CT), magnetic resonance imaging (MRI), spectroscopy (MRS) and diagnostic ultrasonography (US), I predict a future development of complex diagnostics for normal and pathological patterns of structures and functions. Specific tissue-seeking agents and monoclonal antibodies for tumor detection are used in clincial practice. Up to now we have not found compounds which are really unique to specific tumors. But the exploration of labelled agents and their selective binding to tumor cell membrane receptors goes on.

This history of Roentgen diagnostics in the decades before World War II contrasts with the revolutionary course of imaging diagnostics during the last 50 years. It is based on the development of pathophysiology, contrast media, sophisticated new examination methods and adaption of equipment with semiconductor electronics, introduction of computers and digitized radiology. Pictorial generation by several methods, their perception, analysis and interpretation, are now major aspects of imaging diagnostics. In Roentgen's own country, medical radiology has had to fight for specialization and independence for nearly the whole century against the resistance of other disciplines. Now the techniques of diagnostic US, CT and MRI are well established. Their rapid acceptance and expansion proves their great clinical value. All branches of radiology and other medical disciplines profit from it, and that includes the patients themselves. These last decades really have been the 'golden age of radiodiagnostics'. The wind direction will change. We are already nearly suffocated with words and pictures in our daily multimedia lives. A similar development threatens medical diagnostics. Therefore a continuing and broader based education of radiologists is necessary to maintain the current high standards and good clinical practice avoiding 'diagnostic overkill'. It is of great importance for practical medicine to develop the ability to discriminate between benign and malignant lesions in the future.

Diagnosis and therapy are central to clinical radiology. Our contributions mainly deal with the interpretation of the real world, which requires real structures and functions. These techniques have proved their use. Even critics of our 'technical civilization' will not renounce the achievement of today's medicine or other facilitations of life. Thereby we are confronted with new problems of technology and life conditions. As a consequence the approaches to new problems, and the goals of research must be adapted or redefined. In addition we have to deal with changing manifestations of diseases, which are the result of natural events and human interventions. These aspects are also part of our multidisciplinary historical review. Research, further developed diagnosis and therapy made considerable progress possible. One could not expect this to be achieved without errors. On the other hand medical practice is not solely applied science. Other aspects have always been essential and integral parts of medical diagnosis and treatment. They included the individuality, environment and personal history of the patient as well as the mutual relationship between doctor and patient.

Individuality is an important feature of biology, sociology, medicine, but also of philosophy, literature and fine arts. At the centenary of Roentgen's discovery and for historical background information about the mentality of the time I want to mention the biography and work of two individualists, significant thinkers and authors, both born in 1895, Max Horkheimer (1895–1973) and the centennial Ernst Jünger. During this century in Europe, their lives and opinions were shaped by individual and very different experiences. Both provoked a lot of controversy. With their late work the attitude of protest, illusions and doctrines of the epoque is fading. What remains is the question how human beings will be capable of resolving the problems of a technical world and the economy in reasonable harmony with the environment.

Results of radiation research, just like uranium mining, human disasters like Hiroshima/Nagasaki in 1945 and nuclear accidents like Chernobyl in 1986, demonstrate the dependence of human life on natural and artificial ecological and cosmic conditions. Not only radioactive fall-out but also the irrational dread of potential hazards of radiation exposure, have affected people throughout the northern hemisphere. Therefore the first necessity is to provide the population with accurate and detailed information on the nature and degree of danger and possibilities of precaution and protection. Several contributions in this issue deal with different aspects of this topic. One contribution traces the history of uranium mining in the Saxonian Erzgebirge and eastern Thuringia (Germany) with the well known occupational 'pulmonary disease of Schneeberg'. Its relation to special geological conditions and the gaseous radon emanation during radium disintegration, radioactive water and other problems of radioactive waste disposal are all touched on. It is impossible to cover its full range in this short article.

Another aspect is illustrated by X-rays from cosmic sources. The sun as a star is studied for its influence on earth. Causes and effects of solar heating mechanisms and radiation as well as changing magnetic fields, thermonuclear reactions and cycles of solar maximum activity are topics of major scientific projects. Several physical conditions of the sun and parts of the cosmic electromagnetic spectrum, such as X-rays, cannot be examined from the earth due to atmospheric absorption. Therefore X-ray astronomy is based on Second World War rocket development. Ionization of the ionosphere changes its conductivity and, together with other interactions, generates secondary particles that may reach the ground. Finally, a knowledge of solar radiation is the first essential for an adequate protection of passengers during high altitude flights or of astronauts, and for distinguishing nuclear tests from solar events. Assessing the risk/benefit relations of artificial exposure and its amount, we must keep in mind that cosmic and geological radiation are the most important sources of natural exposure before and since the origin of life on earth. There are good arguments to suppose that the natural radiation dose and mutation rate has been much higher in former eras. Because of this, multiple forms of life have developed.

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Most of the authors in this Roentgen Centenary Issue of EXPERIENTIA have followed the whole second half of the 100 years of radiologic development, and have taken part actively in the progress of their disciplines. Through their teachers they had close contact with the oral and written history of pioneer times. The society social mentality and paradigms of science have changed over the generations, and possible future developments are discussed. Above all our contributions should prevent important radiologic events and ideas falling into oblivion. From this point of view the history of science should be part of human education, fostering the development of a critical mentality. Not least it should connect us with other countries and generations.