THE EFFECT OF ROENTGEN RAYS OF DEFINITE WAVE LENGTHS AND "R" UNITS UPON NORMAL OVARIAN TISSUE AND OVA

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Since Roentgen in 1895 discovered a new radiation which he called X-ray, there has been a steady advance in knowledge of this science brought about by constant research and use of X-rays, which are now more properly called roentgen rays.

As early as 1897 Destot (6) did work with irradiation on the skin, and Bergonie in 1906 (1) on the testes of rats. Regaud and his collaborators in 1912 (8) studied the effect of soft roentgen rays upon the skin, stomach, and intestinal tract—all showing non-healing ulcers.

Although the equipment was crude, the medical profession put this new science to practical use in these early days. In 1914 a distinct advance was made by the discovery of the hot filament tube by Coolidge (5). Since 1917 further improvements in the development of roentgen transformers of mechanical and kenetron rectification have placed in the hands of the radiologist a new type of radiation of very short wave length.

The development of instruments for the measurement of wave length, and the simplified methods of measurement such as the Duane method, published by the senior author (2), and a standard "r" unit are other distinct advancements in radiological instruments and methods of precision, making it possible for the work of the roentgenologist to be accurate and intelligible.

Quoting G. L. Clark (3): "There is no question but that greater effectiveness in the treatment will come only with adequate scientific knowledge and with the skilled measurement of dosage in terms of X-ray spectra, the laws of absorption, and the establishment of ionization phenomena. To this end a close research co-operation between physicians and surgeons, physicists, colloidal chemists, and the manufacturers of equipment is absolutely essential."

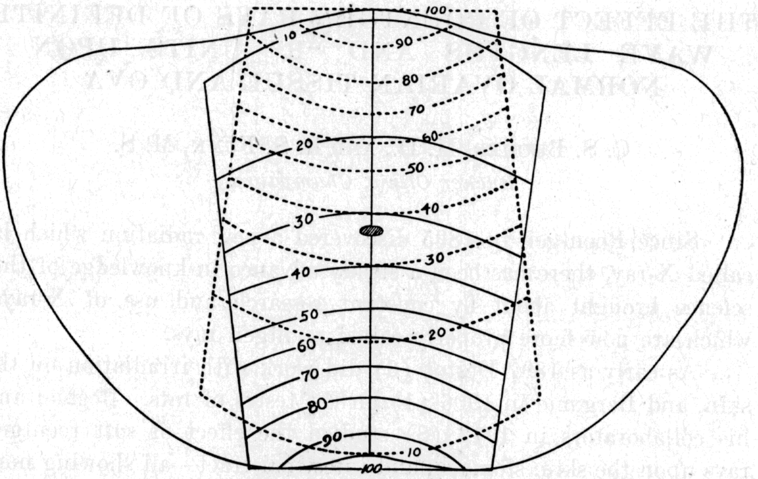


FIG. 1. Curves for Case No. 2365, rayed through two ports. A. P., 18 cm. Transverse, 24 cm. Lat., 30 cm.

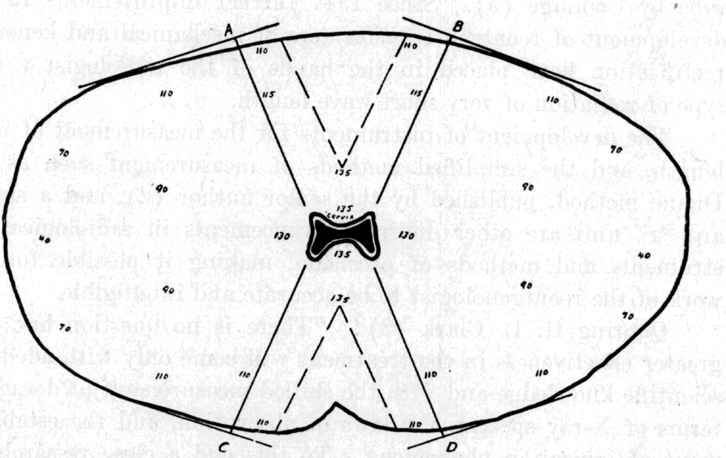


FIG. 2. Anatomical cross-section chart to size of patient, showing number of fields, angle of incidence, tumor area, and depth dose percentages, with four skin portals. Filter ½ Cu, 2 Al. K. V., 200. S. T. D., 50 cm. Erythema, 300 Ma. Min. Tumor Int., 135%. Skin Int., 75%; 225 Ma. Min. (Cross-section No. 9.)

Atoms are solar systems of electrons rotating in orbits. Position of the electrons is wholly indetermined. Tissue cells are composed of innumerable atoms of different kinds arranged to form a complex structure. How do roentgen rays produce their effect? Compton (4) shows how a beam of rays striking an electron drives it in a direction depending upon the angle at which the electron is struck. If it is straight, the electron is driven in the same

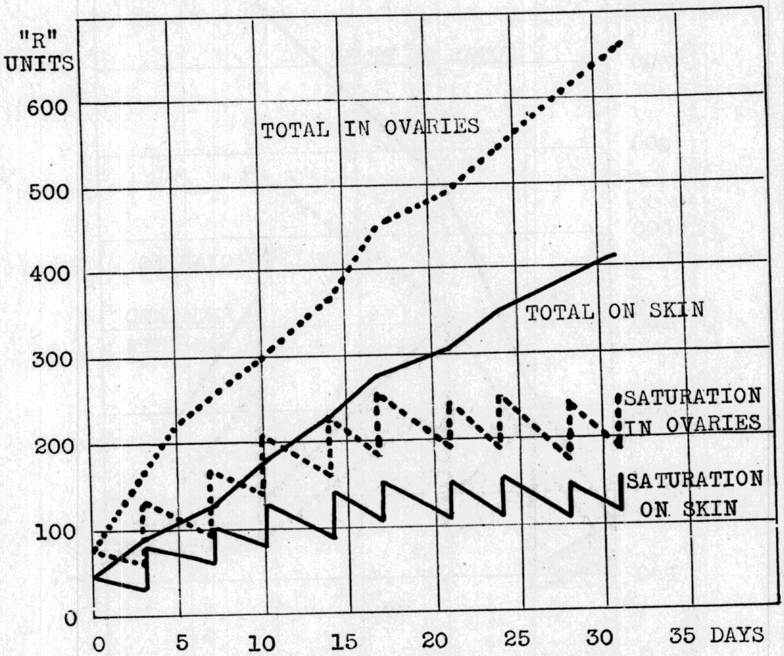


FIG. 3. Plan of treatment of case No. 1447, treated two times per week, beginning April 5 and ending May 6. Four ports. P. K. V., 200,000. M. A., 5. S. T. D., 50 cm. Filter ¾ Cu, 1 Al. Int., 9.12 "R" per min. A. U., 0.178. Port, 8 cm. Surface, 10 cm. Depth dose, A. P. 40%; P. A., 40%.

direction from which the beam of ray comes; if a glancing blow, the electron is driven at an angle from the beam.

What takes place when these complex cells, differing in chemistry, structure, function, normal or pathological and in stages of development or fully developed, are bombarded with rays of long or short wave length, little or great penetrating power, of small, medium, or large dose?

All these questions are of extreme importance and interest to the scientist, the radiologist, and of vital importance to the sufferer of malignant disease curable by radiation when properly applied. With the aid of several lantern slides of histological sections of ovaries having received rays of different wave length and dosage, I will endeavor to show the results of such treatment, but first

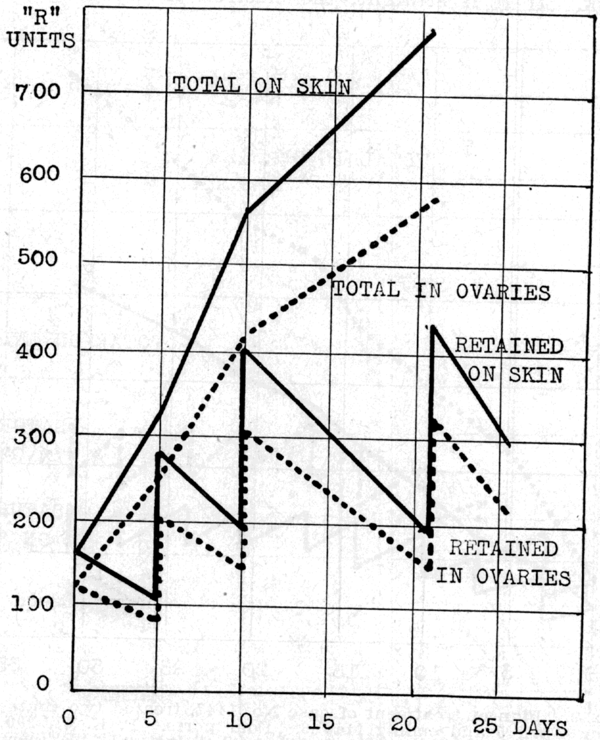


FIG. 4. Chart of rabbit No. 5. Treatment began February 27. Animal killed March 24. P. K. V., 180,000. M. A., 5. Filter, ½ Cu, 1 Al. S. T. D., 50 cm. A. U., 0.21. Int., 11 "R" per min. A. P., 2.5 cm. Depth dose 74.5%.

it is desirable to show a simplified method of determining and charting the amount of irradiation received by the skin and structures beneath. Pfahler (8) and Weatherwax and Widmann (10) have been successful in working out a system of curves and charts for calculating the dose, penetration, and retention. These charts are used for permanent records. Figure 1 shows the method of calculating the percentage of depth dose for two-port entry.

Figure 2 shows a cross-section treatment given in four ports, the numerals representing the percentage of depth dose. Figure 3 is a chart for the treatment of one of our patients. Figure 4 and 5

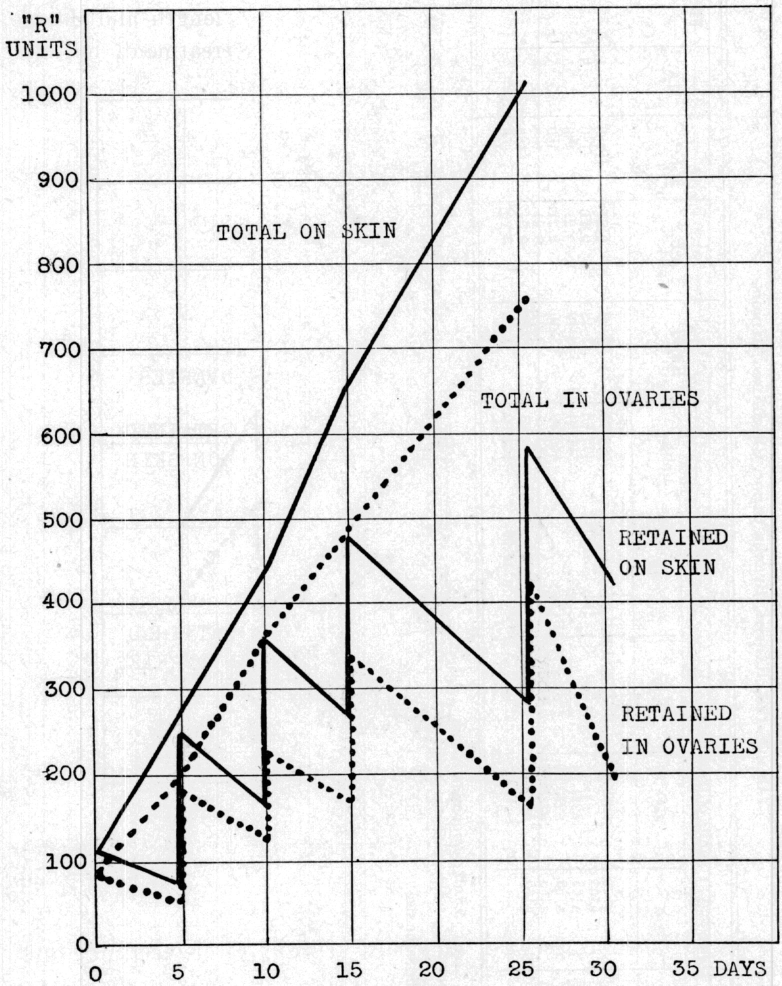


FIG. 5. Chart of rabbit No. 6. Treatment began February 22. Animal killed March 24. First treatment was P. A., 5.5 cm.; depth dose 56%. Other treatments same as for rabbit No. 5.

are similar charts showing treatments of two rabbits. We are using "r" units in place of milliampere-minutes as originally used by the authors referred to above.

TABLE I—1928, RABBITS, BUCHER CLINIC, CHAMPAIGN, ILLINOIS.

No.	Dates and "r" units of treatment.						Total "r" units.	Killed.	A.U.	P.K.V.	MA.	Filter.		Distance.
	2–22	2–27	3–3	3–8	3–19	4–16						Cu.	Al.	
1	----	----	----	a289.75	----	----	289.75	3–22	0.22	180	5	¼	1	50 cm.
2	a165	b165	a165	----	----	----	495.00	3–12	0.21	180	5	½	1	50 cm.
3	----	a165	a165	a221.84	----	----	551.84	3–19	0.21	180	5	½	1	50 cm.
4	b110	a165	a165	a220.00	----	----	660.00	3–19	0.21	180	5	½	1	50 cm.
5	----	a165	a165	a221.84	a230.63	----	782.47	3–24	0.21	180	5	½	1	50 cm.
6	b110	a165	a165	a220.00	a353.65	----	1,013.65	3–24	0.21	180	5	½	1	50 cm.
7	----	----	----	----	----	a144.00	144.00	4.25	0.20	200	5	1	1	50 cm.

Depth of tissue and ovary: Back, 5.5 cm.; abdomen, 2.5 cm.
a. Rayed through the abdomen.
b Rayed through the back.
These rabbits were about the same size.

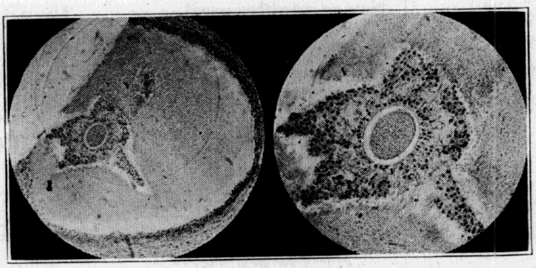


FIG. 6.

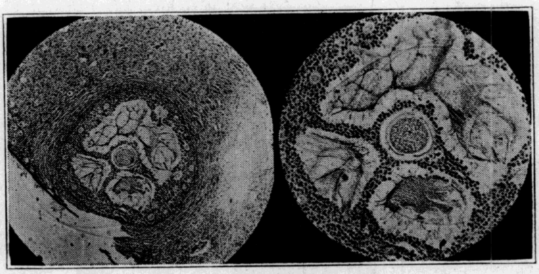


FIG. 7.

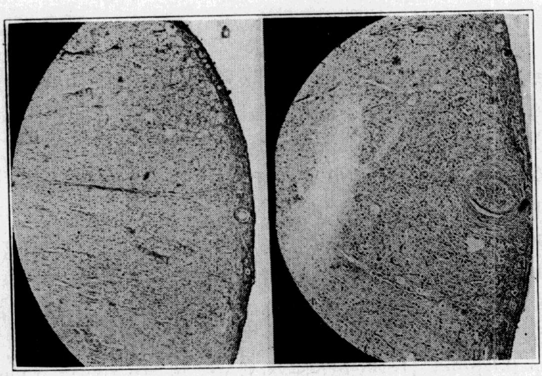


FIG. 8.

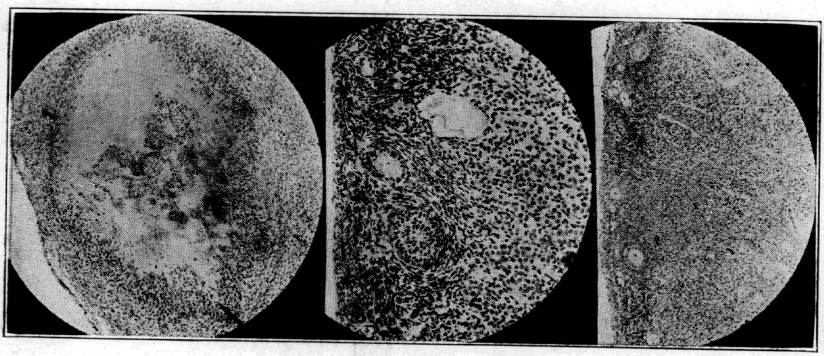
FIGS. 6-8. Photomicrographs of unrayed normal ovary, low power at left and high power at right.

GROSS APPEARANCE

The rayed ovaries were much smaller in size than the unrayed. This decrease in size was progressive from the normal, to the ovaries receiving the smaller dose, to the ovaries receiving the larger dose of roentgen rays. The shrinking was to the extent of about one-third that of the normal ovary. (See Fig. 14.)

HISTOLOGY

Microscopically, in the normal ovary we have a mature corpus luteum and ovum ready to leave the corpus luteum (Fig. 6). On the opposite side of the same ovary we have an ovum in the late



A. B. C.

FIG. 9. Sections of a rabbit's ovary receiving 290 "r" units.

stage of development (Fig. 7). The cells around the corpus luteum are formed in layers, the corpus luteum itself is well formed, and the ovum is freeing itself from its attachments. In no case were we able to find an ovum developed to this extent in the ovaries receiving rayings.

In studying the changes in the ovaries receiving roentgen raying, we see that the stroma is atrophied. This causes a closer arrangement of the cells, which becomes more apparent as the "r" units of rayings are increased.

Figure 9 shows three cross-sections of an ovary receiving 290 "r" units of radiation. Part A shows a nearly developed corpus luteum and ovum with complete disarrangement of the cells forming a fairly homogeneous mass. Part B shows a developing ovum

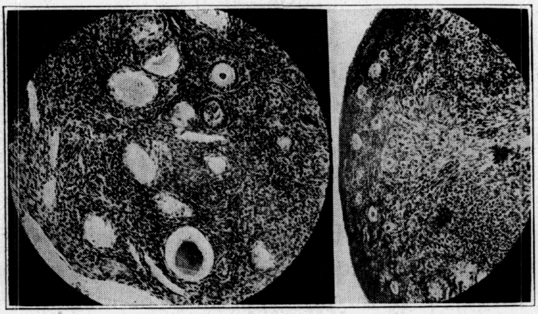


FIG. 10. Treated with 495 "r" units.

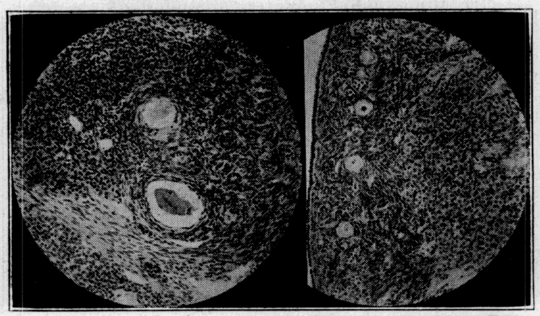
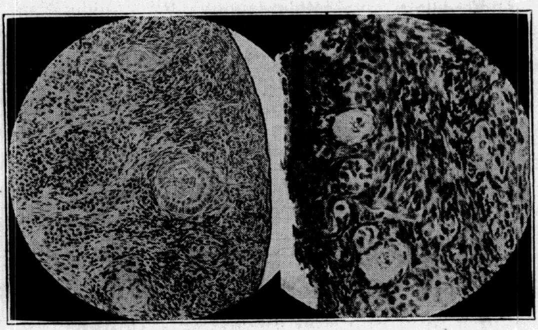


FIG. 11. Treated with 552 "r" units.



A. B.

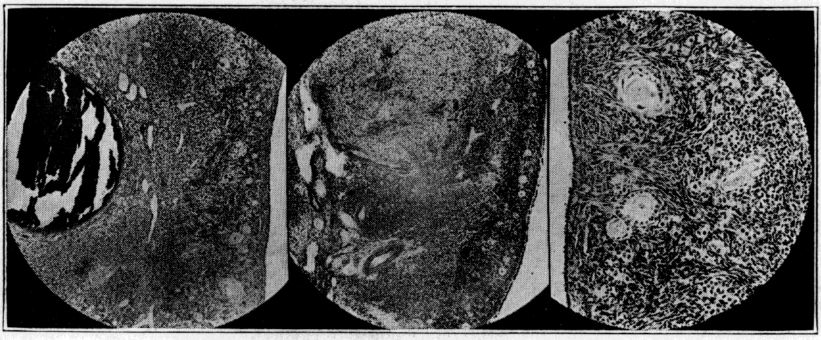
FIG. 12. *A,* treated with 660 "r" units; *B,* with 782 "r" units.

completely broken down, with the atrium filled with blood. Part C shows the close arrangement of the cells of the ovarian structure.

Figure 10 shows two sections of an ovary from a rabbit receiving 495 "r" units divided into three doses. More of the developing ova are broken down than were noticed in sections from the rabbit receiving less raying in a single dose, but the small developing ova are not so much disintegrated.

Figure 11, which is from a rabbit receiving 552 "r" units, in divided doses, shows that the medium-sized developing ova are destroyed, and that the nuclei of the young ova are disarranged. There is also evident a very close packing of cells in this ovary.

Figure 12A is a section from a rabbit receiving 660 "r" units in divided doses, the developing ova being broken down.



A. B. C.

FIG. 13. *A* and *B*, receiving 782 "r" units; *C*, 1013 "r" units.

Figures 12B, 13A, and 13B are sections from the ovary of a rabbit receiving 782 "r" units. In these sections, where the ova were far enough advanced in development to study the changes, the nucleus of the ovum is invariably disarranged. This would indicate sterility. Figure 13A shows a large blood clot in the atrium. Figure 13B shows very closely packed ovarian cells with few primordial ova in the germinal epithelium which are apparently being squeezed out of existence. Figure 13C is a section of an ovary from a rabbit receiving 1013 "r" units, showing broken down ova with germinal epithelium, but almost no primordial ova.

What would a micro-motion picture of irradiation of this kind show if it were possible to carry it on for a month with the rayed tissue in the body in its normal position? It is hoped that every person in America interested in this subject will have an opportunity to see the wonderful film reproductions of Doctor Canti. Some of you I am sure have had this opportunity.

Quoting Ewing (7): "Ultimate knowledge of the mode of action of radiation still eludes our grasp." We can understand, however, that irradiating any cells means the bombarding of the electrons within the atoms. This in turn produces its effect upon the structural arrangement.

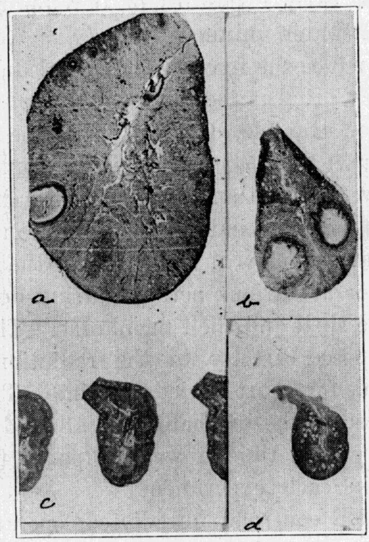


FIG. 14. Gross appearance of rabbit ovaries: *a,* unrayed normal; *b,* small amount of raying; *c* and *d,* receiving larger amounts respectively

BIBLIOGRAPHY

1. Bergonie, J. and L. Tribondeau. Arch. d'elect. Med. 1906, 779, 874, 911.
2. Bucher, C. S. Radiology Review, Dec. 1928.
3. Clark, G. L. Applied X-Ray.
4. Compton, A. D. Scientific Monthly, April, 1929.
5. Coolidge, W. D. American Jour. Roentgenol., 1914, i, 115.
6. Destot, E. Assoc. Franc. p. l'avance de Sci., 1897, 26 session, 2nd part, 518.
7. Ewing, J. Amer. Jour. Roentgenol., 1926, xv, 93.
8. Pfahler, G. E. Ill. Med. Jour. March, 1929, 177.
9. Regaud, C., T. Nogier, and A. Lacassagne. Arch. d'elect. Med. 1912, xxi, 321.
10. Weatherwax, J. L., and B. P. Widmann, Jour. Radio., 297, April, 1929.