realized that the abolition of the nerve impulses by the destruction of a peripheral nerve by a cancer is permanent so long as the cancer exists, and that the destruction by excision of a peripheral nerve is not so permanent, and that pain and tactile sensations can recur in a spot from which cancer has been excised. Possibly the curative action of x rays are related to trophic changes which of necessity include nerve changes.

The knowledge and the extent of these areas of occupation and hence the likely directions of spread would be a fundamental guide in making incisions so long as the removal of cancer by the knife remains a recognized practice.

I have shown that the spread and limitation of cancer in the skin and muscles bear a marked relationship to the presence of nerves, and the absence of nerves where normally they previously existed bears a marked relation to the limitation of cancer. But I cannot say whether cancer can genetically arise in a completely denervated area. Dr. Trevor kindly allowed me to cut a section from the forehead skin in Fig. 37, and Dr. Lunn has allowed me to do the same in Fig. 36. One can detect some rodent ulcer cells among the tissues, hence I know this disease can exist for a considerable time in a completely denervated area, although it does not spread in that area.

For fear of falling into the error that rodent ulcer alone follows definite areas, I would remind the reader that I pointed out that remarkable limitation of cancer, and curiously enough benign but diffuse papillomata of the tongue show remarkable middle line limitations.

The squamous epithelioma beginning on the lip or elsewhere on the naso-labial region, described by Dr. Head, with remarkable regularity covers the whole area, and apparently rather than leave that area it fungates.

I must offer my best thanks to Dr. Sequeira for sending me many cases; to Dr. Lunn, Dr. Harrison of Bristol, and Mr. Lynn Thomas I owe similar debts of gratitude. The ideas contained in this article are rendered more tenable to those who possess a complete knowledge of the published works of Dr. Head and Dr. Sherrington.

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An Address

ON THE

NATURE AND PHYSIOLOGICAL ACTION OF RADIUM EMANATIONS AND RAYS,

WITH OBSERVATIONS ON OTHER RAYS.

Delivered before the Royal Scottish Society of Arts.

By DAWSON TURNER, M.D.,

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OF all the scientific discoveries of the last year one stands out pre-eminent, not only from its scientific importance, but also from the great public interest it has excited. I refer to the discovery by Monsieur and Madame Curie, of radium. This discovery was not, like that of the Roentgen rays, made suddenly, but had been led up to by the researches of Becquerel and of Roentgen, and was ultimately due to the painstaking and laborious analytical work of the Curies. Roentgen's great discovery of a radiation that would render the human body transparent was made in 1895, and Becquerel followed this in 1896 by finding that uranium and some of its compounds emitted a radiation akin to that of the Roentgen rays, but in very feeble amount; lastly the Curies, after examining almost every known element, found that thorium and certain ores of thorium and uranium—namely, the pitchblendes—were also radio-active, and that the latter were even more energetic than the element uranium itself. The next step they took was to separate pitchblende into its constituents, each of which was carefully tested for radio-activity; proceeding slowly and laboriously by this method they gradually separated the chief source of the radio-activity of pitchblende—the elements polonium and radium. As my interest

in this subject is chiefly medical, I will commence by referring to the forms of radiation which have been more or less recently made use of in practical medicine and surgery. They can be divided into five groups, as follows:

1. Radiant heat rays.
2. Ordinary light.
3. Ultra-violet light.
4. Roentgen rays.
5. Radium emanations and rays.

The effluve or brush discharge produced by high-frequency currents and by static electricity has some of the properties of the last two.

Light.

About three of these forms of radiation a good deal is known. Thus, below the ordinary spectrum of white light we have the long radiant heat waves, while above are the short ultra-violet rays; the latter, together with the blue, indigo, and violet, are called after the great Danish doctor who first used them in the treatment of disease, the Finsen light. The chief properties of ultra-violet light are that it is:

- a. Powerfully actinic.
- b. Can excite fluorescence.
- c. Can discharge an electrified body, particularly if it be negatively electrified.
- d. Has clinical and bactericidal effects.
- e. Can produce nuclei for cloud condensation in moist air.

Roentgen Rays.

Coming next to the Roentgen rays we find that their nature is still unknown, though evidence has been accumulating in favour of Sir George Stokes's theory that they are due to irregular impulses in the ether comparable acoustically to a noise. Thus it has been shown by Blondlot that they travel with the velocity of light and that the rays are polarized, but they differ from ordinary light in not being capable of regular reflection or refraction: they can, however, excite fluorescence, affect a photographic plate, and discharge an electrified body. The latter properties are shared by ultra-violet light, so that the Roentgen rays more closely resemble ultra-violet light than ordinary visible light. They differ chiefly in their powers of penetration; ultra-violet rays have but little penetrative power as regards our tissues and are absorbed by the thinnest film of blood, while the Roentgen rays pass through our skin and soft structures with great facility, but throw shadows of the bones. Transparency to Roentgen rays is a question of density, but transparency to ultra-violet light is selective; thus rock-salt and ice are transparent, while glass, mica, and gelatine are opaque. Further, the Roentgen rays appear to have no bactericidal effect, while ultra-violet light has marked bactericidal effects; a very important clinical difference is this, that while the Roentgen rays will produce, if pushed, a severe inflammation and destruction of the skin and nails, the Finsen light never produces such untoward effects.

Whether the clinical effects of the Roentgen rays are due entirely and purely to the rays, or whether the electro-static field and ionization round the tube also play a part, is an unsolved and difficult problem; there are for instance certain diseases, principally of the skin, in which the Roentgen rays usually produce a curative effect. I have, to test this question, treated three such cases with the cathode breeze and have produced the same beneficial results, and in fact in one case where the Roentgen rays utterly failed the cathode breeze was successful. These results favour the view that the curative action produced by exposing a patient to an x -ray tube is not due wholly to the Roentgen rays.

Radium Emanations and Rays.

The distinguishing radio-active properties of radium, according to Professor Rutherford, are that it gives off a radio-active emanation and three kinds of rays— α rays, β rays, γ rays.

It also maintains itself constantly at a higher temperature than its surroundings, and it continually emits heat at an estimated rate of about 100 calories per gram per hour. It is thus in its behaviour in outstanding antagonism to some of our fundamental physical laws.

The emanation is of the nature of a luminous gas which can be condensed by intense cold and which imparts radio-activity to objects in its path; more than two-thirds of the heating effect of radium is due to this self produced emanation, and 1 c.cm. of it would probably instantly melt down the glass tube which contained it.

The α rays consist of a stream of positively charged particles of mass about twice that of the hydrogen atom and projected

with a velocity of about 20,000 miles a second. These rays have but little penetrative power.

The β rays appear to resemble the cathode rays of a Crookes's tube: they are negatively charged, more penetrative than the α rays, and consist of particles of about the one-thousandth of the mass of a hydrogen atom. They are powerfully actinic.

The γ rays are the most penetrative of all, and evidently resemble the Roentgen rays from a hard tube.

Not content with manufacturing this extraordinary emanation and with emitting three kinds of rays, radium appears to have a hand in the genesis of the but recently discovered gas helium, so that we have the antithesis of a gas of absolutely negative properties being produced by a substance of altogether extraordinary properties.

Madame Curie has measured the atomic weight of radium, which is 225; that of thorium is 232; it would be placed in Mendeleeff's table in the group of the alkaline earths.

Attempts have already been made by various observers to use the wonderful properties of radium in practical medicine. It has been suggested by Mr. Soddy that consumptive patients should inhale the emanation so as to bring the powerful agent into as close contact as possible with the diseased lung. A few milligrams of radium bromide might be placed in water in a suitable inhaler, and the emanation drawn into the lungs with a deep breath; what effect if any this treatment might produce is not yet known, but a strong word of warning to patients not to attempt such a remedy without previous medical sanction may not be out of place. Owing to the property the emanation has of imparting radio-activity, the effect of the inhalation would probably continue for a considerable time, for the walls of the air passages would for the time become radio-active themselves.

Experiments have been made by Pfeiffer and Friedberger on the bactericidal action of radium rays; the micro-organisms of cholera, of typhoid fever, and of woolsorters' disease were destroyed by a three days' exposure to 25 mg. of radium bromide placed in close proximity. This result is not very encouraging, still it must be remembered that the Roentgen rays have no bactericidal effect, though their beneficial effects in certain diseases cannot be doubted.

Though the micro-organisms of certain diseases are not very susceptible to radium rays, the human tissues are. It is unsafe to carry radium about in one's pocket; several cases are on record of an inflammation and ulceration of the skin following such a procedure; even the carrying of it in a glass tube from one patient to another may set up an inflammation similar to that induced by an improper use of the Roentgen rays, and any ulcer formed is highly intractable and may last for weeks or months.

E. S. London tested the effects of the rays on mice. Reddening of the ears and blinking of the eyes appeared on the third day; general torpor and paralysis followed, with death, on the fourth or fifth day; the skin and brain were the parts most affected. London has also discovered that persons who are almost blind can perceive light when radium is brought near, and that people with perception of light, but not of form, can detect the shape of objects which are in the neighbourhood of the screen. He thinks that there may be in this a possibility of teaching such blind people to write or draw. Persons who are totally blind are unaffected by radium. The position of the radium can, he reports, be detected with covered eyes, and even when the box is held behind the head. I regret I have not been successful in repeating the latter experiment, possibly because the fragment of radium that I possess is too minute.

The chief physiological effects of radium, so far as at present investigated, can be arranged in three groups:

1. Effects on the skin producing inflammations and ulcers.
2. Effects on the nervous system producing paralysis and death.
3. Luminous effects produced in the partially blind.

The radiations of radium have been tried in various diseases, principally those in which the Roentgen rays and Finsen light have been found useful, and in many cases distinct benefit has resulted. The effects produced appear to be similar to those produced by the Roentgen rays. At present the prohibitive cost of radium precludes its more frequent trial. Should it become possible to obtain it in larger quantities, we may speculate on the uses to which it may be put. In practical medicine it would do away with our bulky and costly x -ray installations; patients would instead be provided with a fragment of radium sealed in a tube which they would themselves apply as directed to the affected part. Radiographs of the teeth or bony walls of cavities could be taken by introducing a fragment of radium

and placing the negative outside. A few grams of radium would light up an x -ray screen brilliantly through an inch or more of lead, and this it would continue to do for perhaps a thousand years; thus we should have a perpetual source of light and heat. An objection to its use would be that the lead would have to be enclosed in running water to prevent it from fusing; another objection would be that it would be quite unsafe to go near it unless one were completely clothed in leaden armour, otherwise one would run the risk of having one's skin destroyed and one's nervous system paralysed. Could this slight difficulty be overcome the reign of coal and smoke would be over; a small receptacle of radium in a house would both warm it by day and light it with a soft diffused light by night; a sufficient block placed in the furnace chamber of an Atlantic liner would drive it backwards and forwards for generations across the ocean.

Our knowledge of Nature's secrets is ever advancing, and for those who wish to join, and there cannot be too many of them, in the investigation of such enthralling subjects as these new elements, much help and encouragement is afforded by this our Royal Scottish Society of Arts.

RADIUM AND ITS THERAPEUTIC EFFECTS.

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ANY statement made at present about the therapeutic effects of radium can only apply to the experimental stage of inquiry. Three questions, at least, may be asked, however, and these are: (1) Have the salts of radium any therapeutic value? (2) In what class of diseases are they likely to prove useful? (3) How do any results yet recorded promise when compared with those obtained from other agents, such as the Finsen light, x rays, or high-frequency currents because the phenomena observed, when studying the salts of radium, suggest at once the possibility of therapeutic action similar to that due to the last-named forces? It may at once be said, from the experiments already published, that, to some extent, they possess therapeutic value, and, for the most part, as yet in the same class of cases in which the other forces have already been tried with success. The third question is more difficult to answer, for reasons which will appear in this paper.

It may be as well also to state here that, just as in the case of all other branches of electro-therapeutics, we have not yet any record of great improvement or cure in any case of serious malignant disease situated deeply in the tissues or within the great cavities of the body. Any records of results so far obtained have been in the superficial parts or within the accessible cavities. It has been suggested that small quantities of radium might be introduced into the deep tissues in serious malignant diseases, and left there, but most surgeons after studying the properties of radium will meantime be careful in carrying out the suggestion, and take due precaution that the active agent can be withdrawn again if required. Be that as it may no results so far of such a suggestion have been fruitful.

Properties of Radium.

During the past six months we have learned much from the physical laboratory about the properties of radium which have a distinct bearing upon surgical work. To begin with, the one important thing when experimenting with a new agent is to find out its nature and strength. At first, when the radium salts were obtained, many concluded that all that was required was what the makers termed a chemically pure salt of the element, if element it be. This is not so, because the salts which are offered to the surgeon vary very much in what is to them the most vital thing—namely, radio-activity. Apart altogether from its enormous cost, the experimenters have the greatest difficulty in obtaining suitable specimens. A considerable number of medical men and others have submitted samples of bromide of radium to me for an opinion, and I am bound to say many of them were doubtfully of any therapeutic value. It would be of the greatest value to the profession if some standard measurement could be obtained, because once in possession of this fact experimenters could regulate the dosage by the distance from which they held the salt from the part, and the time during which it was applied.

Unfortunately no such standard is easily available, and we