RADIUM

A MONTHLY JOURNAL DEVOTED TO THE CHEMISTRY, PHYSICS AND THERAPEUTICS OF RADIUM AND OTHER RADIO-ACTIVE SUBSTANCES

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CONTENTS OF VOLUME I.

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ANNOUNCEMENT

Although the existence of Radium has been discovered not much more than a decade ago its possibilities scientifically, medicinally and commercially, have already become so vast, that it is very difficult to keep abreast of all these developments. For this reason the publishers of this journal have decided to issue from month to month a publication, called "Radium", in which it is intended to chronicle all the important advances in Radio-activity and Radiumtherapy. We propose to cover this field as completely as possible, and no efforts or expenses will be spared in making this journal a publication of value to the physician, to men of science, to scientific schools, to hospitals, clinics, etc., in fact to anyone interested in Radium, its progress and development.

We have been fortunate in securing for this work the collaboration of some of the authorities on Radium in this country, as well as from abroad, who will contribute articles to this journal.

Radium applications and its effects in therapeutics will form a department in this journal to receive the fullest attention, and for this reason alone we confidently believe "Radium" will become to the medical man a source of information, as well as an adjunct of immense practical importance in his profession.

THE RADIUM PUBLISHING COMPANY.

Pittsburgh, Pa., April, 1913.

Radium and its Rays.

C. H. Viol, Ph. D.

Like so many of the great discoveries, the discovery of that property of matter called "radio-activity" was the result of an accident. In 1896, the French physicist, *Becquerel,* was investigating the effect of the fluorescent light of uranyl potassium sulfate upon photographic plates enclosed in a light proof cover. One cloudy day the uranium salt was laid upon the covered plate in a drawer to await a day, when the salt might be excited to fluorescence by the action of sunlight. Several days later, when a new plate was put into the holder and the old one developed, to his great surprise, *Becquerel* found that in the closed dark drawer the unexposed salt had strongly affected the photographic plate, causing a very dark spot. Numerous experiments convinced *Becquerel* that he had discovered a new property of matter, and careful investigation showed, that this property of affecting the photographic plate was peculiar to the element uranium, the effect being proportional, ordinarily, to the uranium content of the various salts which were used.

This property of spontaneously sending out energy in the form of rays which, like the X rays, pentrate through matter and cause such changes, has been called radio-activity, and the rays of these substances sometimes are called Becquerel rays. Later *Becquerel* found that the rays of uranium cause also the discharge of electrically charged bodies, and *Rutherford* showed this to be due to the ionization of the gas through which the rays pass. These phenomena were most remarkable as they seemed to be due to a substance being able to give energy in the form of these rays without undergoing any change or receiving energy in any ordinary form.

The photographic effect and the ionization of gases furnish very delicate tests of radio-activity, the photographic being a qualitative test, whereas the electrical method may be quantitive. Gases ordinarily are nonconductors of the electric current, but when acted on by the *Becquerel* rays, the molecules of the gas are split into electrically charged parts or aggregates called *ions.* The simplest form of instrument for measuring the intensity of the ionization of gas, which is a measure of the intensity of the radiations of a radio-active substance, is some form of a leaf electroscope. A very thin narrow strip of metal foil, gold, silver or aluminum, is attached by its upper end to a well insulated vertical metal support which is contained in a metal case, suitably provided with windows for observing the leaf. When a charge of electricity is communicated to the leaf system, the charge on the leaf is repelled by the charge on the metal support and the leaf moves out towards a horizontal position like an inverted L. This repulsion is proportional to the charge on the leaf system. If a radio-active substance causes the air in the electroscope to be ionized, that is, to become a conductor, the charge leaks away and the leaf moves back to a vertical position. By means of a reading microscope and scale, the rate of movement of the leaf may be observed. This rate is proportional to the intensity of ionization of the gas. If the instrument is calibrated, the result may be expressed as a current, since a current is the rate of passage of a quantity of electricity. These ionization currents are

exceedingly small, that due to a square centimeter of metallic uranium being 0,00000000000026 ampere. But activities of the order of 1-100th that of uranium may readily be detected by this method.

Uranium is not the only radio-active element, for soon after, in 1898, *Schmidt* and independently *Curie* found that the element thorium was radio-active, its activity being a little less than that of uranium. Madame *Curie* in studying the activity of various minerals by an electric method found that certain of these were more active than metallic uranium, which was supposed to be the most highly radio-active substance. On separating the uranium from these minerals, it was found to have its normal activity, and so they concluded that the minerals must contain a *more* highly active substance. In a chemical investigation of the residues from the most active of these minerals, a pitchblend from St. Joachimsthal in Bohemia, Madame *Curie* discovered that the bismuth in the mineral, when separated, possessed a considerable activity. To this new substance she gave the name polonium. Shortly afterwards, Professor and Madame *Curie* and G. *Bemont* found that there was another radio-active substance, which remained with the barium from the pitchblend. This barium salt was converted into barium chloride and subjected to a process of fractional crystallization, resulting in a concentration of this radio-active substance, which was found to possess (in a pure state) an activity several million times that of uranium. This substance was called radium. Later *Debierne* obtained another active product from pitchblend, which he called actinium. Working with the radio-active substances, other interesting properties were discovered. One is their ability to cause many substances, such as barium-platinocyanide and *Sidot's* hexagonal blende (a form of zinc sulfide) to become luminous. *Curie* and *Laborde* found that radium salts are continuously giving off heat in sufficient quantity to keep the salt several degrees warmer than the surroundings. In one hour one gram of radium evolves sufficient heat to warm 134 grams of water through one degree centigrate (134 calories). *Walkhoff, Giesel, Curie, Becquerel* and others, found that radium rays produce burns on the skin, much the same in character as those caused by X rays, and it is well known what important and wide application this property, carefully controlled, has found in dermatology.

It may easily be shown by means of an electroscope that the radiation from uranium, polonium, radium and actinium is not homogeneous. A very thin layer of a radium salt exposed in an electroscope produces a very intense ionization, so that the charged leaf moves rapidly. If the salt is covered with a thin metal sheet, (say 0,006 cm. of aluminum) or mica, or a sheet of ordinary writing paper, the ionization is found to be only a few per cent. of that due to the freely exposed salt. If a second sheet is applied, the ionization is only a little less than that with one sheet. With ten such sheets, the ionization is reduced to about one-half that observed with one sheet. This is due to the fact that the first sheet cuts off completely some rays which have a greater ionizing effect. The residual ionization is due to a penetrating type of rays. With very great thickness of metal screening the radium preparation, there is found to be a *very* penetrating radiation which produces an ionization of the order of one ten thousandth of that due to the freely exposed salt. The *readily* absorbed rays have

been called the *Alpha* (α) rays, those of *intermediate* penetrating power the *Beta* (β) rays, and the *very penetrating* radiation the *Gamma* (γ) rays.

The Alpha rays produce by far the greatest ionizing effects in gases, although after passing through a few centimeters of air, they are completely absorbed. They have been shown to be positively charged helium atoms, shot out with a velocity of about 12,000 miles per second (1-15th the velocity of light). Due to this high velocity and the comparatively great mass of the particles, it is only with the most intense electric and magnetic fields that deviations of these rays could be produced. The deviations, however, proved that the particles are electrically charged, for a moving charged body will always be deflected from its path when passing through a sufficiently intense electric or magnetic field, whereas an uncharged body does not change the direction of its motion. *Crookes*, using a lens, found that the light of phosphorescent zinc sulfide made luminous by the rays of radium, consisted of numerous flashes of light. The spinthariscope is an instrument which he devised to show these scintillations. A small speck of radium or other highly radio-active material is supported a few millimeters above a zinc sulfide screen fixed in one end of a tube, which contains a lens at the other end. In a dark room, the screen is seen as a dark field dotted with brilliant flashes of light, which come and go rapidly. This experiment very vividly impresses the observer with the fact that the radio-active material is continually shooting out particles, whose impact with the screen is marked by a spark of light. This effect was found to be due to the Alpha particles; for, if the radium was moved away a few centimeters or if it was screen with a very thin paper, the scintillations ceased. The length of a path through which an Alpha particle produces its characteristic effects of ionization, photographic effect, scintillations, etc., is called its range. The ranges of the Alpha particles of the various active substances have been measured and are found to be different for the different elements. The range of the Alpha rays of radium is 3.3 cm. in air. This means that at a distance greater than 3.3 cm. from a radium preparation, there will be no ionization in air, so far as the Alpha rays are concerned, and no scintillations on a phosphorescent screen.

The great energy, with which the rays are shot out, is the source of the heat that all radio-active bodies produce, for, on stopping the Alpha rays, their extra energy finally is converted into heat. The Alpha particles produce the greatest heating effect, furnishing 123.6 calories of the 134 calories which one gram of radium produces in an hour. The effect of *Alpha rays* on the skin, because of their ready absorption, is confined to a thin surface layer, and depending upon the activity of the preparation and the time of exposure, the effect varies from a faint reddening to an intense necrosis.

The *Beta rays* are about a hundred times as penetrating as the Alpha rays and have been found to be of the same type as the cathode rays. They are negatively charged particles, having a mass 1/6800th that of Alpha particles, and their velocity is of the order of that of light. The total ionization which the Beta rays of radium produce in gases is about 3% of that due to the Alpha rays, the heating effect being also of this order, since the Beta rays furnish 4.3 calories of the 134 calories given off per hour by one gram of radium. The Beta

rays of radium are nearly all absorbed by 5 millimeter thickness of aluminum or one millimeter of lead. Roughly, it may be assumed that the thickness of matter required to absorb any type of rays is inversely proportional to the density of the substance, or that the absorption is proportional to the density. Beta rays are much more energetic in their action on the photographic plate than are Alpha rays, but while they excite phosphorescent substances, the effect is generally much less than that due to Alpha rays. Changes in coloration take place, when many substances are exposed to the action of the rays—but here again the effects of Beta and Gamma rays are usually much less than those of the Alpha rays, although in the latter case the change is limited to a surface layer, whereas the change due to Beta and Gamma rays penetrates deeper. Glass at first becomes violet, and on longer exposure almost black. The rays cause many chemical changes to take place. They ozonize the air, and under the action of its own rays, the solid bromide of radium exposed to air decomposes its water of crystallization into oxygen and hydrogen, the salt loses bromine and is slowly converted into a carbonate. Under the influence of the Beta and Gamma rays of radium, hydrogen and chlorine combine to form hydro-chloric acid, and water is decomposed to give hydrogen and hydrogen peroxide. The physiological effects of the Beta and Gamma rays—while not so intense as those of the Alpha rays—are much more penetrating and find very useful application in the treatment of many forms of skin diseases, tumors, etc.

The *Gamma* or very penetrating rays are analogous to the X rays, but are much more penetrating than the X rays produced in a hard vacuum tube, and they are from 10 to 100 times as penetrating as the Beta rays. The total heat effect of the Gamma rays of radium is about of the same magnitude as that due to the Beta rays. The nature of the Gamma rays is still an unsettled problem. They are not deviated by the electric or magnetic field. They are closely related to the Beta rays, since they are capable of being transformed into Beta rays. It is quite probable that their ionizing effects in gases is due to these secondary Beta rays, which the Gamma rays produce. The Gamma rays of radium are half absorbed after passing through 115 meters of air. Due to the Gamma rays, a delicate electroscope could readily show the presence of one gram of radium more than 100 meters distant. The Gamma rays of radium are absorbed to the extent of about 40% after passing through one centimeter of lead; and after passing through ten centimeters of lead, there is still 0.6% unabsorbed.

Gamma rays from 30 milligrams of radium can still be observed by means of an electroscope after passing through a foot of iron. As it is difficult to accurately measure the current due to the intense ionization produced by "larger" quantities of radium (quantities of the order of one milligram or more), it is now the practice to compare such quantities of radium by means of their Gamma ray ionization current. The international Gamma ray radium standard was prepared by Mme. *Curie* from a carefully weighed quantity of pure dry radium chloride, and standards prepared by comparison with this international standard, furnish the means of accurately estimating larger quantities of radium.

*This is the first article of a series of three, which Dr. C. H. *Viol*, of the Radium Research Laboratory, of Pittsburgh, Pa., consented to write in order to give to our readers in a very short and comprehensive form an idea of the present status of radio-activity.

Notes and Comments.

The medical faculty of Johns Hopkins University at Baltimore has established a Radium Emanation department and installed rooms for treatment by inhalation of radium emanation.

The annual production of pitchblend ore in the Austrian government mines has been during the last years, as follows: In 1902, 46 tons (according to *Gaubert*, La Radium, Vol. 1, p. 99); in 1908, 9 tons; in 1909, 13 tons; in 1910, 6.5 tons; in 1911, 5.7 tons of ore (average 55% U_3O_8) according to the U. S. A. Daily Consular Reports, 1913, p. 177. This shows a distinct decrease in the production of the richest uranium mines in Europe, which held for years what was practically a monopoly for the manufacture of radium.

Dr. W. *Falta*, of the University of Vienna (Austria), well known for his researches on Radium Emanation Therapy, has been appointed professor in the medical faculty of this university.

Mr. Joseph M. *Flannery*, President of the Standard Chemical Company, Pittsburgh, Pa., which is the only concern manufacturing radium salts in America, has returned from an inspection of the mines of this company in Colorado, and describes the mining conditions there as very favorable. The company is mining Colorado uranium ores (carnotite) at the rate of 1,500 tons annually.

The County Council of Karlsbad, Bohemia, is going to build an Emanatorium, i. e., a building devoted entirely to Radium Emanation Therapy, at a cost of about $250,000.

Dr. Otto *Brill* and Dr. Charles H. *Viol*, of the Radium Research Laboratory of the Standard Chemical Company, Pittsburgh, delivered a lecture on "The Chemistry and Technology of the Radio-active Elements" on February 20th, in Thaw Hall, of the University of Pittsburgh, to the local branch of the American Chemical Society.

That "the therapeutical value of the Hot Springs, Arkansas, baths is dependent upon the radio-activity of the waters" is stated in a pamphlet just issued by the U. S. Government, which also insists, that "to the presence of this rare element in gaseous form (radium emanation) are generally attributed their salutary effects."

Uranium in Colorado.

By O. Brill, D. Sc. (Vienna).

The disintegration theory of radio-activity as put forth by *Rutherford* and *Soddy* in 1903 is now generally acknowledged as giving a perfectly satisfactory explanation of the phenomena of radio-activity. In the early stages of development of this theory, it was one of the strongest arguments in its favor, that the relation of the content of radium to that of uranium in uranium ores was found by *Boltwood* to be constant.

In terms of the disintegration theory, this means that uranium is the parent of radium, or that radium is a disintegration product of uranium. Later researches have shown that this proportionality between the uranium and radium content holds strictly only for very old minerals, in which the radio-active equilibrium is already attained. All such minerals contain for every ton of uranium (figured as metal) 340 milligrams of radium (metal). In minerals of later origin, the radium content is 30% to 40% smaller for the same percentage of

PARADOX VALLEY, COLO.

uranium, but there is no mineral or ore known which carries radium and no uranium.

The possibilities of radium have drawn the attention of manufacturers and prospectors to the deposits of uranium ores in the United States, in the State of Colorado. While the uranium mines in St. Joachimsthal in Bohemia (Austria) have been mined for uranium nearly a hundred years before the discovery of radium, the rich deposits of uranium in Colorado received only recently the deserved attention.

Of more than 15 known uranium minerals, there are only two of practical importance. The one is uraninite, and the other carnotite.

Uraninite is the mineral which gave the opportunity for the discovery of three elements during the last 120 years. In 1798 *Klaproth* discovered the uranium in this mineral from the Bohemian mines, in 1897 and 1898 P. and S. *Curie* used the same material for the discovery and preparation of radium and polonium.

Uraninite occurs almost exclusively in an amorphous modification which is called pitchblend, a nearly perfectly black mineral of density 9 to 9.15, which contains besides the aforesaid elements a considerable amount (3% to 7%) of the elements of the "rare earths," such as yttrium, ytterbium, lanthan, neodymium, etc., and thorium, 4% to 11% lead, and small quantities of nearly all other more common elements. The chief composition was formerly assumed to be that of an uranyluranate, but *Hildebrand* has shown, that the composition of pitchblend varies so much, that it is futile to describe it in one chemical formula. The uranium content of pitchblend varies from 30% to 80% U_3O_8, but it is only very rarely that specimens carrying more than 70% U_3O_8 are found.

Pitchblend is found in Colorado in Gilpin County, in the Kirk, Wood, German and Belcher mines near Central City. It is found in rather thin veins ½ to 4 inches thick, and sometimes, though rarely, in small pockets. R. *Pearce* and later W. F. *Hildebrand* have described the geological conditions under which it occurs and which are rather similar to those at Joachimsthal in Austria. The veins are metalliferous, and some of these mines have been worked before for gold and silver. They are lying in schitose granite, and sometimes in porphyry, and the pitchblend in these veins is bedded in between quartz, galena, chalcopyrite and pyrites. Altogether the amounts found are very small and according to the Bulletins of the U. S. Geol. Survey, only a few hundred pounds of this ore have so far been mined. Judging from the rarity of veins or pockets in the similar deposits in Bohemia and in Cornwall, in all probability the pitchblend mines in Gilpin County are for practical purposes insignificant.

Carnotite is a mineral which is probably some million years younger than pitchblend. The carnotite deposits of Southern Colorado are very likely the largest in the world. The characteristic bright yellow color of this mineral attracted the attention of the early settlers in San Miguel and Montrose Counties, and the Ute and Navajo Indians are said to have used it for the production of yellow pigments.

It was first described by L. *Friedel* and E. *Cummenge* in a paper presented to the Academy of Science in Paris in 1899 (Comptes rendus Vol. 128 p. 532). These French mineralogists received samples of this ore from two French immigrants (Messieurs *Poulot* et *Verilleque*), who did some prospecting in this country. They describe carnotite as a yellow powder, which however is not amorphous. Under the microscope, it proves to be of crystalline structure, though the crystals are so small that the mineralogical system to which they belong has so far not been disclosed. The French scientists named the new mineral after the famous chemist Adolphe *Carnot*. They claim for it the chemical formula of potassium uranyl vanadate $K_2O.\ 2U_2O_3.\ V_2O_5.\ 3H_2O$, but the more complete investigations of *Hildebrand* and *Ransom* in 1900 proved, that the composition in various samples differs so much, that it must be assumed that pure carnotite is rather a mixture of potassium uranyl salts of vanadic acid of varying composition. Pure carnotite mineral contains from 20% to 54% UO_3, from 7% to 18% vanadium pentoxyde, 5% to 6.5% K_2O, 0.3 to 2.8% barium oxide, 1.6% to 3.3% calcium oxide, small quantities of lead and traces of aluminia, iron, arsenic and phosphorous. This mineral powder is always mixed with more or less quartz and sand, and the intensity of

the yellowish color of this mixture permits the prospector to get quickly a rough estimate of the richness of the material. Very rich mixtures of carnotite with sand stone are often found in pockets of considerable size, but the average carnotite sand stone does not contain more than 1.5% to 6% U_3O_8. Such carnotite sand stones were found on accurate analysis to contain from 3.5 to 15 milligrams of radium (metal) per ton.

Carnotite occurs in Colorado mostly in the interstices between the grains of the sand stone and in thin coatings of cracks in the rock. Secondary deposits in pockets and lumps of sometimes up to one-half foot thickness are not rare in the richer mines of Paradox Valley.

There are small deposits in Skull Creek (Routt County), near Coal Creek and La Sal Creeks, but the chief "carnotite domain" is in the country between the San Miguel River and Dolores River and Bull Canyon, comprising the counties of Montrose, San Miguel and Dolores. The richest claims are along the Paradox Valley in Montrose County. This valley extends on both sides of the Rio Dolores (East Paradox

THUNDERBOLT MINE, COLO.

and West Paradox Valley) and is quite remarkable for its geological and topographical formation (comp. figure), which suggest an old lake bed. The average elevation of this valley, which has only very little vegetation, is about 5,300 feet. Here and along the "banks" of this valley are the biggest carnotite deposits. On the south side is the Thunderbolt group of claims, while the Dolores group of claims, which is equally rich, is situated north of the San Miguel and east of the Dolores River (elevation 5,200 feet). There are a number of other important claims here, the aforementioned ones and others, altogether nearly one hundred, belonging to the Standard Chemical Company, of Pittsburgh, Pa., which is the largest producer of carnotite in Colorado.

There are three apparently quite different kinds of occurrences of carnotite. The upper or "mother vein" is about 350 feet above the Dakota sandstone, which has in this district an almost uniform thickness of 90 to 100 feet. Deposits in this formation are, as a rule, very good,

and can be depended upon. About 200 feet above the Dakota sandstone is very often another occurrence of ore, in a blue clay, known to the prospectors in this district as "blue joint." The ore is found here not in veins, but mostly in big pockets, sometimes up to 100 tons or more in one pocket, and there can be hardly any doubt that these deposits are of a secondary character, being washed out of the "mother vein." Another very interesting occurrence is that about 100 feet above the Dakota sandstone.

Conservative experts estimate the amount of uranium in this "carnotite belt" of Colorado to be about 8,000,000 pounds U_3O_8. According to our experience, this would correspond to an amount of about 900 grams of radium, or about 4 pounds of pure radium bromide. There can be no doubt, that by far the greater part of the future supply of uranium and radium will be derived from the carnotite deposits of Colorado.

Radium Emanation Treatment for Rheumatism and Gout.

Especially translated from the German for this paper.

(We give here a translation of a chapter of an excellent little treatise on "Physiological and therapeutical actions of radium" by Dr. A. *Fuerstenberg*, which is just being published by *Marhold* in Stuttgart. The Editor.)

The most important indications for the therapy of radium emanation of today are probably gout and the various forms of rheumatism.

Professor *Neusser* was the first who undertook experiments with waters, which had been made artificially radio-active. Prompted by *Mache's* investigations on the radio-activity of the Gastein springs, he prepared in 1904 "artificial Gastein waters" with the aid of radio-active substances. Residues of uranium pitchblend from St. Joachimsthal were left for 14 hours in a bathtub, which had been filled with city water; and thus he produced in the water the same concentration of emanation as in the most radio-active Gastein Springs. Favorable results were obtained in chronic articular rheumatism, in arthritis and neuralgia, even where before ordinary water baths or hot air baking cures, etc., had been used in vain.

Later it was the nerve specialist, Dr. *Loewenthal* of Brunswick, who closely investigated the therapeutic utilization of emanation. He, also, treated at first principally rheumatic affections and neuralgia with emanation.

The numerous publications, which have later appeared, leave scarcely any doubt that emanation produces therapeutic effects in the various rheumatic affections, as well as in gout. Below are recorded in almost chronological order the results of the works of numerous authors, mostly researches which originated in large clinics or hospitals.

Laqueur, Nagelschmidt, Strasser and *Selka* concluded, as a result of their numerous investigations, that the therapeutic value of the "emanation treatment" is beyond a doubt. Also, *Riedel* and *Fuerstenberg* were able to determine as early as 1908, that out of 23 cases of chronic polyarthritis, which had been given the emanation

treatment at the hydro-therapeutic clinic of the University of Berlin, 15 undoubtedly improved and only 8 showed no improvement. At a re-examination, which took place within six months after the treatment, it was determined that this success was permanent. In the case of gout, they obtained similar splendid results. Dr. *Gottlieb*, who recorded 484 cases mainly of rheumatic and gouty diseases, was able to see material improvement by treatment with the strongly radioactive mine waters of St. Joachimsthal.

His and *Gudzent*, to whom we owe many researches in the field of radium therapy, also report fully upon numerous successes. Professor *His* reports that out of 100 cases of chronic rheumatism 47 were cured, 29 considerably improved, 5 were almost cured, unimproved remained 13; and in 6 cases the results could not be obtained, because the patients moved away. These cases had all been closely and exceedingly critically observed. *Gudzent*, basing his conclusions on his observations upon 400 patients, emphasizes that radium emanation treatment is suitable for all forms of chronic arthritis and the so-called muscular rheumatism or myalgia, and that it is also effective in mild and moderate forms of polyarthritis chronica progressiva. It is worth mentioning, that age plays prognostically an important part. In childhood arthritis reacts considerably better than during senility, when it is difficult to be influenced. According to *Gudzent*, monoarthritis deformans is also less well influenced by radium emanation treatment.

In monoarthritis gonorrhoica, *Gudzent* has also repeatedly been able to note a favorable influence through radium injections.

Mannes and *Wellmann* have cured or improved a large number of rheumatic and gouty cases by means of radium emanation, also patients that had been previously treated unsuccessfully by other methods.

Strassburger says, basing his treatment upon a thorough investigation, that in a considerable number of cases of rheumatic diseases, favorable and even astonishing results were obtained, where any other therapy appeared to have little or no effect. In nine out of eleven of old and very severe cases of gout, the subjective as well as the objective success was exceedingly gratifying.

G. *Klemperer* also emphasizes the favorable effect of radium emanation upon chronic rheumatism. Even in apparently hopeless cases, good results were obtained. As regards gout, *Klemperer* advises caution, because of the often variable and uncertain course of gout; however, his general experience has been, that radium inhalation has a very good influence. He concludes that it remains to be seen how long this influence will last.

Eckert reports upon his experiences at the children's clinic at the "Charite hospital" at Berlin, stating that serious cases of chronic arthritis in children were largely improved through emanation.

Kemen saw in one hundred and fifty-one cases of chronic polyarthritis, seventy-three cures, and seventy-eight improveemnts. Of one hundred seventeen, sixty-three were cured and forty-two improved. The prognostication of arthritis deformans is no longer so serious since the application of radium therapy. Similar successes are also reported by *Jansen* and *Haret*.

Mandel of the University of Munich observed that out of seven cases of genuine gout, four improved considerably, while two cases showed a complete disappearance of all gouty symptoms, due to the effect of emanation. The improvement was objective as well as subjective.

Bickel says, that radium therapy had a pronounced favorable effect in chronic articular rheumatism and arthritis deformans in 60% of all cases treated. According to *Plate*, gout is usually favorably influenced by radium emanation. In chronic arthritis those cases show almost regularly an improvement, which are due to an infection (tonsillitis, pyorrhoea alv., bronchitis, gonorrhoea, etc.) He recommends to apply moist compresses with radio-active mud to the swollen glands.

V. *Noorden* and *Falta* saw exceedingly good results with large doses of emanation in acute cases of articular rheumatism. The chronic articular rheumatism was almost always improved, especially where the smaller joints were affected. In a case of Morbus Bechterew, notable improvement resulted through the application of large doses of radium emanation. *Falta* and *Freund* have continued these researches, and have reported altogether 192 cases. They say that the attempt to treat acute cases of articular rheumatism with emanation is always indicated, because it has decisive advantages against the treatment with salicyl preparations, especially in cases where large doses of salicyl are not tolerated. The treatment should be carried on in acute cases, and not merely as an after treatment. Nearly all the cases of primary articular rheumatism were cured or largely improved. Only in a few cases of primary chronic rheumatism of very large joints, the success was not so sharply defined.

V. *Benczur*, of the University of Budapest, has seen good results with radium emanation treatment in chronic arthritis, and arthritis urica, as also have E. *Sommer* and Carl *Meyer*.

In conclusion, it may be said that all these workers have had more or less favorable results from radium emanation therapy in rheumatic ailments of various kinds and also in gout. Considering that all therapeutical methods suggested so far for these diseases are more or less unsatisfactory, these results are certainly very gratifying.

NEW BOOKS.

†In this department, we intend to give short abstracts of the more important and latest publications in the field of radio-activity, and radium therapy, as well as reviews of books received. (The Editor.)

Dr. H. *Dominici* and A. A. *Warden*. "The Technique and Results of Radium Therapy in Malignant Diseases," J. F. A. Churchill, London, 1912.

Paul *Lazarus*—"Handbuch der Radium Biologie und Therapie," with a preface by Privy. Counc. Professor Dr. Frederich *Kraus* (Berlin). Published: Wiesbaden, by J. F. Bergmann, 1913. 521 pages, 153 figures.

Ernest *Rutherford*—"Radio-active Substances and their Radiations." Published: Cambridge University Press, 1913. 699 pages.

Alfred *Fuerstenberg*—"Physiologische and Therapeutische Wirkungen des Radiums and Thoriums." Published: C. Marhold, Halle a L. 1912. 68 pages.

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We shall be glad to receive for publication from our subscribers and readers articles pertaining to the subject of radium and its application. All inquiries for information will be accorded prompt attention, and will be answered either by letter or through the columns of this paper.

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THE PRODUCTION AND DECAY OF RADIO-ACTIVE MATTER.

C. H. Viol, Ph.D.

The radiations from uranium, thorium, radium, and actinium are heterogeneous, consisting in each case of the three types of rays: the readily absorbed alpha rays, which are positively charged helium atoms shot out with about one-fifteenth the velocity of light; the beta rays, which are about a hundred times more penetrating than the alpha rays, and consist of negatively charged corpuscles moving with a velocity of the same order as that of light; and the gamma rays, which are from ten to a hundred times more penetrating than the beta rays. The first experiments with uranium, thorium and radium showed that the activity of these substances was spontaneous, and since no change in the intensity of the radiations was found, when observations were made during a period of several years, it was supposed that this activity was permanent. In 1899 and 1900, some observations were made, which indicated that some radio-active substances may lose a part of their activity in a very short time. The activity of uranium had been found by *Becquerel* and Mme. *Curie* to be an atomic property, unaffected by the chemical combination of uranium with other elements. In 1900, Sir William *Crookes* found that by a single chemical operation he could separate from uranium a very minute quantity of a substance, free from uranium, which, as measured by its effect on the photographic plate, was hundreds of times more active than an equal weight of uranium. This substance he called uranium X, the "X" indicating, as in algebra, an *unknown*. *Becquerel* found another method for separating uranium X from uranium, by precipitating barium sulfate in a solution of uranium salt, the barium sulfate carrying down the uranium X, leaving a uranium solution that was inactive (photographically). A year later he found the barium sulfate was *quite inactive* and that the uranium had *regained* its *activity*. *Rutherford* and *Soddy* found it possible, by a single chemical operation, to separate a substance from *thorium* which in cases was thousands of times more active than an equal weight of thorium. This substance they called *thorium X*. In the case of thorium it was not possible to completely remove all the activity, a limit being reached when the activity of the thorium was reduced to about a third of its initial value. In a month after its

preparation thorium X was found to be inactive, and the thorium, from which it had been separated, had regained its normal activity. Accurate electrical measurements of the alpha ray activity of thorium X and thorium, free from thorium X, showed that the former product lost its activity at the same rate that the thorium regained its activity, so that in four days half the activity of the thorium X was gone, and the thorium had regained half of its lost activity. In another four days half of the remaining activity of the thorium X was lost and the thorium had regained a corresponding amount, and so on, until by the end of the month the thorium X was practically inactive, and the thorium had regained its original activity. Similar measurements on the beta rays of uranium X (the beta rays are much more active photographically than the alpha rays, so that in *Becquerel's* work the uranium, free from uranium X and producing only alpha rays, was inactive, in comparison with the uranium X, which produces the photographically active beta and gamma rays) showed that the uranium X lost half of its activity in about twenty-five days, and that the uranium recovered half of its lost activity in the same time.

The velocity of all ordinary chemical reactions may be varied by suitably varying the conditions of temperature, concentrations of reacting substances, etc. Hydrogen and oxygen gas may be mixed at ordinary temperatures, and the velocity of formation of water, due to their chemical combination, is exceedingly small. But if the mixture is heated the velocity of reaction becomes so great that the combination takes place with explosive violence. In case of radio-active changes, it has, so far, been *impossible* to *change* in the *slightest degree* the *rate* at which the change of activity of the different substances is taking place. In the heat of the electric furnace or the cold of liquid air, in a state of high concentration, or when mixed with enormous quantities of other forms of matter, the uranium X and thorium X, in fact, all radio-active substances, as we shall see, undergo a loss of activity at a definite rate which is characteristic for each of the substances. The time required for the activity of a quantity of a definite radio-active substance to fall to half its initial value, as measured, for example, by its saturation ionization current in an electroscope, is called the "half value period," or, briefly, its *period*. Radio-activity seems to be due to a spontaneous production of new forms of active matter, as, for example, uranium X from uranium, and the laws which control this production differ from the laws governing ordinary chemical reactions, since by no known means can the rate of formation or decay of the activity of the radio elements be influenced. The alpha, beta, and gamma rays and the very considerable quantities of energy with which their rays are endowed must also be accounted for.

In 1903, *Rutherford* and *Soddy* advanced the hypothesis that the atoms of the radio-active elements are suffering spontaneous disintegration and that each atom so changing passes through a well-defined series of changes, accompanied usually by the emission of an alpha ray. This theory supposes that on an average, in a given time, a certain definite fraction of all the atoms of any radio-active substance become unstable and these atoms break up. This process of disintegration of the atoms is very violent, and usually results in the throwing off of an alpha particle with great velocity. In the case of some substances apparently alpha, beta, and gamma radiations are produced in the breaking up of the atom, while in other cases, as, for example, uranium

X, the atom gives off a beta particle and gamma rays; and in a few cases there is evidence of so-called "rayless" changes. The corpuscular theory of matter supposes the atoms to be built up of corpuscles or beta particles and of positively charged groups of matter in rapid motion about a center of rotation, much as the planets in our solar system move about the sun. With certain space arrangements it is conceivable that the groupings of these parts in the atom should lead to a condition of instability, resulting in the disintegration of the atom, and the throwing off of some constituent part of the atom, with a tremendous velocity, the bulk of the atom remaining to form an atom of a new substance. From this standpoint, we may view the formation of uranium X from uranium, and thorium X from thorium. Some of the uranium atoms become unstable and disintegrate, each one shooting out an alpha particle and leaving an atom of uranium X. Only an exceedingly small fraction of all the uranium atoms present undergoes this change in any short interval of time, and this *very slow decay* of the uranium makes the activity of the uranium, as measured by the ionization current due to its alpha rays, *sensibly constant*. The *period* of uranium is estimated to be about 5,000,000,000 years.

In a given quantity of uranium there are being produced every second a *certain definite* number of atoms of uranium X. If the uranium is initially freed from uranium X by any suitable chemical means, there will be formed in the first second this same *definite* number of uranium X atoms, and of these a certain proportion will be changed into the next product—but *not all* will change. In the next second more uranium X atoms are formed, and since there are now these together with the uranium X atoms which did not disintegrate in the preceding second, the number which do change in the second second is greater, since this number is always the same definite fraction of the total number of uranium X atoms present. This process of piling up of uranium X atoms goes on until the number of uranium X atoms changing in an instant is equal to the number of these which are formed per instant from the uranium. This limiting condition is called that of *radio-active equilibrium*. The exact mathematical development of this state of radio-active equilibrium enables us to calculate the quantity of uranium X which is in equilibrium with a quantity of uranium, this being about one hundred-millionth of a gram of uranium X for a kilogram of uranium. Thorium, which is decaying with a period of about 30,000,000,000 years, gives rise to the thorium X in a similar manner. The remarkable amounts of energy which are associated with radio-active changes may now be accounted for. It comes from the stores of energy that are within the atoms of the transmuting elements. The total extent of this internal energy we can only speculate about, but its probable magnitude may be comprehended when it is understood that the energy changes involved in the complete disintegration of one gram of radium equals the heat energy evolved when half a ton of coal is burned. More than 20,000 years are required for the *complete* disintegration of a quantity of radium, so that the energy is liberated rather slowly, and the cost of radium makes the application of very large amounts of "radio-active" energy almost prohibitive.

In 1899, *Owens* found that the activity of thorium compounds seemed to be variable, if a current of air were passed over the substances. A steady stream of air was found to reduce the activity markedly. *Rutherford* investigated this peculiar effect, and decided

that the thorium was continually giving off *radio-active particles* which possess the property of ionizing gases, acting on the photographic plates, and of rapidly diffusing through porous materials like paper. This substance he called the thorium "emanation," from its gas-like behavior. Special experiments showed that this substance really is *radio-active matter* that is *gaseous*. The thorium emanation must not be confused with the alpha, beta and gamma rays. The emanation is a form of radio-active matter that gives off alpha rays in the process of its disintegration. *Being a gas,* the emanation can easily be blown away in a current of air, and this explains *Owens'* first observations on the variation of the activity of some thorium compounds. The passage of active matter through porous materials is also explained in this way. The thorium emanation, like thorium X and uranium X, decays in a comparatively short time, its *period* being 54 seconds, so that in ten minutes after separating the emanation practically all of it has decayed.

Shortly after the discovery of the thorium emanation, *Dorn* found that radium also gives rise to a characteristic radio-active gas, which from analogy is called the radium "emanation." Thorium emanation and radium emanation are given off only very slowly from the solid thorium and radium salts, but when these are strongly heated or are dissolved the emanations are given off quite freely. The *period* of radium emanation is 3.85 days, and radium free from its emanation will again produce the equilibrium amount of emanation if sealed for about thirty days. Radium emanation is a chemically inert gas of the argon type. Like radium, it shows a characteristic spectrum, and, when strongly cooled, it condenses at —150°C. Diffusion experiments showed that it was a gas of very high atomic weight, and in 1911 R. W. *Gray* and Sir W. *Ramsay* actually determined its atomic weight by weighing a known volume of pure emanation. From their results, the atomic weight was found to be 223. The atomic weight of radium is 226.4, and in changing into the emanation one alpha particle (helium atom) is lost from the radium atom. The atomic weight of helium is 4, so that it is to be expected that the emanation would have an atomic weight of 222.4. Some idea of the delicacy of the work of *Gray* and *Ramsay* may be obtained when it is known that the weight of emanation used in their experiments was less than one-thousandth of a milligram, that the glass vessels containing the emanation weighed about thirty milligrams, and that the microbalance on which the weighings were made, was sensitive to about one-millionth of a milligram. *Gray* and *Ramsay* have suggested the name "Niton" (which is Greek for "the shining one") for the radium emanation, since it now may be definitely admitted to be an element, and a higher analogue of the "noble gases," helium, argon, neon, krypton, and xenon.

Rutherford and *Soddy* found that the thorium X, and not thorium, was the parent of thorium emanation, since thorium X separated from the thorium continued to give rise to the emanation, whereas the thorium, freed from thorium X, no longer produced emanation. Uranium does not produce an emanation.

A very remarkable property of radium and thorium is their ability to cause bodies which are exposed to them, to become temporarily radio-active. A piece of metal foil exposed to thorium hydroxide for several hours behaves, after removal, as though it were itself radio-active. This activity was at first called "induced" or "excited" activity, since it was thought that the exposure to the radio-active substances actually

caused ordinary matter to become temporarily active. This effect is now known to be the result of a deposit of radio-active matter on inactive bodies, and this radio-active matter is called the "*active deposit.*" Matter exposed to radium receives the characteristic radium "active deposit." The source of these active deposits is the gaseous radio-active matter or emanations which thorium and radium produce. The emanations diffuse into the air around the preparations, and in decaying give rise to other radio-active matter, which, not being gaseous, collects on whatever objects may be about, and constitutes the "active deposits." The *periods* of these active deposits have been measured and are found to be 26.8 minutes for the radium deposit, and 10.6 hours for the thorium deposit.

The work of a great many experimenters has shown that these active deposits are complex, consisting of a mixture of various successive radio-active products. The various products in an active deposit exhibit characteristic chemical and physical properties, and, by taking advantage of these, separations of the various forms of radio-active matter in the deposit may be effected. These products are always present in unweighably small quantities (due to their short periods), and so these separations must always leave the radio-active material mixed with certain quantities of ordinary inactive matter necessary in order that there may be something tangible to work with. The active deposit of thorium, collected on a platinum plate, may be dissolved in acid or volatalized by heating the plate to a white heat. In the radium series the first product from the emanation, called radium A, has a *period* of three minutes. This radium A in disintegrating forms what is called radium B, a product that has a *period* of 26.8 minutes. Radium B gives rise to beta rays and the product radium C. Radium C, decaying with a *period* of 19.5 minutes, produces alpha, beta and gamma rays and radium D. Radium D has a longer *period,* 16.5 years, so that while the active deposit on a substance which has been exposed to radium emanation at first devays rapidly—due to the short *periods* of radium A, B and C, there is left a slight residual activity, due to the slow decaying radium D, and the subsequent products radium E and radium F. The *period* of radium E is five days, and that of radium F is 136 days. Radium F gives off alpha rays, and we now know that the product which Mme. *Curie* first isolated with the bismuth from pitchblende residues, and called polonium, is nothing other than radium F, that accumulates in the pitchblende.

In the radium series there are five products that disintegrate, giving off alpha particles (helium atoms), viz: radium, radium emanation, radium A, C and F. Taking the atomic weight of radium as 226.4 and that of helium as 4, it may be supposed that the atom produced, when radium F disintegrates should have an atomic weight equal to 226.4 less 5x4, or 206.4. This is almost exactly the atomic weight of lead, and it is not at all unlikely that the final product in the radium disintegration series is lead. When larger amounts of radium are available, this point may be settled experimentally, but it can be said that in all old radium ores there is always lead.

(NOTE—This is the second article of a series of three which Dr. C. H. *Viol,* of the Radium Research Laboratory, of Pittsburgh, Pa., consented to write in order to give to our readers in a very short and comprehensive form an idea of the present status of radio-activity. The first article, dealing with "Radium and Its Rays," appeared in the April number of "Radium.")

Notes and Comments.

We are glad to be able to correct the erroneous impression, which apparently has been conveyed to the public by a report issued recently from the United States Bureau of Mines, to the effect that, "while there is one company in the United States engaged in the extraction and refining of radium in this country, this firm has not yet entered the radium market."

The company evidently referred to in this report is the Standard Chemical Company, of Pittsburgh, Pa. This company has acquired approximately 100 claims of radium-bearing ore deposits in Paradox Valley, Montrose county, Southwestern Colorado, with a monthly output of 100 tons of carnotite ore, from which it extracts about half a gram of radium. This radium not only can now be purchased in desired quantities, but medical institutions, scientific schools and individuals have already been furnished with radium from the company's laboratories in Pittsburgh.

In this connection the readers of "Radium" no doubt will be interested in learning that, while, as the United States Bureau of Mines says, this country has the largest deposits of radium-bearing ore, it is also the largest producer of radium in the world.

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Dr. William *Duane*, late of the Madame Curie Laboratory, University of Paris, delivered an address last month in Philadelphia, Pa., at the annual convention of the American Philosophical Society on "Some Unsolved Problems in Radio-activity."

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His Excellency, Professor *Czerny*, of Heidelberg University, who is one of the founders of radium therapy for cancer, and to whom we owe a number of important researches on the influence of radio-active substances on cancerous growths, is going to give up the directorship of the institute for cancer research in Heidelberg and his chair at the university, on account of old age.

* * * * *

The new institute for radiology and physical research for radio-active substances in Heidelberg, which is expected to be one of the finest institutions of its kind, will be formally opened in the beginning of June.

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The Imperial Russian Academy of Science has set aside 10,000 rubles for prospecting for radio-active minerals in the Ural, Caucasus and Siberia.

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The following papers referring to radio-activity were read at the Milwaukee meeting of the American Chemical Society on March 24th:

Charles L. *Parsons*: "The Uranium, Vanadium and Radium Situation"; Herbert N. *McCoy*: "The Alpha Ray Activity of a Layer of Radio-active Solid as a Function of its Thickness"; Herbert N. *McCoy*: "The Periods of Transformation of Uranium and Thorium."

The new Radium Institute of the University Sorbonne, at Paris, which is just now in course of construction, will consist of three buildings—the physical department, with Mme. S. *Curie* as director; the chemical department, with Dr. *Debierne* as chief; and the physiological department, or "maison Pasteur," which will be in charge of Dr. *Regnaud*. The idea of separating the physical and chemical departments in different buildings is certainly a very happy one, as this scheme will prevent the physical measuring rooms with their delicate electrical apparatus from being "infected" by induced radio-activity from chemical manipulations of radio-active substances, as has been the case in more than one of the other radium laboratories abroad. The cost of these three departments is said to be only $140,000.

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The following is a list of the lectures and courses on the physics and chemistry of radio-active elements, scheduled for the summer term 1913 in the universities of Germany and Austria, as compiled from their catalogues: University Berlin—Professor *Hahn*, on "Chemistry of Radio Elements"; Dr. *Regener*, on "Radio-activity." University Breslau—Professor *Sackur*, on "Radio-activity." Polytechnic Darmstadt—*Baerwald*, on "Radio-activity and Electron Theory." Polytechnic, Dresden—*Dember*, on "Radio-activity." University Goettingen—*Bestelmayer* and *Rausch v. Traubenberg*, "Radio-activity and Electronics." University Heidelberg—*Becker*, "Radiology and Radio-activity." University Innsbruck—Professor Dr. V. *Lerch*, "Conduction of Electricity by Ions and Electrons." University Jena—Professor *Marc*, "Special Chemistry of Radium and Rare Earths." University Vienna—*St. Meyer*, "Production and Properties of Radio-active Substances." University Zurich—*Greinacher*, on "Radio-activity." Polytechnics, Zurich—*Schmidlin*, "Rare Earths and Radio-active Elements."

The small amount of work done in the science of radio-activity in the universities and colleges in this country, where only very few universities have "radio-active professors," contrasts poorly with the large interest taken on this important subject in the centres of learning abroad.

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Dr. A. *Goldberg* reported recently to the Medical Society of Moscow (Russia) his results of treatment of thirty cases of gout and rheumatism, according to the "Berliner Klinische Wochenschrift," Vol. 1913, p. 618. While he draws attention to the fact that obviously in cases of organic deformations and alterations of bones and cartilages, a complete "restitutio ad integrum" cannot be expected, he records in the milder cases treated, complete cures with radium emanation; in the worst cases, decided improvements; and always regular lessening of pain after treatment. He concludes that radium emanation has secured its place among the most effective therapeutic agents.

RECENT INVESTIGATIONS ON THE USE OF RADIUM FOR MALIGNANT DISEASES.

EMILE F. KRAPF, Phar. D.

From five great centers of medical science in Europe, the warfare against cancer with this new and powerful weapon, radium, has been declared. More eagerly than the Athenians awaited the result of the battle of Marathon, the medical profession of today longs for the bulletins of the progress made as regards the efficiency of radium against this deadly disease.

The "Laboratoire Biologique du Radium" in Paris still maintains the leading position in these ranks. Dr. Louis *Wickham*, "the true pioneer of the region of radium therapy," as Sir Malcolm *Morris* justly calls him, has certainly accomplished more in the treatment of neoplasms with radium than any other. He has reported on his results in over sixty papers, and in collaboration with Dr. *Degrais*, in the excellent book on "Radium Therapy," of which the English translation has been published (1910) by Cassell & Co., Ltd. His institute works in competition with the Hospital de St. Louis, in Paris, where Dr. *Dominici* has charge of the extensive treatment of skin diseases and cancer with radium.

In Germany, the "Samariterhaus," at Heidelberg, of Dr. V. von *Czerny*, is doing excellent work in the same direction, and the papers of *Czerny*, *Caan*, *Werner*, and others have given wide publicity to their results.

Recently three more institutions for the study of radium therapy have been founded; and it is more than a coincidence that the first reports of these clinics have just been published almost simultaneously.

This first report includes the work carried out at the Radium Insti- Institute is presented by its medical superintendent, Dr. A. E. Hayward *Pinch*, in the form of a booklet of 51 pages.

The first report includes the work carried out at the Radium Institute from its foundation in August, 1911, to the close of 1912. For its cautious conservatism, and its true scientific spirit, as well as for the remarkable results recorded, this report will always remain a most valuable document in the history of the war against malignant diseases. Dr. *Pinch* warns repeatedly against the "irrational enthusiasm and that unthinking expectation which so often attends the debut of a new remedy."

The London Radium Institute, of all the medical institutions in the world, certainly possesses the largest quantities of radium, probably over two grammes of radium bromide. From this stock, the chemophysical laboratory of the institution, under the direction of the well-known radium chemist, W. Lester *Alton*, had prepared a large number of radium applicators, varying from 3.5 mgrs. to 75 mgrs. radium (element) content. Two types were used; first, tube applicators, consisting of glass tubes filled with radium sulphate; and secondly, flat shallow applicators, i. e. trays of German silver on which were varnished one-half to six milligrams radium (element) in the form of radium salts. Aluminum, silver and lead filters, ranging from 0.01 to 2 mm. in thickness were applied to cut off part of the less penetrating rays, especially in prolonged applications.

The following table gives a summary of the cases examined and treated:

Examined but not treated	38
Recently treated and results not yet noted	41
Received prophylactic irradiation only	39
Apparently cured	53
Cured	28
Improved	245
Not improved	70
Abandoned treatment	88
Died	51
Total	657

In discussing these statistics, and especially the results in cancer treatment, two points must constantly be kept in mind; Dr. *Pinch* rigidly defines the term "apparently cured" to a condition, in which all traces of the original lesions have disappeared, in which there is no sign of any recurrence, and in which the patient is, so far as can be determined by a thorough and careful examination, free from any indication or symptoms of the disease. While this definition considerably reduces the number of "apparently cured" and "cured" cases in the statistics, it is also only fair to state, that no cases of malignant diseases (except rodent ulcer) have been treated, "other than those in which operation had been declared to be unjustified, or had been declined by the patient," and that obviously by far the larger part of the patients applying for treatment were cases where "all the known resources of medicine and surgery had been exhausted, and their condition being almost hopeless."

Out of the six hundred and nineteen patients treated, one hundred and thirty-four cases were epithelioma. Of these, eight were so recently treated that the results cannot be definitely stated, fifteen received only prophylactic application of radium, and in twenty-three cases the treatment was abandoned, chiefly because the patients removed from London. Of the still remaining eighty-eight patients, twenty-two (or 25%) died, in twenty cases no apparent improvement was observed, while the result was favorable in forty-six (or 52%) of the patients. Of these forty-six cases, Dr. *Pinch* classifies seven as "apparently cured," and thirty-nine as decidedly improved. This result becomes still more interesting when we consider the carcinoma of the uterus separately. Here the London Radium Institute achieves as great success as that in Paris. It seems that, out of twenty-nine cases definitely recorded, three were cured, and nineteen improved (together seventy-six per cent.). In a majority of the cases, hemorrhage was arrested, discharge diminished and rendered inoffensive and ulceration healed.

In cancer of the breast, in fifty-eight cases where definite results are recorded, the treatment failed in twenty-three cases, while in no less than thirty-five (sixty per cent.) it was more or less successful.

The results are less favorable in cancer of the rectum, ten cases being apparently cured, or improved, while ten died or remained refractory. However, in nearly all cases hemorrhage was more or less arrested and pain alleviated.

"In some instances, the growth shrinks in size, undergoes a fibrous transformation, and becomes much less fixed to the underlying tissues,

so that a carcinoma which before radium treatment was regarded as inoperable can be easily and completely removed."

Carcinoma of the stomach and of the liver are treated in the London Radium Institute by applying flat applicators outside near the afflicted region, and obviously very little benefit can be expected from such application, though it is recorded that "the pain was lessened, the frequency of vomiting decreased, and the general health improved."

The splendid success the Institute achieved in malignant cases of carcinoma of thyroid and in two cases of Paget's disease was very remarkable. "Rodent ulcer is," to quote Dr. *Pinch*, "of all the forms of malignant diseases, the one which is most amenable to the action of radium." Of eighty-five cases with complete records, not less than forty-one were decidedly improved; thirty-one "apparently cured" (together eighty-five per cent. successful). The result is even more astounding, as in more than one-half of the cases of rodent ulcer which applied for treatment at the Radium Institute "the destruction of tissue was so great that no hope of satisfactory repair could be entertained." Rodent ulcers of mucous membranes proved to be the most refractory, though very small ulcers of the palebral mucosa responded well to exposures of fifteen to twenty minutes of strong unscreened radium applicators.

Only a few cases of sarcoma were treated, of which two were "apparently cured" and nine improved (together 40%). A very rapidly increasing growth of the superior maxilla of a patient seventy-three years old was treated with excellent success. Four cases of Hodgkins' disease are all recorded as being "improved" after radium treatment.

It is well worth noting that, like the French and German authors, the physicians of the London Radium Institute repeatedly insist on the marked analgetic effect of radium application, even in cases where the treatment was not successful. While the report conservatively advises, that in all operable cases of cancer of the breast and of the rectum the use of the knife should be first resorted to, the general conclusion is, however, that radium application is our next best method for treatment of malignant diseases.

The report insists also on the advisability of the routine adoption of post-operative treatment of malignant growths, and of thirty-nine patients who received such prophylactic radium applications only a few showed recurrences.

We cannot refrain from referring with a few words to the results obtained at the London Institute in the treatment of naevi, especially "port wine stains" and keloids, which are now generally considered as belonging to the domain of radium therapy. Of thirty-eight cases of capillary cavernous naevi, favorable results were obtained in all but one case, and in five of these the word "cured," so carefully avoided throughout the report, is confidently applied. Only fourteen cases of keloid were treated, and here Dr. *Pinch* is compelled to leave his self-imposed restriction and pronounces the results obtained with radium as "admirable." Keloids of recent formation seem to respond especially quick. In pruritus, radium is pronounced to be "undoubtedly of great value," especially if this condition is of long standing and associated with leucoplakia, or hyperkeratosis.

Psoriasis is treated in the London Institute with short exposures of unscreened applicators for two or three minutes for several days, and all seven cases treated have been either cured or improved.

Lupus erythematosus is "usually greatly improved by radium," and weak doses are recommended in this condition. In tuberculosis adenitis, very long exposures of heavily screened radium applicators succeeded in bringing about a steady diminution in size of the infected glands.

Not being satisfied with restricting itself to local radium applications, the new British institution has in the last month devoted some attention to the treatment of arthritic conditions by means of radium emanation drinking water, and it is very gratifying to know that the splendid results of the German and Austrian hospitals with this method are confirmed by the British doctors. They observed also incidentally that the emanation solutions produced a definite diuresis and acted as a slight laxative.

Considering this to be the first report of the institute, the short period of time that has elapsed since its foundation, which time has hardly given the opportunity to work the methods and obtain ex- hardly given the opportunity to work out the methods and obtain experience in the technique of radium, we cannot help but congratulate the London Radium Institute and its able staff for their splendid achievements.

A smaller institution than the London Radium Institute, and not so richly endowed, is the radium department of the Edinburgh Royal Infirmary, which owes its completeness to the efforts of Dawson *Turner*, M.D. He also has achieved some very excellent results, and in his latest report, which was published in the January issue of the Lancet, he gives the results of the treatment received by forty-one patients.

The cases which have been most benefited during the year have been naevi and rodent ulcer. Of eleven naevi, of which two were port wine stains, seven were cured, three are under treatment, and one port wine stain did not return. Dr. *Turner* states that: "Rodent ulcers, if not affecting mucous membranes, cartilage or bone, are also amenable to radium. It is far superior to carbonic snow, because the penetrating gamma rays attack the roots of the rodent ulcer; and, secondly, the treatment is painless."

Twelve patients suffered from malignant disease, and in some of the cases a tube of radium was inserted into the growths and maintained there for periods of up to twelve days, while at the same time external treatment was employed so as to subject the growth to cross fire of the rays. Of these twelve cases, one was healed, three improved, one exhibiting temporary improvement, one (carcinoma of the larynx) was unrelieved and died. Of the remaining six cases, two are still under treatment, one did not return for treatment, one refused treatment, in one a prophylactic dose of radium was given after an operation for the removal of sarcomatous growth in the groin, and in one the growth was so extensive as to render a resort to the treatment with the limited amount of radium hopeless.

Taken as a whole, these results in the Edinburgh Infirmary bear out the results obtained in the London Radium Institute.

The third of the new Radium Institutes is the Radium Department of the General Hospital in Vienna, in charge of Dr. *Riehl*, which the Austrian Government has generously endowed with radium from the Imperial Mines. This department has been but recently formed, and the technique used by Dr. *Riehl* and his assistants is that suggested by Drs. *Wickham* and *Degrais*. Their results with cancer, even in this short time, are sufficient to warrant an encouraging report.

When it is considered that these results mean an advance in the warfare on cancer, it is to be regretted that so far in the whole United States there is no institution devoted entirely to radium therapy. Such extensive researches as those referred to above are only possible in institutions especially endowed for radium research.

The honor of first providing this country with a Radium Institute is one which yet remains to be conferred.

Reviews and Abstracts.

Leop. *Freund.* "Experiences with Radium and Mesothorium." Wiener Klinische Wochenschrift, 1913. Volume 1, page 393.

Author compares the effect of radium with that of mesothorium, which has lately been suggested as a substitute for radium, in a case of lupus vulgaris. Mesothorium also gives off beta rays and gamma rays. but they are of less penetrating power than those of radium. An applicator with 16 milligrams of mesothorium gave practically the same effect as the application of 16 milligrams of radium (metal) covered with a thin mica plate. There remains the one disadvantage of mesothorium, that its efficiency decreases fairly rapidly (to one-half in ten years), while that of radium (which has a half life *period* of 2,000 years) remains practically constant for longer than a life time.

* * * * *

F. *Winkler.* "On the Effects of Radium Emanation." Wiener Medizinische Wochenschrift, 1912, page 2,685.

Small fishes (leuciscus phoxinus and alburnus) and snails (limnaea stagnalis) placed in water containing relatively large amounts of radium emanation (from 2,000,000 to 4,000,000 Mache units) died soon after exposure. Frog spawn in such water showed much more rapid development than controls in ordinary water. Experiments with water weed (elodea and ceratophyllum) gave similar reports. O. B.

* * * * *

H. *Greinacher.* "On a new direct reading measuring apparatus for ions (ionometer)." Radium in Biologie und Heilkunde. Volume 2, page 137 (1913).

Description of a new type of apparatus for measuring small quantities of radium and radium emanation.

* * * * *

K. *Aschoff.* "The New Radium Inhalatorium at Kreuznach Springs." Radiologische Mitteillungen. Volume 5, page 45 (1913).

Description of a new building designed and devoted, exclusively for treatment with radium emanation. The air in the room into which radium emanation is supplied proved on different days to contain between 13 and 72 mache units per liter. This is a very considerable concentration. O. B.

* * * * *

Prof. H. *Kionka.* "The Solubility of Radium Emanation in the Blood." Radiologische Mitteillungen, 1913, page 17.

By means of a kinetic method, it was established that radium emanation is about three to four times as soluble in blood as in water, under the same conditions of temperature and pressure. O. B.

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Recent Work on the Transmutation of Elements

PART I

By A. T. Cameron

Assistant Professor of Physiological Chemistry, University of Manitoba.

In his recent work on "Radio-active Substances and Their Radiations" Professor *Rutherford* (1) thus outlines the guiding idea of those who are engaged in one of the most fascinating and baffling problems, equally in modern and in ancient times: "Since there are strong reasons for supposing that the radiations from active matter actually penetrate the atoms in their path, it seems not impossible that the radiations might themselves cause a disintegration of some of the atoms of matter which they traverse. In consequence of the great energy associated with the alpha particles expelled from active matter, it is to be expected that the alpha rays would be most effective." His conclusions from the published data are: "There is, so far, no good evidence that the ordinary inactive chemical elements can be transformed by the radiations from active matter. On the other hand there is indubitable evidence that atomic transformations spontaneously occur in the radio-active elements themselves."

Before considering recent work on transformation it is desirable to review briefly the results on which *Rutherford* based his conclusions. In the years 1907-09 a series of papers were published by Sir William *Ramsay* and his co-workers (2); in these certain facts were stated, and from these facts certain conclusions were tentatively drawn. An attempt to decompose solutions of copper salts with radium emanation (niton) resulted in no liberation of metallic copper. Analysis after treatment revealed though the spectrum a trace of lithium. There were several possible sources. It might have come from the glass and silica vessels employed during the treatment of the salt with emanation, and the

subsequent analysis. It might be present as an impurity in the copper salt or the reagents employed. It might be formed as a product of the action of the emanation. These possibilities were tested in a series of special experiments.

The pure copper salt, confined for the same length of time in a sealed vessel of the same glass, then subjected to analysis in the same silica vessels, with the same reagents, gave no trace of lithium. This apparently showed that the lithium came neither from the salt, nor from the glass and silica, nor from the reagents. It might be dissolved from the glass through the alpha ray bombardment. A parallel experiment to test this point was made in which distilled water was substituted for the copper solution. No lithium was found. The final supposition seemed therefore not unlikely. Lithium itself is that member of the copper group of least atomic weight, and *Ramsay* suggested that here there might be an unusual degradation, of copper into lithium, induced through the action of the radio-active bombardment. At the same time it was observed that in the experiment with distilled water the gases when examined showed the presence of neon. It was not thought that such an amount of neon could be obtained from air leakage, and it was suggested that it had been also produced by an atomic change. This formation of neon was confirmed in subsequent experiments.

Experiments were carried out with over 200 c.c of a *thorium* solution, in which the gases evolved were examined every second or third month. They consisted chiefly of nitrogen and carbon dioxide. While the former decreased, suggesting adsorption on the walls of the containing vessel as its source, the latter remained proportional in amount to the time of accumulation. Carbon is the member of the thorium group of lowest atomic weight. It appeared possible that here a similar change took place to that in the copper experiments. Further experiments were made in which the relatively feeble alpha ray bombardment from thorium and its products was supplemented by that from radium emanation, and other elements of the thorium group were also treated with the emanation. The amounts of solution were only 2 or 3 c.c. While a check experiment with a lead salt gave only the merest trace of carbon dioxide, in experiments with thorium, zirconium, titanium, and silicon salts quantities of this gas ranging from 0.06 c.c. (silicon) to 0.55 c.c. (thorium) were obtained where the total space was only 2 or 3 c.c., and there was practically no possibility of air leakage. These results also appeared to support the theory of a degradation of carbon. So much for the positive side of the question.

Mme. *Curie* and Mlle. *Gleditsch* (3) attacked the copper-lithium problem. They found that when pure water remained for some time in a glass or silica vessel, and was then evaporated, the small residue contained a trace of lithium. They therefore carried out the whole of their experiments—otherwise similar to those of *Ramsay*—in platinum vessels, and obtained no lithium. *Rutherford* and *Royds* (4) tested the formation of neon in experiments with distilled water. They found that when one-fifteenth of a c.c. of air was subjected to the same analytical treatment (separation by charcoal cooled to liquid air temperature, and spectral analysis), neon was perceptible in the spectrum of the residual gas. They devised special apparatus to exclude air leakage completely. They obtained no neon. *Herschfinkel* (5) carried out experiments *not* exactly parallel to *Ramsay's* since he subjected large amounts of thorium salt solutions to the action of radium emanation. He obtained carbon

dioxide. He obtained *more* carbon dioxide when he replaced the emanation by small quantities of potassium permanganate. He concluded that the carbon dioxide resulted from traces of organic matter, destroyed alike by emanation and permanganate, that these were probably traces of oxalate present in the thorium nitrate used, and that this was the cause of the carbon dioxide in *Ramsay's* experiments. *Ramsay* (6) answered that in his later experiments all organic matter was removed by initially heating the thorium nitrate to redness, and that *Herschfinkel's* explanation applied, therefore, only to his own results, and not to the original ones of *Ramsay*.

At this stage the problems remained for some time. It will be observed that there is in each case one series of experiments for, and one against, each suggested transmutation. I shall now deal briefly with the more recent work.

In a paper published a year ago *Ramsay* (7) states, referring to his previous work, "It appears to have been generally assumed that the neon found by us owed its presence to atmospheric contamination. I have now other evidence which make it almost certain that neon is either a product of degradation of niton, or is produced by the action of niton on water, preferably the latter alternative." His evidence is both observational and experimental. The experimental evidence adduced consists in a measurement of the amounts of residual gases (neon and helium) obtained after treatment of thorium nitrate solution with radium emanation in a small bulb under conditions which excluded air leakage. He obtained 0.485 cubic millimetre of inert gas. Of this 0.308 was helium, according to calculation from the known radio-active transformations. The neon spectrum was possibly strong enough to account for the remainder, 0.177 cubic millimetre. *Ramsay* and *Collie* estimated from the relative brightness of the spectra in the mixed gas that the neon was at any rate present in amount one-quarter that of helium, while 0.05 cubic millimetre would imply a leakage of 4 c.c. air, were air the source. Absence of argon confirmed absence of air.

The *observational* evidence brought forward was derived from analyses of the gases liberated from the mineral springs at *Bath, England*. The King's Well there liberates in 24 hours 5 cubic metres of gas, containing per litre 36 c.c. of carbon dioxide and 964 c.c. of nitrogen and inert gases (7.263 c.c. argon, 2.334 c.c. neon, 0.297 c.c. helium). Both water and gas contained radium emanation. The water contained a trace of radium. Atomspheric air per litre contains 9.32 c.c. argon, 0.0124 c.c. neon, and 0.00408 c.c. helium, so that while the evolved gases contained only 0.78 times the atmospheric content of argon, they contained 188 times the corresponding amount of neon, 73 times that of helium. The helium (1.5 litres per 24 hours) could be attributed to the normal radio-active transformations. The relatively enormous liberation of neon (12.5 litres per 24 hours), and the presence of neon in the experiment described, *Ramsay* considered best explained as due to the action of radium emanation on water.

In all the work so far described, atomic change, if change took place, could be ascribed chiefly to the action of alpha rays, electrically charged helium atoms moving at high speed. In the subsequent experiments the changes postulated are ascribed to the action of cathode rays — to the electrons, with far minuter mass, but moving with greater speed.

(To be continued in the next number, which will include the table of references.)

NOTES AND COMMENTS

In the May 17 number of the Journal of the American Medical Association we note the following abstract of a paper on "Radium in Surgery," delivered at the annual meeting of the New York Medical Society at Rochester, N. Y., April 28-30, by Dr. Howard A. *Kelly,* of Baltimore, Md.:

"Radium is destined to produce a change in surgical and medical work not less marked than the introduction of the Roentgen ray, perhaps even more decided. Radium in surgery will definitely cure many forms of cancer, especially in the early stages; it will cure 96 per cent. of skin cancer, recurrent uterine cancers if taken early, and some cases of rectal cancers; it acts most favorably upon parotid growths; it will cure some cancers of the lip, tongue and breast, and acts also very positively on sarcomas. It also cures various other fibrous and epithelial growths, especially on the surface of the body. One of its happiest effects is in curing angiomas, even the large vascular growth which cannot be treated at all surgically. In gynecology radium acts happily, outside of its value in cancer, in checking the growth of fibroid tumors, in stopping uterine hemorrhages and in relieving some forms of pelvic inflammatory trouble. One of its happiest uses is in the cure of obstinate pruritus of the vulva and anus. In exophtalmic goiter there is promise for a definite field of utility. Its use in surgery, dermatology and medicine bids fair to bring about either a realignment or a readjustment of the work in these special branches."

* * * * *

The fourth International Congress for Physio Therapy was held in Berlin from the 26th to the 30th of March. The following papers, referring to radium therapy, were read:

Dr. *Wickham* (Paris): "The Morphological Effects of Radium Rays."

Dr. W. *Falta* (Vienna): "Chemical and Biological Effects of Radio-active Elements."

Dr. *Degrais* (Paris): "Treatment of Rhinophyama with Radium."

Dr. *Giraud* (Paris): "Absorption of Radium Rays in Tissues."

Dr. *Mesernitzky* (St. Petersburg). "Radium Emanation Therapy in Gout."

Dr. *Marckwald* (Berlin): "The Disintegration Theory of Radio-active Elements."

Dr. *Salle* (Berlin): "Biological Effects of Thorium X."

Dr. *Stefan Meyer* (Vienna): "Radium Standard and Methods for Measuring Radium."

Dr. *Sieveking* (Karlsruhe): "The Measurement of Radio-activity of Springs."

Dr. *Delherme* (Paris): "Treatment of Sciatica with Radium."

Dr. *Werner* (Heidelberg): "Radio Therapy and Radium Therapy of Neoplasms."

Dr. *Beclere* (Paris): "Radium Treatment of Acromelalgia, Gigantism and Pituitary Tumors."

Dr. *von Scuffert* (Munich): "Mesothorium and X-ray in Treatment of Carcinoma of the Uterus."

* * * * *

Dr. Otto *Brill*, director of the Radium Research Laboratory of the Standard Chemical Company of Pittsburgh, has gone abroad for a two months' vacation.

* * * * *

Professor *Schmidt*, formerly of the University of Giessen, has been appointed professor of radio-activity in the School of Mines at Freiberg in Germany.

* * * * *

We learn from "Science" that Professor Bernhard *Kroenig*, professor of obstetrics at the University of Freiburg in Germany, has accepted an invitation to lecture on Roentgen and radium therapy before the American Surgical Society in Chicago.

* * * * *

The effect of radium in the treatment of cancer is to be made the subject of special investigation at Harvard Medical School, under the direction of Dr. William *Duane*. Dr. *Duane* has studied in the laboratory of Madame *Curie*, the discoverer of radium, and has been in touch also with the work of the Radium Institute in London. The announcement of the plan says that a group of investigators is being assembled to attack the problem of cancer treatment from various points of view.

* * * * *

The new Institute for Radium and Radiology in Heidelberg, under the direction of Professor *Lenard*, was formally opened on May 1st.

THE RADIO-ACTIVE ELEMENTS

C. H. VIOL, Ph.D.

Radio-activity, as generally understood, is the property which certain elements possess, of spontaneously sending out rays capable of penetrating through metals and other substances. These rays are further characterized by their ability to affect the photographic plate, to cause the discharge of electrified bodies, and to excite phosphorescence and fluorescence in some substances. *Rutherford* and *Soddy*, to account for the phenomena of radio-activity, assumed that, in the case of the radio-elements, the atoms become unstable and disintegrate. This transmutation takes place at a definite rate that is characteristic for each of the radio-active substances. As far as present experiments show, the rate of transmutation of the *radio-elements* is unchangeable, so that the time required for the decay of one-half of any amount of a radio-element, the so-called "*half decay period*," or, briefly, "*period*," is definite for each of the substances. Thus in 2,000 years half of all the radium now present in the world will have disappeared, 2,000 years being the *period* of radium. The transmutation of the radio-elements in usually accompanied by the violent shooting out of an alpha ray (positively charged helium atom), the remainder of the atom becoming an atom of a new element. In this way the atom of radium, a metal, changes into an atom of *niton* or *radium emanation*, a gas. This emanation atom in turn is unstable, and breaks up, giving off an alpha particle and forming an atom of a substance that has been named radium A. Radium A, being a solid substance, settles and forms the *active deposit* of radium. This radium A in turn decays, giving rise to radium B, which produces radium C. Radium C gives off not only alpha but also the beta and gamma rays, when it changes. The beta and gamma rays are more penetrating, being in nature like the cathode and Roentgen rays, respectively. It may be seen then, that radium salts freshly prepared will give only the alpha rays, but if the emanation is not lost, that is if the specimen is kept sealed, then this emanation will produce the active deposit, which contains radium C. It is by means of these gamma rays of radium C, which reach a maximum intensity about a month after the sealing of the radium preparation, that quantities of radium, from one hundredth of a milligram upwards, may most accurately be determined.

The radio-elements now known number about thirty, and may be grouped into four families—the uranium group, the radium group, the actinium group, and the thorium group.

In 1898 G. C. *Schmidt* and, independently, Madame *Curie* discovered that the element thorium is radio-active. In 1899 *Owens* discovered the thorium *emanation*, and in 1902 *Rutherford* and *Soddy* found the substance thorium X, which is being continually formed in thorium compounds and which in turn is the immediate parent of the thorium emanation. It was first supposed that thorium itself gave rise to thorium X, but later work has shown that there are three intermediate products between thorium and thorium X. Hahn in 1905 discovered the substance radio-thorium, which has been found to be the immediate parent of thorium X. In 1906 certain discrepancies found by *McCoy* and *Ross* and by *Boltwood* in the specific activity of thorium prepared from minerals and from commercial salts, led *Hahn* to suggest

that a "rayless" product came between thorium and radiothorium. This new substance was soon after found and called mesothorium. It was found to be complex, and the first product, which gives no rays in changing, is called mesothorium 1. This substance has a period of 5.5 years. A short-lived product coming between mesothorium 1 and radiothorium called mesothorium 2, decays with a period of 6.2 hours, giving rise to strong beta and gamma rays. It has been possible to separate and concentrate quite considerable quantities of the mesothorium 1 from the enormous quantities of residues left in process of manufacturing the pure thorium salts which are necessary for the incandescent mantle industry. This mesothorium, weight for weight, is much more active than even pure radium preparations. It is sold on the basis of its gamma ray activity being equal to the gamma ray activity of so many milligrams of radium, but it has a comparatively short life, being half decayed in 5.5 years. Thorium emanation, like radium emanation, gives rise to a solid form of radio-active material, which constitutes the thorium *active deposit*. Careful work has shown that this deposit is complex, consisting of a series of successive products which have been called thorium A, thorium B, thorium C_1, thorium C_2 and thorium D, respectively. The longest lived of these is thorium B, with a period of 10.6 hours, so that the decay of activity of the thorium active deposit takes place with this period. Thorium X can be separated from radiothorium preparations in which it forms, and it has been used in medicine, where it has been found to have a considerable effect on the blood, although in several cases injections of high doses of thorium X have led to fatal results.

The actinium series is characterized by the short periods of its products. Actinium itself gives off no rays, in changing, and its period is unknown. Radioactinium, the next product, has a period of 19.5 days, and actinium X, which forms from radioactinium, has a period of 10.2 days. Like thorium X and radium, actinium X gives rise to a gaseous form of radio-active matter, which is called the actinium *emanation*. This gas has a period of 3.9 seconds, and in decaying gives rise to a characteristic actinium active deposit. This active deposit is also complex, consisting of four successive products that have been called actinium A, actinium B, actinium C and actinium D. Actinium A, the product formed when the emanation atom changes, has a period of 0.0029 second—truly a short-lived element!

Since the period of radium is only 2,000 years, it is evident that in about 20,000 years practically all the radium now existing will have transmuted, and, in order to account for the presence of radium today, a longer-lived product must be sought. This parent is the element uranium. A number of researches, beginning with the work of *Boltwood*, *McCoy*, and of *Strutt*, have shown that there is a relation between the amount of radium and of uranium in most uranium minerals. Experiments were carried out to test whether the newly-formed radium could be detected in uranium initially freed from radium. The experiments gave negative results, and *Boltwood* found that there is a long-lived product, *ionium*, in the series between uranium, uranium X and radium.

Actinium is always found in the uranium minerals, and its origin is obscure, though it seems probable that it results as a branch product in the uranium series. That is, one of the products in the uranium series is thought to disintegrate in two fashions, one of the products

being actinium, the product of the other method of changing being a substance which finally leads to radium.

The following diagrammatic representation of these series of radio-active elements shows the order in which the products occur, their periods, and the rays which they give off in the process of their transmutation:

URANIUM 1 5,000,000,000 years alpha rays		
URANIUM 2 1,000,000 years (?) alpha rays		THORIUM 13,000,000,000 years alpha rays
URANIUM X 24.6 days beta, gamma rays		MESOTHORIUM 1 5.5 years Rayless
URANIUM Y 1.5 days beta rays	ACTINIUM Period unknown Rayless	MESOTHORIUM 2 6.2 hours beta, gamma rays
IONIUM 200,000 years (?) alpha rays	RADIO ACTINIUM 19.5 days alpha rays	RADIOTHORIUM 2 years alpha rays
RADIUM 2,000 years alpha rays	ACTINIUM X 10.2 days alpha rays	THORIUM X 3.65 days alpha rays
EMANATION (Niton) 3.86 days alpha rays	ACT. EMANATION 3.9 seconds alpha rays	TH. EMANATION 54 seconds alpha rays
RADIUM A 3 minutes alpha rays	ACTINIUM A 0.002 second alpha rays	THORIUM A 0 14 second alpha rays
RADIUM B 26.8 minutes beta, gamma rays	ACTINIUM B 36 minutes beta rays	THORIUM B 10.6 hours beta rays
RADIUM C 19.5 minutes alpha, beta, gamma rays	ACTINIUM C 21 minutes alpha rays	THORIUM C 1 60 minutes alpha rays
RADIUM D 16.5 years beta rays	ACTINIUM D 4.71 minutes alpha, beta, gamma rays	THORIUM C 2 Period very short (?) alpha rays
RADIUM E 5.0 days beta, gamma rays		THORIUM D 3.1 minutes beta, gamma rays
RADIUM F (polonium) 136 days alpha rays		BISMUTH (?)
LEAD (?)		

The study of the chemistry of the radio-elements presents many new problems of great difficulty. In the case of the "rare earths"

the great difficulty has been to separate the chemically similar elements and make certain that the substances so separated were really not mixtures. Thus the element long known as didymium was later separated by von *Welsbach* into two substances, which are called neodymium and praesodymium, which are supposed to be elements. In the case of the radio-elements this chemical similarity of elements is also encountered, and in some cases the resemblance of several elements is so great that no means so far tried avails to separate them, although the separate elements may be prepared in a state of radio-active purity by round-about means. Thorium, radiothorium, and ionium, when together, cannot be separated from each other, and this is also true of mesothorium and radium. Uranium is supposed to be a mixture of two inseparable products called uranium 1 and uranium 2. All the radio-elements are decaying with a period that is characteristic for each element, and this enables one to work with these elements and recognize their presence even when any ordinary means, such as the spectroscope or atomic weight determinations, etc., would be futile. Thorium and radiothorium are chemically identical and inseparable, but mesothorium, which comes between thorium and radiothorium as an intermediate disintegration product, may easily be separated from these. Mesothorium in turn produces radiothorium, which may then be separated in a state of radio-active purity, that is, quite free from thorium. Likewise if thorium is continually treated to remove the mesothorium as fast as it forms, the production of radiothorium in the thorium is prevented, and in the course of time (more than twenty years would be required for this particular case) the radiothorium originally present in the thorium, and inseparable from it, will decay finally, leaving thorium free from radiothorium.

Except in the case of radium and radium emanation, and the long-lived elements uranium and thorium, quantities of the radio-elements have not been prepared which would permit of accurate atomic weight determinations, and in the case of the greater number these elements of short life, it is doubtful whether such quantities will ever be obtained. This makes the study of the chemistry of these elements very difficult, and this problem is being attacked in several ways, notably by a study of the electrolytic behavior of the elements, by their behavior in the presence of other ordinary elements (e.g. the great resemblance of radium salts and barium salts would allow us to predict the nature of radium, even if it had not been possible to isolate the salts in a state of high purity, and to demonstrate that radium is a bivalent metal similar to barium), and by a study of their volatility.

The study of the phenomena of radio-activity and the properties of the radio-elements has proved valuable in ways too numerous to detail. We may now see the evolution of matter, the more stable forms resulting finally from the more complex; we realize somewhat of the enormous amounts of energy stored in our ordinary matter; geology and astronomy must take into consideration these new sources of energy, the radio-elements; and medicine has been endowed with valuable new agents which present great possibilities, even the dream of the old alchemists, the transmutation of matter, is now not to be scouted as beyond reason. We may not ever be able to actually cause the transmutation of ordinary forms of matter, we may never be able to unlock the tremendous stores of subatomic energy, but even if we should fail

in this, the efforts made cannot but be of the greatest benefit in teaching us much that is of value.

(This is the last of a series of three articles which Dr. C. H. *Viol*, of the Radium Research Laboratory of Pittsburgh, Pa., has written, to present to our readers in a short but comprehensive form an idea of the present status of radio-activity. The first article, dealing with "Radium and Its Rays," appeared in the April number, and the second, dealing with "The Production and Decay of Radio-active Matter," appeared in the May number of Radium.)

REVIEWS AND ABSTRACTS

Francis H. *Williams* and Samuel W. *Ellsworth*. "Treatment of superficial new growths by pure radium bromide." Journal of the American Medical Association, Volume 60, No. 22, page 1694, 1913.

The authors have worked with 120 milligrams of pure radium bromide and about 20 grams of less pure salt, about 50 milligrams of the purer material being generally used in the applicator, which was suitably screened with alluminum. Tabulated data on a total of 181 cases of cancers, affecting parts of the face, neck, hand and breast, show a total of 154 cases healed, 7 not healed, 3 under treatment, and 17 discontinued. Of the 154 listed as healed on Jan. 1, 1911, at present 135 are still healed, 16 have had recurrences, and there have been 3 deaths. Growths affecting the lymph nodes, the tongue, mouth and tonsils, respond to radium treatment only if taken in the very early stages, but in keloids, and in skin diseases such as eczema, warty growths, psoriasis and in birth marks, the treatment with radium has given excellent results. The following conclusions are given in regard to the application of radium:

"1. The application of pure radium bromide in sufficient amount, properly used, is a harmless, painless and efficient method of treating early superficial new growths. Radium is well adapted to cancers of the face, as the cosmetic results are excellent, and particularly to the eyelids, where operation may offer special difficulties and disadvantages. With proper care there is no danger to the eye."

"2. Operation is still considered today the method of choice in early skin cancers by most practitioners, but the results obtained here and abroad show, we believe, that radium should be used first in early cases, and operation reserved for such as are not readily controlled by it."

"3. Radium is more successful when it is the first treatment employed than when it is used after operation, X-rays or other forms of treatment, although even under these circumstances it does well."

"4. The number of treatments required in some cases is from two or three to ten, while in others more than twenty are needed. Improvement usually takes place after two or three applications of the radium."

"5. Many people dread the knife, even for a simple operation, and, fearing surgical interference will be advised, delay coming for

treatment, thus lessening the chances of recovery. Radium is free from dread, as its action is painless."

"6. The analgesic action of radium is noteworthy."

"7. For keloids, unless extensive, radium is by far the best treatment known to us."

"8. Where radium is obtainable, it would be well to use it for skin lesions of small area which do not heal readily under simple applications."

"9. All powerful remedies have dangers, but they can be avoided if care is taken. During the seventeen years the X-rays have been used at the Boston City Hospital, no patient has been burned, nor have any untoward results occurred in about ten years during which radium has been employed there."

J. *Kemen.* "Comparison of different methods of emanation treatment by means of examination of the blood." Radiologische Mitteilungen. Volume 5, page 25 (1913).

The question whether the undoubted results of treatment with baths containing radium emanation can be ascribed to the permeability of the skin for radium emanation has been answered by *Kohlrausch* and *Plate* in the negative. These authors ascribed the effects of radium emanation baths rather to the inhalation of this gas, out of the water, by the patient during the bath. The careful experiments of *Kemen* tend, however, to show that even if, by a special device, inhalation of the air of the bathroom is excluded, after a bath in water containing about 50 to 100 Mache units per air, the blood of the patient is radio-active, and contains from 1 to 4 Mache units per liter. This is about the same concentration as has been found by other authors in the blood of patients who have remained for one hour in an emanatorium room of 10 Mache units per liter air.

In other experiments, the author shows that even after application of a "radium compress" on the skin the blood acquired a concentration of 1.5 to 2.5 Mache units radium emanation per liter. This seems to prove conclusively the permeability of the skin for radium emanation. In this case, as in the case of radium baths, the effect of the radio-active decay products of radium, deposited on the skin, is probably also a factor in the results from this treatment.

F. *Gudzent* and W. *Neumann,* "Permeability of the Human Skin for Radium Emanation." Radium in Biologie und Heilkunde. Volume 2, page 144 (1913).

Working in the Radium Institute of the Royal Charity Hospital in Berlin (Director *His*), the author attacks the same problem as *Kemen* (see preceding abstract) by another way. A patient was placed nude in a very small hermetically sealed room, which was filled with

radium emanation of 120 Mache units per liter air. A mask was fitted to the mouth of the patient, so that he could inhale only inactive (external) air, and his exhaled air was collected and analyzed for radium emanation. The results show that under these conditions practically no radium emanation was exhaled, and the authors conclude that radium emanation does not enter the body through the skin.

The abstractor believes, however, that this experiment is not so conclusive as those of *Kemen,* because the method of measuring was not accurate enough to determine such a small concentration of radium emanation in the exhaled air as might reasonably be expected. Even assuming that the results of *Gudzent* and *Neumann* are correct, it is still possible that the wet skin permits the radium emanation to diffuse into the body more rapidly than does the dry skin. O. B.

E. *Vollmer.* "The Effects of Radium in Dermatology." Radiologische Mitteillungen, 1913, page 20.

A capsule with six milligrams of radium (element) was applied six to eight times for ten minutes without filters, but kept about a half an inch away from the skin: One case of tuberculosis of the skin (cheek) cured; one case lupus of the upper lip improved; one case epidermolysis digitorum manus utriusque permanently cured; one carcinoma of the cheek apparently cured; a few cases of psoriasis improved. O. B.

NEW BOOKS

E. *Sommer.* "On Emanation and Emanation Therapy. (German). 2 enlarged editions. Publ. Munich. Verlag der aerztlichen Rundschau, (1913), 161 pages.

E. *Frank.* Die Neueren Wendungen in der Pathologie and Therapie der Gicht. Urban and Schwarzenberg. Vienna, 1912.

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FORBES AND MEYRAN AVENUES, PITTSBURGH, PA.

We shall be glad to receive for publication from our subscribers and readers articles pertaining to the subject of radium and its application. All inquiries for information will be accorded prompt attention, and will be answered either by letter or through the columns of this paper.

VOL. I JULY, 1913 No. 4

RECENT WORK ON THE TRANSMUTATION OF ELEMENTS

PART II

By A. T. CAMERON

Assistant Professor of Physiological Chemistry, University of Manitoba.

(Continued from last month.)

At the meeting of the Chemical Society of London on February 6th last two papers were communicated, one by Sir William *Ramsay* (8), the other by Professor *Collie* and Mr. *Patterson* (9). *Ramsay* gave an account of experiments demonstrating the presence of helium in the glass from old X-ray tubes, traces of neon being also discernible in the spectrum of the inert gases. "(The) source is, of course, a matter for conjecture; it may be that under the influence of the cathode discharge helium and neon are able to penetrate the walls of the bulb, which exclude oxygen and nitrogen. Or it is possible to imagine another explanation less likely to be received without challenge: that these gases are in some way the product of the cathode rays."

Collie's and *Patterson's* experiments were carried out independently, in different laboratories (at University College, London, and the University of Leeds). Their initial aims differed. *Collie* observed that when fluorspar was bombarded by cathode rays for several hours gases were continuously evolved. He proceeded to study these gases. He found that neon was invariably a constituent. Its presence was not dependent on the fluorspar. Bombardment of artificial calcium fluoride, of cleaned glass-wool, or passage of cathode rays through hydrogen at low pressure, invariably resulted in the presence of neon. Various sources were tested for it. The experiment tube maintained a perfect vacuum over night, so that leakage was not the cause. Moreover, the gases after an experiment never contained nitrogen. In blank experiments with the same hydrogen, and the oxygen used during the analyses, no neon was found. A glass balloon was sealed to the pump and the glass heated to softening. The gas liberated contained neither helium nor neon. Hence this did not come from the glass, and at the temperature employed the glass is not porous to atmospheric neon and helium.

Samples of the glass employed were powdered and heated to fusion. The gas evolved contained no neon. The electrodes used were from new aluminum wire. A large amount of this was fused by heating it in a hard glass tube. Some hydrogen was evolved, but no neon. In another test, the negative electrode was fused by an extra powerful discharge. The gas evolved contained hydrogen, but no neon. It was still possible that, although glass was not porous to neon when heated, it might become so when subjected to cathode bombardment. This was specifically tested. A tube was constructed so that the end containing the negative electrode was surrounded by an outer tube, connected to a separate pump. This outer tube was filled with pure neon at a pressure of half an atmosphere. The cathode ray bombardment was carried out for the usual time in the inner tube. The usual amount of neon resulted, no more, and no less. Then the neon in the outer tube was replaced by helium. After an experiment lasting four days there was no trace of helium in the inner tube, but the usual amount of neon. These experiments prove that the glass is not porous for helium and neon under the action of the bombardment. In a further experiment a new tube was taken, and completely surrounded by an outer tube, the intermediate space being evacuated. After two days' bombardment (six hours each day), with hydrogen in the inner tube, the usual amount of neon was obtained. "Merely for curiosity 1 c.c. of oxygen was admitted into the outer tube and pumped out. It gave a very faint explosion (hydrogen) when a spark was passed through it in an eudiometer. The residual oxygen was then treated with cooled charcoal. The residue that remained was about 50 times as great as the residue from the inner tube, and when examined it was *mostly helium, with enough neon present to give the neon spectrum.* In all *Collie* carried out 35 positive experiments, and found neon in all.

Patterson commenced his investigation with the object of endeavoring to verify certain deductions from the formula for electronic mass. His idea was that by giving a second electric charge to the seat of mass of the hydrogen ion, it could be converted into an alpha particle, and so hydrogen changed to helium. In order to do this he subjected hydrogen at low pressure to the cathode discharge. His actual results confirmed *Collie's* throughout. Latterly they were working in full knowledge of each other's results. *Patterson* repeated *Collie's* experiment with the jacketed tube, and confirmed it. In another experiment he placed in the outer tube pure oxygen at 15 mm. pressure, in the inner hydrogen at 2 mm. pressure. The residual gas from the outer tube in this experiment was *mostly neon,* with a small amount of helium. The quantity of helium plus neon in each of these two experiments was about a cubic millimetre.

The conclusions put forward in this paper are very cautious. "Whatever the explanation of the above results may be, the facts seem to be the following: (i) Neon cannot be obtained from either the glass or the electrodes by heating alone. (ii) The neon found is not due to air leakage into the pump or the apparatus during the experiment. (iii) Glass, neither when heated to near its softening point, nor under the action of cathode rays, is permeable to ordinary neon or helium. (iv) The hydrogen and oxygen used in the experiments did not contain neon. Moreover, the appearance of helium and neon in the outer tube, as well as neon in the inner tube, is most important. It would appear impossible that particles of these gases are shot through the

glass from the inner to the outer tube: the question is where do these gases come from? The answer to that question at present cannot be given with any certainty. . . . . "

According to the account of the delivery of the paper published by the London papers (10), various hypotheses were suggested. "It might be that the elements of the tube or the electrodes gave neon or helium under the influence of the discharge. This gave them ten or a dozen elements to choose from as the source. Again there was the chance that the hydrogen was the source, or the mercury vapour, or it was possible that they were dealing with a primordial form of matter, the primordial atom which, when produced, had all the energy necessary for forming the universe. By a combination of these 'atoms' the atoms of the elements would be formed." The later experiments suggested the reaction: oxygen, 16, plus helium, 4, yields neon, 20.

A further explanation of the results was suggested by Sir J. J. *Thomson*, in a preliminary account of some experiments communicated to *"Nature"* a week later. He considered that the electrodes were the probable source of the gases. His own experiments were made specifically to test the gas of molecular weight 3, which he terms X_3, and supposes to be a modification of hydrogen. To test the gases he obtained he used the method of positive ray analysis, discovered by himself, and more sensitive than spectral analysis. His experiments included the bombardment of metals and other substances with cathode rays, and discharge through a gas at low pressure from iron wire electrodes. The latter method showed especially that if the same electrodes were used continuously the amounts of X_3, neon, and helium, gradually disappeared, and finally no more could be obtained however long the tubes were run. By taking fresh electrodes a fresh supply was immediately obtained. Of the various substances employed in the first method, platinum yielded the largest amount of X_3, a specimen of black mica most neon. After bombarding the substances 3 or 4 days in most cases the neon and helium were barely visible, while the X_3 occasionally persisted to the sixth day. *Thomson* suggests that the gases are present in the metals, cannot be removed by heating, but are liberated by the action of the cathode rays. In one experiment with lead three-quarters was distilled away without liberation of the gases. The remaining quarter liberated X_3 and helium on bombardment. The tenacity of the substances for the gases he exemplifies by the fact that platinum sponge, freshly prepared from platinic chloride, gave X_3 and helium (though no neon). "The reason helium is obtained by heating the glass of old Roentgen ray bulbs is, I think, that after liberation by the cathode rays, the helium either adheres to the surface or is absorbed in a much looser way than before it was liberated. The question as to how these gases get into the metals is a most interesting one. Are they absorbed in the process of manufacture? * * * Sometimes when suffering from the difficulty of clearing out these gases I have been goaded into speculating whether they do not represent the partially abortive attempts of ordinary metals to imitate the behavior of radioactive substances; but whereas in these substances the alpha particles and the like are emitted with such velocity that they get clear away from the atom, in ordinary metals they have not sufficient energy to get clear, but cling to the outer parts of the atom, and have to be helped by the cathode rays to escape."

It is just possible that the explanation suggested by *Thomson* is the correct one and that the gases obtained by *Collie* and *Patterson* are derived from the electrodes. True, in one experiment *Collie* fused an electrode by the discharge itself, with negative results, and they both appear to have used tubes consecutively on a number of occasions without noting any diminution in the amount of neon, such as *Thomson* observed. But even if *Thomson's* is the correct solution, it is only a partial explanation. The theory into which he is "goaded" is far less simple than that put forward by them. It is certainly still consistent with a continuous break-down of matter to simpler forms. But such a continuous break-down of itself indicates that under some conditions the reverse process must be possible. The only simple explanation of *Thomson's results* (not involving atomic change) which suggests itself is that the various substances with which he experimented possessed extremely selective absorbability for the inert gases neon and helium (apparently not for argon). This point could easily be tested, since many chemsits and physicists possess some quantity of these gases. If this is not the case, then a new atomic phenomenon of some kind is indicated.

We are now bound, in any event, to accept the idea that the atom is a very complex body, built of smaller units of some kind, and whatever the outcome of the experiments, of which an account has been briefly given, whether further work confirm their unusual nature or elucidate some simple explanation for them, no unbiased observer can doubt that sooner or later the secret of atom-change will be discovered, while in all probability we shall ourselves be able to cause changes, both in the nature of syntheses, and of decompositions of the chemical elements."

Bibliography.

(1) E. *Rutherford*, "*Radio-active Substances and Their Radiations.*" Cambridge University Press, 1913.

(2) *Ramsay* and *Cameron*, *J. Chem. Soc. London*, *91*, 1593, 1907; *93*, 992, 1908; *Ramsay*, *ibid.*, *95*, 624, 1909; *Ramsay* and *Usher*, *Ber. d. d. Chem. Ges.*, *42*, 2930, 1909.

(3) *Curie* and *Gleditsch*, *Compt. rend.*, *147*, 345, 1908.

(4) *Rutherford* and *Royds*, *Phil. Mag.*, *16*, 812, 1908.

(5) *Hirschfinkel*, *Compt. rend.*, *153*, 255, 1911.

(6) *Ramsay*, *ibid.*, *153*, 373, 1911.

(7) *Ramsay*, *J. Chem Soc. London*, *101*, 1367, 1912.

(8) *Ramsay*, *ibid.*, *103*, 264, 1913.

(9) *Collie* and *Patterson*, *ibid.*, *103*, 419, 1913.

(10) See for example *Nature*, *90*, 684, 1913.

(11) J. J. *Thomson*, *Nature*, *90*, 645, 1913.

NOTES AND COMMENTS

The Standard Chemical Company of Pittsburgh, Pa., recently exported 45 milligrams of Radium element, in the form of radium sulfate of high purity, to Vienna, Austria. This is the first exportation on record of radium produced in America from American ores.

* * * * *

The Austrian Government about a year ago loaned to the General Hospital of Vienna a half gram of radium, which has been used under the direction of Prof. Gustav *Riehl* in the Radium Station of the Hospital. This radium in the form of applicators, and the emanation water prepared from part of it, were also available to the Vienna physicians, and so successful was the arrangement that the half gram has proved to be insufficient for the demands. Lately the very successful results obtained with large quantities of mesothorium, (quantities equivalent to several hundred milligrams of radium element) in the treatment of cancer of the uterus, has created a demand for the use of large quantities of radium. In view of these necessities the Austrian Government has agreed to loan an additional gram of radium to the Radium Station. By using this radium during the day in the various clinics, and renting it to physicians, the Station is made self supporting. During the night hours the radium is used in the gynecological clinic where the application of larger quantities of radium is now being studied.

* * * * *

The report of the chief registrar of mines of South Australia gives information as to radium mining in South Australia during the latter half of 1912. According to this report, there are four companies in the field at present, only one producing a finished product. Thus far, only 2½ milligrams of pure radium bromide have been prepared, although larger quantities are reported in process of concentration.

* * * * *

The Bettina pavillion of the Elizabeth Hospital in Vienna, has been presented with a considerable sum of money by the Barons Louis and Alfred *Rotschild*, for the purpose of buying radium to be used in the treatment of cancer.

* * * * *

"The application of Radium in the domain of medicine and the possibilities of its ultimate efficiency in the treatment of diseases are still too little understood to permit of any generalizations or unchallenged statements in respect to radio-therapy." ".... it must be admitted that radium with its unknown possibilities as well as its marvelous properties has entered into both medical thinking and doing in a way that cannot be overlooked." These extracts are quoted from an editorial in the June 14th, 1913, issue of the Journal of the American Medical Association, discussing the report of the experts of the Bureau of Mines, as presented by Prof. Charles L. *Parsons*, in the Journal of Industrial and Engineering Chemistry.

The reports made at the Gynecologic Congress in Halle, of the success following the use of larger quantities of mesothorium in the treatment of cancer of the uterus, have caused so great a demand for this substance that its price has increased considerably. Mesothorium is the product of the decay of thorium, and has a period of five and a half years (that is in 5.5 years, half of any quantity of mesothorium will have transmuted). Mesothorium 1 is rayless, but the product next formed, called mesothorium 2, gives off beta and gramma rays, which are only a little less penetrating than the corresponding rays from Radium C.

The following is quoted from the Vienna "Neue Freie Presse" of June 17th, 1913. "Prof. Dr. Stefan *Meyer*, director of the Institute for Radium Research of the Vienna Academy of Sciences, writes: "In the past few days various remarks have been made concerning the significance of these two wonderful substances (radium and mesothorium) from the standpoint of their application in medecine, and the values of these substances have been compared. To avoid any misunderstanding, we may say: what is called a milligram of mesothorium is not to be conceived as the weight of a milligram. It is merely a brief and inexact form of the expression; as much mesothorium as has the same gamma ray effect as one milligram of pure radium bromide. If such a "milligram of mesothorium" costs about forty-nine dollars, bearing in mind that it will half decay in five and a half years, it certainly has no advantage over radium bromide, a substance which lasts thousands of years and costs about seventy dollars per milligram (i. e. one hundred and twenty dollars per milligram of radium element). In the course of a few years, because of its decay, mesothorium becomes more expensive than the initially equivalent amount of radium."

"Another advantage which has been mentioned is its greater availability. Here, too, the facts are not clearly enough stated. If, there really is produced annually mesothorium equivalent in gamma ray effect to from five to seven grams of radium bromide, even this quantity corresponds to less than the present world's annual production of radium. With the production of such quantities of mesothorium each year and the known rate of decay of mesothorium, it may easily be calculated that at this rate of production, in thirty years, a maximum of about 40 gram *equivalents* of mesothorium will have been reached, this being the total supply in the world, since then the production would just counter-balance the decay of the supply on hand. On the other hand, the world's supply of radium, if not dissipated, will continue to increase for thousands of years. For each 100 metric tons of thorium, there is an equilibrium amount of approximately a tenth of a gram *weight* of mesothorium. The penetrating radiation of this quantity of mesothorium is *equivalent* to the penetrating radiation of about 30 grams of radium. From this it may be seen what an enormous task the preparation of mesothorium entails, and we must admire the work of its discoverer."

"Mesothorium which, as has been said, is defined by the amount of radium producing an equivalent radiation effect, is undoubtedly a valuable supplement to radium, when it is only a question of radiation effects. Radium, however, has the great advantage of possessing in its emanation a product that cannot be replaced by the corresponding thorium or actinium products, since the emanations of these are too short lived."

THE INTRAVENOUS INJECTION OF SOLUBLE RADIUM SALTS IN MAN.

FREDERICK PROESCHER, M. D.

The intravenous injection of Radium salts in man, in the form of bromide or chloride for therapeutic purposes, has not as yet been tried. Subcutaneous injections of small doses (10 to 20 micrograms) of soluble radium salts show no harmful effects. The safe maximum dose which can be injected into human beings and the lethal dose for lower animals, has not been determined.

According to the experiments of *Bouchard*, *P. Curie* and *Balthazard*, we know that guinea pigs and mice, after 15 hours exposure to the emanation of one gram of radium, die within four days. The exact dosage (several million mache units), has not been ascertained. For guinea pigs I have found that a concentration of from 55,000,000 to 70,000,000 mache units per liter will kill the animals from within 3½ to 6 hours, after an exposure of from 1½ to 2 hours. Later I will dwell upon the pathological changes. For the present, I will give a brief resume of my experience with intravenous injections of larger doses of radium bromide for therapeutic purposes, and reserve the right for an elaborate paper on the subject later. It appears to be premature to report on these experiments, but the results are so encouraging, that the announcement is justifiable.

For these experiments, radium bromide dissolved in physiological salt solution, which was sealed in ampules and sterilized, was used. The salt solution must be absolutely free from sulfates, otherwise, the radium will be precipitated as an insoluble sulfate. For injections, glass syringes only, should be used, without any rubber connections, to avoid a precipitation of the radium by the traces of sulfates contained in the rubber. This precaution is necessary to avoid any loss of the minute quantity of radium salts present.

Injections were made in the cephalic vein of the arm, the skin being disinfected with tincture of iodine. The injected solution measured from two to five cubic centimeters. According to our experience, analysis shows that the quantity of radium left in the syringe without rewashing, is about four per cent. So far I have treated the following cases:

One case of pernicious anaemia, 0.25 milligram radium element.

One case of recurrent uterus carcinoma, 0.50 milligram radium element.

One case of subacute polyarthritis, 60 micrograms radium element.

One case of traumatic neuritis, 100 micrograms radium element. In all cases injected, no alarming symptoms were observed, and a marked reduction in blood pressure was noticed. In the pernicious anaemia case, the blood pressure was 170 and dropped to 120 within two hours, and since the injection, (three weeks ago), has remained 120. In the uterus carcinoma case, the blood pressure dropped from 146 to 95, and in the traumatic neuritis case, the blood pressure dropped from 115 to 90.

The red blood cells in the pernicious anaemia, the subacute polyarthritis and the traumatic neuritis cases, after a few days, showed a marked increase to over 6,000,000. The red cells in the recurrent uterus carcinoma case, after twenty-four hours, showed a diminution of from 4,150,000 to 762,500. The highest count, which was observed

six days later, was 5,250,000. The leucocytes in this case, showed a marked reduction. In the other cases, no pronounced leucopenia was observed.

Intravenous injection of radium salts, produced without doubt, a marked analgetic effect. In the uterus carcinoma case, there existed a severe pain for several months, which was relieved two hours after injection, but which could not be controlled with one injection, the pain occuring again after several days.

In the subacute polyarthritis case, twenty four hours after injection, a marked reaction in all the joints was noticed. Sensitiveness and stiffness was observed, but there was no rise in temperature. After an additional twenty four hours, the sensitiveness and stiffness was almost gone. This reaction could be repeated after another injection of 10 micrograms of radium element. The joint reaction could probably be utilized in differentiating genuine rheumatism from other forms of joint affection. A marked analgetic effect was also noticed in the case of traumatic neuritis, in which case an intense pain in the back, together with insomnia, existed for several months, but was relieved a few days after the injection. That we have reached with $\frac{1}{2}$ milligram, the maximum dose of radium which can be given intravenously, without danger, I leave open.

The marked diminution of the red blood cells in the case of uterus carcinoma, seems to indicate that higher doses may have injurious effect.

Further experiments in this line which we propose to make will soon decide this question.

THE DISTRIBUTION OF RADIO-ACTIVE SUBSTANCES IN THE UNIVERSE.

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I. THE PROPERTIES OF RADIO-ACTIVE PRODUCTS.

Before discussing the distribution of radium and thorium in the rocks, in the oceans, in the seas, in the sun and in the stars, it is necessary to consider the wonderful relationships that exist between the various radiactive elements or products as they are called. Not many years ago chemists believed that the atoms of matter were created "out of the void" and that since creation they have remained "unbroken and unworn, the foundation stones of the Universe." As far as most of the elements are concerned this is as true today as it was twenty years ago. One atom may possess properties similar to those possessed by another atom but they are no more "related" than two bricks in a pavement. But the radioactive elements are related; related in much same way as parent and child, in that one atom 'begets' another atom; and in some cases 'begets twins.'

One of the remarkable facts about these families of radioactive elements is that the parent atom may disintegrate into a product that possesses quite different physical or chemical properties. The parent element may be a solid substance (radium) and the following product may be a gas (radium emanation). It is on account of properties such as these that the problem of the distribution of radio-active substances is much more difficult and complicated than the same problem as re-

lated to gold or a similar element. We shall see that radium is quite universally distributed in the various rocks and soils of the earth's crust. Since radium decays to a gaseous product we would naturally expect to find radium emanation gradually diffusing into the air and then being carried about by the winds. The distribution of the radium emanation will therefore depend upon the amount of radium in the surface rocks, the porosity of these rocks and the rate of decay of the radium and of the radium emanation, for the radium emanation decays into another product, radium A. The amount of radium emanation in the air is therefore a very variable quantity and is not constant as is approximately the case of carbon dioxide in the air.

Radium and thorium products in the rocks decay and emit alpha, beta and gamma rays in the same way that they do in the laboratory. Helium is accumulating in these rocks in the same way as it accumulates in the radium used in laboratory experiments, as will be shown later. Radium emanation in the air emits the ionizing alpha and beta rays in the same way that it does in an emanation chamber. After the alpha particles have ceased to ionize the air molecules they become helium atoms in exactly the same way that they were first found to do by *Ramsay* and *Soddy*. One thus sees that all about us are alpha, beta and gamma rays; rays coming from the radio-active products in the ground and rays coming from the radio-active products in the air. It is true that in many instances the amount of this radio-active matter is very small and that the intensity of these radiations is very weak. But the fact remains that they are ever present with us and that they often play a much more important role in atmospheric phenomena than we would at first imagine.

After we have described some of the radio-active products and indicated some of the ways in which they may affect atmospheric, terrestrial or cosmical phenomena we will discuss briefly the following phenomena:

(*a*) Radio-active matter in the air and its effect upon atmospheric electricity and the weather.

(*b*) The radium and thorium in the rocks and soils.

(*c*) The radium and thorium in the ocean.

(*d*) The gamma or penetrating radiation.

(*e*) The heat produced by the radio-active matter in the earth and the geological effects due to radio-activity.

(*f*) Radio-active matter in the sun and stars and some possible cosmical effects, evolution and devolution.

If one has a gram of pure radium one will find that it slowly changes, the radium atoms becoming radium emanation atoms at a certain rate that depends upon the amount of radium present. At the end of 2,000 years only a half gram of radium will remain. The time required for half the amount of radio-active matter to change is called the period. Each radio-active product possesses a definite characteristic period. The following are a few of the properties of the radio-active substances.

The Uranium and Radium Family.

Uranium 1 and 2. Uranium is very widely distributed throughout the rocks. It has a period of about five thousand million years. It emits alpha rays.

Uranium X is a solid possessing a period of 24.6 days. It gives off beta and gamma rays. It is similar to thorium in its chemical properties.

Ionium is like thorium and possesses a period of about 200,000 years. It emits alpha rays.

Radium has a period of 2,000 years. It emits alpha rays. On account of the comparative ease of measuring small quantities of radium much work has been done in determining the amount of it existing in various rocks and soils. It is present in minute quantities everywhere.

The Radium emanation is a gas. It behaves in every way like an inert gas such as helium. Its period is only 3.85 days so that in a closed vessel it will soon decay sufficiently so as to practically disappear. Some radium emanation is to be found in the air of all parts of the world.

Radium A, B and C are formed from the radium emanation. They are all solids and their periods are only a few minutes in length. If a negatively charged wire is surrounded by radium emanation it will be found that radium A, B and C will be deposited upon the wire. For this reason these products are frequently called the "active deposit." Trees, houses, grass, the surface of the ground, in fact all surfaces exposed to the air have a small amount of "active deposit" formed upon them.

The following products are solids and have the periods given: radium D or radio-lead, 16.5 years; radium E, 5.0 days; radium F or polonium, 136 days, and lead, the period of which is not known.

The Actinium Family.

Not very much is known about the distribution of the actinium products. Some evidence favors the view that small amounts of actinium emanation may exist in the air. As actinium does not play a very important role in atmospheric and terrestrial phenomena it will not be considered here.

The Thorium Family.

Thorium emits alpha rays. It has a very long period and, like uranium and radium, is a very widely distributed element. The following products are solids and usually remain with the thorium mineral; mesothorium 1 and 2; radiothorium and thorium X.

Thorium emanation is a gas. Like radium emanation it diffuses out of the soil and rocks. As its period is only 54 seconds it cannot diffuse to any very great distance from the thorium source so that comparatively little thorium emanation exists in the air. It emits alpha rays.

Thorium A, B and C form an active deposit in the same way that the active deposit of radium is formed. Like the active deposit of radium it emits beta and gamma rays.

The problem of the distribution of radio-active substances includes the distribution of the radium and thorium products in the rocks and soils and of radium emanation in the air. In the following paper we will discuss the distribution of radio-active matter in the air and more of the effects due to its presence.

REVIEWS AND ABSTRACTS.

Robert *Knox:* "Radium in the Treatment of Malignant Disease." British Medical Journal, No. 2736, p. 1196–99. (1913). A lecture at the Cancer Hospital in Brompton, England, in which the author speaks of the remarkable success following the use of radium on superficial lesions of the skin, naevi, keloid, lupus, rodent ulcer and epithelioma. Enlarged glands treated with radium rays diminish in size, only a slight erythema being produced on the overlying skin. In sarcomas of the round cell type, large growths gradually diminish in size, and smaller growths disappear. In cancer of the breast, the oesophagus, the uterus, the rectum and the bladder, the radium treatment has beneficial effects.

The author gives his conclusions, as follows:

1. "In all cases of early cancer, the operative treatment is undoubtedly the best; it is quicker, safer and offers the best prospects of a cure.

2. Radium is a useful adjunct to the treatment of all cases; first, as a prophylactic after operation, and failing operation, the next best method we possess. It must, however, be stated that X rays are in selected cases quite as useful as radium.

3. In patients who refuse operation, or are for other reasons not suitable for operation, radium is a useful remedy.

4. In inoperable cases, radium may help to render the case operable; and, failing that, is undoubtedly useful as a palliative measure.

* * * * *

Louis *Wickham*: "The General Histological Changes of Tissues under the Action of Radiations." Lecture at the International Congress for Physio-therapy, Berlin, March, 1913. Berliner Klinischer Wochenschrift **50**, 1006–1008; **50**, 1058–1062.

This interesting lecture, dealing with the effects of all forms of radiations is difficult to abstract because of the great amount of detailed information which it contains. There are three general divisions covering generalizations, effects of rays on normal tissues, and effects of rays on pathological tissues.

Every ray, whatever its source, influence in some way any cell that absorbs it. The main factors involved in the cell changes are: 1st, the sensibility of the cell for the particular radiation; 2nd, the concentration, or quantity, of the rays absorbed in a given time. (A given dose applied for a short time works differently from the same dose applied over a longer period, or only partially absorbed); 3rd, the characteristic properties of the various rays; 4th, the time interval between the action of the rays and the observation of histological changes in the tissues; 5th, the screening effect of the tissue itself, on the rays.

Different cells possess a characteristic degree of sensibility for various rays, and so it is that a penetrating radiation after passing through a layer of normal tissue without causing change, can act therapeutically upon a deeper lying layer of pathological cells. The general effects of X and radium rays upon the normal skin tissues; mucous membrane, the testicle and ovary, the hematopoietic organs,

and the eye are given. About the effects on muscles, bone, nerve tissue, the liver, the thyroid glands, kidneys, little is known. The histological changes in malignant tumors, in the hematopoietic organs, and the blood (leukaemia) in vascular tumors, in keloids and lupus, are then discussed in detail.

In conclusion, the author points to the necessity of more extensive histological studies in this field of work.

* * * * *

Wickham, Louis and *Degrais*, Paul: Le Radium, Son Emploi dans le Traitement du Cancer. (Radium, its use in the Treatment of Cancer.) Bailliere et Fils. Paris, 1913.

This little book of 95 pages of the "Collection des Actualites Medicals" gives in a condensed form a great deal of information concerning the application of radium in cancer and other diseases. After a general discussion of radium, its preparation, properties and rays, there are given the details of filtering the rays, the technique of "cross fire," descriptions of apparatus which is being used, and of the effects of the rays of radium upon malignant tumors, angiomata, keloids, lupus, etc. Photographs are reproduced showing the results of radium application in typical cases.

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VOL. I AUGUST, 1913 NO. 5

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RADIUM

A Monthly Journal Devoted to the Chemistry, Physics and Therapeutics of Radium and Other Radio-Active Substances

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Forbes and Meyran Avenues, Pittsburgh, Pa.

We shall be glad to receive for publication from our subscribers and readers articles pertaining to the subject of radium and its application. All inquiries for information will be accorded prompt attention, and will be answered either by letter or through the columns of this paper.

Vol. I AUGUST, 1913 No. 5

Radium Emanation Therapy in Arthritis Deformans.

By William H. Cameron, M. D.

The following is a preliminary report on the use of radium emanation in so called cases of arthritis deformans. The author has been conducting this clinic for the past five months.

CLASSIFICATION OF CASES.

All arthritic cases treated at the Radium Emanation Clinic are classified according to the primary cause, in so far as same can be determined by clinical evidence and laboratory findings.

This method was selected in order, if possible, to secure a simplified, uniform and definite working basis for many dissimilar pathological processes presenting a somewhat similar clinical picture and having, as a rule to a greater or less extent, the same clinical end result.

ACUTE STAGES.

Cases are placed in the acute stage when motion in affected joints is not impaired other than by the acute inflammatory process and where there is a constant temperature curve.

SUBACUTE STAGES.

When the joints can be moved by voluntary or passive motion without causing additional or recurring local inflammatory symptoms or fluctuations in temperature.

CHRONIC STAGES.

When degeneration, or organized exudates, causes fixation and deformity.

OUTLINE OF CLASSIFICATION.

1. Primary Infectious Arthritis....	a. Acute State.....	Acute Articular Rheumatism Rheumatic Fever
	b. Subacute and Chronic....	Rheumatoid Arthritis Chronic Arthritis

Characterized by sudden onset with severe constitutional and joint symptoms. Tendency for complete recovery. In many cases, however, joint conditions never return to normal, the end result being arthritis deformans.

2. Secondary Infectious Arthritis ....
   - a. Acute State..... { Rheumatic Fever; Gonorrheal Rheumatism, etc.
   - b. Subacute and Chronic Stage..... { Chronic Arthritis; Arthritis Deformans; Degenerative Arthritis

Mono or polyarticular symptoms coincident with or following a demonstrable acute infection, such as tonsilitis, gonorrhea, syphilis, pneumonia, tuberculosis, etc. Characterized by sudden onset with constitutional symptoms of greater or less intensity and a prolonged subacute stage. Tendency of joint symptoms to become chronic.

3. Primary Toxic Arthritis.....
   - Acute..... Difficult to Demonstrate
   - Subacute..... Chronic Arthritis
   - Chronic..... { Arthritis Deformans; Polyarthritis, etc.

Coincident with virulent toxin producing conditions such as chronic appendicitis, pyorrhoea, etc. Characterized by slow onset with slight general symptoms, and having many acute exacerbations with apparent quiescent periods with gradual tendency to deformity.

4. Secondary Toxic Arthritis.....
   - Acute..... Difficult to Demonstrate
   - Subacute..... Chronic Arthritis
   - Chronic..... { Arthritis Deformans, polyarthritis, etc.

Coincident with a nonvirulent toxin producing agent, such as found in what we know as faulty metabolism. Characterized by gradual onset, joints affected, never becoming normal, having a long life history, and finally having the end result of deformity.

CLINICAL REPORT

March 16th, 1913, to July 20th, 1913.

Combined Radium Emanation and Radium Emanation Drinking Water.

Amount of Dosage in Use.

One 12 patient Room Emanator 2 to 8 mgr.. Radium element giving a concentration of 0.003-0.025 microcuries per liter (about 15 to 70 mache units per liter air).
One 12 patient Room Emanator 60 mgr. Radium element giving a concentration of 0.16 microcuries per liter (about 450 m.u. per liter air).
One 2 patient Room Emanator 20 mgr. Radium element giving a concentration of 0.7-0.8 microcurie per liter (about 2000 m.u. per liter air).
One 2 patient Portable Emanator 2.7 mgr. Radium element giving a concentration of 0.1 microcurie per liter (about 300 m.u. per liter air.)
Drinking Water 20 microcuries per liter. Patients given 1 liter per day.
Patients receiving not less than 30 hours Emanation and 30 liters of Drinking Water.

Type of Case.	No. of Cases	Improved	Not Improved	Cured	Still Receiving Treatment
Acute Primary Infectious Arthritis	..	..	..	..	..
Subacute Primary Infectious Arthritis	1	..	..	1	..
Chronic Primary Infectious Arthritis	3	1	..	2	1
Acute Secondary Infectious Arthritis	1	1	..	..	1
Subacute Secondary Infectious Arthritis	5	1	..	4	1
Chronic Secondary Infectious Arthritis	9	5	1	3	5
Acute Primary Toxic Arthritis	..	..	..	..	..
Subacute Primary Toxic Arthritis	2	..	..	2	2
Chronic Primary Toxic Arthritis	5	4	..	1	4
Acute Secondary Toxic Arthritis	..	..	..	..	..
Subacute Secondary Toxic Arthritis	..	..	..	..	..
Chronic Secondary Toxic Arthritis	10	5	4	1	6
Chronic Myositis	1	..	..	1	..
Sciatic Neuritis	3	3	..	..	2
Gout	1	..	..	1	..
Total	41	20	5	16	22

NOTE:—Patients marked *Cured* show no signs of returns from 30 to 60 days after discharge. The period of onset in these cases ranges from 1 to 20 years. The age of patients ranged from 20 to 65 years.

Patients with subacute and chronic primary infectious arthritis show marked improvement under radium emanation treatment. Daily 1½ hours treatment by emanation inhalation and drinking water [½—1 liter, 20 microcuries radium emanation per liter] seems sufficient dosage for these cases.

The acute, subacute and chronic secondary infectious arthritis also show marked tendency to recovery, but these patients require longer time and larger dosage. Source of infection should be removed, if possible.

Cases of subacute and chronic primary toxic arthritis should have source of toxemia removed either immediately before or after treatment, as there is a tendency to recur while the process is active.

The chronic and secondary toxic cases are most obstinate, should have high dosage extending over a period of at least ninety days. If no reaction occurs after that time, no result will be obtained. The nonarticular joints are most obstinate.

The most remarkable thing about radium emanation therapy, as noted on 130 cases, is that it improves the general conditions, is very effective in some cases of insomnia, equalizes blood pressure, if we are permitted to use such a term, and that joints apparently fixed become movable. No motion is, however, expected or seen where degeneration has taken place or where surrounding structures have become involved in the deformity.

Female patients over forty years of age, and suffering with any form of infectious or toxic arthritis, are the most difficult to handle, and show less tendency to complete recovery.

Tests of our emanation and drinking water dosage are made at stated periods in the Radium Research Laboratory of the Standard Chemical Company.

THE PATHOLOGICAL ANATOMICAL CHANGES IN GUINEA PIGS KILLED BY EXPOSURE TO HIGH CONCENTRATION OF RADIUM EMANATION.

By FREDERICK PROESCHER, M. D.

The study of the pathological anatomical changes in the internal organs of animals, killed by extremely high concentrations of radium emanation, has been very incomplete. Careful histological examinations using different fixing and staining methods, have not yet been made. Exact data concerning the concentrations of radium emanation have not been given. Our present conceptions of the modus of the effect of radium on the various cells is very limited and therefore close histological examinations are very much desired. These investigations are not only of scientific interest in themselves, but will also form a basis for the successful therapeutic application of radium. At present it is not possible to compare the different experiments that have been performed, as the different investigators have used different quantities of radium, different forms of application and different times of exposure. The direct radiation from radium is only useful in comparative studies of the effect on the skin. On account of our limited knowledge of the powerof penetration of the radium rays, and of the absorbtion of these rays by the different tissues, the direct radiation is of less value for comparative experiments in the effects on the in-

ternal organs. The insertion of tubes containing radium salts, into different organs is not advisable, since the changes that occur owing to the surgical operation, render the differentiation of the effects of the radium very difficult.

There are two methods for exact experimentation. Either the animals are exposed to a known concentration of radium emanation in a closed vessel, containing a sufficient quantity of oxygen, and with provision for the absorbtion of carbon dioxide; or intravenous injections of soluble radium salts may be made. The first is the more exact and economical method, especially for a series of experiments. The animals can be kept for a given time in practically the same concentration of radium emanation. In the intravenous injection of soluble radium salts the experimental conditions cannot be so well defined, since the radium salt is soon transformed into an insoluble salt or absorbed. Here the selective effect of the different organs for radium salts has to be taken into consideration. To kill animals by the intravenous injection of soluble radium salts has not been tried, and the literature enumerates but few experiments concerning the effect of high concentrations of radium emanation upon animals.

E. S. *London* reported that frogs, exposed twice for forty-eight hours to radium emanation (concentration not stated), were less active, showed signs of drowsiness, difficulty in breathing, and the epidermis was covered with mucus. The frogs died thirteen to sixteen days after exposure to the radium emanation. The position of the frogs and the appearance of the water in which they were kept was characteristic. The control frog's legs were not affected in the least and the water was clear, while the exposed animal remained stretched out, and the water was cloudy.

London demonstrated the radio-activity of the frog, on the first day, and showed that alpha, beta and gamma rays were coming from the body. The skin showed the greatest radio-activity. On autopsy it was found that the blood was of a dark color, and the skin was atrophied. The skin only, was examined microscopically, and a marked exfoliation of the stratum corneum, hyperemia of the corium, fatty degeneration of the glands of the skin and hyalin degeneration of the connective tissue were found. *London* further reported that young mice kept in radium emanation, (concentration not stated) died on the third day. The following symptoms were noted; the mice lie on their side, show signs of difficulty in breathing and die with symptoms of asphyxia. Microscopical examinations of the organs were not made. The cause of death according to *London* was the disturbance of breathing.

Similar experiments have been made by *Bouchard*,P. *Curie* and *Bathazard* on guinea pigs and mice. It is to be regretted that no exact data concerning the concentration of the radium emanation used have been given. The animals died on the fourth day, after an exposure of fifty hours to the radium emanation; and on the ninth day, after fifteen hours exposure to the emanation from a gram of radium. No details of the symptoms or of examinations of organs are given.

EXPERIMENTS OF THE AUTHOR.

In the following experiments guinea pigs were used. The guinea pigs were placed in a glass dessicator and were exposed to a known high concentration of radium emanation. To maintain normal breathing conditions, pieces of sodium hydroxide and some moistened sodium

peroxide were placed in the bottom of the dessicator to absorb the carbon dioxide, and liberate oxygen. The radium emanation was introduced into the dessicator by means of a glass tube passing through a tubulus in the cover of the vessel. Air drawn from the dessicator through another tube, was blown through the radium solution contained in a stoppered flask, by means of a rubber hand bellows, the charged air passing back into the dessicator. The maximum concentration of radium emanation is attained in the dessicator after the air has been vigorously circulated for five or ten minutes. After this time the tubes are closed by means of clamps and the animal is left in the dessicator for the desired time.

EXPERIMENT No. 1:

Male guinea pig (a) Weight 300 grams. Blood count May 26th, 1913.
5,000,000 red cells
8,250 white cells
14.02 grams haemoglobin

DIFFERENTIAL COUNT:

Pseudoeosinophiles	81.48%
Lymphocytes (small)	6.22%
Lymphocytes (medium)	1.03%
Monocytes	7.12%
Lymphoidocytes	4.15%

10 A. M., May 26th, 1913, guinea pig placed in the dessicator, exposed to the emanation of 135 milligrams of radium element, in the manner described above.

The 135 milligrams of radium (element) in the form chlorides had been dissolved in three liters of water, and the solution had stood in a 3½ liter stoppered flask for nine days and eighteen hours. The volume of the dessicator used was (allowing for the volume of the pig) 1600 cc., and the volume of the blast bellows, 300 cc. The air was circulated through the dessicator and radium solution for ten minutes. The dessicator contained 58 millicuries of emanation, corresponding to a concentration of 95,000,000 mache units per liter. The pig was left in the dessicator for two and a half hours. During this time the pig was quiet, apparently normal. After the two and a half hours exposure, the guinea pig was removed and kept in the open air, where it seemed apparently well for two hours. A blood count was made at 12:30 noon. immediately after removal from the dessicator.

4,350,000 red cells
9,250 white cells
11.96 grams haemoglobin

DIFFERENTIAL COUNT:

Pseudoeosinophiles	91.93%
Eosinophiles	0.35%
Lymphocytes	5.30%
Basophiles	0.13%
Lymphoidocytes	1.94%
Monocytes	0.35%

After several hours, the pig became drowsy, with increased respiration, and at 4.05 p.m. of the same day, it died with symptoms indicating

asphyxia. The autopsy done immediately after death, showed hyperemia of both lungs, and the heart blood was still fluid and of normal color. All the other organs including the brain and spinal cord, showed slight hyperemia. Otherwise no microscopical changes were observed.

EXPERIMENT No. 2:

Male guinea pig (c) June 2nd, 1913, weight 320 grams.
Absolute blood count:

6,000,000 red cells
15,000 white cells
14.36 grams haemoglobin.

DIFFERENTIAL COUNT:

Pseudoeosinophiles	47.60%
Eosinophiles	0.58%
Lymphocytes (small)	42.55%
Lymphocytes (medium)	2.51%
Lymphocytes (large)	0.19%
Monocytes	1.74%
Lymphoidocytes	4.83%

At 2.07 P. M., June 2, 1913, the guinea pig was placed in the dessicator and exposed to the emanation from 189 mgm. of radium (element) as described above. The 189 mgm. of radium in form of chloride, was dissolved in 3000 cc. of water in a 3½ liter flask, and the emanation had been accumulating in the stoppered flask for four days. The air was circulated through the radium solution for ten minutes. The dessicator of 1.6 liter capacity—(corrected for volume of guinea pig) contained 47 millicuries of emanation, which corresponds to a concentration of 74 million mache units per liter. The pig was exposed to the emanation for one and a quarter hours.

Blood count, after exposure to radium emanation, 3.25 P. M.,

6,225,000 red cells
5,000 white cells
14.36 grams haemoglobin

DIFFERENTIAL COUNT:

Pseudoeosinophiles	44.00%
Eosinophiles	3.00%
Lymphocytes	49.00%
Lymphoidocytes	4.00%

The guinea pig, after exposure to the emanation, was apparently well for about three hours, after that slightly drowsy, and respiration increased. The pig died about 8:00 P. M. the same day, about six hours after the exposure to the emanation.

The autopsy showed the blood vessels of the subcutaneous tissue distended. Blood vessels leading to the inguenal lymph gland markedly dilated. The visceral organs also hyperaemic, both lungs markedly distended with a few subpleural hemorrhages about the size of pin heads. Heart filled with fluid blood. Blood of a normal appearance, brain and spinal cord hyperaemic.

(To be continued in the next number)

SOME UNITS AND TERMINOLOGY USED IN RADIUM AND EMANATION THERAPY.

By C. H. VIOL, PH. D.

Radium therapy is a field of medicine that is becoming more interesting to physicians every day. Unfortunately for the physicians, radio-activity is a highly mathematical field of physics and physical chemistry, and it is impossible for one wholly unacquainted with the subject of *radio-activity* to grasp many of the essential points in radium therapy. The study of the application of radium therapy dates back only to 1901, and radium therapy has not yet outgrown its childhood ailments.

The several recent foreign text books* dealing with the subject are excellent, but the English translation of the first edition of *Wickham* and *Degrais'* "Radiumtherapy", the most extensive work available in English, treats the physical side in such a way as to lead to some confusion.**

Results in a great many cases reported in the literature have been made unintelligible through the inexact and vague use of the term "radium", when radium salts were really meant, and these not always of known purity. These difficulties can be entirely removed if radium preparations are always described in terms of their content of radium element, e. g. 10 milligrams of radium element in the form of radium barium sulfate. It is the radium element that possesses the property of radio-activity, and since the percentage of radium element in its pure salts, varies, as we pass from salt to salt, it is much more enlightening to specify the *quantity of radium element*, rather than the weight of the salt.

Radio-activity is a property of some forms of matter which is due to a process of spontaneous atomic disintegration taking place. Most forms of radio-active matter are characterized by the sending out of rays. These rays are of three types, the easily absorbed or alpha rays, which are positively charged helium atoms shot out with terrific velocity from the disintegrating atoms; the more penetrating beta rays, which consist of negative electons [particles 1,700 times smaller in mass than the hydrogen atoms] moving with velocities approaching that of light; and the very penetrating gamma rays, a form of radiation analogous to the Roentgen rays. When the radio-active atom disintegrates or transmutes, one or several of these rays are emitted, the remainder of the atom constituting a new atom, which may again undergo another transmutation into the next product. In some cases, the transmutation takes place without any rays being emitted. The final radio-active forms of matter resulting from the decay products of the uranium, actinium and thorium series, are not definitely known, although lead would seem to be the end product in the uranium-radium series, and bismuth has been suggested as the end product in the thorium series.

Radium is a metallic element that is transmuting at a much more rapid rate than is uranium. Considering equal weights of uranium and radium element, in a year 0.00000000014 of the total quantity of the uranium, and 0.00035 of the total quantity of radium, will decay.

*P. *Lazarus*. Handbuch der Radium-Biologie und Therapie J. F. *Bergmann*, Wiesbaden, 1913.
Louis *Wickham* et Paul *Degrais*. Radiumtherapie. (Second Edition) J. B. *Bailliere* et Fils. Paris, 1912.
S. *Loewenthal*. Grundriss der Radiumtherapie und der biologischen Radiumforschung. J. F. *Bergmann*, Wiesbaden: 1913.
**L. *Wickham* and P. *Degrais*. Radiumtherapy, translated by S. Dore, from the first French edition. Cassell & Co., London. (Funk & Wagnalls Co., New York. 1910).

The ratio of the quantity of radium to the quantity of uranium decaying is 2,500,000. From this, it may be seen that for *equal weights* of radium and uranium, there will be enormously more rays from the radium than from the uranium, since a larger proportion of all the radium atoms undergo a transmutation in any given interval of time.

The measurement of radio-activity may be made in various ways, as, for example, the effect of the rays on a covered photographic plate, or the measurement of the heat emission of a preparation, or by actually counting the alpha rays which a preparation emits, by observing the scintillations which these rays produce when they impringe upon suitable screens [willemit, sidot-blende, diamond]. The methods which are simplest and most readily give quantitative results are electrical methods.

The alpha rays when they are shot out from the transmuting atom, are endowed with a tremendous kinetic energy, and in passing through a gas this energy is expended in ionizing the gas, that is, splitting the gas molecules into electrically charged parts called ions. The beta rays are much more penetrating and are only about one-hundredth as effective in ionizing gases as the alpha rays. The gamma rays are much poorer ionizers than even the beta rays. An electrically charged body, when surrounded by an ionized gas, loses its electrical charge, and the rate at which the charge "leaks" off is proportional to the intensity of the gas. The ionizing power of radio-active substances is used to detect their presence, and it may be used to determine qualitatively what element is present, and to quantitatively determine certain of the elements.

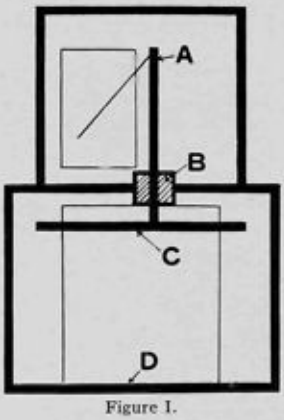

Figure I.

Figure I gives the diagram of a simple electroscope which can be used to compare the alpha ray activity of radio-active preparations. A leaf of thin aluminum or gold foil is fastened at the upper end of a flat rod [A], which in turn is held in an insulating plug [B]. This insulating plug is fastened in the top of a metal case, the leaf holder and leaf being covered with another metal case suitably provided with windows to allow observing the leaf by a reading microscope with an ocular carrying a graduated scale. The rod terminates in the lower metal chamber in a plate [C]. Through a door in this vessel, the plate [C] may be touched with an ebonite rod which has been rubbed, thus communicating an electric charge to the leaf system. This charge causes the leaf to be repelled from the rod [A] and it moves out at an angle which depends upon the potential of the leaf system. With a good insulation, the leaf system will hold its charge for hours. If any radio-active matter, a gram or so of uranium salt, is brought into the lower chamber at [D], the leaf is seen to fall. The rate of fall [which is observed on the microscope scale, and using a stop watch] will depend upon the electrostatic capacity of the leaf system, and upon the intensity of ionization of the air between [D] and the plate [C] due to radioactive preparation. The electrostatic capacity of the instrument may be considered constant, if the electroscope is used under the same conditions each time. The rates of discharge of the electroscope, when equal weights of different preparations are introduced [each preparation being distributed over the same superficial area] are proportional to the intensities of ionization of the air by the rays

from the samples, and the ionization of the air is proportional to the radio-activity of the material.

Due to its high activity, it is not convenient to work with even a hundredth part of a milligram of pure radium salt in an ordinary electroscope, and quantities of radium of from 0.01 milligram up to a gram are best compared by means of the gamma rays. When a radium salt has been kept sealed for a month, the maximum amount of emanation and active deposit has accumulated and the gamma ray activity reaches a maximum. Under these conditions, it is possible to determine the quantity of radium in a preparation using an electroscope similar to the one described which, however, now must have a case made of lead, at least a centimeter thick [to absorb beta rays]. The radium preparation is placed near the charged electroscope and the rate of discharge is observed. This discharge is due to the gamma rays, which pass through the lead case and ionize the air inside of the electroscope. The preparation is removed to a great distance, or put in a thick lead box and a standardized preparation [i.e. one which contains a known amount of radium] is placed in the *same position*, near the electroscope and its gamma ray ionization current observed. The rates of discharge of the instrument are proportional to the quantities of radium contained in the preparations, so that the unknown quantity of radium can easily be calculated.

The radio-activity of uranium metal has been suggested as the unit of radio-activity. A gram of pure radium bromide gives an ionization current which is about 2,000,000 times as great as that due to one gram of metallic uranium. So that on this uranium unit basis, pure radium bromide [$Ra\ Br_2\ 2H_2O$] has an activity of 2,000,000. A salt containing 50 per cent. by weight of pure radium bromide would be said to have an activity of 1,000,000, and a radium bromide of 25 per cent. purity, an activity of 500,000. *Wickham* and *Degrais*, in the first edition of their text book on "Radiumtherapy" make use of the uranium units in describing the strength of their preparations [i.e. purity], and then by dividing this "strength" by the area on which the radium salt is spread, they obtain a figure which they call the "total available radiation per square centimeter." In the second edition, this is changed and in describing their applicators, they merely mention the shape and the size of the applicator, the area covered by the radium preparation, the purity of the salt used [i. e. ¼ pure radium sulfate]; the total weight of salt used on an applicator, and then its equivalent in terms of pure radium salt [sulfate]. They say [loc cit p. 38] "the salt of radium chosen for use is generally the sulfate, because it is insoluble and attacks the varnish less". "In general, 1 centigram of salt is used per square centimeter of surface, this being the proportion which seems most useful." 10 milligrams of pure radium sulfate contain 7.0 milligrams of radium element, so that the ordinary strength flat varnish applicator, according to *Wickham* and *Degrais*, would contain 7.0 milligrams of radium element per square centimeter of area.

We quote the following from the Report of the Director of the Chemico-Physical Laboratory of the London Radium Institute:*

"Before describing the varnished apparatus, it will be well to point out that consideration must be paid to the concentration of the radium salt per unit area, as well as to the purity of the salt. It is obvious that a different therapeutic result will be obtained from 10 mg. of

*"A Report of the work carried out at the Radium Institute", London. Appendix Report of the Chemico-Physical Laboratory. W. L. S. *Allon*, British Medical Journal, p. 163. Jan. 25th, 1913.

radium bromide spread over 1 sq. cm. of surface, than from the same amount spread over twice the area."

"For this reason a unit of concentration has been adopted. This consists of a centigram of radium bromide spread over a square centimetre. Applicators containing radium salts to this extent of concentration are said to be "full strength" applicators; similarly "half" and "quarter" strength applicators contain respectively 0.5 and 0.25 cg. of radium bromide respectively to each sq. cm."

"Radium bromide has been accepted by the medical profession as the unit of measure for describing the content of radium applicators. This salt was the first salt of radium prepared, and happens to be most unsuitable for fixing to applicators by means of varnish, or for filling tubes."

"In all probability all the apparatus at the Institute will be measured during the course of the coming year, and its radium content stated in terms of the element radium; not only will this procedure be more exact, but the applicators containing emanation can be more closely compared with those containing radium salts."

Ten milligrams of pure radium bromide [$Ra\ Br_2\ 2H_2O$] contain 5.36 milligrams of radium element, so a full strength varnish applicator, according to the London Radium Institute, would have 5.36 milligrams of radium element per square centimeter. The French workers use 10 milligrams of radium sulfate, and the English, 10 milligrams of bromide, but these weights represent different quantities of radium element. In reporting results, *Wickham* and *Degrais*, and the London Radium Institute give data from which it is possible to calculate how much radium [element] was used in treating a particular case. However, in the literature, there are many reports in which such data is not given, bare mention being made of milligrams of "radium". This may be interpreted as milligrams of pure bromide, or it may actually represent the weight of the preparation, which more frequently is not a pure salt, and the size of the applicator or the area over which the radium salt is spread is left to the reader's imagination.

All the difficulties and uncertainties which arise due to the practice of speaking of "radium" without qualifying the term, will be overcome if *radium element* is made the basis of all reports on quantities of this material used.

The great confusion consequent to the discrepancies which were found to exist between the so called radium standards of the various workers in radio-activity, led the Congress of Radiology and Electricity, which met in Brussels in 1910, to appoint a committee to make arrangements for the preparation of the International Radium Standard. 21.99 milligrams of pure anhydrous radium chloride prepared by Mme. *Curie*, were sealed in a glass tube, and this preparation, containing 16.75 milligrams of radium element, was accepted by the Committee as the International Radium Standard. Preparations of pure radium chloride, purified by *Honigschmidt* at the Radium Institute of the Vienna Academy of Sciences, for atomic weight work, were compared by the Committee with Mme. *Curie's* preparations and found to agree within a limit of 1 part in three hundred. These three Vienna preparations contained 10.11, 31.17 and 40.43 milligrams of anhydrous radium chloride. Secondary radium standards may now be obtained, which have been compared with these standards, and there is no excuse for discrepancies in the determinations of quantities of radium.

We give in conclusion definitions of various terms which have been used in describing radium and other radio-active preparations, since these terms are frequently encountered in the literature, and are not always clearly defined.

Until recently, the milligram of pure radium bromide [$Ra\ Br_2\ 2H_2O$] has been the standard for radium salts. This salt contains 53.6 per cent. radium element. Pure radium chloride [$Ra\ Cl_2$] contains 76.1 per cent. of radium element; pure radium sulfate [$Ra\ SO_4$] contains 70.2 per cent. radium, and pure radium carbonate contains 79.0 per cent. of radium element. One milligram of radium element corresponds to 1.87 milligrams of bromide [$Ra\ Br_2\ 2H_2O$]; to 1.42 milligrams of the sulfate; to 1.31 milligrams of the chloride; and to 1.265 milligrams of the carbonate.

Calling the radio-activity of metallic uranium unity, pure radium bromide has an activity of 2,000,000. The other salts of radium will have higher activities in the proportion to their higher content of radium element. On the basis of 2,000,000 for pure bromide, radium element would have an activity of 3,731,000.

Increasing use is being made of the vague term milligram-hours referring to application of radium and mesothorium. One milligram of radium bromide applied for ten hours is 10 milligram-hours, or ten milligrams applied for one hour is 10 milligram-hours. This is a very slovenly way of stating results, since the concentration factor is wholly ignored. If the number of milligrams of pure radium salt and kind of applicator are specified and the time of application, there is no doubt as to what procedure was used; and unless such data is given, results are much less useful for purposes of comparison.

Mesothorium is spoken of in terms of "milligrams". Actually weight for weight, pure mesothorium [which has never been prepared] would be about 350 times as active as radium, since it is disintegrating about 350 times faster than radium. What is called "one milligram" of mesothorium, commercially, is that quantity of mesothorium that has a gamma ray effect equal to the gamma ray effect of one milligram of *pure radium bromide* [0.536 milligram radium element].

The desirability of expressing quantities of radium in terms of "milligrams of radium element" cannot be too strongly urged, and in this connection it might be desirable to change the definition for mesothorium, so that "one milligram" of mesothorium would be equivalent in gamma ray effect to one milligram of radium *element*.

The investigation of the radium emanation content of various mineral and other natural spring waters and sediments, led to the selection of a suitably small unit to express these results. These investigations were carried out by electroscopic methods, and results were expressed roughly in "volts fall of potential of the leaf system per hour" due to the radio-active matter, or the ionization current, was made the measure—this being expressed in suitably small units.

The action of the Committee for an International Radium Standard in defining a "curie" as the quantity of radium emanation in equilibrium with one gram of radium [element], has met the approval of the scientific world. Unfortunately, the smallest unit usually used, the microcurie, is rather large for expressing the concentration of radium emanation in natural spring waters, etc. But, rather than have two systems of units, it is the writer's conviction that it would be less confusing to use the term, millimicrocurie, for these special cases, where the microcurie is too large. The term "curie" has the advantage over "mache units" that it is a more directly defined quantity, whereas the "mache unit" depends upon several factors [volume of ionization chamber of electroscope in which measurements are made, etc.].

1 CURIE is the quantity of radium emanation [0.60 cubic millimeter at 0°C. and 760 mm. pressure] in equilibrium with one gram

of radium element. This quantity gives a saturation current [in an ionization chamber of infinite dimensions] of 2.67 million electrostatic units [0.89 milliampere]. One curie of emanation per liter would equal a concentration of 2670 million mache units.

1 MILLICURIE is the quantity of radium emanation in equilibrium with 1 milligram of radium element.

1 MICROCURIE is the quantity of radium emanation in equilibrium with 1 microgram [1 millionth of a gram] of radium element. 1 microcurie per liter equals a concentration of about 2700 mache units.

1 MILLIGRAM MINUTE is the quantity of radium emanation which 1 milligram of pure anhydrous radium bromide produces in one minute. [Used by P. *Curie* and *Laborde* as a unit for quantities of emanation contained in spring water, etc.] This quantity is 0.073 microcurie and would give per liter a concentration of about 180 mache units.

1 MILLIGRAM SECOND is the quantity of radium emanation produced in one second by one milligram of pure anhydrous radium bromide. This is 0.00122 microcurie.

1 ELECTROSTATIC UNIT [e. s. u.] is a measure of a current measure equal to 3.33×10^{-10} [0.000000000333] ampere.

THE MACHE UNIT [m. u.] is a term to express *concentration* of radium emanation. It is defined as the saturation ionization current due to the radium emanation [free from decay products] from a liter of solution or gas, expressed in electrostatic units multiplied by 1000. [This current is measured in a cylindrical ionization vessel of 10 to 15 liters capacity]. Unfortunately, the term mache unit has been badly misused. For example, a bath of 200 liters of emanation water containing a *concentration* of 150 mache units per liter is usually now spoken of as containing [150X200] 30,000 mache units. Then other radioactive substances [thorium X. for example] have been standardized by ionization current measurements. Such currents in e. s. u. multiplied by 1000 are reported as so and so many mache units. For example, an injection of "500,000 mache units of Thorium X".

VOLTS PER HOUR [incorrectly "volts"]. The scale for reading the position of the leaf of an electroscope may be calibrated to correspond to the potentials of the leaf system, in volts. If the *emanation from a liter of gas or solution* is introduced into the electroscope and the rate of movement of the leaf is noted, this rate can be expressed in volts fall of potential per hour [i. e. an observed fall of 120 volts per minute corresponds to 7,200 volts per hour]. This form of expression gives very large numbers, which have no significance unless the electrostatic capacity of the particular measuring instrument used, is known. If this capacity is known, it is better to express the results as a current, [i. e. in e. s. u. or mache units], or, if the instrument has been calibrated using an emanation standard, the result may be expressed in microcuries or millicuries. For the "Fontaktoscope" of *Engler* and *Sieveking*, the result expressed in "volts per hour" divided by 80, gives the result in mache units. A modification of this instrument by *Kohlrausch* and *Loewenthal* requires the dividing by a factor 116. From this, it is very evident how misleading the statement of results in "volts per hour" may be, unless further qualified.

Expressing the value of the emanation ionization current in billionths of an ampere is a form that has been suggested, but not adopted to any extent.

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We shall be glad to receive for publication from our subscribers and readers articles pertaining to the subject of radium and its application. All inquiries for information will be accorded prompt attention, and will be answered either by letter or through the columns of this paper.

Vol. I SEPTEMBER, 1913 No. 6

Radium in the Treatment of Skin Diseases.

By Fernand L. de Verteuil, M. D. (Edn.) M. R. C. S. (Eng.) L. R. C. P. (Lond.) Surgeon R. N. (ret.)

Radium is undoubtedly a very valuable therapeutic agent in many pathological conditions. Radium emanation given by inhalation or dissolved in water, has been used in Medicine with marked benefit in gouty and rheumatic conditions; and radium has proved to be an effective adjunct to surgery in malignant disease either to render an inoperable growth operable or as a prophylactic after operation to prevent recurrence, in gynaecology it has given satisfactory results in various uterine conditions; while in opthalmology it can be considered almost a specific in trachoma and follicular conjunctivitis. It is however in dermatology that radium has hitherto found its largest and most useful field.

In this paper I propose to deal very briefly with the principal cutaneous disorders in which radium therapy is specially indicated. In doing so I shall draw from my own personal observations supplemented to a large extent by a critical review of the literature on the subject.

As regards applicators, the most generally useful form for the treatment of skin diseases is a flat varnish applicator, which may be either round or square in shape. The square form is preferable, since when considerable areas need to be treated, the affected part is gone over a part at a time, and the square form makes it possible to do so without overlapping.

My equipment consisted of three applicators, two of them square varnish applicators containing 10.7 and 2.0 milligrams of radium element respectively, and a varnished flexible cloth applicator containing 2.7 milligrams of radium element. The areas of these applicators covered with the radium salt are 8, 11.2 and 20 square centimeters respectively.

These applicators are applied directly to the part to be treated; they are either applied naked, that is merely wrapped in a covering of gutta percha tissue (to protect the applicators) or metallic screens of various thicknesses are interposed between the applicator and the skin. The duration of the application may be anything from a few

minutes to a few days. These factors (time and screening) will have to vary according to the quantity of radium used, the nature of the rays emitted by the applicator, as well as by the nature of the condition to be treated. The proper application requires the exercise of sound judgment as well as experience. It will be sufficient to state that as a general rule the more superficial the condition to be treated the shorter will be the time needed with little or no screening of the applicator; the deeper the condition the longer the time with heavy metallic screening of the applicator. In the first instance we make use of the less penetrating rays, viz what are known as the *alpha* and soft *beta* rays, in the latter case we utilize the hard beta and the gamma rays. The gamma rays as they go through the metallic screen produce secondary radiations known as *"rayons de Sagnac."* These being of very low penetrative power easily produce an erythrema; it is therefore necessary that the metallic screens should be covered over with several layers of paper which absorb these irritating secondary rays. An overdose may produce a burn, leading on, if severe, to ulceration. This ulceration like that from the X-rays is extremely slow to heal. It is however a much easier matter to prevent burns in radium therapy than it is with X-rays. This is in large manner due to the possibility of more accurate dosage with the former. There appears moreover to be a distinct difference in the physiological reaction of the two forms of radiation, the rays from X-ray tubes producing an erythema much more rapidly and easily than the radium rays. In fact it is quite possible to obtain the most satisfactory results with radium without producing the slightest inflammatory reaction. One can effectively act on a subcutaneous growth without causing any irritation of the overlying skin.

It is important to know that there is a long latent period before any apparent reaction takes place. This latent period usually lasts 12 to 15 days after the application of the radium. A longer period may however elapse; I have seen it extend to over three weeks. This latent period depends to a large extent on the nature of the radiations utilized (alpha, beta, or gamma rays) the strength of the applicator as well as the time it is left in place. There seems moreover to be an unknown personal factor. Certain pathological conditions also react much quicker and easier to the rays than others e. g. a soft angioma will respond much quicker than a keloid.

The *cross fire method* introduced by *Wickham and Degrais* consists in the use of two or more applicators applied simultaneously to opposite sides of the part treated. In this manner a very powerful effect is obtained.

Radium has been found useful in quite a large number of skin conditions, but its use is most especially indicated in the following:- Cutaneous Cancer, Angiomata, Pruritus, Keloid and Vicious Scars.

CUTANEOUS CANCER. It is in cases of cutaneous cancer that radium probably finds its most important therapeutic application.

We might classify malignant disease of the skin under four main headings: 1. Pre-cancerous conditions. 2. Rodent Ulcer. 3. Epithelioma proper. 4. Secondary Carcinoma.

1. Under this heading are to be included the various conditions which may be precursors of malignant disease such as senile warts, irritated papillomata, small suspicious looking growths or sores which will not yield to ordinary treatment and which though not definitely malignant are probably in a kind of transitional stage. The bearers of these often refuse operation as it is difficult to make them realize the

possible serious nature of their condition. Moreover occurring as they usually do in old people an operation may not always be desirable. Radium is an ideal treatment for such conditions, for it will rapidly and painlessly remove them without leaving any perceptible scar.

2. In *Rodent ulcer* radium acts almost as a specific. Under the influence of the radiations, all induration and thickening rapidly vanish, the ulcer dries and heals up leaving a firm white smooth cicatrix, far superior and much more normal in appearance than the scar left by any other known form of treatment, A single dose of about an hour's duration with a naked applicator is sometimes sufficient to cure a small rodent ulcer. The treatment does not cause the least pain or inconvenience. There are various other successful methods of treating a rodent ulcer such as X-rays, carbon dioxide snow, zinc ionization. But the results of *Radium* treatment are on the whole so much superior and more certain that when this form of treatment is available there can be no choice of treatment.

3. *Epitheliomata* vary a great deal in their malignancy. Radium will give brilliant results in the more benign forms. In these cases the growth is primarily superficial and the glands become involved late. In the deeper and more malignant type of the disease when the glands are early involved, the results are usually unsatisfactory. The radium it is true is capable of removing the primary growth, but it apparently exercises little or no influence on the exension of the disease in the glands. The general experience is thatt epithelioma of the mucous membrane especially of the mouth, is refractory to radium treatment. I have however obtained excellent results as far as the local disease was concerned in a case of infiltrating epithelioma situated near the labial commissura on the lower lip, but impinging very freely on the mucous membrane; it had developed in a patch of leucoplakia. Within three months the epithelioma was completely healed leaving an almost imperceptible scar. At the time of starting radium treatment the glands of the neck were already involved. These remained stationery for a while but subsequently took on very rapid growth and in spite of heavy doses of radium (a tube being inserted in the glandular mass) finally caused the patient's death a year after the apparent cure of the disease on the lip.

4. Radium treatment often gives highly satisfactory results in the removal of the secondary nodule occurring in the operation scar of malignant cases. The treatment should however be started at the earliest sign of any recurrence in the scar. In fact it would be a wise plan for the tissues to be well irradiated by the radium rays immediately after the operation with the object of destroying any residual malignant cells which may have escaped the attention or have been beyond the reach of the operator. Statistics that are being collected show that recurrence in such cases are much less than without prophylactic raying. Nammacher reports 16 cases of carcinoma of the uterus in which he used radium after removal of the growth. Several of these cases had been operated on more than 8 years ago and not one of them has had a recurrence.

ANGIOMATA OR NAEVI. Among benign affections there is none which causes its unfortunate victims so much mental worry and suffering as a vascular birthmark, especially if it be at all extensive.

Radium gives satisfactory results in all the various forms of angiomata. These can be divided into three main types.

1. Flat angiomata which are on a level with the surface of the skin; the angioma can be quite superficial or it may infiltrate deeply

into the cutaneous and subcutaneous tissues. The colour varies from a light red to a deep purple hue. These are popularly known as *port-wine stains.* They are occasionally very extensive and may occupy the whole of one side of the face. In a case under my care both sides of the face including the eyes were almost completely taken up.

2. Raised angiomata with a smooth or irregular corrugated surface which do not disappear on pressure; these are usually hard in the whole of their extent and are not very vascular. They might be classified as fibro-angiomata.

3. Cavernous angiomata; these are raised above the surface and usually form a soft fluctuating erectile tumour of variable size. Small angiomata of this type constitute what is popularly known as the *strawberry mark.* Radium gives the most brilliant results in this last type, especially when occurring in children. Care must however be exercised that no ulceration is produced as this may cause a severe secondary haemorrhage. This can easily be avoided by giving repeated short applications, or preferably using the metallic screens with more prolonged applications. The large *port-wine* stains are the most troublesome to treat. Both the physician and patient have to excercise a good deal of patience if anything like a good result is to be obtained. A small patch is first treated "a *titre d'essai*"; in this manner one can judge what dosage is necessary. Small telangiectases may form on the resulting scar. The second type mentioned—the hard angioma—may be treated from the first with heavy doses, as there is no danger here of causing any haemorrhage. Carbon dioxide snow and liquid air have of late been very much used in the treatment of vascular naevi. It seems to me that the scar resulting from radium is much more satisfactory. Moreover radium has one very important advantage—it is quite painless. This is a matter of great moment in young children to whom the treatment can be applied while they are asleep.

PRURITUS-ANALGESIA. Radium acts as a powerful local analgesic, the constant bombardment of the alpha and beta particles exercising a soothing influence on the nerve endings. Besides arresting the discharge in cases of *ulcerated* malignant growths, radium allays any pain that may be present often acting as a veritable charm. The following will serve as as illustration—Nurse, age 43, with a small irritable rodent ulcer of the left lower eyelid. The pain from this was so intense that it would keep the patient awake at nights, and for six months she had not been able to have a single good night's rest in spite of the local application of cocaine. This had affected her general health to such an extent that she stated "she felt she was going off her head." A naked radium applicator was applied for 2 hours one afternoon over the ulcer. That night she slept soundly for 12 hours. When she awoke next morning she said she had been able to forget for the first time that she had an ulcer on the eyelid.

It will be seen from the above that the anelgesic action of radium is exercised very rapidly, within a few hours, unlike its specific action on the tissue cells which usually takes as many weeks to manifest itself. In the treatment of *Pruritus,* radium is unapproachable. It will not only allay the itching, but will also completely eradicate any skin lesion with which the pruritus may be associated. This does not of course include itchy skin eruptions due to parasites. In these cases a vicious circle is usually established. Whether the pruritus is the cause of the eruption or vice-versa, the one acts unfavourably on the other. The itching causes an intensification of the eruption which in its turn causes a further intensification of the itching. Radium will act

when everything else has failed. The following case will seem as an example. Commercial traveller age 45, with a patch of *lichenfied eczema* at back of neck, which was about the size of a dollar piece and consisted of an erythematous scaly area over which there were a number of small closely set papules which could be better felt than seen giving the sensation of passing the hand over a nutmeg grater. This patch was intensely itchy and on that account gave the patient a considerable amount of annoyance, especially as his collar was constantly rubbing against it. He had seen a number of medical men and had tried practically every ointment in the Pharmacopoeia, but only with temporary benefit. He had suffered with this for 15 years. After three applications of radium the whole thing cleared up leaving the skin smooth and supple. It is now over a year since the treatment and the patient has never had the least recurrence of his old and persistent trouble.

KELOIDS AND HYPERTROPHIC SCARS. Radium will often give excellent results in these conditions. According to *Wickham* and *Degrais*, it exercises a specific action on keloids, though one may also utilise what is known as the destructive action of radium. According to these authors there will not be, as is the case in Surgical interference, any recurrence when once the keloid is removed. The applications have as a rule to be very prolonged before any appreciable result is obtained. The keloids most amenable to radium treatment are those of recent formation and in process of evolution, as well as those affecting young children.

Before concluding, I shall briefly refer to some other conditions in which radium may occasionally be of service. NON-MALIGNANT GROWTHS yield more readily to treatment than the malignant varieties. Radium can be used with success in the removal of such conditions as hairy moles and warts, being an excellent depilatory agent. LUPUS VULGARIS and ERYTHEMATOUS. In the extensive form of these diseases, radium treatment is tedious and not always satisfactory. It is however eminently suitable for localized patches, lupus erythematosus being the more amenable of the two to treatment.

I might here add that excellent results have been obtained in some cases of tubercular glands in children. Under the influence of radium radiation, the enlarged glands gradually shrink in size and may ultimately disappear.

ULCERS. Radium will cause the rapid healing of most forms of ulceration. A case of tertiary syphilitic ulceration under my care which had been refractory to mercurial treatment, quickly healed after two applications of radium.

PSORIASIS, LICHEN PLANUS. Chronic patches of those diseases which are refractory to other forms of treatment, will often yield to radium treatment. I have already referred to LICHENFIED ECZEMA.

LEPROSY. I may here give a short account of some interesting observations which I had the opportunity of making as regards the effect of radium on this disease.

The nodules of tubercular leprosy will gradually diminish and may even disappear under the radium rays. The most interesting change is however in the effect of the rays on the bacillus leprae. These undergo a degenerative change, the bacilli in the nodules being gradually converted into a mass of red granules as seen by the *Ziehl-Neilson* method of staining. There is no change to be observed for about 14 days after the application of the radium. The bacteriolysis of the bacilli is then noticed to take place, attaining its full effect between the third and

fourth week, when there is not a single bacillus to be seen, the whole being converted into a mass of granular debris. This bactericidal effect of radium is much more marked than that observed after Nastin treatment, a method of treatment which has already produced a number of cures. It seems to be chiefly due to the beta rays.

If it were possible to impregnate the whole system with radium radiations, it is likely that we would have an effective method of combating this fell disease. It is conceivable that this could be done by inhaling a strong and large amount of the emanation or drinking it dissolved in water.

I have given a rough and I am afraid but an imperfect sketch of the use of radium in dermatology. In order to avoid a lengthy article, I have as much as possible refrained from giving quotations or references to the various authorities, merely contenting myself with a summary of the present knowledge on the subject. I hope however I have been successful in showing the highly important place occupied by radium in the treatment of Skin diseases. Indeed, it is the most valuable therapeutic agent introduced into the dermatologist's armamentarium for many a long year.

Royer's Block,
Vancouver, B. C.

FIRST PURE RADIUM SALTS PREPARED IN AMERICA.

By C. H. VIOL, PH. D.

It is of historical interest to note that the first pure radium salt prepared in the United States from Colorado carnotite ores, has been made by the Standard Chemical Company, in its Radium Research Laboratory in Pittsburgh, Pa. Recently this Company delivered to a well known Baltimore,(Md.) surgeon, one hundred milligrams of radium element in the form of anhydrous radium chloride. The salt, weighing 133 milligrams, was sealed in two tiny glass tubes, each 15 mm. long and 2.4 mm. in diameter. The radium content of this material was determined by a comparison with radium standards by the gamma ray method. The Radium Research Laboratory of the Standard Chemical Company has three radium standards; one prepared and standardized by Professor Stefan *Meyer*, director of the Radium Institute of the Imperial Academy of Sciences at Vienna, another standardized in Madame *Curie's* laboratory at Paris, and a third which was also standardized at the Vienna Radium Institute. These standards contain 1.966, 5.83 and 19.24 milligrams of radium element, respectively. These measurements are based on the International Radium Standard which was prepared by Madame *Curie*, a prototype of the International Standard being in the possession of the Vienna Academy of Sciences.

Colorado carnotite does not contain thorium in quantities that can be detected by ordinary analytical methods. If thorium is present in a radium ore, the mesothorium, a decay product of thorium chemically analogous to radium, is separated along with the radium. Thus far it has not been possible to separate radium and mesothorium by any ordinary physical or chemical methods. The half decay period of mesothorium is 5.5 years, and that of radium is 2000 years. Since mesothorium gives rise to penetrating rays, it is not possible, by a

simple gamma ray measurement, to distinguish between radium and mesothorium. Practically all minerals contain traces of uranium and thorium and consequently radium and mesothorium are also present. *Meyer* and *Hess* have estimated that about 0.001% of the gamma ray effect of radium extracted from Austrian pitchblende is due to mesothorium. Preliminary work by the writer using the radium prepared from Colorado carnotite ores, shows that the quantity of mesothorium present, as determined by actually separating the radiothorium which the mesothorium produced in six months, is very small, being estimated at less than 0.01% of the total gamma ray effect. Since the gamma ray method of comparing quantities of radium is only accurate to about 0.3%, it is quite evident that 0.01% due to mesothorium in a radium preparation could have no effect even if the preparation were being used as a "radium standard," and for all ordinary uses this small quantity of mesothorium need never be taken into consideration. A more accurate determination of the quantity of mesothorium in the American radium is being carried out and will be reported later.

THE PATHOLOGICAL ANATOMICAL CHANGES IN GUINEA PIGS KILLED BY EXPOSURE TO HIGH CONCENTRATION OF RADIUM EMANATION. II.

By FREDERICK PROESCHER, M. D.

TECHNIQUE. For microscopical examinations the organs of both guinea pigs were fixed in alcohol, formalin, Zenkers fluid, bichloride, imbedded in paraffin and the sections stained with eosin-hematoxylin, Van Gieson, Giemsa solution and methyl-green-pyronin.

The microscopical changes of organs of both guinea pigs were practically the same.

LYMPHATIC SYSTEM AND SPLEEN. Specific changes were found in the lymph glands, spleen, peri-bronchial lymph nodes, solitary lymph-follicles of the small intestine and bone marrow.

The lymphatic tissue showed everywhere to a lesser or greater degree the same change consisting of a granular destruction of the lymphocytes. The protoplasm as well as the chromatin was split into smaller and larger granules and had retained their specific staining properties.

The methyl-green-pyronin stain differentiated in an excellent manner the chromatin and basophilic protoplasm of the destroyed lymphocytes.

The granular degenerated lymphocytes, lay isolated or clumped in smaller or larger roundish or irregular shaped masses; this was found especially the condition in the lymph glands and the spleen. The clumped, granular, degenerated lymphocytes were separated by smaller and larger empty spaces.

In some sections were found beginning reparatory changes, consisting of pale, large, round or spindle like cells of connective tissue origin, which phagocytised the destroyed lymphocytic masses.

The stroma cells of the lymph glands and also the pulp cells of the spleen were somewhat loosened and less stainable. The trabecel of the spleen did not show any changes.

The eosinophilic infiltration in the lymph glands seemed to be more pronounced than in normal conditions. The blood vessels in

the spleen and in the lymph glands were greatly distended and filled with blood.

The bone marrow showed granular degeneration of the small and large lymphocytes, the special granulated cells did not show any changes.

LUNGS. The capillaries were regularly distended as in an artificially injected specimen. No change was noticed in the alveolar epithelium, in both lower lobes the alveoli were partly filled with a homogenous exudate and with proliferated epithelium cells.

No change was noticed in the larger bronchi. The bronchial walls seemed to contain a larger amount of eosinophilic cells than is normal.

HEART. The muscle fibers of the heart were less distinct, the striations somewhat effaced, here and there were found some small hemorrhagic foci. No change was noticed in the endocardium.

DNEYS. The capillary net of the glomeruli was markedly distended with blood and also were the large blood vessels. No hemorrhages were noted in the glomeruli and no distinct changes were visible in the lining epithelium of the uriniferous tubules.

LIVER. The capillaries were greatly distended, the liver cells less distinct, the neuclei less stainable and somewhat swollen. The bile capillaries and the larger blood vessels were without change.

STOMACH AND INTESTINES. The blood vessels of the mucous membranes of both stomach and intestines were markedly distended. The epithelium was without change. The lymphocytes which were found migrating through the mucous membranes, showed the same granular destructive process that has been described heretofore.

PANCREAS, SUB-MAXILLARY GLANDS, SUPRA-RENAL CAPSULES, AND THYROID AND PARATHYROID GLANDS. These organs did not show any marked changes excepting dilatation of the capillaries. Careful examination of the urogenital organs especially the testes did not show any change in the spermatogenesis.

CENTRAL NERVOUS SYSTEM. The capillaries of the pia-arachnoidia and the brain substance show marked dilatation. The large pyramidal cells of the cortex and the Purkinje cells of the cerebellum show a decrease in tigroid. No change was noticed in the nerve fibers and the neuroglia.

SUMMARY. The exposure of guinea pigs to a concentration of radium emanation of from 55,000,000 to 70,000,000 mache-units effected the animals after a latent period of from two to three hours. Death ensuing within two to six hours after the animals showed symptoms of increased respiration and drowsiness.

Death was due to respiratory paralysis probably of central origin due to the exhaustion of the nerve cells, which could be demonstrated microscopically by a diminution of the tigroid. This seems probable as other changes noted in the organs were insufficient to cause death.

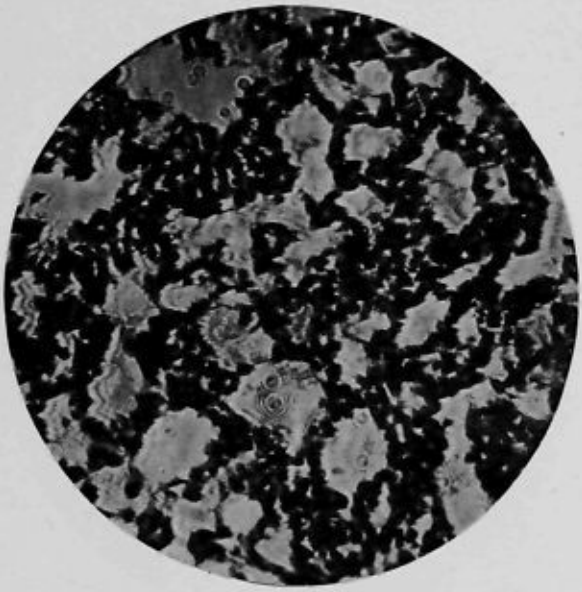
The concentration of radium emanation just sufficient for a lethal dose has yet to be determined by further experiments, but it seems likely from the foregoing experiments that a much smaller concentration than 50 million mache units is sufficient.

The changes noted in the blood after exposure to radium emanation were not very pronounced.

In the first experiment it was noted a decrease of the red cells from 5,000,00 to 4,350,000. The white cells showed a slight increase from 8,250 to 9,250. The differential count showed a slight increase in the pseudo eosinophiles, the other cell forms did not vary very much.

No effect was noticed in the structure of the lymphocytes. The monocytes decreased from seven to two per cent.

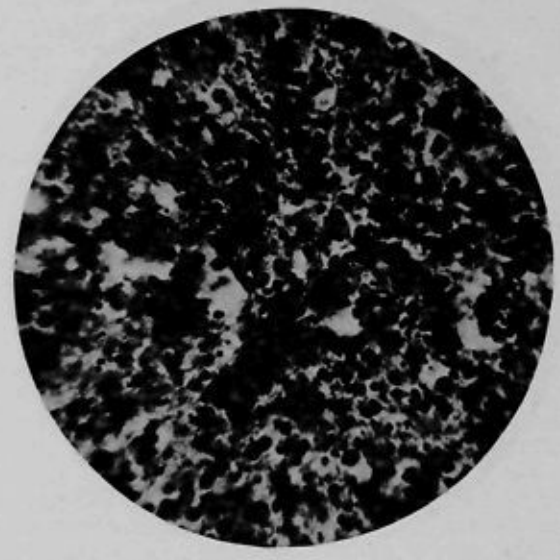
In the second experiment the red cells were increased from 6,000,000 to 6,225,500, the white cells were reduced from 15,000 to 5,000. The differential count did not show any change. No change was noticed in the structure of the red cells.



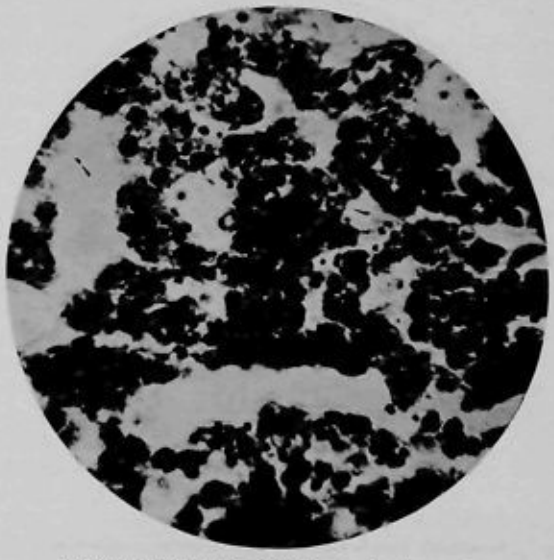
Lung showing marked dilatation of the capillaries.
Leitz objective 6, ocular 4.

Mesenteric lymph gland showing granular destruction of lymphocytes.
Leitz objective 6, ocular 4.

In conclusion it would seem that an extremely high concentration of radium emanation has very little effect on the erythrocytes and the hematogen lymphocytes. The difference in the blood pictures of both experiments may be due to the difference of the concentration of radium emanation or to individual differences of the animals. This point I will leave undecided for future research. No specific microscopical changes

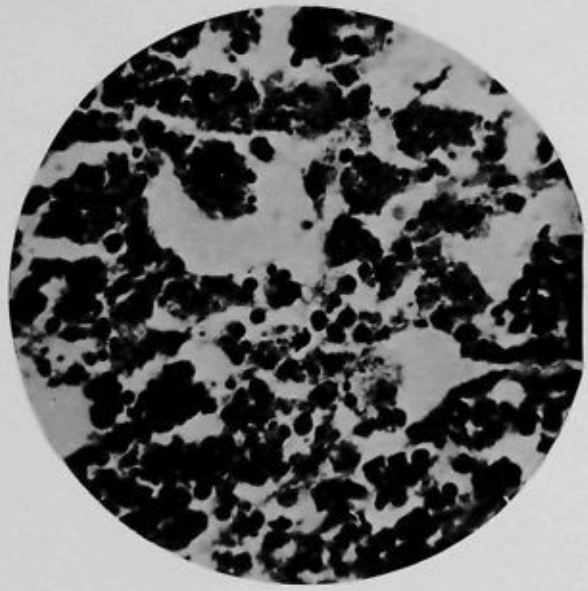


Solitary lymph follicle of the small intestine, showing granular destruction of lymphocytes.
Leitz objective 6, ocular 4.

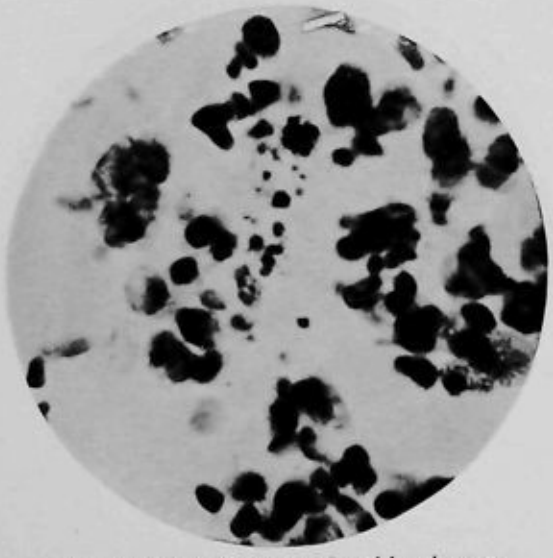


Inguinal lymph gland showing granular destruction of lymphocytes.
Leitz objective 6, ocular 4.

were found at the autopsy. The only microscopical change noticed was hyperaemic condition of all the organs. Microscopical changes were only found in the lymphatic system, spleen and bone marrow, which consisted of granular destruction of the lymphocytes. The effect of high concentrations of radium emanation on animal organism is similar to that of the X-ray. Animals exposed to continued X-ray

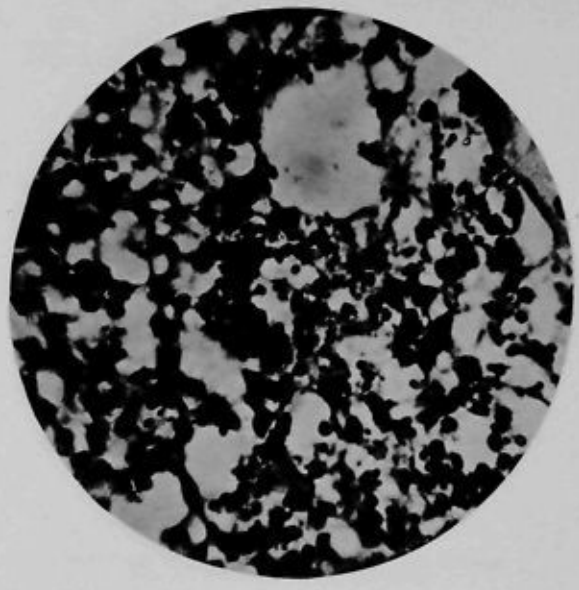


Spleen showing destruction of follicles.
Leitz objective 6, ocular 4.

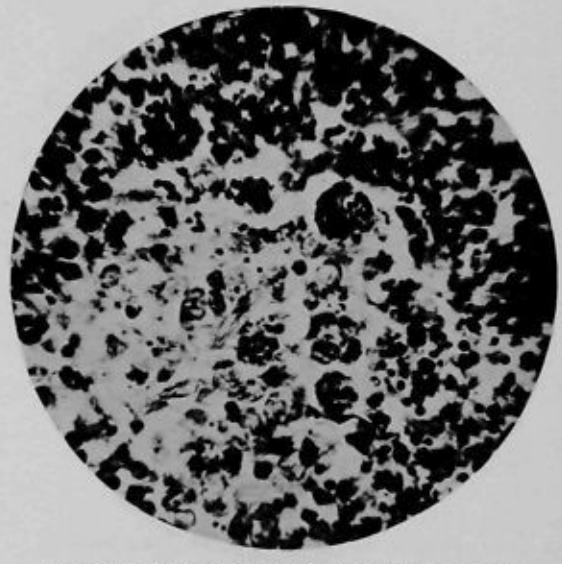


Bone marrow showing destruction of lymphocytes.
Leitz objective 6, ocular 4.

treatment show a similar destruction of the lymphatic tissues. 'Death after intense X-ray radiation occurs in from five to six days. In both instances the gamma rays seemed to be responsible for the destruction of the lymphatic tissues. The rapid lethal effect of concentrated radium emanation is probably due to the tremendous kinetic effect of the alpha rays.



Peribronchial lymph node showing granular destruction of lymphocytes.
Leitz objective 6, ocular 4.



Mesenteric lymph gland showing connective tissue cells phagocytising destroyed lymphocytes.
Leitz objective 6, ocular 4.

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RADIUM

A MONTHLY JOURNAL DEVOTED TO THE CHEMISTRY, PHYSICS AND THERAPEUTICS OF RADIUM AND OTHER RADIO-ACTIVE SUBSTANCES

VOLUME TWO
OCTOBER, 1913 TO MARCH, 1914

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RADIUM

A Monthly Journal Devoted to the Chemistry, Physics and Therapeutics of Radium and Other Radio-Active Substances

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We shall be glad to receive for publication from our subscribers and readers articles pertaining to the subject of radium and its application. All inquiries for information will be accorded prompt attention, and will be answered either by letter or through the columns of this paper.

Vol. II OCTOBER, 1913 No. 1

Radium and Mesothorium In The Treatment Of Malignant Tumors. I.

By Otto Schindler, M. D. (*Vienna*).

The splendid results which *Kronig, Bumm* and *Doderlein* were able to obtain in the treatment of uterus cancer by using large doses of filtered Rontgen and mesothorium gamma rays, as reported at the Gynecological Congress in Halle, have justly attracted the attention of the whole medical world. Stimulated by a several months sojourn in 1907-8 at the Paris Radium Institute of Doctors *Wickham* and *Degrais*, I have been working with radium in the treatment of malignant tumors for the past four years and with mesothorium for the past year. As I have had opportunity to treat a comparatively large number of cases in this time, it now seems desirable to give a report of results, especially since I have worked with sufficient quantities of both radium and mesothorium, and can make a comparison of their effects.

As regards the physical side, I will assume that the properties of the gamma rays of radium are known, and will only mention that commercial preparations of mesothorium vary considerably in composition and in radiating power. It has been said that 25% of the gamma ray activity of mesothorium is due to radium, but Prof. Stefan *Meyer* found that an Austrian mesothorium contained only between 2 to 4 per cent. of radium. The activity of mesothorium varies with time, increasing because of the formation of radiothorium and its products. The ratios of the activities due to the different forms of rays vary because of the formation of these new products. While pure mesothorium gives no alpha rays, the alpha ray activity slowly increases due to the formation of radiothorium and its subsequent products. To this will also be added the considrable alpha ray activity of the radium and its decay products present in the mesothorium. As regards the beta rays of mesothorium, it may be said that these are somewhat less penetrating than those of radium, and they show a somewhat different absorption curve from that of the radium beta rays. The gamma rays of mesothorium are about equally as penetrating as those of radium. Some workers have said that gamma rays of thorium D have about 10% greater penetrating

power than the gamma rays of radium C* however, this is not entirely certain (private communication from Prof. Stefan *Meyer*). In any event, the difference in penetrating power of the gamma rays of radium and mesothorium is so slight as to have no significance as far as the medical uses of these substances are concerned.

The hardest gamma rays of radium are far harder than the hardest X rays (Cf. the scheme of *Bayet* in *Lazarus*' Handbuch der Radium-Biologie und Therapie). The variations in activity and efficiency of mesothorium can possibly best be illustrated by the following measurements which Dr. *Paneth*, assistant in the Radium Research Institute of the Vienna Academy of Sciences has kindly made on my mesothorium preparation.

Activity measurements of Mesothorium Applicator 2
Based on International Radium Standard.

Date of Measurement	Activity corresponds to Mgm. of Radium Element	Activity corresponds to Mgm. $RaBr_2 2H_2O$.
July 17, 1912	7.41	13.82
Oct. 25, 1912	7.85	14.65

The initial activity of this mesothorium preparation was stated by the Knofler Company of Plotzensee to be equivalent to 15 mgm. of radium bromide, which is about 10% higher than the first measurement above shows. The increase in activity of the mesothorium during the three months is in accord with the fact, that the activity of mesothorium after its preparation should increase, due to the slow formation of radiothorium and its subsequent products. According to the manufacturer's statement, the activity of this particular mesothorium preparation should reach a maximum after 3.2 years, falling to the initial activity in about 10 years.

The following table gives a list of the radium and mesothorium applicators which I have, and the measurements have all been made on the basis of the International Radium standard, at the Vienna Radium Institute.

Applicator No.	Radioactive Element	Date of Measurement	Activity corresponds to Mgm. of Radium Element
1	Radium	Oct. 25, 1912	11.04
2	Mesothorium	Oct. 25, 1912	7.85
3	Radium	June 23, 1913	14.98
4	Radium	July 10, 1913	14.88
5	Radium	July 10, 1913	15.05

The radium in applicator No. 1 was purchased in 1908 from Braunschweig as 25 mgm. of radium bromide and at that time it was fixed upon a square applicator of 2.25 sq. cm. area in the form of sulfate incorporated in a varnish, by the Armet de Lisle Company in Paris. The mesothorium applicator was obtained in 1912 from Knofler in Plotzensee, this material being enclosed in an oval *Wichman* capsule, having the dimensions; 13 mm. long. 7 mm. broad, 2.5 mm. thick with a silver cover 0.05 mm. thick. Applicators 3, 4, and 5 were obtained in finished form from the Standard Chemical Company of Pittsburgh. Applicators 3 and 4 are silver *Dominici* tubes about

*Russell and Soddy, Phil. Mag. Vol. 21, Page 130 (1911).

3 cm. long and applicator 5 is a square metal holder of 9 sq. cm. area on which the radium is fixed with varnish. The results obtained with the last three applicators are as yet few in number.

As regards the technic of application I have followed the practice of *Wickham* and *Degrais* in all details. In all superficial skin cancers the applicators were used screened only with several layers of lead foil and with 2 mm. of rubber. In larger deep seated carcinoma, the applicators were screened with from 0.5 to 2.5 mm. of lead or silver sheets. To absorb the irritating secondary rays, which may cause painful burns when long applicators are made, 20 to 40 sheets of tissue paper were put over the applicator and one or two thicknesses of muslin used as an outer covering. Lately platinum screens have been used, and these, because of their half smaller volume with an equal absorbing capacity as compared with lead screens, have proven very practicable. Wherever possible the "cross fire" method was utilized. This is accomplished by using several applicators at different points on the surface in such a way as to cause the paths of the rays to cross each other in the growth; in this way obtaining the most intense radiation effect within the tissue, with a minimum of superficial irritation.

Adrenalin injections to desensibilise the skin for X ray treatments as practised by *Reicher* and *Lenz*, are not practicable here, because of the long time of exposure used in the radium treatment.

The applicators were fastened by means of adhesive tape where the lesion was on the surface of the skin. When used in the various body cavities into which the applicators were introduced, a rubber finger cot was used to protect the valuable material, the rubber tube being tied tightly to keep out moisture, and to keep to applicator free from contamination. In the mouth cavity the applicator was fastened to a rod of aluminum bronze wire, covered with cotton, the radium or mesothorium being held in place, after having been properly arranged, by having the patient bite on the cotton covered rod. In this way an applicator could be held in place for hours. When used in the rectum, a *Foges'* rectoscope was used, by means of which it could readily be seen when the applicator was in the desired position. The applicator was then fixed in place by means of a tampon of greased gauze. In this way the applicator could be used without great inconvenience to the patient, for periods of 12 to 24 hours. To avoid irritating tenesmus a few drops of tincture of opium were finally used. In the vagina an applicator could be readily inserted in a similar manner. Two methods are available to bring the applicators into the larnyx and both of these having been utilized. Either the applicator is passed in directly on a flexible rod *per vias naturales* after cocainizing the mucus membrane, the application lasting as long as the effect of the cocaine makes it possible; or else the applicator is introduced directly into the larynx after a laryngo-fissure has been made. In applying the radium within a tumor or in artificial openings the applicator must be covered with a sterilized rubber finger cot, which is finally disinfected with tincture of iodine. For the oesophagus a bougie was used into which the mesothorium applicator could be passed.

Regarding dosage it may be said that in superficial lesions where lightly screened applicators can be used, thus utilizing the greater part of the available rays, relatively short periods of exposure are sufficient. Thus it was frequently possible to remove (without subsequent recurrence) the ordinary benign skin epithelioma of the face (epithelioma perlee of the French) in a single application lasting 50 to 60 minutes, using only a rubber covering over the applicator. In the case of the

deep seated skin cancers and particularly in deep seated nodules and infiltrations and in the treatment of carcinoma of mucus membranes the treatment is quite different. Heavy lead filters 0.5 to 2.5 mm. thick must be used, and to absorb the irritating secondary rays 20 or more thicknesses of paper must be interposed. In this case, using the thickest lead screens, only the gamma rays and a very small percentage of the hardest beta rays pass through, the "rayons ultrapenetrants "of the French. Since these rays form only a very small percentage of the total radiation it is necessary to have very powerful radioactive preparations and to apply these for a long time—days to a single exposed part. In inoperable cases experience has led me to use maximum doses. It is, however, not necessary to use such exceedingly large quantities of radium as are now being described in Germany in connection with the use of mesothorium. According to my observations a quantity of radium is sufficient for most uses, which can give a radiation dosage sufficient to destroy a carcinoma by three to four weeks of continual application, since in this relativey short period the radiation effect is cumulative. It seems to be a matter of choice, assuming that the time required for the treatment did not exceed three of four weeks, whether the effect is attained by means of a cumulative equivalent radiation dose using smaller but nevertheless rather considerable quantities of radium or mesothorium during correspondingly longer periods of exposure, or whether several hundred milligrams of radioactive material are used for correspondingly shorter intervals, as *Kronig* does for example. In general, according to my experiences, several applicators each containing about 15 mgm. of radium element are sufficient to treat a case, if these are used continually day and night till the desired radiation dose is attained. For certain purposes, as for example in the treatment of cancer of the mouth, pharynx and larynx where longer exposures can only be made with the greatest difficulty, it is a great advantage to possess considerably more powerful applicators. So if only a small quantity of radium is available, the applicator must be used continuously for weeks on a single case and of course the position of the applicator must be varied in a suitable manner.

In a case of an inoperable recurrent carcinoma of the cheek and the mucous membrane of the palate, which will be cited later, a single treatment lasting 31 days was given which equalled 7,200 mgm. hours. (Ra. element). To my knowledge no such dose has ever been given before.

With reference to the expression "milligram hours" which is frequently used now, it may be said that this is strictly incorrect as a measurement of dose viewed from a purely physical standpoint. It is obvious that it makes a great difference whether the same quantity of radium is spread over a small area or over a much larger area and the extent to which an apparatus is screened makes a tremendous difference in the results. With the same applicator applied for the same interval (that is the same number of "milligram hours") very different results will be obtained when the instrument is used with little screening, so that the greater part of the available radiation is effective, as compared with the results obtained using a heavy lead screen which absorbs all but the hard gamma rays. Furthermore, there will be a great difference depending on whether the applicator is applied on the surface of a tumor so that only the rays are utilized which pass in the direction of the tumor, or whether the same applicator is in-

serted in the tumor mass, thereby utilizing the radiations that pass in all directions. The term "milligram hours" will only serve as an approximate measure of dose if it is restricted to strongly screened applicators where only the gamma rays are effective; and particularly to apparatus in which the area over which the radium is spread is small (e. g. tubes and small applicators). Further the term "milligram hours" should not refer to any salt (bromide, sulfate, etc.) but rather to the activity of the applicator expressed in terms of milligrams of radium element, on the basis of the new International Standard.

In concluding this discussion* of the matter of dosage a few remarks may be made concerning certain idiosyncrasies towards radium rays. The sensibility of the skin to the radium rays varies within certain limits with the individual. Children are much more sensitive than adults, and old people often stand surprisingly large doses without noticeable reaction. People with a delicate skin, particularly women of delicate complexion show in general a greater sensitiveness to the radium rays. Even the different portions of the skin of an individual shows different degrees of sensibility, but this sensibility varies, if the dosage is taken into consideration, within such limits, that it is not in general possible to speak of a true local idiosyncrasy. At least in the several thousands separate radiation treatments which I have carried out, I have not as yet been able to observe a single undoubted case of local idiosyncrasy. It cannot, however, be said that such an idiosyncrasy could not occur. The tissues become hypersensitive through previous radiation treatment. If the tissue has been treated even months before, subsequent treatment produces a much more vigorous reaction than the same treatment would produce on an untreated place. This point must be carefully considered. This circumstance often leads to difficulties in the treatment of recurrences in tissues affected by previous raying. In such cases the result may be much the same destructive action that is observed in the case of tumor cells. If the treatment is made with smaller dosage, the cancer cells are not sufficiently affected and if the treatment is intensive enough to affect the cancer cells, there is the danger of causing necrosis of the surrounding healthy tissue, which has become sensitive because of previous treatment. It is often a matter of difficulty to attain the proper dosage in such cases.

SYMPTOMATOLOGY OF RADIATION TREATMENT

The rays of radium like the X ray, do not cause any pain or sensation during the period of exposure. The tissue may be badly injured, although the patient feels nothing of it while being "burned." Even shortly after the raying there is no objective change to be observed in the part that has been treated. The reaction which occurs (as *Wickham* and *Degrais* say, the answer to the disturbance which the passage of the radioactive energy causes) will differ depending on whether no screen or thin screens or heavy metal screens covered with paper are used. In the former case, after a suitable exposure (a few minutes to an hour) an inflammatory reaction takes place, a sharply

*A quotation is given from *Wickham*. and *Degrais* whose work has laid the foundations of modern radium therapy and whose authority in this field is recognized. "It may be said once for all, that it is impossible to use radium without being confident in all the details and indications which the various methods and technics necessitate, and this confidence is only to be gained by long experience. If all cases that come under consideration are treated with large quantities of radium without using judicious discrimination, if the suitable dose and screening for each case is not given careful consideration, bad results will be obtained, burns will result and the method will be discredited. In brief, radium is a fine and delicate therapeutic agent and its use necessitates the most skillful handling by a clinician having wide experience in Radium Therapy." (*Lazarus* Handbuch der Radium-Biologie und Therapie, Page 403).

defined erythema occurs on the spot treated after a latent period of from several hours to three weeks. (1st degree reaction) If the dose has been low, the resulting erythema slowly disappears in the course of several weeks, scaling of the skin sometimes occurring. If the dose is stronger, the erythema will be followed by the formation of a crust. (2nd degree reaction) The crust falls off in from two to six weeks, re-forms several times, the successive crusts being thinner, the radium dermatitis finally disappears leaving a somewhat depigmented spot, soft, and not like a scar, If the raying was more intense, a superficial or even a deep necrosis of the tissue results which requires many weeks to heal. (3rd degree reaction) Different statements with regard to the length of the latent period are to be found in the literature, being given as from a few hours to four weeks. In general it is found that the latent period, that is, the interval elapsing between the raying and the first visible reddening, is inversely proportional to the applied radiation dose. (cf. *Sticker*, in *Lowenthal's* Handbuch der Radium Therapie) This is true up to a certain point, but the early appearance of the reaction depends upon whether wholly unfiltered applicators which give off the soft rays are used or whether screens are used. With varnish applicators where a part of the alpha rays may pass through the varnish, a primary erythema may result in several hours. Even if thick metal filters are used, if the secondary rays are not sufficiently absorbed a faint redness may often be noticed at the spot treated, after a day. The reaction caused by the harder rays usually only occurs after two or three weeks. Usually in the case of prolonged rayings the main reaction follows gradually upon the primary erythema, where this does occur, so that a gradually increasing erythema or an erythema with crust formation is observed. The early or late occurrence of the reaction will also depend upon the dosage—as has been said before. A consideration of these varying relations makes it possible to explain satisfactorily the variations in the reported latent periods. If a suitable thick lead screen has been used, and the secondary rays have been absorbed by interposing layers of paper, very large doses may be given without irritating the surface. In the case of maximum doses applied for penetrating raying, an erythema or superficial dermatitis must be expected. However, this dermatitis soon heals without causing further damage. Sometimes when using maximum doses for penetrating effects, a rather far reaching edema results which may be some time in disappearing. After placing radium into an operative opening a somewhat protrated course was observed in the wound.

The effects of the radium rays upon carcinoma vary depending on the sort of carcinoma and upon the sort of radiation treatment. As regards the first point it must be emphasized that the carcinoma tissue shows less resistance to the destructive action of the radium rays than does normal tissue; so that there is a selective effect exerted by the radium rays on the carcinoma tissue. The radiosensibility of various cases may differ and in a fashion that cannot be foretold *a priori*, though often soft tumors rich in cells are found to be very sensitive to raying. While some cases react promptly to the raying, others are less easily influenced, and a small percentage have proved refractory with the dosages so far used.

The effect on the carcinoma tissue will also depend upon the method of raying. If little or no filtering is used, so that there are soft beta and sometimes even alpha rays along with the harder rays, then there results as has been said, a vigorous reaction leading to superficial or even deeper necrosis of the carcinoma tissue. The rays in the main are

acting as a sort of local caustic. It is these violent undesirable reactions which make this method undesirable in most cases. It is because in this method the most irritating rays, which also form the greater part of the total radiations, are effective and unless applied for only a short time, cause bad burns. The effect is mainly superficial since in the time of application the proportionally fewer penetrating rays cannot have an effect deeper in the tissue. So this method is only applicable in cases of superficial skin cancers where in the short time of application the penetrating rays do not have a chance to cause any considerable effect. For other cases large doses using heavy screens is the method of choice. This sort of treatment results in less violent effects since here only the very penetrating gamma rays, freed from the secondary rays, come into play, thus obtaining an intense deep seated effect in utilizing the selective effect of the radium rays on the carcinoma tissue. However, it must be observed that the dose is sufficient to retard the growth of the cancer cells in the deepest and most remote parts of the neoplasm. Otherwise there is a destruction of the nearlying tumor mass, but as the intensity of the rays diminishes proportionally to the square of the distance, finally only a stimulating dose reaches the youngest tumor cells and this simply stimulates these cells to more rapid proliferation, as I have been able to plainly observe in a case of colon carcinoma. Therefore, to avoid this danger, not only must maximum doses be applied, but the whole affected part must be thoroughly rayed. It is well to even place a tube applicator within the tumor mass.

Objectively, the results of the raying are as follows: The cancerous lesions begin to clear up, often after the disintegration of necrotic tumor material, the putrid secretion diminishes and loses its fetid character, hemorrhage ceases, hard infiltrated margins break down and the loss of substance which results is finally covered with skin from the margin. This process may also take the form of a simple softening and resorportion of the tumor mass without any necrosis of the tissue. Hard carcinomatous infiltrations become soft, of the consistency of normal tissue, after first showing a temporary reaction edema or swelling due to the raying. Subcutaneous nodules and gland tumors disappear leaving small indurations apparently of connective tissue. It must be emphasized that metastases of the glands often show a great resistance to radium treatment. *Werner* distinguishes three reaction forms of tumors towards Roentgen rays; 1st, shrinking into connective tissue; 2nd, colliquation; 3rd, necrosis. While I have often observed the 1st and 3rd reactions after radium applications, only in one case have observed a partial colliquation, that is a liquifaction of the tumor, this occurring in a case of colon carcinoma treated by placing a mesothorium capsule within the tumor itself.

Subjectively, the influence of radium application makes itself known by a diminution of the pain. This analgetic effect is very important and especially to be emphasized because as is well known the pains caused by carcinoma are of the most painful nature and often are not to be relieved by the use of the highest doses of narcotics. Radium is valuable in inproving the subjective condition even in quite hopeless cases, where there is no prospect of prolonging life or of affecting the cancerous growth, since it lessens the pain or even causes it to cease. As an example of such a case I will mention a later cited case of primary endothelioma of the pleura.

In the rapid softening of large tumors as a result of intensive raying toxemic conditions often result, patients showing a fever up to 39.5° C, and a high degree of exhaustion and fatigue, often even when the height of the fever is not sufficient to explain the latter condition. Nausea and vomiting are often associated as symptoms, which point to a severe toxemia in the organism due to the resorption of decomposition products. I could often notice a direct parallelism between the height of the fever and the extent of the radiation dose. Great care must be taken in regard to this toxemia in the treating of large tumors, since it may stand in the way of using an intensive raying which would otherwise be desirable.

Corresponding to the local improvement of condition there is also a general improvement, the patient regains his appetite, the body weight increases appreciably and the cachexia disappears. Even in cases where the objective improvement is not very pronounced, the favorable influence of the raying on the general condition is to be observed.

Histologically the influence of the radium rays on carcinoma tissue as *Exner* first observed is a necrobiosis of the tumor cells with vacuolization and finally a disappearance of these cells together with the appearance of a sclerotic connective tissue which tears the cancer cells apart and breaks them into small groups, where they eventually are destroyed.

In addition to the above mentioned toxemia which may result from the radium treatment of large tumors, the following phenomena must also be considered: 1st, burns, undesirably intense reactions leading to necrosis of tissue; 2nd, hemorrhages due to erosion of the blood vessels; 3rd, perforation of hollow organs. With respect to the first it may be said that suitable dosage and screening can only be learned by long experience with each particular applicator. This experience will enable one to keep the damage to the skin and mucous surfaces within such limits, that the resulting reaction soon passes without further bad effects. Erythema and superficial crust formation on the skin have no serious significance and soon heal not being at all comparable, as was first thought, to the severe X ray burns. The more undesirable deeper necrotic effect upon tissues may be avoided by using suitable screens and carefully controlled doses. As regards the hemorrhages which various writers have observed after very intense raying, I wish to state that I have never observed any such effects, not even in two cases where the applicators were in attached quite near to the large cervical vessel for twenty-four hours. In all about 500 milligram hours were applied to the vessel wall without harm resulting. However, I took care to enclose the applicator in two mm. of lead and covered this with suitable thickness of rubber tissue to absorb the irritating secondary rays. With insufficient screening for the absorption of the secondary rays, it is quite possible that a direct necrosis of the vessel wall may lead to bad hemorrhages. This undesirable result may even be avoided in the case of carcinomatous infiltrations of the vessel wall itself, by a suitably selected dosage and sufficient screening. If this condition of a vessel is suspected the greatest care must be used, preventive ligature of the threatened vessel being necessary. As to perforation of hollow organs. I have only seen one such perforation in an osephagus carcinoma (together with Dr. H. *Marschik*). Still in this case, because of the whole clinical course and because of the small radiation doses used (30 milligram hours of mesothorium screened with 1 mm. silver

and a suitable thickness or rubber), it is probable that the perforation was not due to the raying, since it formed after the second one hour application, and it is likely that it would have occurred in any event. In another case later cited (H. St., carcinoma of the mucus membrane of the cheek) by an accident the rubber covering was torn, and so the irritating secondary rays came into play. These acting on a spot sensibilized by previous large doses, led to a perforation in the cheek, about the size of a dime. Except for the unfortunate fault in screening which was due to poor manipulation by the patient to whom the applicator had to be entrusted, it is probable that the perforation would not have occurred, even with the high doses applied, and this illustrates the importance of cutting off the irritating secondary rays. It is necessary to work very carefully on the case of infiltrations in the walls of the hollow organs (stomach, intestines, bladder, oesophagus, etc.) where the accelerated disintegration of tumor masses may lead to perforations that may result fatally. By suitable screening and dosage the dangers can be reduced to a minimum. Although I have applied doses of thousands of "milligram hours" in cases of carcinoma of the colon and rectum, I have never had any such accident occur.

(To be concluded in the next number)

NOTES AND COMMENTS

The Bureau of Standards at Washington, D. C., has recently secured several radium preparations from the Standard Chemical Company of Pittsburgh, Pa., which will be calibrated for use as radium standards. Heretofore the Bureau has not been in a position to make measurements of quantities of radium, but we are informed that it is expected that in the near future this work will be carried out; and the acquisition of radium for the Bureau's standards marks a step in this direction.

* * * * *

A very interesting display of radium salts and pharmaceutic radium preparations was exhibited by the Radium Chemical Company of Pittsburgh during the Annual Meeting of the Medical Society of the State of Pennsylvania, at Horticultural Hall, Philadelphia, September 22nd to 25th, 1913. The display consisted of radium salts (over a hundred milligrams of radium element being shown in the form of salts mounted in various forms of applicators), radium solutions for injection, radium drinking water, radium bath water, radium, compresses and radioactive earth. These are all products of the Standard Chemical Company of Pittsburgh, which produces its radium from Colorado carnotite ores. In addition to the radium preparations, an Emanator built by the Standard Chemical Company was displayed. This apparatus is used in the preparation of radium emanation drinking water, and for charging air with emanation for inhalation. Various forms of instruments used in the application of radium for the treatment of cancer and other diseases, were also shown, and demonstrations were made of the methods of measurement of radium.

* * * * *

The Report for 1912 of Director *Jungmann* of the Lupus Institute in Vienna, shows the very favorable results obtained in the treatment of lupus with the radium rays. While surgical treatment in suitable cases is still considered the method of choice, radium comes next as the best method of actinic treatment. Of the patients treated, 561

were treated surgically and cured; 605 were treated by Finsen light, 935 by X-rays and 610 by radium.

* * * * *

Dr. William H. *Cameron* of Pittsburgh, Pa., presented a paper to the Medical Society of the State of Pennsylvania, on "Mechanical and Physical Agents." at the annual meteing of the Society in Philadelphia, September 24th, 1913. In this paper Dr. *Cameron* gave an account of his work with radium and radium and radium emanation in the experimental clinic of the Standard Chemical Company, at Pittsburgh, and in his private practice, and he stated it as his opinion that radium is the most valuable physical agent that Medicine possesses.

* * * * *

Madame *Curie* has been engaged in founding a Radium Institute at Warsaw, Poland, during the past summer, but will, according to a note in Science, return to her position at the Sorbonne in Paris this fall.

* * * * *

As a result of the success in the application of radium in the treatment of malignant tumors, and particularly in the treatment of cancer of the uterus, there has been a general movement on the part of the larger German cities, including Berlin, Frankfurt, Munich, Essen, Mannheim, Hannover and Duisburg, to secure larger quantities of this valuable material for use in the municipal hospitals at these places. The market supply of radium produced in Europe has been exhausted and Germany now returns to America for supplies of radium.

* * * * *

Professor Karl *von Noorden*, has given up his position as director of the First Medical Clinic of the University of Vienna, and will return to Frankfurt. Professor *von Noorden's* work is world famous, some of his more recent work being on the applications of radioactive substances in internal medicine. Considerable difficulty is being experienced by the authorities in finding a successor to Dr. *von Noorden*, Professor *His*, of Berlin, also well known by his work on radium emanation therapy, being the latest to refuse the Vienna position.

* * * * *

At the Seventeenth International Medical Congress which met in London, August 6th to 12th, 1913, the application of radium was much discussed in the section of Obstetrics and Gynecology, of Dermatology and of Radiology. Dr. Foveau de *Courmelles* of Paris gave a very favorable report of the use of radium and X-rays in malignant diseases. Of 100 cases of inoperable carcinoma, improvement was obtained in 70 for from one to four years. Professor *Doderlein* was very enthusiatic in his support of the claims of radium and mesothorium, and Professor *Jacobs* of Brussels, preferred radium to radical operation in extensive malignant cases. The discussion as a whole was very favorable to nonoperative treatment, but the dangers of possible degeneration, developing malignancy and sterilization were pointed out fully. In the section on Dermatology, Mr. A. E. H. *Pinch*, Director of the Radium Institute, London, opened the discussion on the use of radium in skin diseases, and he stated that radium is the best agent for the treatment of many diseases such as rodent ulcer, warts, eczema and for moles and vascular nevi and keloid radium treatment gives splendid results and psoriasis while later recurring—responded to very short applications. There results fully confirmed by the French works, including the pioneers in the radium application; Drs. *Wickham* and *Degrais*.

II. Radio-Active Matter In The Atmosphere.

By W. W. Strong, Ph. D.
Mellon Institute of Industrial Research, University of Pittsburgh.

In the year 1901, *Geitel* and C. T. R. *Wilson*, working independently of each other, showed that air is not a perfect insulator. Many of the greatest physicists had held the view that dust free air is a perfect non-conductor, but *Geitel* and *Wilson* proved conclusively that ordinary air is slightly ionized. This ionization of the air varies in intensity from place to place and from time to time and it was to explain some of these remarkable variations that *Elster* and *Geitel* proposed the hypothesis that this ionization was due to radioactive products in the air. Experiments carried out by many investigators all over the world indicate that this hypothesis is correct.

The study of the ionization of the air has resulted in the discovery of two more gaseous constituents of the atmosphere, radium emanation and thorium emanation. These emanations disintegrate into the solids, the radium and thorium active deposits. These active deposits thus form a virtual "radioactive dust" in the air, a "dust" that plays a much more important role than would be expected of such a minute quantity of matter.

THE RADIOACTIVE DUST IN THE AIR.

The early investigators thought that new radioactive substances might be discovered in the air, but up to the present time only radium and thorium products have been detected with certainty. The usual method of collecting "radioactive dust" consists in exposing a negatively charged wire (several hundred or thousand volts) to the air and then studying the activity of the deposit. This activity is found to behave in every way like a mixture of the radium and thorium active deposits, the relative amount of radium and thorium depending upon the locality. By making exposures of the charged wire for twenty or thirty hours one obtains equilibrium quantities of the radium and thorium deposits. For such a "maximum deposit" *Bumstead* found 30 per cent. to be due to thorium (New Haven); *Blanc* 70 per cent. (Rome); *Wilson* 60 per cent. (Manchester, England) and S. J. *Allen*, 60 per cent. (Pittsburgh). The amount of "radioactive dust" is usually greatest in stagnant air such as is found in rooms, cellars and caves. According to *Elster* and *Geitel*, greater quantities are to be found when the temperature and barometric pressure are low. It is washed from the air by rains and snows, thus making rain water and snow slightly radioactive. Through the great cyclones, anticyclones and other air currents of our atmosphere the "radioactive dust" becomes very widely diffused. Comparatively large quantities of the dust have been observed at altitudes of 15,000 and 20,000 feet, and at sea for distances of a thousand miles or more from land. As seen from the following table its intensity seems about as great over the Arctic regions as it is in the warmer regions of the earth's surface.

Observer	Locality	Activity		
		Mean	Maximum	Minimum
Elster and *Geitel*.	Germany.	19	64	4
A. *Gockel*.	Switzerland.	84	170	10
Simpson.	Norway.	93	432	20
Simpson and *Wright*	Indian Ocean	6	21	1
Simpson and *Wright*	Australia.	124	...	..

The negative ions and dust particles of the air probably collect the "radioactive dust" in much the same way as a charged wire. In Pittsburgh the radioactive dust is probably gathered by the smoke and much of it falls with the soot. All exposed surfaces thus become coated with a thin deposit of this "radioactive dust" so that the air is ionized to a greater extent near the ground and near the surfaces of plants than it is at greater altitudes. Whether this ionization aids the growth of plants or has any effect upon living matter is still an open question. The fact that the air is ionized has a very considerable effect upon the potential gradient of the air and it is quite possible that the existence of this gradient, averaging about 100 volts for each increase of 3 feet in altitude above the ground, does influence life processes. The emanations and the "radioactive dust" also cause the formation of small amounts of ozone, hydrogen peroxide and oxides of nitrogen.

THE RADIOACTIVE GASES IN THE ATMOSPHERE.

The electrical condition of the air, the existence of thunder-storms and of various kinds of lightning, the aurora and many magnetic effects are due to the radioactive gases and "radioactive dust" in the air, to dust storms, to the splashing and breaking of water surfaces, to ultra-violet light and possibly to penetrating radiations coming from the voids of interstellar space. Probably by far the most important element affecting the electrical state of the atmosphere is that due to the radioactive gases and dust. The formation and breaking of water surfaces may be important for a short time during a rain but the effect of radioactive matter is going on ceaselessly—during the night as well as during the day, in summer and in winter. Probably a large percentage of the ions in the air are formed by the alpha, beta and gamma rays from these products and the only way that the air can conduct electricity is by the motion of these ions. As the air is usually positively charged with reference to the earth, it follows that there is a current of electricity flowing down through the air into the ground. This current has been frequently measured.

Several painstaking researches have been made to determine the amount of radium emanation in the air. *Eve* at Montreal and *Satterly* at Cambridge (England) have caused known volumes of air to pass through charcoal. The cold charcoal absorbed the radium emanation and on heating, the quantity of radium emanation given off is measured. Radium emanation is condensed on being cooled to liquid air temperatures and *Ashman* (Chicago) has used this method of separating the emanation from known volumes of air. The average content of radium emanation in the air as measured by these investigators is given in terms of the amount of pure radium that would have to exist in a cubic meter of air in order to give the equilibrium quantity of emanation existing there.

Eve	60×10^{-12} gm. radium per cu. m.
Satterly	100×10^{-12} gm. radium per cu. m.
Ashman	89×10^{-12} gm. radium per cu. m.

This means that every cubic centimeter of air would require about 400,000 radium atoms to generate the amount of radium emanation that is being transformed into radio-active dust. This would mean that from 6 to 8 alpha particles are produced per cubic meter of air per second and these would generate about 2 ions per cubic centimeter of air per second. The beta and gamma rays would also generate ions. The number of ions produced per cubic centimeter per second has been

found to be somewhat larger than this value so that it is not yet certain whether all the ions in the air are produced by the radioactive gases and dust or not. Experiments like those of C. T. R. *Wilson* on the tracks of alpha and beta rays should throw light on this problem.

If it is assumed that the radium emanation has a density corresponding to the equilibrium value of 80 x 10^{-12} grams of radium and that it extends to a height of 10 kilometers about one gram of radium would be required for each square kilometer of the earth's surface to give off the above amount emanation.

THE IONS OF THE AIR.

We have seen that the radio-active gases and dust generate ions in the air. What becomes of these ions? The answer is that they may combine with water dust or other small solid particles and thus form "large" or "*Langevin*" ions or the positive and negative ions may neutralize each other's charge by recombining. Near the ground and in the region of large cities there are very large numbers of "*Langevin*" ions, thousands of them per cubic centimeter of the air. In the pure air of the mountains and over the sea there are compartively few dust particles and large ions. The ions are then "small" or "intermediate" in size and number a few hundred per cubic centimeter. "Small" ions are of the same order of size as the oxygen and nitrogen molecules, whereas the so-called "intermediate" ions are hundreds of times as large. The *Langevin* ions are do large that they can either be seen by the eye or by the microscope. In the upper layers of the atmosphere—where the aurora discharges take place, the ions are probably all "small" ions or electrons.

Up to the present time very little accurate work has been done upon the ionization of the air. The work of *Elster, Geitel, Gockel* and the German School has brought to light a large amount of important and interesting data on the rate of discharge of charged insulated bodies in the air, on the potential gradient and upon the number and rate of recombination of ions in the air, but the condions under which the experiments were carried on are so complex that the answer to many of the riddles of atmospheric electricity has not been given. The weather bureaus of the various nations should take up this problem.

In the section discussing the cosmical effects of radio-active matter, further references will be made to the ionization of the air.

THE RADIUM AND THORIUM IN THE ROCKS AND SOILS.

Among the first to make a quantitative determination of the amount of radium in the soils was R. J. *Strutt*. Small quantities of radium were found in practically every kind of rock tested. The rocks formed by igneous processes gave an average radium content of 1.7 x 10^{-12} gm. of radium per gm. of rock, the values ranging between 0.3 and 4.8 x 10^{-12} gm. The sedimentary rocks were found to possess a smaller radium content than the igneous rocks. Since then, *Eve, Joly* and many others have continued this work. In general, the disintegrated rocks, such as the ordinary soils, are found to be poorer in radium than the unweathered rocks. Weathering thus removes a considerable part of the uranium and the radium.

Blanc, Joly and others have found thorium to be present in minute quantities in practically all rocks and soils investigated. In some rocks *Blanc* found a thorium content so great that it would emit six

times as intense a gamma radiation as the uranium and radium combined. *Joly* obtained an average content of about 1×10^{-5} gms. of thorium per gm. of rock, for 19 various rocks. A series of calcareous and dolomitic rocks gave only 0.07×10^{-5} gms.; the St. Gothard tunnel rocks 1.13×10^{-5} gms. (the uranium content being 1.46×10^{-5} gms.); the Transandine rocks 0.56×10^{-5} gms. and Leinster granite 0.7×10^{-5} gms.

This comparatively small number of analyses show that radium, thorium and uranium are distributed throughout all the rocks and soils. As the study of radium promises to tell a great deal about the processes of diffusion of small quantities of matter through the body, so a study of the rocks and soils promises to tell much concerning the processes that are involved in geological changes. The uranium and thorium products emit alpha particles in the rocks just as they do in the laboratory and the alpha particles possess a characteristic range (or distance they penetrate before being stopped) in a given rock just as they do in air. Thus a little uranium or radium in a glassy like rock will be surrounded by a spherical portion of discolored material. These spherical portions of rocks are known as pleochroic halos. The cause of these haloes was a mystery before the discovery by *Joly* that there was a small quantity of radioactive matter at their center.

THE RADIUM AND THORIUM IN THE OCEAN.

The amount of radium in sea water is much smaller than that in the rocks, being on the average only about a thousandth part as great. *Eve* found about 0.9×10^{-15} gms. of radium per gm. of sea water while *Joly* obtains higher values.

The thorium and uranium content of the ocean and its sediments is one of the most important factors concerning the problem of the radioactive deundation of the continents. From the work of *Joly* it seems altogether possible that the radium of the surface waters of the ocean is removed through precipitation by the action of decaying organic life. Notwithstanding the small radium content of the ocean water, *Joly* estimates that there is 20,000 tons of radium in the oceans.

The small radium content of the ocean water seems to be balanced by a large quantity of radium spread over the ocean floor. It is probable that in the main the continents and the big ocean bottoms have been very permanent parts of the earth's surface and that radium has been accumulating in the red clay, the globigerina, the radiolarian and the diatom oozes at the bottom of the oceans. The extraction of the lime salts does not seem to carry the uranium down, however. *Joly* and others believe that uranium remains in solution in the oceans and that the radium present in the water is generated there by the uranium. One argument in favor of this view is the fact that it takes about 50,000 years for the rivers to carry enough of water to fill the oceans while the period of radium is only about 2,000 years. Then again rain water contains a very low radium content. The rivers therefore, seem to carry uranium to the ocean and the radium is generated there in situ.

It is well known that mountain building takes place mostly near the coasts of the continents where sediments are being laid. It is also known that volcanic action seems to fringe the oceans with a line of volcanoes. Several geologists have put forth the hypothesis that volcanic heat is generated by local rich radioactive deposits and that the whole process of mountain building and of volcanic action is intimately related with the concentration of radioactive matter through the weathering and erosion of the continents.

THE PENETRATING RADIATION.

Almost simultaneously in 1902, *Rutherford* and *Cooke*, working at McGill University and *McClennan* and *Burton* working at Toronto University, announced the discovery of the existence of a penetrating radiation, a radiation much like the gamma rays of radium, that seems to exist everywhere over the land. This radiation is so penetrating that a considerable portion of it is transmitted by lead screens several centimeters in thickness. The intensity of the penetrating radiation varies at any one place and it seems to show a double diurnal period, there being two maxima and two minima every twenty-four hours. There is a great deal of discrepancy among the various observers concerning the amplitude and the time of these periods.

Wulf has studied the intensity of the penetrating radiation in various parts of Germany and France, including measurements made on the top of the Eiffel Tower. In his work the intensity of the penetrating radiation is measured in terms of the number of ions (q) which it will generate in a cubic centimeter of air per second. The following table shows how the intensity of the penetrating radiation may vary inside of buildings, due largely to the kind of material in the walls.

Place	Material of the Walls.	Age(years).	q
Abbey of Maria-Laach, near Audernach-sur-Rhine.....	Volcanic tufa	50	13.7
Fauquemont, College.....	Brick	15	5.7
Louvain, College	Brick	30	8.0
Namur, College.....	Brick	100	3.7
Wijnandsrade, Chateau.....	Brick	210	0.0

The work of *Gockel, Wulf, Hess, Pacini,* and others, indicate that at high altitudes, even to heights of 10,000 feet or more above the ground, the intensity of the penetrating radiation is as great as it is near the surface of the ground. On the other hand, it appears from the work of *McClennan, Wright, Simpson* and others that the penetrating radiation is very weak over the ocean and the larger lakes.

The penetrating radiation was predicted in that it was known that the ground and the air contained radioactive products. But how much of the penetrating radiation comes from the ground and how much from the air? The writer suggested that the part showing a diurnal variation probably came from radioactive products in the air or the active deposit resulting from the decay of these products, whereas the more constant portion came from the radium and thorium in the ground. As the intensity of the radiation shows quite a large diurnal range it was argued that a considerable part of the radiation came from radium emanation, A, B and C in the air, or deposited on the surfaces of buildings, etc. The quantitative measurements of the amount of radium emanation in the air indicate that it would require about twenty times as much radioactive matter in the air as was obtained by *Eve, Satterly* and *Ashman* to give the value of q as obtained by *Hess* in his balloon experiment. So at the present time it may be said that the penetrating radiation is very much stronger and extends to much higher altitudes than would be expected from the amount of radium and thorium products in the ground and in the air.

Although it does not seem to have been tried it is possible that the penetrating radiation might serve as a means of detecting rocks with a high radium or thorium content. It is known that potassium and rubidium emit beta rays. Whether gamma rays are emitted or not by these elements is at present unknown. If these elements do emit gamma rays, then regions where there are large potash deposits should show an intense penetrating radiation.

Is there a penetrating radiation in space? Do the stars, the sun, the moon etc. emit a penetrating radiation? It is quite probable that they do—expecially those bodies such as the moon, that possess little if any, atmosphere. It is doubtful however, if any such radiation can penetrate our atmosphere, it being equivalent in absorbing power to 30 cms. of mercury. If the radiation was more highly penetrating it could easily pass through our atmosphere. Up to the present time no evidence of any cosmical penetrating radiationh as been obtained.

If it were possible to focus the gamma radiation and to transmit parallel beams of it, and if radium was not so expensive, it might be used as a means of signalling. Imagine a prisoner in a cell with a small quantity of radium. He moves this back and forth in front of his window so that at one time the gamma rays are cut off by the wall while at other times the rays pass on to the outside. His motion is made to correspond to the dots and dashes of a *Morse* telegraph code. A man at a distance has an ionization chamber connected to a galvanometer and the galvanometer needle records the dots and dashes. This constitutes probably the simplest possible form of wireless apparatus.

Another question, do the radium and thorium emanations in the air, the active deposit or the penetrating radiation either directly or indirectly affect our health? Does it affect the growth of plants? At the present time no definite answer can be given but the writer has thought that such effects existed, especially as regards the growth of plants. The existence of the emanations and of the active deposit certainly affects the ionization of the air very greatly in the neighborhood of plants and this affects the potential gradient. The potential gradient should have a very pronounced influence upon the flow of the sap.

In the early days of radioactivity it was suggested that there was either a penetrating radiation or a kind of pervading energy that the disintegrating radioactive atoms could transmute into kinetic energy. It may be that there is a penetrating radiation coming from space that penetrates the upper 10 or 20 kilometers of the earth's surface and causes the thorium and uranium radioactivity. The generally accepted belief today is that the cause of radioactivity depends upon the structure of the atom itself. The quantitative relations between the atomic constants, the decay constant and the initial velocity of the alpha particles of the different radioactive elements supports the latter view. *Swinne* finds that the difference between the initial velocity of an alpha radiator of one family and the corresponding element of another family is nearly a constant. On the other hand, it may be these properties of certain atoms that gives them the power of absorbing outside energy. If there is such a very penetrating radiation and its intensity showed periods of maxima and minima, the amount of heat generated by radioactive processes would fluctuate. These fluctuations might aid in the explanation of the glacial epochs.

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We shall be glad to receive for publication from our subscribers and readers articles pertaining to the subject of radium and its application. All inquiries for information will be accorded prompt attention, and will be answered either by letter or through the columns of this paper.

Vol. II NOVEMBER, 1913 No. 2

Radium and Mesothorium in the Treatment of Malignant Tumors. II.

By Otto Schindler, M. D. (*Vienna*)

REPORT OF CASES

Epithelioma of the Skin.—Twenty-five cases in all were treated, of which 22 (including two cases of epithelioma of the eye-lid) were benign, superficial forms varying in size up to that of a silver quarter. Of these cases I was able to follow up 18, and 13 were found free from recurrence, one case of epithelioma of the eyelid being among these. The longest period of freedom from recurrence is now about four years. Five of the 18 cases showed small recurrent nodules at the margin of the original area. Of these five, three were again given radium treatment and these three now appear to be entirely cured. Wholly unscreened or only slightly screened applicators were used, the period of exposure being rather short, since in these superficial forms it is of especial advantage to use the softer rays to obtain more vigorous tissue reactions. One must take the precaution here to ray fairly well out into the sound tissue, since occasionally recurrence takes place on the edge of the area of radium reaction.

Aside from these, three cases of large, deep-seated forms of skin epithelioma were treated. One of these cases (from Prof. *Ehrmann's* division) was demonstrated refractory to the moderate doses used at that time—more than three years ago. In another case (Miss F. O., 60 years old) there was a protuberant, knobby tumor of the forehead to be dealt with, a growth about the size of a plum protruding about 2 cm. above the skin surface. It had existed for two years and for the last six months had been treated elsewhere with insufficient doses of radium without any beneficial effect. (Histological diagnosis: epithelioma). The result of the insufficient doses which had been given elsewhere was a definitely stronger proliferation of the tumor.

By means of 2640 mgm. hours referred to radium bromide of the old standard, for 14 days, the tumor was completely removed within five weeks after the beginning of the treatment and now two months

after the beginning of the treatment a beautiful soft scar exists with no trace of carcinomatous infiltration. In a very extensive deep-seated epithelioma (case G. K., Rothschild Hospital, Prof. *Braun's* division) which extended to the bone in the region of the left ear and in which there had been signs of metastases in the cervical vertebrae for some time, it was possible to obtain a very far reaching improvement of the local process and a partial scarring. The patient died however from the spinal metastases which already existed at the time of his entrance to the Hospital. The post-mortem findings showed that, aside from the spinal metastases, there existed some carcinomatous tissue in the center of the lesion on the bone. It should be noted that it was possible to treat the patient only with relatively moderate doses.

Epithelioma of the Penis.—Up to the present time 3 cases of penis epithelioma have been treated. All three have remained free from recurrence up to date, one case nearly 3½ years, one case 4 months and one case 2½ months. Concerning the first case, which I presented before the k. k. Gesellschaft der Aertze on January 12, 1912, I wish to go into further detail.

Case I. P., 42 years, motor-man. Denies having had venereal disease. Two years before beginning this treatment, patient noticed a little nodule on the glans penis, which soon ulcerated. Stationary at first, it has lately extended rapidly and is larger now than a quarter-dollar.

Status Praesens on Dec. 2, 1909.; Upon the glans penis in the region of and extending over on to the frenulum is an irregularly outlined area of tissue destruction larger than a quarter, which is only slightly covered over with pus. The edges of the ulceration are markedly elevated and thickly infiltrated. Inguinal glands not palpable, no evidence of lues.

Clinical diagnosis (Prim. *Rusch*) Epithelioma of the penis.

Histological diagnosis (Assistant Dr. *Lipschutz*) Epithelioma.

From Dec. 13, 1909, up to Jan. 17, 1910, two treatments each about 1200 milligram hours referred to radium bromide; 1.0 mm. lead filter.

Jan. 25. Edges flattened down, the ulcer covered with a fairly tight fibrinous cover. An excision of the tissue for examination showed no more carcinomatous tissue present. On the side of the glans penis opposite to that point exposed to the rays is a superficial erosion about the size of a dime or smaller. This is visibly situated where the main bundles of strongly penetrating rays cross and so have a cumulative action.

March 1. Edges of the ulcer at the level of the surrounding surface; diminution of the area of tissue destruction by epithelial extension from the edge.

March 15. Ulcer completely covered over by skin.

Oct. 25, 1910. At examination enlarged inguinal glands are found on both sides about the size of hazel-nuts and fairly solid. These must be considered as glandular metastases of the carcinoma.

Nov. 5, 1910. Extirpation of the enlarged inguinal glands, which microscopically show no evidence of carcinomatous infiltration. The histological examination of the glands showed a peculiar fatty infiltration along the hilus. Whether this noteworthy finding, which so far as I know has never been described in literature as following radium-ray exposure, has a definite relationship to the radium treatment or not, is uncertain. *Since this time the patient has been entirely well;* on

the site of the carcinoma is a beautiful soft scar; sexual functions are undisturbed. An incision done recently for material to examine shows absolute lack of carcinomatous cells. Time of freedom from recurrence: Nearly 3½ years.

Carcinoma of the Lip.—A superficial epithelioma of the underlip of a 49 year old man without regional gland involvement was treated with 800 mgm. hours, 1 mm. lead filter. After a mild superficial reaction, complete healing. Time of freedom from recurrence: over 3 months.

Carcinoma of the Mucous Membrane of the Mouth.—The treatment of carcinoma of the mucous membranes of the mouth gave unsatisfactory results, not only when surgical methods, but also when radium was used.

Wickham (Arch. f. Derm. u. Syph., Jahrg. 1912, Bd. iii, p. 83) writes the following from his very rich experience: In order to obtain results in the use of radium in irritable carcinomatous tumors such as those which develop in the mouth, one must use weak doses for definite periods of time. The treatment must be of considerable duration, in order that the doses may have time to accumulate in sufficient quantity. In order to make a result certain it is necessary to use thick, and consequently heavy, filters. It could be foreseen that, as has already been otherwise established, the virulent nature of the carcinomas situated in this particular location becomes an obstinate obstacle to the effect of the radium.

Exner has worked with moderate doses, weakly filtered; *Wickham* and *Degrais* have given relatively weak doses of stronger filtered rays in order not to break up the carcinoma cells into rapid proliferation.

Since the use of unfiltered rays, such as *Exner* employed, has accompanying disadvantages, bad burns, etc., while on the other side the weak doses of stronger filtered rays (*Wickham* and *Degrais*) gave no favorable results, I undertook in September 1911 for the first time a post-operative exposure with maximum doses of strong filtered rays (1½ mm. lead) dose 5300 milligram hours. This case is that of R. P. described below and has remained up to the present free from recurrence. In a second case, that of H. St., an inoperable carcinoma of the cheek and gum (mucous membrane), I gave within 31 days nearly 14,000 mgm. hours (radium bromide) of strong filtered rays, with the result that the huge tumor became entirely healed clinically. I had at my disposal only my radium applicator No. 1, containing 20.16 mgm. radium bromide (11.04 mgm. radium element). In order to reach the dosage I was obliged to make an exposure of about 28 days, continuously day and night.

I desire to lay especial stress upon the case of H. St., 52 years, commercial traveler. In January 1911, the patient noticed a swelling on the right side of the floor of the mouth, together with a little ulcer. Potassium iodide had no effect. Wasserman reaction negative. Prof. *Schnitzler*, who was consulted, made the diagnosis of carcinoma mucosae oris and noted the following findings: On the arcus palatoglossus and extending to the bordering parts of the mucous membrane of the cheek is an ulceration about the size of a dollar, with hard edges; an infiltrated gland in the submaxillary region; opening of the mouth as well as movements of the tongue are difficult.

Operation (Prof. *Schnitzler*) April 7, 1911. Extirpation of the glands, extirpation of the tumor cutting into sound tissue, after osteotomy at the angle of the jaw. Subsequent healing.

Nov. 11. Appearance of a rapidly ulcerating tumor in the scar in the region of the right cheek and gum. Impossible to open mouth.

Dec. 18, 1911. Operation for recurrence (Prof. *Schnitzler*). After again cutting through the angle of the jaw a large piece of the floor of the gum and the cheek as well as the side wall of the jaw was removed. Patient recovered rapidly, although in Februaruy, 1912, a new recurrence appeared whereupon the patient was now exposed to Roentgen-rays for 4 weeks. In spite of this the swelling spread very rapidly with most extreme pain. Upon the patient coming under my care on March 30, 1912, I noted the following findings:

There exists a huge, very firm, extremely sensitive (to pressure) infiltration of almost the entire right cheek, jaw and submaxillary region. Mouth can be opened only a few millemeters. A tumor, superficially cracked and ulcerated, protruding far into the oral cavity, can be mapped out over the posterior floor of the gums into the throat. From March 31 until April 30, 1912, in toto, 645 hours, the patient was exposed to the rays, first from without (1 mm. lead filter) and then as the patient became better able to open his mouth, from within, with the same filtration. Under this exposure, where in 31 days (744 hours) 680 hours were used for exposure, there was a dosage of nearly 14,000 mgm. hours referred to radium element. The tumor absorbed completely, the infiltration softened, the loss of tissue in the mouth scarred over with astounding rapidity. There resulted a complete clinical healing, with a firm, callous scar demonstrable at the site of the former tumor in the mouth. Nowhere was there a trace of suspicious tissue. The external skin surface had responded to the rays with a superficial radium dermatitis which healed in about 21 days with a moderate depigmentation but a completely preserved structure. While the tumor was disappearing the patient's temperature went up as high as 32.9° C. with great indisposition and exhaustion. After the main part of the tumor had gone, however, the temperature remained fairly normal, the general findings improved in spite of continuous repetition of the treatment. After recovery the patient went back to his accustomed occupation as a commercial traveler and gained about 10 kg. in body-weight. Patient objected to further prophylactic exposure because he felt quite well. About the end of December, 1912, there again appeared a firm, painful swelling in the region of the under-jaw, with accompanying sub-febrile temperature, loss of appetite, loss of weight, and extreme pain.

Roentgen-examination showed a focus in the resection stump of the under-jaw.

Jan. 3 to 14, 3120 mgm. hours referred to radium element.

Jan. 20. General condition and appetite better, pain more moderate, infiltration gone back and almost disappeared. In the forward part of the cheek is nevertheless a firm infiltration.

Feb. 9 to 12. 1056 mgm. hours radium element. Patient is not to be persuaded into having further exposure in spite of earnest advice to that effect.

Feb. 23. Corresponding to the site of the resection of the under-jaw is a submaxillary fistula out of which pours a large amount of pus.

April 5. Patient has lost weight. A scar on the inner surface of the cheek is now beginning to raise up as a flat tumor. Patient refuses treatment.

April 26, 1913. There exists a flat tumor which includes the entire scar on the inner surface of the cheek together with the right portion of the soft gums and the floor of the gum, all infiltrated. The entire

region of the horizontal portion of the under-jaw, as well as the bordering parts of the cheek and regio submaxillaris greatly infiltrated, painful both spontaneously and upon pressure, increased pus secretion from the submaxillary fistula. In this condition the patient submitted to a new series of treatments with the rays. From April 27 until May 20, about 2700 mgm. hours radium bromide and 1400 mesothorium.

May 25. The tumor has for the most part receded, although a perforation about the size of a quarter dollar has formed in the middle of the cheek and extends into the oral cavity. The mesothorium capsule with a 1 mm. silver filter was laid once in this place for 16 hours. The caoutchouc filter for the absorbtion of the secondary rays was torn by the manipulations of the patient, whom it was necessary to permit to take the applicator home, so that the applicator was applied all this time without a filter for the secondary rays, which sufficed to cause necrosis of the tissues already made hyper-sensitive by the earlier exposures.

June 5. The opening externally of the perforation is now about the size of a cent, internally the size of the mesothorium plate, and is for the most part cleansed of the necrotic shreds. Further exposure from within and without.

June 2 to 21. 1800 mgm. hours radium bromide and 840 mgm. hours mesothorium.

June 25. Perforation the same size. Internally about the size of a dime and externally as large as a cent, entirely cleansed of necrotic shreds. About 1 cm. from the periosteum is a blanched, necrotic node. Submaxillary fistula almost ceased discharging. The decayed area in the region of the base of the gums has been decreased by the formation of firm scar-tissue. Pain moderate, appetite and general condition show definite improvement; patient continuing treatment.

Subsequent radium treatment after extirpation of the tumor was carried out in 3 cases.

Case R. P., 63 years, retired from business. The affection began 3 months ago after the patient had suffered considerably with "thrush" in the mouth. A very rapidly developing growth formed on the mucous membrane of the right cheek and soon ulcerated. Although the patient had no pain from this mass, nevertheless the bad taste in his mouth and evil-smelling breath was a great hardship to him. Primarius Dr. *Reinprecht* established the diagnosis of carcinoma and made a histological examination which confirmed the clinical diagnosis. As there appeared to be a very poor prognosis as to the end results of an operation, although the tumor was still operable, Prof. *Reinprecht* was kind enough to turn the patient over to my care.

Stat. Praes. Sept. 21, 1911. Fairly well nourished man of 63 years. A definite swelling was visible from without on the right cheek. Opening of the mouth was only slightly hindered. On the mucous membrane of the right cheek, about the middle of the horizontal portion of the lower jaw, is a tumor about the size of a dove's egg, superficially ulcerated and covered with pus. The tumor is bound fast to the gingiva of the lower jaw. The infiltration extends almost to the corner of the mouth on one side and to the angulus mandibulae on the other side. The corresponding submaxillary glands somewhat enlarged.

Sept. 21, 1911. Operation (Dr. Max *Hirsch*). Splitting of the cheek, extirpation of the tumor and the suspected glands. No plastic efforts, the wound being left open. Externally at the site of the extirpation of the glands, two sutures. Drainage.

Oct. 1 to 14, 1911. Radium treatment of the entire affected

region from without and within for 250 hours. There was used 2750 mgm. hours referred to radium element. Lead filter 1½ mm.

Oct. 20. 1911. Wound internally undergoing process of being covered by epithelium; externally there is a moderate radium dermatitis on the skin.

Feb. 2, 1912. Wound completely healed. Patient feeling generally well.

May 17, 1913. At examination the scar appears in fine condition. Nowhere is there a suspicious area, splendid subjective findings. Time of freedom from recurrence, more than 1½ years.

Case, St. P., 62 years, retired from business, (consultation with Dr. H. *Marshik*). Beginning of treatment July 16, 1912. Since 6 weeks ago there has been an infiltrated ulcer about the size of a quarter dollar on the inner surface of the right lower jaw near the posterior margin of the processus alveolaris. Clinical diagnosis. Infiltrating carcinoma mucosae oris.

July 18. Operation (Dr. H. *Marshik*). Extirpation of the cervical glands on the right side and the glandula submaxillaris. Two glands the size of peas, several glands varying in size from that of beans to cherries on the carotid. Excision of the tumor going as far as possible into sound tissue, with a part of the tongue substance and enucleation of the right tonsil. Radium applicator laid into the wound cavity for 48 hours, about 530 mgm. hours radium (element). Uncomplicated healing of the wound although the field of the operation remained swollen and densely infiltrated for 3 weeks like a beginning phlegmon of the neck, but with no fever and no secretion. The drainage fistula was lightly covered over with granulations, discharging slightly.

Sept. 8. Wound completely healed after a somewhat protracted course.

June 13, 1913. At examination the scar appears splendidly, no trace of recurrence, excellent health generally, freedom from recurrence about one year.

Carcinoma of Tongue.—Two cases of recurrence of tongue carcinoma were treated with fair sucess.

Carcinoma of the Upper Jaw.—Case, Mrs. L., 38 years (consultation with Dr. *Metall*), (up to this time a patient in *Chiari's* Clinic). Beginning of illness was 2 years ago, onset having the appearance of empyema of the antrum of Highmore. Operated upon twice for this condition. Since about January of this year a very dense swelling has developed in the region of the upper jaw and cheek, spreading rapidly to the nose and upper lip. With increase in the swelling most intense pain began, for which the patient was treated with Roentgen rays for 5 weeks without success. This case was then referred to me.

Status praesens on April 5, 1913. The entire left upper jaw to the mandibular process of the cheek bone of the one side and to the nose on the other, as well as the entire cheek, was included in a huge swelling which feels very tense but is not superficially ulcerated. The cleft of the eye-lids is narrowed by the extent of the swelling, the upper lip is infiltrated to its middle, opening the mouth has become much more difficult. The gingiva of the left upper jaw as well as the mucous membrane on the hard gums on the left around the fistula of the operation are infiltrated with carcinoma into the antrum of Highmore. On the right and left the enlarged submaxillary glands are palpable. Sub-febrile temperature. Most intense pain. Pyramidon does not give sufficient relief.

From April 5 to May 21, 1913, about 4700 mgm. hours radium bromide plus 1425 mgm. hours mesothorium.

With this treatment the tumor diminished to less than one-half its original size, the pain disappeared completely so that the patient was able to get along without any narcotics. With the disappearance of the tumor the temperature went to over 39° C. and it was possible to demonstrate an exact parallel between the height of the temperature and the amount of rays furnished.

At the same time the patient suffered from weakness, indisposition and general malaise. These evidences of toxaemia, which at times became threatening symptoms, made it necessary, out of consideration for the general condition of the patient, for the radium treatment to be restricted to 8 hours every second day, whereas at first it was carried out 15 to 18 hours daily. With this restricted regime the general condition was better, the temperature was 38° C., no pain. Result—considerable improvement.

Oesophageal Carcinoma.—Case I. A., 56 years, hotel-keeper. March 14, 1912. For several months increasing difficulty with swallowing. An oesophagoscopic examination showed that at 20 cm. the oesophagus was completely occluded, without there being any demonstrable change in the wall. To pass bougies is impossible, it being possible only once to pass a No. 20 bougie into the stomach. Up to April 9, attempts to pass bougies of all possible diameters were in vain. Progressive tracheal stenosis.

April 9. Tracheoscopic examination showed marked bulging forward, to the middle of the lumen, of the posterior wall of the trachea at the level of the first tracheal cartilages. Diagnosis: Carcinoma oesophagi perforans in trachea. Excision of the tracheal tumor for examination material showed it to be a flat-celled carcinoma. During the next two weeks the patient went through a severe pneumonia. Tracheal stenosis increased to the extent of causing nightly attacks of suffocation.

May 3. Interior tracheotomy. (In the incision there lay exposed the tumor of the posterior tracheal wall.)

May 9. Radium applicators were laid in the incision on the posterior wall of the trachea for 24 hours, because swallowing had become practically impossible and passing of bougies again failed.

May 14. Swallowing was decidedly better.

May 18. Superficially the tumor is lightly covered over. (Radium reaction).

June 3. Oesophagoscopic examination. Condition considerably improved.

Larynx Carcinoma.—Case B., 56 years, forest inspector.

Oct. 17, 1910. Since six months ago moderate difficulty with swallowing and a feeling as of a foreign body in the throat on the left. Stat. praes.: Carcinoma recessus pyriformis sinistri encroaching upon the larynx. About the first of November, 1910, a radical operation (Hofrat *Eiselsberg*) Hemipharyngolaryngectomy without extirpation of the glands, with preliminary tracheotomy.

February, 1911. Healing of the wound resulted in a fistula about the size of a cherry which passed from without into the larynx and pharynx. On account of this fistula a gastrostomy was necessary.

May, 1911. Secondary operation on account of recurrence in the scar on the posterior wall of the throat; excision plus cauterization with Paquelin cautery (Klinik *Eiselsberg*).

October, 1911. Laryngoscopic examination; no recurrences.

June 1, 1912. Up to this time without recurrence. In consequence of the closure of the pharyngeal fistula, normal eating has become possible. For several weeks past, increased swelling in the throat, local recurrence advancing rapidly out of the resection scar, including more and more of the left tonsil. A second point of recurrence exists on the posterior wall of the throat behind the right stationary arytenoid cartilage. From June 12 to 24, exposure of the retro-laryngeal node of recurrence with mesothorium and radium, in all about 1,000 mgm. hours, referred to radium bromide.

July 24. Enucleation of the tonsillar area of recurrence, excision of the same as in tonsillectomy. The tumor can only be radically removed upwards and outwards; down and out it would be necessary to tear the carcinomatous tissue. Introduction of the 1 mm. silver filtered mesothorium capsule for 48 hours.

July 30. Moderate reaction oedema of region of the wound which is heavily covered over. Introduction into the wound of the radium applicator, 1 mm. lead filtered. Time of exposure, 12 hours.

October 6, 1912. Wound completely healed, no evidence here of carcinoma. Recurrent nodule behind the arytenoid cartilage, still as large as a pea (formerly larger than a bean).

March, 1913. The retro-laryngeal recurrence on the right had grown distinctly, filling entire the recessus pyriformis. Glands on the carotids on both sides infiltrated. Exposure of the glandular metastases on the right, size of beans to the size of a dove's egg. Patient withdrew from further treatment for irrelevant reasons.

May, 1913. The treated glands considerably reduced. The immovable part of the larynx is strongly infiltrated by advancing retro-laryngeal recurrence of the growth. Furthermore a new, rapidly advancing recurrent node on the site of the left-sided tonsillectomy which up to this time had remained free from recurrence. The indisputably beneficial effect of the radium treatment is to be seen in this case on the tonsillar recurrence, which could not be radically removed and which healed up with a beautiful scar after the exposure, but later again underwent recurrence The extraordinarily large shrinkage of the gland metastases is also demonstrable in this case. The patient could not, however, be treated on account of other reasons with the massive doses which I desired to use.

Colon Carcinoma.—Three cases treated. All three considerably improved.

(To be concluded in the next number.)

III. Radio-activity and Geology. The Evolution of Elements.

By W. W. Strong, Ph. D.

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The Heating of the Earth by Radio-active Matter and the Age of the Rocks.—Geologists have usually claimed that the earth has been cooling during the past and that at one time it was a molten mass. These conclusions were inevitable as long as there was no source of heat in the earth. Since radio-active matter is evolving heat continually, it follows that its existence in the rocks furnishes a

source of heat and if it generates heat more rapidly than the rocks conduct it to the surface, the temperature must rise. Assuming that the rocks of the earth possess the radio-active content as determined by *Strutt, Eve* and others, it follows that a thickness of about 30 miles of the radio-active bearing rock would generate the heat which is being lost by conduction and radiation. If radio-active matter is distributed in the same way throughout the earth, two conclusions follow—either the earth is getting hotter or radio-active processes are different under these conditions from what they are in the laboratory. Up to the present no one has been able to affect in any way the velocity of radio-active transformation, either by the action of high pressure or by high temperatures.

It seems possible that the outer part of the earth's crust is very different from the interior and this condition may be due to the accumulation of comets, shooting stars and other cosmical matter over the earth's surface. There may be an outer crustal zone containing radio-active matter to a depth of 30 miles and possessing a density of about 2.8. Extending below this for some 600 or 800 miles there is a stony zone of a density of 3.4, while the remainder of the earth is possibly largely composed of iron, with a density of about 8. These zones can be explained on the planetesimal theory without assuming that the earth has been in a molten state. The transmission of earthquake waves and tremors also requires the existence of zones.

The accumulation of helium in the rocks and the radium, uranium and lead ratios probably serve as the best registering thermometers of time that geologists possess. The work of *Strutt* and others in determining these ratios indicate that the earth is really an "old world" after all, much older than we used to think. The ages of the various rocks are about as follows:

Carboniferous rocks	340,000.000 years.
Devonian rocks	370,000,000 years.
Ordovician rocks	430,000,000 years.
Algonkian rocks	1,000,000,000 years.
Archaean rocks	1,300,000,000 to 1,600,000,000 years.

Continued work of this kind will undoubtedly serve as a very important aid in really making geology a chronological science and giving "dates" to geological history.

THE POSSIBLE RADIO-ACTIVITY OF THE SUN AND STARS.—The presence of considerable amounts of helium (helium gas was first discovered in the sun and is named for it) in the solar atmosphere would lead one to suppose that this helium came from the disintegration of uranium, thorium or other radio-active substances in the sun. The properties of the aurora indicate that these may be due to alpha and beta like radiations from the sun striking our atmosphere. This with some evidence of radium and radium emanation in the solar chromosphere is at present the only information available. It is quite possible that the sun's heat may be partly or wholly due to radio-active processes. It is true that the sun would only generate about one fourth as much radio-active heat if it were composed of uranium as it does now, but it is quite possible that the rate of transformation would be quite different under solar conditions than what it is even in the electric arc.

Giebeler has observed several spectrum lines in the light from the new star, Nova Geminorum 2, which he attributes to uranium, radium and the radium emanation. The new star of March 22, 1912, showed

a strong continuous spectrum, numerous broad bands and many dark lines in the early stages. Each of the hydrogen bands showed a multiple structure. Rapid changes took place in the spectra from night to night. The helium lines showed up strongly in a few months but disappeared by August, being replaced by a nebulae spectrum. None of the spectral changes tell anything directly concerning radio-active processes, but it is probable that if radio-active phenomena play any important part in the origin of new stars, the spectrum of helium will be of considerable service in aiding us to determine the nature of these phenomena.

The existence of auroral discharges in the upper air and of magnetic storms makes it altogether possible that the sun and stars are constantly emitting alpha and beta rays. Interstellar space is therefore probably filled with a very thin stream of electron and ionic radiations. A considerable amount of attention to these radiations has been given by *Arrhenius, Birkeland* and *Stormer*.

THE EVOLUTION AND DEVOLUTION OF THE ELEMENTS.—In the radio-activity of uranium and thorium we see the disintegration of complex atoms into simpler atoms with the liberation of comparatively enormous quantities of energy. Does the reverse process take place? Is there an evolution of the elements?

In seeking an answer for this question we must consider two worlds, the intra-atomic world and the extra-atomic worlds. What are the processes and the laws that govern the internal mechanism of atoms? Is there such a thing as an intra-atomic temperature determined by the average kinetic energy of its parts? What are the means of conveying energy into and out of the atom?

Our extra-atomic world consists of the motions of molecules and atoms. Temperature is a measure of the amount of this motion. We, on the earth, are fairly well familiar with a range of temperature extending from absolute zero to say 2000° Centigrade. The upper limit of temperature velocities is given by the velocity of light. No electron and hence no molecule can move with any greater velocity. But before such velocities are reached electrons and even other atoms begin to move "through each other" (e. g., the alpha particles). We no longer have ordinary molecular collisions any more. Thus when the temperature becomes sufficiently high the relations between the phenomena of the intra- and extra-atomic worlds become very intimate. Our world is one of great inanition compared with a world at 2000° C. A world at 2000° is one of comparative rest compared with a world at a temperature of 200,000° or higher, one where the average kinetic energy of atoms is equal to that of an electron moving with a velocity almost equal to that of light. It is in this latter temperature region that things really become interesting and it is probably under these conditions that atoms are born. If there is an evolution of the elements it must be expected under these conditions. At our ordinary temperatures the intra-atomic world is surrounded by an almost perfect refrigerator—there is practically no relation with the outside world at all.

Recently quite a number of interesting papers have appeared which indicate that matter may be much more complex than we consider it to be and that all the elementary atoms are closely related through their origin by radio-active evolution. *Soddy* and others consider that many of the elements are practically identical from a chemical point of view. Among these groups are Ur X, radio-actinium and thorium; mesothorium and actinium; Th B, lead and possibly Ra B

and Ac B; and probably Th C, Ra C, Ac C, and bismuth. According to *Fajans* the expulsion of an alpha particle moves an element two places to the left in the periodic system, while the expulsion of a beta particle moves the element one place to the right without changing the atomic weight. Following this rule the radio-active products can all be placed in the periodic system. That this can be done is a very strong indication that every element originated by a process of radio-active disintegration such as takes place in the thorium and radium families.

At the present time the only evidence of the evolution of the atoms is to be found in a study of the nebulae and the stars. The highly attenuated nebulae contain only a few elements, mostly helium and hydrogen. Apparently as these nebulae condense and grow older, carbon, silicon, magnesium, calcium and iron appear. Apparently sodium does not appear until later and the nitrogen family is often absent(as it is in the sun). Just how the elements can grow is entirely speculative, though one would expect the combination of the elements to be the inverse of the disintegration process. In this connection it is interesting to mention *Nicholson's* process of building all the elements out of four protyles: coronium, 0.5131; hydrogen, 1.008; nebullium, 1.6277, and protofluorine, 2.3604. It is very remarkable that many of the atomic weights can be made to be an almost exact multiple of integral multiples of one or more of the above protyles. According to this view radium is a compound as follows: 8 (He_3 Nu_3 Pf_2 H_2) 2 (He_2 Pf_3 H_3) He_3.

SUMMARY.—1. The existence of radio-active matter in the air accounts for the ionization and many of the other phenomena of atmospheric electricity.

2. The radium, uranium and thorium content of the rocks and the oceans helps to explain many geological processes and serves to establish a chronology of the rocks.

3. The recent discoveries in astronomy indicate that radio-active processes are probably cosmical. At the present the cause of the penetrating radiation is not known.

4. The disintegration of the elements appears to follow definite laws that fit in with the periodic table and it seems entirely possible that the evolution of suns and other heavenly bodies is very intimately related with a concomitant evolution of the elementary atoms themselves. The birth of atoms and stars may take place simultaneously.

5. The wide distribution of radio-active matter probably affects many phenomena of life, especially plant life and the weather. These effects are probably small, except when cumulative. It is the effects that are cumulative for millions and millions of years that are the most important and these probably form the basic structure of our whole cosmogeny.

REVIEWS AND ABSTRACTS.

L. G. *Rowntree*, M. D., and W. A. *Baetjer*, M. D.,—Radium in Internal Medicine, Its Physiologic and Pharmacologic Effects. Journal of the American Medical Association, Vol. LXI, No. 16, October 18th, 1913. Page 1438. This article gives a short and comprehensive review of what has been accomplished with the use of radium in internal medicine. That part of the article devoted to "theories, facts and data relating to radium in internal medicine" although brief, is excellent.

"Methods of Administration and Dosage of Radium Emanation:

As the Bath.—It is doubtful whether or not radium emanation can penetrate the skin—the good effects are usually considered to result from the inhalation of radium emanation as it constantly escapes from the surface of the water. As Injection.—Emanation water containing from 500 to 1,000 mache units to the cubic centimeter (0.2 to 0.4 microcurie) being injected subcutaneously or intramuscularly in the neighborhood of an envolved joint is a valuable addition to treatment. No injurious local effects result. As Local Applications.—Compresses, Fango Baths.—*Lowenthal* and *Gudzent* do not believe that radium emanation can pass through the skin, while *Lazarus* and *Engelmann* believe that it can. All admit that the beta and gamma rays of its decomposition products can penetrate the skin. As a Drink Cure.—Radium emanation in solution is administered by mouth by varying and increasing doses, 330, 1,000, 2,500, 5,000 and 10,000 mache units (0.1, 0.4, 1.0, 2.0 and 4.0 microcuries) repeated three times a day. (In this connection it is to be noted that the Radium Institute of London has recently been administering doses from 0.5 to 1.0 millicurie, or about 1,300,000 to 2,600,000 mache units). As Inhalations.—This is the best but also the most expensive method of administration. Masks have been introduced in an attempt to do away with the expensive emanatorium."

"Reactions in the Course of Treatment.—Often during the first week or two of treatment, sometimes even after the first treatment, a pronounced increase in the subjective and objective manifestations of the disease occurs. Its occurrence early in the treatment of rheumatism is a good omen, since these cases usually do better than those not exhibiting the reaction."

"Indications.—The value of radium is unquestionably established in chronic and subacute arthritis of all kinds (luetic and tuberculous excepted), acute, subacute and chronic joint and muscular rheumatism (so-called), in gout, sciatica, neuralgia, polyneuritis, lumbago and the lancinating pain of tabes. In certain other conditions it is said to be of some value, although more data are necessary before this can be accepted—chronic bronchitis, chronic pharyngitis, pneumonia, myocarditis, arteriosclerosis, vasomotor disturbances, *Raynaud's* disease, scleroderma, idiopathic enlargement of the lymph-nodes and in chronic constipation."

"Clinical Results Obtained.—The collected results of treatment in these various groups of diseases are brought together in Table 9, from which it will be seen that in 837, or over 80 per cent. of the 1,038 cases, benefit was derived from radium treatment."

"Table 9.—Summary of results of radium treatment in various groups studied.

Disease	No. of Cases	Improved
Chronic arthritis	411	371
Arthritis deformans	24	16
Muscular rheumatism	59	49
Gout	166	86
Neuralgia	59	47
Sciatica	115	91
Lumbago	5	4
Polyneuritis	8	8
Neuritis	5	2
Miscellaneous	186	163
	1,038	837

"Gudzent, His, Furstenberg, Somner and *Klemperer* speak in glowing terms of its value. The introduction of emanatoriums in a large number of the German spas as well as the establishment of a radium institute in Berlin for the treatment of medical cases express confidence in it on the part of the profession abroad."

"It should be emphasized that the foregoing statements are based entirely on the results published by various foreign observers and not on the cases treated by us. Furthermore, the cases treated have been of a most unfavorable nature, since we have not felt that the results published in the literature, justified the exclusive use of radium therapy except in those cases which had been given the benefit of all other forms of treatment without improvement."

"We must state frankly that the results in our small series of cases comprising only eighteen patients have not been gratifying. Our patients were treated *entirely* by the *Drinking Method* with water activated with radium emanation *by abstractor.* They were under observation from two weeks to three months and were given daily doses of from one-half to forty microcuries. Our series include the following diseases:

DISEASE	No. Cases	Improved	Not Improved	Cured
Arthritis Deformans—(Infectious type,	5	3	2	..
Muscular rheumatism and neuralgia	5	1	3	1
*Tabes (pains of)	3		3	..
Acute rheumatic fever	1		1	..
Sciatica	1	.	1	.
Parkinson's disease	1	(temporary)		.
‡Chronic nephritis	1	1	..	.
Gout	1	..	1	..
	18	6	11	1

"CONCLUSIONS.—We make no attempt to draw any conclusions as to the efficacy of this form of therapy from our small number of cases, but feel that any form of medication which has yielded the results reported by the European writers should be the subject of a much more exhaustive test, until its real value can be definitely established and its limitations rationally outlined."

Paul *Lazarus,* Radium Therapy in Carcinoma; Berlin. klin. Wochenschrift, No. 28, July 14, 1913, pages 1304 and 1305. The author gives his opinions as regards the treatment of carcinoma, particularly of the uterus. He advises the use of not less than 30 mgm. of radium sulfate (21 mgm. of radium element) nor more than 100 mgn. (70 mgm. radium element) radium sulfate, when one mm. of silver or lead is used to filter the rays. Smaller quantities of radium serve to stimulate growth, and the massive doses, unless heavily filtered, may injure the surrounding tissues. The author also worked with intravenous injections of thorium X and thorium X administered per os in cases of pseudo leukemia and sarcomatosis in abdomine. In the former the normal blood picture was restored and in the latter case, in spite of the multiple tumors still present, the patient has been working during the past $2\frac{1}{2}$ years. The permanent value of thorium X therapy still remains to be demonstrated.

*Treated for a period of two weeks with doses never exceeding two microcuries.

‡Lasting diminution of the pressure from over 200 mm. to about 180 mm., with marked improvement in the subjective symptoms.

F. *Gudzent.* The Dosage and Methods of Application of Radioactive Substances in Internal Diseases and the Results Obtained. Berl. klin. Wochenschrift, No. 35, Sept. 1, 1913, Pages 1597—1602. This contribution from the Radium Institute of the Royal Charite (Prof. His, Director) gives a summary of the writer's work with various radio-active substances, radium, radium emanation and the various mesothorium products. Radium emanation was used by inhalation in an emanatorium, in drinking water; radium for injection in physiological salt solutions; thorium emanation for inhalation, and thorium X for injection and for drinking water.

Treating two groups of patients affected with chronic articular rheumatism in emanatoriums containing 3-5 and 25 to 30 mache units respectively of radium emanation, the author finds practically the same results in each group. In the first case (3-5 mache units), 19% of the cases are much improved, 40% improved, 23% little improved and 18% unaffected; while in the other group (20-35 mache units) 27% of the cases were much improved, 27% improved, 28% little affected and 18% unaffected. Considering the effects of different concentrations of radium emanation in producing hyperleucocytosis in the effort to find a qualitative or quantitative means of differentiating results obtained, the author concludes that between his two groups there is no noticeable difference.

When 60-200 mache units concentration of emanation is applied the hyperleucocytosis is somewhat greater, but not at all in proportion to the increased emanation concentration. The author states expressly, that he does not wish to attack the right to use higher doses as v. *Noorden* has recommended. The author then gives the results obtained in 20 cases of chronic articular rheumatism treated with 1500 mache units per day, given in 6 doses of drinking water, during a period of six weeks. Ten per cent. of the cases were much improved; 25% improved, and 20% little improved and 45% unaffected. This is the author's basis for claiming that the "drink cure" alone is not as effective as the "inhalation cure." In this the author agrees with v. *Noorden* and *Falta.*

A fourth group of 78 cases of chronic articular rheumatism was treated six weeks on a combined inhalation (3-5 mache units) and injection treatment (2 to 5 micro-grams soluble radium salt injected 10 to 15 times in from 4 to 5 weeks), injections being made in the neighborhood of the affected part. Of these cases, 33% were much improved, 32% improved, 12% little improved and 23% unaffected. Taking the total of all cases treated in the four groups mentioned this gives a result of 25% of the cases much improved, 33% improved, 21% little improved and 21% unaffected.

In some cases the patients found themselves improving two to four weeks after discontinuing the treatment. This same effect has been observed before in balneological practice. As regards the permanence of the cures, the author states that, of 91 patients observed after six months, 70 of them had had no recurrence, and of 15 of the 70, observed six months later, 11 still had no recurrence.

In treatment of gout the author cites results in 86 cases treated by the inhalation method. Few of the patients were of the laboring class, the greater proportion being from the higher social classes. This is of advantage in following the cases afterwards. The uric acid was found to disappear from the blood of 10 patients out of 13, subjected to the treatment. Of the 86 cases treated, 77 were improved and 9 were unaffected. Of 29 cases improved by treatment in 1911, 21 were

observed and of these 4 had recurrences in the first six months and 5 more within the year, the remainder being free from pain. Of 32 cases improved by treatment in 1912, 23 have been followed, 4 of these having recurrences within six months and 2 within a year, 17 remaining cured. The recurrences were invariably observed in the particularly severe cases of gout. Some of the patients free from recurrence, had been previously subject to monthly attacks of gout. Since in some cases the treatment dates back two years, it may be said that radium emanation can give permanent results. The tests of the blood for uric acid in two cases, showed the blood free from uric acid. Cases of sciatica, diabetic neuralgia, and sclerodermi were improved by emanation treatment. A case of arteriosclerosis was improved, and in two cases out of five of tabes, the lancinating pains were improved. In ten cases of neurasthenia no improvement was noted, while in a case of *Basedow's* disease, temporary improvement was obtained for three months.

The author gives also the results of the effects of thorium X and thorium emanation in the treatment of chronic articular rheumatism. Lower dosage not giving very good results, higher doses were tried, but the results even here were not better, and much less satisfactory than those obtained by radium treatment. Two cases of lymphosarcoma treated with injections (intra muscular) of thorium X equivalent to 0.1 mgm. radium bromide (total injected equals 0.6 mgm. radium bromide) gave no observable results.

The author gives details of thorium X treatment of anemia and leukemia. A case of secondary anemia due to bleeding of the uterus was improved by the injection of the thorium X and a case of pernicious anemia was considered to be fully cured after an intra muscular injection of the thorium X equivalent to 0.01 mgm. radium bromide. However, in a case of pernicious anemia of some years standing, the injections of thorium X showed only a slight effect on the blood and the patient's condition becoming worse, the treatment was abandoned. A case of myelogenic leukemia treated with thorium X equivalent to 0.34 mgm. radium bromide, showed only a slight fall in the leucocytes from 97,000 to 72,000 and in a month the number was 85,000 again.

* * * * *

P. G. *Mesernitzki.* Latest Results with Radium Emanation Treatment of Gout. Berl. klin. Wochenschrift No. 27, Page 1248, 1913. Reports on 158 cases of gout treated with 3-4 daily doses of from 10,000 to 25,000 mache units of radium emanation (ca. 4 to 10 microcuries) in the form of drinking water. Beginning with smaller doses (1000 m. u.) the quantity administered was increased to the maximum in 4 days.

Reaction pains not always observed, the patients were treated for from six to twelve weeks, and the following results were noted:

Total number of patients treated	158
Cured	45
Improved	21
Unchanged	69
Worse	23

The permanence of the results is a question, although the author cites three of the cured cases in which no recurrence has been noted for three years.

The author cites his experiments showing that radium emanation does not make the mono-sodium urate soluble as *Gudzent* claimed, and in this the author confirms the work of *Lazarus* and *Knafl* and *Lenz*. The radium emanation was used in sterile solutions of mono-sodium urate in concentrations up to 100,000 mache units. The effect of emanation on the enzyenes still remains to be proven, but the fact remains, that radium emanation does influence the purin metabolism as the author and *Kemen* have shown, and it does cure a certain per cent. of cases of gout.

* * * * *

Kroenig and *Gauss*. The Treatment of Cancer with Roentgen Rays and Mesothorium. Deutsche medizinische Wochenschrift. **39**, 1233-37. (June 26th, 1913). The authors used large quantities (300 to 800 milligrams) of mesothorium in their work, only the gamma rays being used, the other rays being absorbed by thick screens. Heavily screened X rays were also used, a combination of the mesothorium and X ray treatment being regarded as the best method. Of the total of 146 cases of carcinoma treated, 26 were treated with unfiltered or slightly filtered rays. The results in these cases were similar to those previously reported by others working under similar conditions. The bleeding stopped, the surface became cicatrised, and the tumor became movable, but in all these cases the patient eventually died. In 64 cases, prophylactic treatment, similar to that used by the French workers, was used to prevent carcinoma recidives. Of the 64, 43 were treated almost exclusively with unfiltered X rays, whereas 21 cases were treated with both the filtered as well as the unfiltered rays. Of the 43, 23 have since died of carcinoma (20 lost sight of) and of the 21, one has been lost sight of. The remaining 20 are still free from recidives. Of these cases, only 7 have been under observation for less than a year. 56 cases which were not operated, were treated with the penetrating rays; 10 cases with X rays exclusively; the other 46 being treated with a combination of X ray and mesothorium rays, or the latter alone. Of the 46 cases, 5 have died, 7 discontinued treatment and were lost sight of; 19 cases are under treatment; and 15 cases are considered healed. These 15 cases show histologically on test excisions no evidence of cancer.

* * * * *

E. *Bumm*. Results of Roentgen Ray and Mesothorium Treatment in Carcinoma of the Uterus. Berliner klinische Wochenschrift. **50**, 1001-1006. (June 22, 1913). Gynaecologic Clinic of the University of Berlin. The author reports on 11 cases of carcinoma of the cervix and two of carcinoma of the urethra treated with very hard X rays, and very large quantities of mesothorium. 499 milligrams of mesothorium were available and long exposures to hard X rays (10,000 Kienbock X) and the hard gamma rays of mesothorium (25,000 milligram hours) were used in these cases, with remarkably good results. The genital organs in women are remarkably tolerant to the rays, although the bladder is more sensitive. With inoperable cancer, this treatment gives better results than any other treatment. The author believes that operative treatment is best in all quick growing soft carcinomas of the uterus, particularly in younger persons. Repeated systematic radiation treatment, afterwards, is urged to prevent recidives. This new technique of intense filtered deep penetrating rays, in radiation therapy of cancer, has brought remarkable results, and even more may be expected with improvement in the methods.

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We shall be glad to receive for publication from our subscribers and readers articles pertaining to the subject of radium and its application. All inquiries for information will be accorded prompt attention, and will be answered either by letter or through the columns of this paper.

VOL. II DECEMBER, 1913 No. 3

RADIUM AND MESOTHORIUM IN THE TREATMENT OF MALIGNANT TUMORS. III.

By OTTO SCHINDLER, M. D. (*Vienna*)

REPORT OF CASES.

Rectum Carcinoma.—Four cases of inoperable rectum carcinoma were treated. For certain reasons 2 cases (K. K. and Sch.) could carry out only an entirely insufficient course of treatment although they showed the beneficial effect of the exposure, namely cessation of hemorrhage and the troublesome tenesmus. In 2 cases I found it impossible to give higher doses. In both cases there was a complete cessation of the hemorrhage, disappearance of the tenesmus and definite increase in weight. The local findings were only slightly influenced in one case; the other case exhibited, however, a clinical cure of the condition which lasted for several months. Concerning this case I will speak in greater detail.

Case D. R., 75 years (consultation with Prof. *Schnitzler*). A papillary carcinoma of the rectum was removed by Prof. *Schnitzler* on Feb. 2, 1912, by making traction and then cutting it off, since a more thorough operation appeared inadvisable on account of the age and general condition of the patient. Since July, 1912, increased difficulty with bowel movements and hemorrhage. Emptying of the intestine was hindered, being possible only in small portions.

Stat. praes. Sept. 16, 1912. On palpation a transverse lineal scar is found in the ampulla recti. At the right end of this one can feel a node about the size of a hazel-nut, whereas at the opposite end there is a somewhat smaller node, painful on pressure. Upon inspection by means of the *Foges'* rectoscope it was seen that the larger nodule was ulcerated. This crescent-shaped ulceration is outlined by dense raised borders and bleeds upon being even slightly disturbed.

Sept. 16 to Dec. 11, 1912, in two series, about 1700 mgm. hours (radium element). Patient convalesced after he had suffered from increased tenesmus 14 days after operation. The tenesmus disappeared completely, the hemorrhage ceased, appetite became better and simul-

taneously the general condition. Increase in weight up to the middle of January, nearly 7 kg.

Jan. 29. At an examination by Prof. *Schnitzler*, the findings were a dense scar at the site of the earlier tumor, the ulceration entirely healed. Carcinoma could not be definitely made out at any place. Patient feels completely well and sound and because of this will not submit to further radium exposure, although this was recommended.

Carcinoma of the Ovary.—A case of extremely rapidly growing recurrence, the size of a child's head, after an extirpation of an ovarian carcinoma. Only moderate doses could be employed, since the patient reacted to the rays with a high fever. Patient died soon after the treatment was instituted.

Recurrent Breast Carcinoma.—Four cases were treated, 3 of which are of recent date and the treatment is still incomplete. In all cases a favorable influence upon the pain has been shown, as well as a decrease in the size of the glandular metastases which in two cases nearly disappeared. One case died after a far-reaching local improvement had resulted from the exposure and an almost complete inhibition of the pain had been obtained for many months.

Case H. R., 55 years (consultation with Prof. *Schnitzler* and Dr. *Robinsohn*). Eight years ago amputatio mammae sinistrae was done by Prof. *Schnitzer* for carcinoma with subsequent good health up to one year ago. At this time there began shooting pains in the left arm and light pains in the left side of the neck, extending to the occiput. The patient herself had noticed uneveness of the left side of the neck for which she consulted the physician. Since June of the preceding year the patient has taken, with interruptions, Roentgen-ray treatments (Dr. *Robinsohn*). At first this gave favorable results, later in spite of continuous Roentgen treatment the pain grew constantly worse, so that the patient could not sleep and even internal medication for relief from the pain did not give entire freedom from pain. For the past 5 months patient has noticed a swelling at the joint of the left upper ribs. This had the feeling of a foreign body as though, for instance, a piece of wood stuck there.

Stat. praes.: On April 15, 1913. Supraclavicular there is palpably a large densely infiltrated gland the size of a walnut. Over the joints of the first three ribs on the left one finds a prominent dense swelling about the size of the palm of the hand projecting about 1 cm.

April 15 to May 28, 1913. Mesothorium and radium exposure, about 2400 mgm. hours (referred to radium element). The pain completely gone; above the clavical the glands have shrunken to small indefinite points of resistance situated deeply. Patient is to be treated further.

Sarcomas.—Case E. R., 17 years, Wiedner Hospital. For 3 months there has existed a swelling of the left half of the lower jaw, which appeared following the extraction of two teeth.

Stat. praes.: In the middle third of the left half of the under-jaw a swelling is palpable which is about 1½ cm. thick, dense hard and painless.

Jan. 7, 1913. Operation. Cutting around the mucous membrane, excochleation of the hole in the under-jaw, whereupon some soft tissue and bone splinters were extruded.

Histological examination: Small spindle-celled sarcoma with many small giant-cells interspersed among which are "Knochen-bolkchen."

Jan. 21 and 22, mesothorium corresponding to about 380 mgm. hours (referred to radium element).

Jan. 24. Fever 39. 2° C. Swelling and tenderness in the region of the under-jaw with fluctuation.

Jan. 27. Opening of the fluctuating point from without.

Feb. 2. A small amount of pus is discharged daily from the opening.

April 1. Fistula completely closed.

July 1. Examination shows that the tumor has become definitely smaller and apparently consists everywhere of solid, compact bone. It appears probable that the formation of the abscess occurred in conjunction with the exposure. The pus, unfortunately, was not examined bacteriologically. This case of abscess formation following exposure to mesothorium is probably analogous to one described by *Voigt*. (Muench. med. Wochenschr. June 3, 1913). In this case of *Voigt's* an abscess the size of a goose-egg appeared in the cul-de-sac of Douglas, after 48 hours exposure to rays of 20 mgm. of mesothorium filtered through 0.08 mm. silver. The puncture in this case gave a sterile pus.

Case K. B., 8 years, Wiedner Hospital. After treatment after removal of an epulis of the left lower jaw of an 8 year old boy. Dose about 620 mgm. hours radium element, filter 1 mm. lead. According to communication by letter the boy is still free from recurrence—now 8 months. It is further noteworthy that the little patient had a tooth appear on the spot which was operated upon and then radium-rayed. In other words the energetic radium treatment did the tooth no harm.

Case III. Mrs. P., 52 years, primary endothelioma of the pleura (consultation with Dozent A. *Hammerschlag*). In this case which had progressed very far and where the tumor masses included a great part of the chest-cavity it was at once evident that only an amelioration of the pain, which was most exquisite, was possible. In spite of maximum doses of morphine and scopolamine this pain had become unendurable. Since the patient reacted to comparatively small doses of the rays with prostration and vomiting, it was necessary to proceed very cautiously with the treatment. It became possible finally to so decrease the pain by means of the treatment that the patient had an endurable existence up to the last moments and as a result of the improvement in the subjective findings was able to take new hope. The post-mortem (Prof. *Kolisko*) disclosed a primary endothelioma of the pleura. Those portions of the tumor which had been exposed to the rays were, in contradistinction to the other parts of the tumor, of a strikingly soft consistence.

Conclusions.—If one takes a critical view-point of all of my cases, there becomes evident a group of cases which were handled with very large doses (up to 7000 mgm. hours referred to radium element, within 31 days), and a second larger group, which because of entirely irrelevant reasons had to be treated, unfortunately, with relatively weak doses. A comparison of the results reported discloses without a doubt a surprising superiority of the massive doses of filtered rays. These favorable experiences of mine, together with the observations of *Wickham* and *Degrais*—already published— as well as the signal results in Germany with large doses of strongly filtered mesothorium and Roentgen-rays, encourage me to energetically follow up the course laid down by me about $1\frac{1}{2}$ years ago—namely, maximum doses of filtered rays.

Up to this time it was impossible for me, principally because of a lack of enough radium, to give the desired dosage in all cases. Now,

however, since I have at my disposal a new supply of radium, equivalent to 70 mgm. radium element or about 115 mgm. pure radium bromide—I am in a position to actually carry out in all cases the large doses which I have recommended and so I hope to improve upon the results reported up to the present time.

It further appears from my cases as well as from the various observations of *Wickham* and *Degrais, Nahmacher* and others that it will be possible for us to obtain at least as good results with the large doses of strong filtered radium rays as have been reported by the German gynecologists from the gamma-rays of mesothorium. It has been demonstrated that the very penetrating rays (chiefly the gamma-rays) of radium and mesothorium have the same physical properties, a thing which it had already been necessary to concede from purely theoretical reasons.

In contradistinction to filtered Roentgen-rays, whose beneficial influence upon carcinoma has been established beyond a doubt by the long experience of earlier writers and first through the publication of the German gynecologists, the gamma-rays of radium and mesothorium have the advantage of much greater power of penetration and ergo also of working at a greater depth. Furthermore, there is the possibility of inserting the source of the rays into the body in tubes and capsules and so having the rays pass radially in all directions. The great convenience in handling radium and mesothorium is a factor to be considered by both patient and physician.

I believe I may draw the conclusion from the case of H. St. that it is not necessary to work with several hundred mgm. of radio-active substance. When we had smaller quantities at our disposal (in special cases 11.04 mgm. radium element) and exposed to the rays for weeks at a time, reaching the same number of mgm. hours, the result was that in this relatively short time this cumulative effect of the rays produced the same beneficial results as when using considerably greater quantities for a decidedly shorter time. At the same time the efficiency of a very large quantity for certain cases should not be denied. In general, I believe that one would find 20-30 mgm. of radium element quite sufficient for a case, only it will be necessary to expose to the rays longer and constantly *day and night.*

We are further able to recognize from my cases, without a doubt, even though there were only a few, that post-operative treatment with the rays exerts a beneficial effect. 2 out of 3 cases of carcinoma of the oral mucous membrane, treated post-operatively, have remained free from recurrence up to date, one case $1\frac{1}{2}$ years, one case, 1 year. The third case (H. K.) had a recurrence on a spot on the under-jaw which had been only weakly exposed because of other reasons, whereas the primary area on the mucous membrane of the cheek which had been handled with stronger rays showed no recurrence. Even though these few cases do not make up a sufficiently large series and even though the periods of subsequent observation—namely $1\frac{1}{2}$ and 1 year—are too short to permit the drawing of any definite conclusions, I should like to believe, nevertheless, that the rays must exert a favorable influence since experience shows that in more than 60% of the cases of carcinoma of the oral mucous membrane the recurrences take place within one year. From these results and in common with the impressive series of experiments of *Kroenig* and *Gauss*, I believe it not only correct but also one's duty to follow up each case of carcinoma

with post-operative exposure to radium rays or mesothorium rays, alone or in combination with large doses of filtered Roentgen-rays.

The exposure in such cases must be to maximum doses, in order to flood the entire area from all sides with the rays, since small doses (as I have been able to convince myself) have a direct influence upon carcinoma cells to the extent of increasing the rapidity of proliferation.

I believe, furthermore, as a result of several cases wherein a condition of clinical cure was reached following the treatment and in which a local recurrence took place later, that a further prophylactic treatment should be recommended according to the teaching of *Kroenig*.

The post-operative exposure to the rays is only a part of the method which *Wickham* calls "radio-therapeutic surgery." This method comprises an intimate cooperation between surgical procedures and radium ray treatments. *Wickham* employs pre-operative exposure of operable carcinomas to the rays in order to favorably influence the field of operation, so that the malignant cell-elements are in abeyance just at the time of operation and the malignance of the tumor is thereby diminished. On the other hand, he, as well as the German authors, found it possible to make inoperable tumors operable by means of the treatments. In these cases the treatments made subsequent operations possible. Finally in several cases the tumor masses could be removed so well by the surgeon's knife after having had these treatments that the site was not treated further by the rays.

A second series of operative procedures done in order to make the tumors more pervious to the rays also belongs here; the operation of forming fistulas around the stomach and portions of the intestines in order to introduce the tubes, as well as the formation of artificial cavities in the tumor itself for the reception of the radium applicators.

Kroenig goes much further in his ideas of "indications" and includes primarily a great part of his operable cases within the domain of "ray-therapy" since he is of the opinion that one still has time to operate when the rays fail. Whether or not this radical view is correct only time will show. I prefer to conform with the position of *Wickham* on the subject of indications since he is not so radical as to absolutely reverse the older views concerning the treatment of carcinomas.

If I were to lay down indications for radium and mesothorium treatment of malignant tumors, according to my observations of my own cases, and the results published up to date, I would express myself as follows:

1. "Ray-treatment" may be employed without a preceding operation, in all operable and inoperable cases of epithelioma of the skin. If it does not give the desired result, it is still not too late for an operation. The end-results of these treatments in these cases are at least as good as those of surgical intervention, so far as permanent cure and freedom from recurrence is concerned; in view of the functional and cosmetic results this treatment is superior.

2. In all operable carcinomas, especially the carcinomas of the mucous membranes and glands, the most thorough extirpation of the tumor and its regional glands by the surgeon's knife is the most important thing to be done. In connection with this procedure a preliminary treatment with the rays may be valuable. In all cases, however, in order to improve the chances of a permanent cure a post-operative course of treatment with radium or mesothorium, alone or in combina ion with Roentgen-rays should be carried out immediately, this-

treatment being as intense as possible. These prophylactic treatments, according to *Kroenig*, should be repeated at definite intervals.

3. In some operable cases, where it would be necessary to cause considerable mutilation, an excellent method of treatment is to intensely expose the primary area, with simultaneous extirpation, surgically, of the regional lymph-glands, since it is a matter of experience that the glandular metastases are less easily influenced by the rays. A case of carcinoma of the penis which was treated by me in this manner has remained free from recurrence up to the present time, a period of $3\frac{1}{2}$ years.

4. In cases of operable carcinoma, where the operation appears to be inopportune on account of a bad general condition of the patient it is possible to bring the case—by ray-treatment—to a condition of clinical cure. Since it appears to be the rule, up to the present time at least, that recurrences tend to occur, the operation should be done secondarily wherever possible with subsequent post-operative exposure to the rays. Where this is not possible the patient should undergo further prophylactic treatment during the state of "clinical cure."

5. In cases of inoperable carcinoma with sharp outlines and without disseminated metastasis formation one must endeavor to make the tumor operable, according to the teaching of *Werner*, by means of most intense exposure to the rays and, if necessary, radiation treatment in combination with other kindred methods (thorium-X injections, radium injections, etc.), then to follow up the operation with a thorough after-treatment with the rays on the field of operation.

6. In inoperable cases with disseminated metastasis formation, namely those cases which in the past have appeared absolutely without a future, it is possible by means of the "ray-therapy" to diminish the tortures of the patient and provide for him an endurable existence up to the last moments.

NOTES AND COMMENTS.

The Standard Chemical Company of Pittsburgh, Pa., has been awarded the great gold medal for its display of standardized radium products and radium salts at the 3rd International Pharmaceutical Exposition, held in Vienna, Austria, in September 1913. The largest European manufacturers of pharmaceutical radium preparations and the Department of Mines of the Austrian Government also displayed their products, and this award of the gold medal to the Standard Chemical Company fittingly marks the European debut of the first American and the world's largest producer of radium.

* * * * *

"Our Radium Resources," is the title of an address given by Dr. Charles *Parsons* at the 16th Annual Convention of the American Mining Congress, which met in Philadelphia, October 20–24th, 1913. He said that the Colorado radium deposits were the most extensive in the world. So far, the main part of the ore mined in Colorado has been sent abroad, however, during the past year, due to the activities of the Standard Chemical Company of Pittsburgh, radium is now being produced on a large scale in America from the carnotite ore from Colorado.

In closing, the speaker announced the cooperative agreement between the Bureau of Mines and the newly organized National Radium Institute. This Institute, under the Presidency of Dr. Howard A. *Kelly*, of Baltimore, has secured claims in the Paradox Valley, from which radium ore will be mined. In cooperation with the experts of the Bureau of Mines the radium will be extracted for use by the Institute in the work on the radium therapy of cancer. None of this radium will be for sale however, and it will all remain in the United States.

* * * * *

The Oesterreichische Chemiker Zeitung for November, No. 21, 1913 (page 299) states that in view of the great demand for radium preparations, orders have been given to increase the output of pitchblende ore at Joachimsthal in the government mines. In 1914 it is hoped that 50 tons of ore will be secured, which will allow an increase in the radium output over the two grams of radium (element) which is the present annual output.

* * * * *

The U. S. Department of Agriculture, through the Bureau of Chemistry, has issued the following warning to the public in regard to the so-called radio-active mineral waters offered for sale in bottles.

"There are indications of the beginning of an attempt to perpetrate a great fraud on the American people through advertising certain mineral waters as possessing radio-activity. These waters, in some cases, are taken from springs the waters of which as they come from the ground do possess certain radio-active properties. Examination of many of these waters by the Department's specialists indicate that whatever radio-activity they possess at the spring is due almost entirely to radium emanation rather than to the presence in the water of any substance possessing radio-activity. These emanations in the form of gas quickly disappear from the water, and as a result, after the water has been bottled a short time, it will possess practically no radio-activity. The belief long held by many people that some mineral waters used at the springs are more efficient than when bottled has been explained by some authorities on the ground that the beneficial effect of these waters is due to radio-activity. As the radio-activity disappears soon after the water is taken from the spring, an effect due to the radio-activity must be lost in a short time. If the radio-activity of a water in the spring is 100, four days after bottling it will be only 50 and twelve days after bottling, 10. In a month it will be practically nothing compared with the original radio-activity of the water at the spring. The public, therefore, is warned to regard with suspicion any water advertised as possessing radio-activity. As far as the Government's specialists have been able to ascertain, no bottled water, no matter how radio-active it may have been at the spring, retains this radio-activity for any length of time.

"The Department is now investigating a number of the so-called radio-active waters with the object of securing evidence that can be made a basis of prosecution for misbranding. In the past, before the Food and Drugs Act was enacted, a number of mineral waters made claim to curative properties which they did not possess and succeeded in creating a misplaced confidence on the part of the consumers. This was particularly true of a number of imported waters which were sold extensively in the United States with a statement on the bottle that

they were wonderful or magical cures for all sorts of incurable or chronic ailments. The Treasury Department, acting in cooperation with the Department of Agriculture, now refuses admission to the country of foreign waters labeled so as to mislead consumers as to their real or curative properties. The Department fears that unless the public is warned that the fraudulent trade in so-called radio-active waters will develop, just as the fraudulent trade in other mineral waters was developed to the point where people with strong imaginations will supply their bottlers with all sorts of testimonials asserting that these supposed radio-active waters have effected wonderful cures."

* * * * *

Great interest was displayed by the physicians in the standardized radium preparations and radium salts which the Radium Chemical Company of Pittsburgh, Pa., had on exhibition during the meetings of the Tri State Medical Association at Memphis, Tenn., Nov. 11th to 14th, and at the meeting of the Southern Medical Association at Lexington, Ky., Nov. 18th to 20th. Radium salts of high purity were shown, and demonstrations of the radiations were made. The various types of applicators in which the radium salts are mounted for use in the local application of radium were also shown, together with the radium drinking water, radium bath water, radium compresses, radium ointment, radium solutions for intravenous injections and radio-active earth.

* * * * *

Dr. Louis-Frederic *Wickham*, formerly chief of clinic of diseases of the skin at the Faculte de Medecine de Paris, and physician of the Maison de Sainte Lazare, is dead at the age of 53. Dr. *Wickham* was a pioneer in the application of the rays of radium in therapeutics, especially in the treatment of cancer. He organized the Laboratoire Biologique du Radium in Paris, where, together with his co-workers, he carried out extensive researches in radium therapy. Together with Dr. Paul *Degrais*, he is the author of the first comprehensive text dealing with the subject of Radiumtherapy. This excellent work, the first edition of which was crowned by the Academy of Medicine of Paris, has been translated into English and German.

* * * * *

The Clinical Congress of Surgeons of North America was held in Chicago during the week of Nov. 10th to 15th. In addition to the clinical demonstrations held in the various hospitals of the city, eight evening sessions were devoted to the reading and discussion of papers. Among those who made addresses before the congress were Dr. Edward *Martin*, Philadelphia; the retiring president, Dr. George E. *Brewer*, of New York; Sir W. Arbuthnot *Lane*, London; Dr. Carl *Beck*, Chicago; Dr. John B. *Deaver*, Philadelphia; Dr. Howard *Kelly*, Baltimore; Dr. C. J. *Gauss*, Freiburg; Dr. Roswell *Park*, Buffalo; Dr. James *Ewing*, New York, and Dr. Charles *Mayo*, Rochester.

* * * * *

Dr. Howard A. *Kelly*, presented a paper on "Radio-Therapeutics in Surgical Affections" before the National Academy of Sciences, which met at Baltimore, November 18-19th, 1913.

The following courses of lectures on "Radio-activity" will be held in the Universities of Germany and Austria during the winter term, 1913—1914:

University Berlin: Prof. *Hahn*, "Chemistry of Radio-active Elements."
Dr. *Regener*, "Radio-active Measurements," practical course.
University Breslau: Prof. *Sackur*, "Radio-activity."
University Goettingen: Dr. Rausch von *Traubenberg* "On Radio-activity."
University Heidelberg: Prof. *Becker*, "Radiology."
Prof. *Ebler*, "Radio-active Substances."
University Innsbruck: Prof. von *Schweidler*, "On New Researches in Radio-activity."
Techn. University Karlsruhe: Dr. *Fajans*, "Chemistry of Radio-elements."
University Leipsic: Dr. *Vollmer*, "The Importance of Radio-activity for Chemistry."
Techn. University Stuttgart: Prof. *Kaufmann* "On Radio-activity."
University Vienna: Prof. St. *Meyer* "On Radio-activity."
University Wurzburg: Prof. von *Halban* "The Radio-active Elements."

* * * * *

"Internal medicine is destined to surpass surgery in value to the human race within the next twenty-five years" is the prediction made by Dr. J. B. *Murphy*, the famous surgeon, at his clinic at Mercy Hospital in Chicago, which was attended by members of the Clinical Congress of Surgeons of North America. American surgeons are far behind their European brethren in realizing the value of radium in the treatment of cancer. It is to be hoped that this state of affairs will soon cease to exist, and when radium has displaced the knife, a long step will have been taken towards the fulfilling of Dr. *Murphy's* prediction.

THE TREATMENT OF ALVEOLAR PYORRHEA WITH RADIUM EMANATION. A REVIEW.

By W. H. CAMERON, M. D.
Medical Director, Radium Chemical Company.

In view of the many requests for information regarding the uses of radium and radium emanation which have come to the writer, it has been deemed advisable to publish from time to time reviews of the work that has been carried out in the treatment of different diseases by means of radium or radium emanation.

Below are given reviews of three articles which have recently appeared, dealing with the treatment of alveolar pyorrhea and other dental and aural diseases by means of radium emanation and the radium rays:

Franz *Trauner*. The Treatment of Aural Diseases, Particularly Alveolar Pyorrhea, with Radium. Oest.-unger Vierteljahr-schrift fuer Zahnheilkunde. Heft. 1, P. 83. 1913. The author successfully treated about 20 cases of alveolar pyorrhea with water containing

radium emanation (in some cases as high a concentration as 20 microcuries per liter or ca. 50,000 mache units) and with radioactive wax. The treatment consisting in having the patient irrigate the mouth twice a day with about 300 cc. of the radium emanation water. Each mouthful of water was vigorously passed back and forth through the teeth for a minute or two, in order to bring the emanation into contact with the teeth and gums. Such a procedure requires from 20 to 30 minutes and the patient was directed not to eat or drink anything for several hours afterwards. This treatment the author found gave surprisingly good results. The suppuration and the subjective pain diminished after two or three days, occurring only in a lesser degree where there were tartar accumulations on the teeth. This tartar must be carefully removed. This again leads to a diminution of the suppuration. Larger pockets in the gums were treated by washing them out with the high concentration emanation water, using a Pravaz's syringe. Also pieces of radio-active wax, about the size of a pin head, were introduced into such pockets, fistulas or abscesses and held in place for several hours by means of a cotton plug. Essentially the treatment consisted in irrigating the mouth with strong emanation water; in the use of radio-active wax, and in the very careful removal of all tartar incrustations.

M. *Levy*. The Use of Radio-active Substances in the Treatment of Dental and Aural Diseases, including Alveolar Pyorrhea. (Radium Institute of the Charite, Berlin, Prof. *His*, Director). Deutsche medizinische Wochenschrift. No. 23, 1913. In 1912 the author found improvement in a case of psoriasis of the mucous membrane of the mouth, as a result of treatment with radium emanation water and massage with a radium paste. Since then a number of cases of dental and aural diseases have been treated with various of the radio-active substances; radium and mesothorium applicators, radium compresses, radium salt injections, radium emanation by inhalation and in solution for drinking and irrigation, etc.

The author does not agree with *Trauner* in believing the good results after using radium emanation are due to the direct action of this upon the mucous membranes of the mouth. The action of the emanation, a gas, upon the membrane would be but for a moment, and it would seem more logical to attribute the good results to the action of the emanation upon the blood and the metabolism. The author inclines to the belief that most of the diseases in the mouth have a constitutional derangement for a basis. Alveolar pyorrhea is the exception to this, he says.

The author successfully treated psoriasis of the mucous membrane of the mouth, alveolar pyorrhea, loosening of the teeth where there was no suppuration, marginal gingivitis, leukoplakia of the tongue and mouth, dental fistula and ulcerative stomatitis. Some cases of alveolar pyorrhea and of chronically recurring apthae were refractory to this treatment.

H. J. *Mamlok*, Radium as a Curative Agent in Alveolar Pyorrhea. Correspondenz-Blatt fuer Zahnaerzte. Vol. 42, No. 3. 1913. The author states his belief that a gouty diathesis plays an important role among the predisposing causes of alveolar pyorrhea. This he gives as a basis for the use of radium emanation in alveolar pyorrhea, since the work of *Gudzent, Loewenthal, His, Klemperer, v. Noorden* and others has demonstrated the value of this treatment in gout, where it leads to the disappearance of the uric acid from the blood. In addition the

author sought to destroy the granuloma-like growths in the alveoli, which he holds responsible for the suppuration in alveolar pyorrhea, and the local application of radium as in the treatment of cancer, etc., was used.

For this purpose one milligram of radium was used, without screening, for short periods, and larger quantities (15 to 25 milligrams), suitably screened with metal and rubber, were applied for 20 to 30 minutes in order to have the gamma rays affect the pathological tissue. In the 50 patients which the author treated he found that three were burned by the radium, although the primary inflammation diminished. Three cases of abscess formation were noticed which were thought to be due to the effect of the radium rays on the leucocytes. One case resisted all treatment; however, generally the severe cases showed a reaction, consisting in an increased severity of symptoms, this exacerbation being due probably to the local hyperemia caused by the raying. The author points out that this treatment cannot prevent recurrences, since the radium rays and the emanation cannot remove all the obscure causes of alveolar pyorrhea. Radium is no miracle worker, he says, and rational treatment is always necessary.

It is evident from the work of *Trauner*, *Levy* and *Mamlok* that radium emanation water is valuable as the treatment of alveolar pyorrhea where it is used to irrigate the mouth. The use of radium rays in affecting the removal of various benign and malignant growths hardly needs to be mentioned. As an analgesic in toothache the rays of radium give splendid results, only precautions must be taken to prevent radium burns on the face, and in the mouth. One milligram of radium element applied for three to five hours or ten milligrams applied for twenty to thirty minutes has been found to relieve severe cases of toothache. The radium preparations are screened with about a half millimeter thickness of lead foil and this is in turn covered with several millimeters thickness of rubber, cloth or paper. The radium preparation is held or fastened on the cheek over the affected tooth.

REVIEWS AND ABSTRACTS.

Robert *Abbe*, M. D., The Use of Radium in Malignant Disease. The Lancet, London. Vol. II, No. 8, Aug. 23, 1913. A paper read in the Section of Radiology at the 17th International Congress of Medicine which met in London. "It is safe to say that surgery is entering upon a new era of hope and attainment in the treatment of malignant disease. Whatever the primary cause of cancer, in its broadest sense, is for the hour a question of less importance than the practical one—as to what deterrent effect can be produced on disordered cells by new physical agents. It is a trite saying that there has been no known cure for cancer. Surgery has expended its utmost force in cutting out every vestige of disease, or to destroying by cautery, caustics or freezing. These occasionally cure the patient; they never cure the disease, they only remove it. We must look to forces like organic chemistry, or biochemistry, or agents like Roentgen rays or radium—which latter we will now discuss."

"We can safely form an opinion of the action of radiant matter upon animal cells by its action on those of vegetable life, for who can differentiate the vital force actuating each? In the laboratory of nature we study the effect of radium on seeds and bulbs. This is a foundation-stone of its effect on animal cells. After suitable exposure of seeds to varying amounts of soft and hard rays, issuing in incessant streams from this wonder-working mineral, we watch them grow and see three results:

(1) A death-dealing force has played upon the near-by seeds so that their life is destroyed; (2) upon seeds a little further removed, a stimulating effect has occurred, wonderful to relate, so that their growth is greater than that of seeds which have had no radium; and (3) at distances beyond that of stimulation, where the hard gamma rays have played relentlessly on the seed life, they show a retarded vitality, and are depressed in their growth more and more up to a point several inches away from the radium. The range of action of alpha rays, we are told, is within a half inch, that of beta rays somewhere about an inch and a half, but the gamma rays are ultra-penetrating." . . .

"I shall endeavor to show that the surgeon can utilize the third so that he can at will produce that retrograde change in cells which have shown erratic overgrowth and formed life-destroying tumors. Partial success, or discouraging failures of the past, may be largely due to ignorance of the baneful influence of the alpha and beta rays which one can now eliminate. In this I think we put our finger on the weak spot in radium treatment. If the beta rays stimulate we certainly do not want them; it is fair to say that gamma radiation is our aim. The study of the effective use of radium in briefest report—stripped of complicated observations and intricate notes necessarily accumulated about the cases narrated—will occupy our attention during the brief time at our disposal."

"It was my good fortune to acquire 150 mgm. of Madame *Curie's* strongest radium barium chloride (X300,000) in 1903 and to add to this later 250 mgm. of pure radium bromide (X2,000,000) of French and German make, which gave opportunity to study its effect on cases of surgical interest—cases chosen largely from those refusing the use of the knife, or beyond its aid. During ten years I have been able to study the efficiency of these specimens on more than 750 individual cases in private, including 250 epitheliomas of all parts; 180 carcinomas of the tongue, throat, oesophagus, rectum, uterus, breast, etc.; 50 sarcomas of the skin, parotid, bones, etc., besides goitres, tumors of the liver and mediastinum, and a variety of naevi, moles, papillomas, etc. Of the numerous failures I can truly say that they seem due to inadequate amount, or insufficient time of application, or error in using the proper rays. In other words, it has been evident that all three types of results seen in seed experiments are to be recognized in radium work, to wit: (1) destruction of tissues too closely in contact; (2) stimulation and harmful results; and (3) efficient retrograde degeneration of malignant growths with lasting benefits amounting at times to a surgical cure."

After giving details of a number of cases treated, the author says: "In conclusion, there has been established: 1. An undoubted retrograde degeneration of malignant cells under correct dosage of gamma radiation. 2. Effective use of radium lies in the application of a large enough quantity to avoid the stimulating action of little doses at short range. 3. The utilization of gamma radiation with its deep penetration can be made by the removal of alpha and soft beta rays by filtration through lead. 4. Such filtration requires many times as long for a sufficient amount of gamma rays to act, as when other rays are eliminated by what may be called "distance filtration." One and a half inches or four centimetres seems in practice to exclude most of these and gives free and instant play of the entire gamma range without delay of passage through lead. 5. Cross firing of several specimens simultaneously or of one large specimen moved successively to several nearby places is necessary for the best work. 6. Normal tissue resists many times as large doses of gamma rays as are required to check and dissipate morbid growths, as shown in the larynx."

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The Intravenous Injection of Soluble Radium Salts.

By Frederick Proescher, M. D.

Director of the Laboratory for Experimental Therapy, Standard Chemical Company.

In a preliminary communication in this Journal* I reported, in brief, the result of the intravenous injection of soluble radium salts in human beings—a procedure heretofore never attempted with such large dosage. The results obtained encouraged me to further investigation and I selected a series of cases which are favorably influenced by the direct radium emanation method. As I have already stated the intravenous method has a decided advantage over the present method of administration in that it can be given by the general practitioner, and also reduces the length of time necessary to obtain a result—a matter of considerable importance to the patient.

The concentration of radium emanation introduced into the organism is, because of many factors, not always constant and it is exhaled in time; the emanation soon passing from the body through the lungs, and the active deposit of radium A, B and C soon decaying to form the rayless radium D.

When soluble radium salts are injected intravenously, the radium is carried through the body and deposits in the form of carbonate and sulfate. The radium is to a small extent excreted in the urine and feces, the greater portion, however, being deposited in the bone marrow. We therefore render the organism not only passively but actively radioactive for a considerable period and, what is more important, the action is constant. In other words, the body becomes a vital emanatorium due to the deposit of radium salts.

At present, we can safely say that radium salts introduced intravenously (in a quantity up to one milligram radium element) are per-

*The Intravenous Injection of Soluble Radium Salts in Man. Radium Vol. 1, No. 4, July 1913.

fectly harmless. Thirty patients given one, and sometimes several injections, did not show the slightest alarming symptom or any injurious effect to any organ. This observation extended over a period of from three to six months.

One hundred to two hundred micrograms of radium (element), or smaller doses of ten to fifty micrograms, (given at once or in repeated doses) were administered by me for therapeutic purposes. However, I am inclined to believe that, with further experience, even much larger doses could be safely given.

The technic of the injection was the same as described in my previous communication. Radium in the form of chloride or bromide, dissolved in sterile physiological salt solution sealed in glass ampulles was used. The injections were given by means of a glass syringe without rubber attachment, the injection being made into the cephalic vein.

The following cases have been treated:–

Polyarthritis and Oligoarthritis	16
Pernicious Anemia	1
Leukemia	1
High Blood Pressure	8
Tabes Dorsalis	1
Epilepsy	1
Multiple Sclerosis	2

At this time I wish to submit reports on the 16 cases of arthritis.

CASE NO. 1. MALE; AGE 28 YEARS. LABORER.

Previous History.—Negative.

Present History.—On May 23, 1913, patient contracted a severe cold and the following day he felt feverish and weak, and this condition became worse during the next 24 hours. On May 26th he complained of pain in back and neck. Three days later his knees and ankles began to swell and were tender and painful and he was unable to get out of bed, and was removed to the hospital.

Objective Symptoms.—Knees and ankles swollen and very painful.

Diagnosis.—Acute polyarthritis.

Course of Illness After Injection of Radium.—6-11-1913. Patient given 10 micrograms radium (element) intravenously.

6-12-13. All joints more or less tender and stiff and slightly swollen.

6-13-13. Pain has left all joints except shoulders which are still stiff. 10 micrograms radium (element) injected intravenously.

6-14-13. Joints less swollen and painful. 20 micrograms of radium (element) injected intravenously.

6-15-13. All joints stiff, no pain.

6-16-13. General condition good, joints still stiff, swelling in knees and ankles disappeared.

6-17-13. 20 micrograms of radium (element) injected intravenously.

6-25-13. Slight stiffness in both knee joints, but able to walk. 10 micrograms radium (element) injected intravenously.

6-26-13. Complains of a slight stiffness in both hands. Sleeps very well. No pain in knee and ankles.

6-28-13. Feels generally very good, no pain in joints. Discharged from hospital.

Final examination, October 23, had no recurrence since May. General condition very good. Result—Temporarily cured.

CASE NO. 2. MALE: AGE 21 YEARS. ELECTRICIAN.

Previous History.—Patient had his first attack of rheumatism in 1909. The knees, ankles and at times the hands were involved.

Present History.—In the latter part of June, 1913, the patient was suddenly incapacitated by pain and swelling involving knees and ankles. He was unable to move about and was confined to his bed. His condition was complicated by an endocarditis with mitral systolic murmur.

Objective Symptoms.—Swelling of knees and ankles.

Diagnosis.—Chronic progressive polyarthritis complicated by endocarditis.

Course of Illness After Injection of Radium.—7-3-13. Patient given 100 micrograms radium (element) intravenously.

7-4-13. Moderate pain in both knee articulations and some slight pain in all articulations. Both knee articulations swollen.

7-5-13. No pain in articulations.

7-7-13. Stiffness in knee, shoulder and elbow articulations.

7-8-13. Swelling of both knee articulations entirely disappeared. General condition, improved.

7-10-13. Slight tenderness in both knee articulations, elbows not swollen.

7-15-13. Patient feels better. Able to walk.

10-19-13. Final examination. He has had no return of rheumatic symptoms. Is feeling very well. Result—Temporarily cured.

CASE NO. 3. MALE: AGE 36 YEARS. CARPENTER.

Previous History. First attack of rheumatism April 1st, 1913. All articulations were involved. Patient had taken salicylates during the entire course of his illness.

Present History.—All articulations are involved to a greater or less degree. Ankles are very painful and swell intermittently.

Objective Symptoms.—All articulations are more or less swollen and tender to the touch.

Diagnosis.—Chronic polyarthritis.

Course of Illness After Injection of Radium.—7-2-13. Patient given injection of 100 micrograms of radium (element) intravenously.

7-3-13. All articulations are stiff and tender to touch.

7-4-13. Patient walks much better. Feels better than he has for a long time. Voids freely.

7-7-13. Patient has no pain. Walks better. His general condition is good. Patient, by chance, having been caught in a rain storm, had his feet dampened. He has had no return of rheumatic trouble since. This would seem to indicate much improvement in his general condition, especially ir reference to his rheumatic diathesis.

8-1-13. General condition, very good. All articulations appear normal. Is able to get about as usual.

11-3-13. Both ankles sore and swollen. Patient unable to walk and cannot wear high shoes. Both arms from hand joints to elbow tender but no swelling. General condition good. 50 micrograms of radium (element) injected intravenously.

11-5-13. Two days after the radium injection, swelling of ankles and tenderness of both arms disappeared. Able to walk. Result—Considerably improved.

CASE NO. 4. FEMALE: AGE 26 YEARS. HOUSEWIFE.

Previous History.—Negative.

Present History.—Patient complains of pain in left foot and ankle since the middle of May, 1913. Pain more exaggerated when walking.

Objective Symptoms.—Left foot and ankle swollen. Cannot wear high walking shoes.

Diagnosis.—Subacute polyarthritis.

Course of Illness After Injection of Radium.—7-3-13. Intravenous injection of 100 micrograms of radium (element).

7-4-13. Left foot swollen and painful; more or less pain in all articulations.

7-9-13. Swelling of left foot reduced.

7-10-13. Intravenous injection of 100 micrograms of radium (element).

7-11-13. Subsidence of swelling of the left foot.

7-12-13. Swelling of foot almost gone. No pain.

7-14-13. Ankle slightly swollen; some pain but can wear shoes.

7-23-13. Is now able to wear shoes. Ankle slightly tender to touch.

8-25-13. Swelling subsided permanently. Has not had reappearance since. Is now able to wear shoes comfortably. Result—Temporarily cured.

CASE NO. 5. FEMALE; AGE 39 YEARS. DOMESTIC.

Previous History.—Patient had an attack of tonsilitis in 1907. In May, 1912, patient was stricken with pain and swelling in both shoulders, elbows, knees, ankles and fingers.

Objective Symptoms.—Fingers of both hands are swollen and painful; patient cannot close her hands.

Diagnosis.—Chronic progressive polyarthritis.

Course of Illness After Injection of Radium.—7-6-13. Patient given 100 micrograms of radium (element) intravenously.

7-6-13. Both elbow and finger articulations are painful and swollen.

7-9-13. Both wrists and finger articulations are less painful.

7-10-13. Both wrist articulations are less painful; swelling is subsiding.

7-11-13. During night both ext. malleoli are very tender to the touch and very painful. No pain in wrist articulations.

7-12-13. Patient feels better; pain absent in both hands and ankles.

7-17-13. No pain in ankles; walks very well. Hands slightly swollen but not painful; patient sleeps well. General condition much improved.

7-20-13. Patient had a recurrence of pain in hand, elbow and left shoulder. Ankle not painful but slightly stiff when walking.

7-21-13. Both feet very painful, as is also right shoulder.

7-22-13. Some stiffness in all articulations when attempting to move about.

7-23-13. Patient feels apparently well; has no pain in articulations, but some slight stiffness when attempting to move the various articulations.

8-5-13. Patient had a relapse affecting hands and ankles.

8-5-13. Patient given 50 micrograms of radium (element) intravenously. Patient did not return after the last injection. Result—Improved.

CASE NO. 6. MALE; AGE 36 YEARS. CARPENTER.

Previous History.—Patient was stricken with his first attack of rheumatism about 15 years ago, being confined then to his bed for a long period.

Present History.—On May 20th, 1913, he was suddenly stricken and incapacitated by an attack of rheumatism involving his limbs. For a period of three weeks all the articulations were affected and patient was hardly able to move his limbs.

Objective Symptoms.—Both shoulder articulations slightly swollen and tender to touch and painful on movement. Cannot use his shoulder articulations. Both ankles are swollen and painful on movement.

Diagnosis.—Chronic progressive polyarthritis.

Course of Illness After Injection of Radium.—7-3-13. Patient given 100 micrograms of radium (element) intravenously.

7-4-13. There is a general stiffness of all articulations. Left ankle and left knee articulations slightly painful when attempting to use them. Slept very well.

7-5-13. Patient is relieved of pain for the first time since May 20th, 1913. Feels generally improved. Stiffness in articulations less marked.

7-7-13. Some pain in both shoulder articulations. Otherwise feeling very comfortable.

7-8-13. Pain in right shoulder articulation. Patient given 50 micrograms radium (element) intravenously.

7-10-13. Condition unchanged. Patient given 50 micrograms radium (element) intravenously.

7-12-13. Right shoulder still impaired.

7-14-13. No pain but slight stiffness in both shoulder articulations. Slept very well. Was able to dress himself for the first time since May 20th, 1913.

7-17-13. Feels good. No pain in articulations. Shoulder somewhat stiffened.

7-21-13. Pain in both feet. Planta pedis very tender. Walks with difficulty. Pain in both shoulders. Right elbow very painful and tender.

7-28-13. Pain still continued in right shoulder articulation. Biceps muscle very painful and tender. Unable to raise both arms owing to adhesions in both shoulder articulations. Result—Considerably improved.

CASE NO. 7. FEMALE; AGE 23 YEARS. DOMESTIC.

Previous History.—Patient developed an attack of acute rheumatism which confined her to bed for a period of 18 weeks during 1909. Both knees and hands were involved. Patient has never been entirely free of rheumatism since her first attack.

Present History.—Knee, hand, finger, shoulder and elbow articulations are very painful and tender to touch. Cannot walk and has to be carried around in a chair.

Objective Symptoms.—Both knees enlarged and patient unable to walk. All phalangeal articulations are spindle shaped, swollen and deformed.

Diagnosis.—Oligoarthritis deformans.

Course of Illness After Injection of Radium.—7-8-13. Patient given 100 micrograms of radium (element) intravenously.

7-9-13. No reaction in articulations. Slight rise of temperature about one degree above the normal.

7-20-13. Pain in all articulations; more painful in left wrist. Left wrist swollen.

7-21-13. All articulations are stiff but not as tender to the touch as originally. Patient sleeps well.

7-24-13. Pain still continues in all articulations. Feels generally in decline.

7-28-13. Some slight improvement in condition. Articulations still painful.

8-2-13. Patient feels much improved. Tenderness of articulations have almost disappeared. Sleeps well.

8-25-13. 250 micrograms radium (element) given intravenously.

8-28-13. Reaction in all articulations with tenderness.

9-5-13. No improvement noted.

11-28-13. Final examination. Result—Not improved.

CASE NO. 8. MALE; AGE 74 YEARS. PLAYWRIGHT.

Previous History.—Patient has his first attack of rheumatism at the age of 55, continuing then for a period of six consecutive months, involving all articulations.

Had similar attack five years ago. Complained of having painful knees but no swelling. Later, during the course of this attack, shoulders and elbows of both arms became involved, also both hands.

Objective Symptoms.—Phalangeal articulations are deformed and ankylosed. On the second metacarpal-phalangeal articulation there appears a movable nodule the size of a cherry, which is not painful on pressure and apparently never appears red. On the olecranon processes of both elbow articulations there appears a nodule the size of a plum, easily movable and at no time inflamed.

Diagnosis.—Oligoarthritis deformans.

Course of Illness After Injection of Radium.—7-19-13. 100 micrograms of radium (element) given intravenously.

7-21-13. Slight reaction in all articulations. Feels a general stiffness and has aching of the muscles and bones throughout his body.

7-23-13. Less pain in all articulations. Feels generally improved.

8-5-13. No pain in articulations but general health poor.

Patient given 30 micrograms of radium (element) intravenously.

11-7-13. Final examination. Result—Not improved.

CASE NO. 9. FEMALE; AGE 50 YEARS. HOUSEWIFE.

Previous History.—Negative.

Present History.—About January 1, 1913, patient suddenly developed an inflammatory process affecting the 3rd finger of the right hand and also the thumb of the left. Process continued almost a week. The articulations of both hands and the muscles of both arms became swollen and very painful.

Objective Symptoms.—The 3rd finger of the right hand and the thumb of left were swollen, movements of finger and wrist articulations are impaired.

Diagnosis.—Chronic progressive polyarthritis.

Course of Illness After Injection of Radium.—7-5-13. Intravenous injection of 100 micrograms of radium (element).

7-7-13. Affected finger articulation and backs of both hands are swollen and painful.

7-8-13. Finger articulations less swollen and more movable.

7-10-13. Finger articulation somewhat tender minus pain. Swelling seems to be reduced.

7-12-13. Finger articulation in about a similar condition as on the 10th day.

7-18-13. Swelling of both hands and finger articulations reduced. Feels generally improved.

8-5-13. Final examination. Feels generally improved. Swelling of fingers and hand disappeared. Result—Considerably improved.

CASE NO. 10. FEMALE; AGE 43 YEARS. HOUSEWIFE.

Previous History.—Patient had her first attack of rheumatism in 1904, which affected the fingers of both hands. Later developed the same condition in all articulations.

Present History.—Patient is suffering for the past ten weeks with pain and swelling of both knee articulations, and is confined to her bed most of the time.

Objective Symptoms.—Can hardly walk; both knees painfully stiff and crepitating when attempting to move.

Diagnosis.—Chronic progressive polyarthritis.

Course of Illness After Injection of Radium.—7-14-13. 100 micrograms of radium (element) given intravenously.

7-15-13. Knee articulations very stiff but not painful; slept well; better than usual.

7-17-13. Slight soreness in knees; better able to ambulate.

7-21-13. Knees somewhat stiff but not painful; rests very well at night. 50 micrograms radium (element) given intravenously.

Final Examination.—Since having taken treatment with radium, patient seems better than formerly. Has no pain in knee articulations, but articulations are stiff and painful. Result—Considerably improved.

CASE NO. 11. MALE; AGE 43 YEARS. LABORER.

Previous History.—Patient had his first attack of polyarthritis 10 years ago. He was then sick for 9 consecutive months. Right hip articulation was involved. Occasionally other articulations became involved.

Present History.—Constant pain in right hip articulation when ambulating.

Objective Symptoms.—Negative.

Diagnosis.—Chronic progressive polyarthritis.

Course of Illness After Injection of Radium.—7-8-13. 100 micrograms of radium (element) given intravenously.

7-9-13. Pain in right hip articulation. General stiffness of muscles.

7-10-13. Able to walk. No pain.

7-13-13. Has pain in right hip articulation.

7-17-13. No pain in right hip articulation.

7-21-13. Pain in right hip and left knee articulations. 50 micrograms of radium (element) given intravenously.

7-26-13. Left leg very painful. Right thumb swollen and painful. Pain absent in right hip articulation.

7-28-13. Slight pain in all articulations. Knee articulations, slightly stiff. No pain in right hip articulation. Result—Considerably improved.

CASE NO. 12. FEMALE; AGE 48 YEARS. DOMESTIC.

Previous History.—Negative.

Present History.—Patient is suffering with severe pain in all her articulations for the past year and a half and has been confined to the hospital for that period.

Objective Symptoms.—Examination reveals both knee articulations to be swollen and tender to the touch, crepitation being present when moving same. The fingers of both hands are involved to the extent that she is unable to close them tightly.

Diagnosis.—Chronic progressive polyarthritis.

Course of Illness After Injection of Radium.—8-11-13. Patient given 50 micrograms of radium (element) intravenously.

8-13-13. Stiffness in fingers of both hands and ankles and also of muscles of the lumbar region.

8-15-13. Slight pain in the muscles covering the sacral region. Some pain in the phalangeal articulations of both hands and also the right knee articulation.

8-16-13. Pain on the dorsal aspect of the right hand and in the first metacarpo-phalangeal articulation.

8-18-13. Pain in shoulders, arms and in the region of the sacrum.

8-20-13. Pain in right hand and right knee articulation. Patient given 100 micrograms of radium (element) intravenously.

8-21-13. Slight pain in the sacral region.

8-22-13. Some slight pain in both shoulder articulations.

8-23-13. Final examination. Patient has pain in the back. Pain in the sacrum and right shoulder have disappeared. Feels generally better. Result—Considerably improved.

CASE NO. 13. MALE; AGE 50 YEARS. LABORER.

Previous History.—Patient had chronic rheumatism for the past nine years involving both elbow and shoulder articulations.

Present History.—He has been unable to follow his occupation for the past five years and at times was compelled to take to bed in the hospital, being incapacitated for weeks.

Objective Symptoms.—Both elbow articulations are tender and painful to the touch and when attempting to move them are painful and crepitate. There is wasting of muscles of the shoulders, partial inability to raise the arms and also partial inability to flex or extend same.

Diagnosis.—Oligoarthritis deformans.

Course of Illness After Injection of Radium.—8-13-13. 100 micrograms of radium (element) given intravenously.

8-14-13. Pain in both elbows.

8-15-13. Pain in both elbows. Not much improvement.

8-16-13. Patient feels generally much better. Has some slight pain in right elbow.

8-19-13. General condition about the same.

10-11-13. Very slight improvement in elbow articulations.

12-4-13. Final examination. Marked improvement in both elbow articulations. Able to shave and wash himself. Result—Considerably improved.

CASE NO. 14. FEMALE; AGE 44 YEARS. DOMESTIC.

Previous History. Patient was taken sick about six months ago with pain involving all articulations and she was obliged to remain in bed for a period of ten weeks. Had an attack of sore throat occasionally.

Present History.—Patient walks with difficulty and has pain in both knees when ambulating.

Objective Symptoms.—Both knees enlarged with crepitation on movement.

Diagnosis.—Chronic progressive polyarthritis.

Course of Illness After Injection of Radium.—8-11-13. Intravenous injection of 100 micrograms of radium (element).

8-12-13. Both knees very stiff.

8-14-13. Slight improvement in stiffness of left knee.

8-16-13. Patient feels apparently better; walks better than formerly.

8-20-13. Intravenous injection of 100 micrograms of radium (element).

8-21-13. No pain in knees.

8-22-13. Swelling disappeared, markedly improved.

9-25-13. Final examination. Apparently improved but has occasional slight twinging in right knee articulation. Result—Improved.

CASE NO. 15. MALE; AGE 55 YEARS. STONEMASON.

Previous History.—Patient had an attack of acute polyarthritis involving all articulations in 1872, which confined him to his bed for a period of six weeks. Has had repeated attacks now and again involving one articulation or another, for the past 40 years.

Present History.—Patient has been confined to the hospital for the past year suffering from occasional attacks of pain in all articulations, especially the knees and ankles of both legs and also severe pain on movement of muscles of lumbar region.

Objective Symptoms.—Knees and ankles of both legs are swollen, tender and crepitating; also inability to use muscles of the lumbar region when attempting to stoop forward.

Diagnosis.—Chronic progressive polyarthritis.

Course of Illness After Injection of Radium.—8-15-13. 1 P. M. Patient given 50 micrograms of radium (element) intravenously. 4 P. M. Patient given 50 micrograms of radium (element) intravenously.

8-16-13. Has less pains in bones and ankles than usual.

8-21-13. Feels generally better.

8-25-13. Swelling of both ankles has disappeared.

10-13-13. Final examination. Result—Considerably improved.

CASE NO. 16. MALE; AGE 25 YEARS. DENTIST.

Previous History.—Dates back two and one half years. Patient complains of pain and swelling affecting right ankles and knees. Had an attack of tonsilitis about one year ago.

Present History.—Has occasional pain in elbows, also pain in lumbar region.

Objective Symptoms.—Negative.

Diagnosis.—Chronic polyarthritis.

Course of Illness After Injection of Radium.—9-25-13. 100 micrograms of radium (element) given intravenously.

9-26-13. No re-action in joints.

9-30-13. Feels generally improved.

10-30-13. Final examination. Had no pain in articulations since radium was given. Result—Temporarily cured.

NOTES AND COMMENTS.

Prof. Harry C. *Jones*, of the Johns Hopkins University, delivered an illustrated lecture on "Radium and Its Properties," December 2nd, before the Natural History Society of Harrisburg, Penna.

* * * * *

A Preliminary Report on Uranium, Radium and Vanadium. Bulletin 70, Bureau of Mines, by R. B. *Moore* and K. L. *Kithil*. Washington: Government Printing Office, 1913. This report of about 100 pages gives descriptions of the Colorado and Utah carnotite deposits, and of the Colorado pitchblende deposits. The European and Australian uranium ores and the vanadium ores other than carnotite are also discussed. Methods are given for testing radio-active substances and for quantitative determinations of radium. The technology of vanadium, uranium and radium extraction is described, and analytical methods for uranium and vanadium are given. A list giving a classification and description of the minerals of uranium and vanadium concludes the report.

* * * * *

In the December number of the American Review of Reviews, an article is given on an interview with Dr. H. A. *Kelly* of Baltimore, Md., about "The Treatment of Cancer with Radium."

"Dr. *Kelly* has had an exceptional opportunity to experiment, because he has had in his possession an unusually large quantity of this precious element".

"Radium is a precious handmaid to surgery; it does not supersede it. Even if radium could cure all cases readily—and this remains to be demonstrated—we could not yet utilize the new remedy on a large scale, owing to the extreme scarcity of the element. This situation is aggravated by the fact that Dr. *Burnam* and I believe that it is only radium in comparatively large quantities that accomplishes the most satisfactory results. The movement, therefore, for early diagnosis and prompt treatment will still go on, and surgeons will still use the knife with even greater success than ever. It would, therefore, be lamentable if such success as has been attained with radium should induce patients to postpone the established methods of treatment."

"Radium gives off rays of three kinds, named alpha, beta, and gamma. These rays, however, affect non-cancerous and cancerous tissue very differently. In small quantities the gamma rays of radium penetrate good, healthy, normal tissue without producing any noticeable effect."

"These rays, however, and in these same amounts, do exercise a selective affect upon diseased tissue, such as that affected by cancer. Brought to bear upon a particular area, part of which consists of normal cells, the effect is soon apparent. The normal cells remain practically unchanged. The tumor cells show fundamental alterations. They swell, lose their characteristic appearance, break down, and are absorbed. Sometimes they seem to melt back into the normal tissues."

"The essential point is that with proper dosage they will pass through healthy tissue without bad effects, while at the same time these same quantities will destroy the cancerous tissues. Technical skill consists, therefore, in finding the dosage that will affect the sick cells without injuring the healthy."

"Now, the radium treatment does about the same thing that the surgeon's knife does. The surgeon gets rid of the cancerous tissue by cutting it out in mass; the radium gets rid of it by destroying it cell by cell."

"When the growth has widely infiltrated surrounding structures, the surgeon is often helpless. After removing the primary growth, however, he can irradiate these surrounding tissues and so have a greater chance of removing any stray cells that may be left. Radium, I believe, can thus be used to make doubly sure all ordinary operations for cancer."

"Perhaps radium's greatest triumph is in treating a particularly distressing and difficult form of cancer—that of the uterus. This and cancer of the breast are the commoner forms in which cancer chiefly attacks women, just as men suffer more from cancer of the stomach. Early operation with the knife cures this in a good many cases, but the operation is a radical one, and is not free from danger. Radium is extremely valuable in cases of this kind, as testified by experiences of the French, German, and American observers. It sometimes makes inoperable cases operable; in numerous instances radium, by itself, has established what seems to be a complete and perfect cure. Radium bids fair to establish a new era in the treatment of cancer of the uterus."

"Let me recapitulate," said Dr. *Kelly* in closing, "that there may be no misunderstandings:

1st.—Radium is not a specific cure for cancer. It does not take the place of surgery; it is another help to it. Cancer patients, in the early stages, as before, must submit to operation.

2nd.—It is most useful in cancers on the outside of the body. In many of these cases it effects cures without pain and without deformity.

3rd.—It is especially useful in connection with surgery, when it can be used to destroy vestiges of the tumor which the knife may have left behind. It can also be used to good purpose in irradiating the cancerous area preceding operation.

4th.—There are certain structures which cannot be operated on,—excised or seriously invaded,—without disastrous consequences. Radium has cured inoperable cases of this kind. It is like a microscopic knife which goes after the individual cell.

5th.—It is especially valuable in cancer of the uterus. Permanent cures even of inoperable cases have apparently been obtained.

6th.—It is effective only when there is no wide dissemination of the disease."

"What makes radium particularly useful is the simplicity of the technique. It does not necessitate the use of an anesthetic, and its administration causes no pain and almost no discomfort. The radium salt is kept enclosed in a fine platinum tube about an inch long. This tube is again encased with lead, which is used because it acts as a filter, keeping in the alpha and beta rays—which are more destructive to normal tissue—while letting the gamma rays slip through. The tube, further screened with some soft substance, is then laid in immediate proximity to the diseased part; if necessary, it can be attached by surgical plaster; in some cases incisions into the diseased part may be made as recommended by Dr. *Abbe*. Its action upon the cancerous tissues begins at once; the application lasts from 4 to 6 to 24 hours. Sometimes in a month or six weeks the growth vanishes. The radium so used can be used over and over again."

The Annual Report of the International Committee on Atomic Weights for 1914 leaves the 1913 values unchanged. Radium is given the atomic weight 226.4 (O=16.00). From analyses of radium bromide, *Hoenigschmid* finds Ra=225.97, in confirmation of his former analyses of the chloride. The discordance between this value and the higher value obtained by others is unexplained. The presumption is in favor of *Hoenigschmid's* determination, but a change in the table may well be deferred until more evidence is available.

* * * * *

Dr. H. A. *Kelly* of Baltimore, Md., and Dr. Robert *Abbe* of New York, addressed the Philadelphia College of Physicians on December 15th, 1913, speaking of the treatment of cancer with the radium rays. The following statements are taken from an account of the address appearing in the Philadelphia Public Ledger: Radium is a cure for cancer. "It was not a mere announcement—ocular demonstrations were made by Dr. *Kelly*, in which he showed "positive cures" of cancerous growths. Dr. *Abbe* produced scores of plaster casts, which only recently were exhibited by him in Madame *Curie's* laboratory as a demonstration to her that radium had effected marvelous cures of diseases."

"In addition, Dr. *Kelly* stated with positive emphasis that malignant tumors may be removed as if by magic, the rays of the radium eating into the growths and causing them to disappear, in many cases, within 48 hours."

"After briefly speaking of the dangers of handling radium, Dr. *Kelly* touched upon the present supply. The speaker ended this portion of the address by declaring the United States probably would produce the greatest supply of radium in the world."

"At this point Dr. *Kelly* launched into his personal work and averred with great emphasis that the word "cure" may now be applied to this form of treatment."

"Dr. *Abbe* said that the work of Dr. *Kelly* and the few experts had dissipated the thought that cancer and tumors were incurable. He described the diseases as mere "riotous cells" which were brought back into their normal conditions and functions by the penetrating power of the radium rays."

Dr. *Abbe* has given ten years to the study, and he was one of the pioneers, if not *the* pioneer, in this country in applying radium to diseases.

"Dr. Arthur W. *Goodspeed*, professor of physics at the University of Pennsylvania, opened the evening with a paper on the radio-active properties of radium."

REVIEWS AND ABSTRACTS.

Flemming.—Experimental and Clinical Studies on the Action of Radio-active Rays in Eye Diseases. v. *Graefe's* Archiv fuer Opthalmologie. Vol. 84, pp. 345-400, 1913. (University Eye Clinic of the Charite. Prof. *Greeff*, Director).

The reports of *Cohn, Selenkowski, Darier, Uhthoff, da Gama Pinto, Birch-Hirschfeld, Falta, Thielemann, Dinger, Greiz, Neuschueler* and *Steiner, Esdra, Braunstein* and *Samkowski, Jakoby, Fortunati, Lawson* and *Davidson, Altmann, Lubarsch* and *Ostertag, Newcomet* and *Krall,*

Kardo-Sisojeff and *Muschelow* on the treatment of trachoma with the radium rays have shown very contradictory results—some finding radium remarkably effective and others finding poor results.

The workers mentioned, used quite different quantities of radium (bromide) varying from 1 to 30 mgm. Different modes of application and screening have been used, and varying intervals of application. These facts, together with the fact that trachoma in its clinical course is not well defined, make it difficult to decide whether there is any value in the use of a therapeutic agent like radium.

Little has been done with radium in other eye diseases, with the exception of the treatment of cancroid, lupus and xanthoma, in which good results were reported by *Strebel, Wichmann* and *Schindler.*

Darier obtained favorable results by the action of radium rays in the diseases of the cornea and iris, and he found the analgesic effects noteworthy. *Lawson* and *Davidson* using up to 30 mgm. of radium salt in glass tubes, with one exception found favorable results in many diseases of the cornea, corium and eye-lids. In ulcus serpens particularly good results were obtained. *Koster* and *Cath* obtained good results with radium treatment in keratitis, leukoma of the cornea, iridocyclitis, iritis, chorioiditis, blepharo-conjunctivitis, neuralgia and naevus pigmentosus, etc.

In spite of this fairly extensive literature, the action of the radium rays on the eye is far from being clearly defined. This is mainly because of the different experimental conditions used; quantity of radium, size of applicator, screening, distance from which radium acted, time of application, etc., which make the repetition of the work impracticable.

With these facts in mind the author has worked with carefully measured preparations, the action of which he first tested on normal skin (the arm), then on normal eyes (rabbit's), then on eyes which had been infected. The effect of the rays was tried on bacillus tuberculosis emulsions; on the clinical course of the disease in the eye, (a) when the eye was rayed before inoculation; (b) when the eye was rayed during the incubation period after inoculation (prophylactic raying); (c) when the eye was rayed after clinical symptoms were observed (therapeutic raying). Then the action of the radium and mesothorium rays on the normal human eye was tried, and the effects of the rays in various eye diseases.

The author worked with two applicators, one containing about 9 milligrams of radium bromide (ca. 4.8 mgm. radium element), mounted in a flat applicator 1.1 by 1.3 cm. square, screened with a thin glue layer over which was a thin layer of paraffin and an aluminum sheet 0.01 mm. thick. Due to loss of salt, and escape of emanation, this applicator was found to have a penetrating radiation corresponding to 5.8 mgm. of radium bromide, two days after it was prepared in the form indicated. 18 days later the activity corresponded to 4.8 mgm., three months later to 2.6 mgm., and about four months after that it attained a steady value equal to 1.4 mgm.

This indicated that by reason of loss of emanation, the applicator was only about 25% effective, assuming that 5.8 mgm. of the radium bromide was actually in the applicator. By tightening the covering of this applicator and thus preventing the loss of emanation, the activity was found to increase, corresponding to 4.0 mgm. of pure radium bromide. A mesothorium applicator 1.0 by 2.0 cm., containing mesothorium equivalent to 12 mgm. pure radium bromide, screened by

0.1 mm. aluminum, was also used. A uniform distribution of the radioactive material is necessary. (Note by abstractor: Better results would probably be obtained by use of a "varnish" applicator, as described by *Wickham* and *Degrais*).

The author's conclusions may be stated as follows:

Physically equivalent quantities of radium and mesothorium (by comparing gamma ray ionization currents) have equal biological effects. The distribution of radium salts determines the time required to secure a biological effect. Collected in a lump as in a tube, the effect is obtained sooner than when the salt is spread uniformly over a flat surface.

The radium applicator used, having an activity equal to 4.0 mgm. of pure radium bromide, spread on a surface 1.1 by 1.3 cm. screened with 0.01 mm. aluminum, caused an enduring pigmentation of the skin after 15 minutes' application. After an hour's application it caused a scarlike change in the skin and even after a year there developed from time to time small telangiectases.

The intensity of the biological effect on the normal skin was directly proportional to the strength of the preparation and the period of application. The incubation period, i. e. time between application and the first observation of clinical symptoms, was found to be inversely proportional to the strength of the preparation and to the period of application.

The biologic effects of a polonium (radium F) preparation (10 mgm.) even after an exposure for 1½ hours, were of a wholly superficial nature, and limited to a reddening which disappeared after four weeks.

Microscopic investigation of the skin which had been rayed 40 days previously with the 4.0 mgm. radium applicator, showed a cicatricial cutaneous ulcer with partial degeneration of the cell nuclei, depilation, no changes in the glands or elastic fibers, no eosinophile and but few plasma cells. The healing of the rayed skin after making an excision of a piece of skin, was not smooth, in spite of joining the margins of the wound with a suture, and healing took place after slow granulation.

The normal cornea and the ocular conjunctiva of the rabbit are more resistent to radium and mesothorium rays than is the normal skin. Twenty hours direct raying of the cornea of a rabbit with the radium applicator produced a superficial keratitis which healed without a scar after the raying, while three hours direct raying with the mesothorium produced a transient superficial keratitis, and only after eight hours raying with the mesothorium were deeper ulcers and lasting scars produced.

In the experimentally produced wounds in the cornea of the rabbit, cicatrization and healing took place earlier in the rayed eye than in the control eye.

Eyes sensitized chemically by the injection of dionin showed no essential differences because of this injection either with respect to resorbtion of the infiltrate or to the action of the rays.

After the injection into the anterior chamber of the rabbit's eye of a quantitatively dosed emulsion of tubercle bacilli, it was found that the normal incubation period was increased by eight days, if the tubercle bacilli had been previously rayed at least 47 hours with the radium preparation. After 14 hours raying with the mesothorium there was no infection of the eye. The bactericidal power of the radioactive substances is slight in comparison with that of sunlight, since no infection was produced in the rabbit's eye if the t. b. emulsion was

exposed for 30 minutes to sunlight on the ground, or for 5 minutes at an altitude of 5000 to 6000 meters (where the ultra violet rays are more effective).

Raying the rabbit's eye for from 5 to 45 minutes with radium or mesothorium caused no change in the effect of a subsequently injected t. b. emulsion.

Raying the eye immediately after injection of tubercle bacilli had the effect with the radium applicator of delaying the perforation and with the mesothorium applicator of increasing the incubation period.

The normal human eye could be rayed directly for 4½ hours in intervals and 2 hours at a single time with the radium applicator, or 9¼ hours in intervals or 45 minutes at one time with the mesothorium applicator, without producing permanent disturbances.

Certain deeper ulcerative conditions of the cornea (marantic) which do not react to other agents, were quickly healed by radium rays with remarkably little opacity. In some cases of ulcus serpens there were good results, and in ulcus gonorrhoricum, keratitis eczematosa and parenchymatosa, leukoma and sclerosis there was no betterment.

In diseases of the iris the analgesic effect of the radium was noted but there was no objective improvement or shortening of the duration of the disease. Good results were obtained in the treatment of conjunctivitis chronica simplex. In some cases of trachoma the follicle retrograded with remarkable rapidity, while in other cases there was no improvement in spite of treatment for several months.

In a case of pannus with recurrent intense irritation, the raying gave very good results after all other means had failed to relieve. In the remaining cases, however, other well-known methods of treatment were found better than the ray treatment, both as regards intensity of action, shortness of the time and certainty of cure.

Tumors (cancroid, sarcoma, melanosarcoma, warts, lupus, angioma, xanthoma) as long as they were not above a certain size, were treated with extraordinarily good results. For example, sarcoma of the eye-ball which had been treated surgically without results, was completely removed in several cases, and in others the growth was so reduced during the period of observation as to lead to the expectation of a complete cure in the course of time. As it is an important property of the rays of radio-active substances to affect pathological tissues more than normal tissues, it is to be expected that radium and mesothorium rays will play an important role in the treatment of tumors of the eye, since after surgical interference disfiguring scars are usually left.

As a result of handling the radium and mesothorium applicators through a period of more than two years, without observing any particular precautionary measures, the only effect which the author noticed was the peeling off of the skin from the tip of the thumb and first finger of the right hand, which occurred every three or four weeks, a year after the experiments were begun. Aside from a sense of a numbness at times, there were no subjective effects which persisted. An excellent bibliography is given of the work in this field of radium therapy.

* * * * *

Pasteau and *Degrais*, (Paris). Journal d' Urologie, Medicale et Chirurgicale, Sept. 15, 1913. Also English translation (arranged and edited by W. H. B. *Aikins*).—The Employment of Radium in the Treatment of Cancer of the Prostate, O. *Pasteau* and P. *Degrais*.—Canadian Practitioner and Review. Vol. 38, No. 12, pp. 703-729. (1913).

Prostatectomy for carcinoma, either as a palliative or as a radical operation, has given very poor results. This fact has stimulated the authors to attempt to obtain better results by radium treatment. At the outset they point out that perseverance by the surgeon and by the patient are indispensable elements in the treatment; in a number of their cases the patients disappeared from observation satisfied that they were "cured."

After analyzing the various routes along which radium could be applied, the authors decided upon a "cross-fire" between a tube of radium placed against the prostate through a perineal incision and a second tube inserted in the rectum. In this paper the authors describe only the details of the technic of radium therapy through the urethra. The results in the few cases they report are remarkable. Although in none of them was the diagnosis of carcinoma established by microscopical examination, they were all considered to be typical cases of advanced carcinoma of the prostate, in no sense operable. In the first case treatment was begun in 1911. Not only is the prostatic tumor now notably diminished in volume, but the large masses of inguinal glands are also less than half the original size. The second case, treated for one year, is even more strikingly improved. The mass of glands in the right inguinal region, at the beginning of treatment the size of a child's fist, is now almost entirely gone. In the other cases cystostomy was performed; all three demonstrated tremendous improvement, for the authors stated that the diagnosis of carcinoma could not have been made when the prostate was felt through the open bladder; all three cases were operated upon for cystitic symptoms at considerable periods after radium therapy had been applied. 50 milligrams of pure radium sulfate (35 mgm. radium element) were used in most of the cases treated and in none did the radium treatment appear to result in any harm.

* * * * *

Frank E. *Simpson*: Radium in Skin Diseases. The Journal of the American Medical Association. 61, 80–83. (July 12th, 1913). A preliminary note presented to the section of dermatology of the American Medical Association at the Minneapolis meeting, June, 1913. The results presented are based on the author's experiences with radium used on forty-five patients, fifteen different skin affections being treated. Success results were obtained with radium in cases of tuberculosis verrucosa cutis, nevus pigmentosus, epithelioma, hypertrichosis, dysidrosis, neurodermititis, psoriasis, lupus erythematosus and lupus vulgaris. Improvement is being obtained in cases of angiomata blastomycosis, keloids, trichophytosis of finger nails, and lichen planus. Large flat scaly plaques of a syphilitic eruption, appearing six or seven years after the primary lesion, were treated with radium, and their disappearance followed in three weeks, although untreated lesions persisted. The discussion of this report was interesting. The use of mesothorium in place of radium was suggested, and it was poined out that mesothorium really is not cheap. (c. f. the citation on page 8 of the July number of "Radium," of a letter by Prof. Stefan *Meyer*, on this subject). The abstractor ventures to hope that in the final report of this work, that a statement will be made of the quantities of radium (element) used, the form and size of applicators, and the screening, and the time intervals of treatments, together with the number of treatments. This data is essential if the results obrained are to be compared with the results of others.

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We shall be glad to receive for publication from our subscribers and readers articles pertaining to the subject of radium and its application. All inquiries for information will be accorded prompt attention, and will be answered either by letter or through the columns of this paper.

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THE INTRAVENOUS INJECTION OF SOLUBLE RADIUM SALTS. II.

By FREDERICK PROESCHER, M.D.

Director of the Laboratory for Experimental Therapy, Standard Chemical Company.

In the following I wish to report the influence of the intravenous injection of soluble radium salts upon the blood of the polyarthritis cases.*

The blood counts were taken with the usual precautions, the haemoglobin was estimated with the Fleischel-Miescher Haemoglobinometer. For the differential counts the blood smears were stained for three minutes with a methyl alcoholic solution of eosin-methylen blue, toluidin blue, and then for fifteen minutes with Giemsa solution (1 drop to 1 cc. of water). This combined staining method differentiated in an excellent manner, the granulocytes (neutrophiles, eosinophiles, basophiles), and agranulocytes (lymphocytes, monocytes), as well as the regenerative and degenerative forms of erythrocytes. On the average 300 to 500 leucocytes were counted in each smear.

CASE No. 1.
Before Injection of Radium.

Date	Haemoglobin	Red Cells	White Cells	Neutrophiles	Eosinophiles	Basophiles	Lymphocytes	Monocytes
6–11–13	14.24 gr.	5150000	8000	68.68	3.00	0.33	27.99	.....
6–11–13	10 micrograms radium (element) intravenously.							
6–12–13	15.00 gr.	5150000	6750	60.50	1.00	.....	35.75	1.00
6–13–13	10 micrograms radium (element) intravenously.							
6–17–13	20 micrograms radium (element) intravenously.							
6–21–13		6425000	8750	67.50	0.25	2.00	30.25	.....
6–25–13		6200000	5250					
6–26–13		6100000	5250					

*See preceding article by Dr. *Proescher*, in January number of RADIUM, in which reports were given on sixteen cases of arthritis treated by the intravenous injection of soluble radium salts.

CASE No. 2.
Before Injection of Radium.

Date	Haemo-globin	Red Cells	White Cells	Neutro-philes	Eosino-philes	Baso-philes	Lympho-cytes	Mono-cytes
7– 3–13	13.16 gr.	5600000	11250	65.40	3.40	0.20	31.00	.....
	7–3–13	100 micrograms radium (element) intravenously.						
7– 5–13	11.26 gr.	5550000	8700	61.00	3.50	0.75	34.50	0.25
7– 7–13	12.84 gr.	6000000	5000	60.24	1.13	.....	38.04	1.59

CASE No. 3.
Before Injection of Radium.

Date	Haemo-globin	Red Cells	White Cells	Neutro-philes	Eosino-philes	Baso-philes	Lympho-cytes	Mono-cytes
7– 2–13	10.04 gr.	5200000	8725	64.10	0.60	.....	32.90	1.20
	7–2–13	100 micrograms radium (element) intravenously.						
7– 3–13	11.36 gr.	4800000	7500	68.78	2.33	0.66	25.66	2.67
7– 4–13	11.36 gr.	4950000	4000	50.62	3.60	.....	43.63	2.15
7– 5–13	11.06 gr.	4450000	8000	45.34	2.96	0.91	48.74	2.05
7– 7–13	6.84 gr.	5250000	5000	55.58	2.44	.....	41.32	0.66
7–11–13	13.16 gr.	5800000	8750	65.40	2.40	.....	29.00	3.20

CASE No. 4.
Before Injection of Radium.

Date	Haemo-globin	Red Cells	White Cells	Neutro-philes	Eosino-philes	Baso-philes	Lympho-cytes	Mono-cytes
7– 3–13	12.84 gr.	4987500	8750	72.54	0.24	0.24	23.78	3.20
	7–3–13	100 micrograms radium (element) intravenously.						
7– 4–13	13.16 gr.	4750000	9500	80.76	.....	0.20	18.23	0.81
	7–4–13	100 micrograms radium (element) intravenously.						
7–10–13	8.96 gr.	3900000	7250	66.56	2.37	0.19	27.12	3.76
7–11–13	8.96 gr.	5800000	6750	69.55	2.03	0.67	20.98	6.77
7–14–13	.....	5000000	10000	62.54	1.00	0.20	36.26	.....

CASE No. 5.
Before Injection of Radium.

Date	Haemo-globin	Red Cells	White Cells	Neutro-philes	Eosino-philes	Baso-philes	Lympho-cytes	Mono-cytes
7–6 –13	9.84 gr.	6250000	11000	67.16	2.07	0.17	29.74	0.86
	7–6–13	100 micrograms radium (element) intravenously.						
7– 9–13	11.36 gr.	5100000	11000	63.93	4.39	1.21	27.06	3.41
7–10–13	8.96 gr.	6500000	12000	71.73	1.67	1.19	23.74	1.67
7–11–13	7.76 gr.	5200000	10250	69.89	0.10	0.20	29.60	0.20
7–12–13	10.16 gr.	5175000	10750	70.75	1.25	.....	25.00	3.00
7–20–13	11.36 gr.	5350000	13500	66.75	2.00	.....	26.00	5.25

CASE No. 6.
Before Injection of Radium.

Date	Haemo-globin	Red Cells	White Cells	Neutro-philes	Eosino-philes	Baso-philes	Lympho-cytes	Mono-cytes
7–3– 13	16.16 gr.	5425000	9375	69.25	1.25	1.00	25.75	2.50
	7–3–13	100 micrograms radium (element) intravenously.						
7– 4–13	16.44 gr.	5650000	6750	68.25	1.75	0.25	19.25	4.75
7– 5–13	16.44 gr.	6500000	8500	63.25	1.75	0.50	29.50	0.05
7– 8–13	9.56 gr.	6150000	5500	51.36	6.90	0.98	38.80	1.31
	7–8–13	50 micrograms radium (element) intravenously.						
7–10–13	9.56 gr.	6000000	7000	69.44	.....	0.70	27.98	1.88
	7–10–13	50 micrograms radium (element) intravenously.						
7–12–13	8.96 gr.	6350000	7250	58.27	3.57	0.54	24.71	12.91
7–21–13	14.64 gr.	4150000	9280	55.80	2.87	0.86	30.70	9.77

CASE No. 7.

Before Injection of Radium.

Date	Haemoglobin	Red Cells	White Cells	Neutrophiles	Eosinophiles	Basophiles	Lymphocytes	Monocytes
7– 8–13	14.36 gr.	6150000	7500	55.40	1.60	.....	40.60	2.40
	7–8–13	100 micrograms radium (element) intravenously.						
7– 9–13	8.96 gr.	5800000	8000	66.10	1.92	0.72	31.26	.....
7–20–13	14.96 gr.	6050000	9750	63.00	1.25	0.25	34.50	1.00

CASE No. 8.

7–19–13	14.96 gr.	5700000	8000	79.00	3.50	0.75	16.75	.....

CASE No. 9.

Before Injection of Radium.

Date	Haemoglobin	Red Cells	White Cells	Neutrophiles	Eosinophiles	Basophiles	Lymphocytes	Monocytes
7– 5–13	11.64 gr.	5450000	7250	66.50	2.50	0.50	27.25	3.25
	7–5–13	100 micrograms radium (element) intravenously.						
7– 7–13	14.04 gr.	5125000	8250	69.50	0.75	.....	25.00	4.75
7– 8–13	9.24 gr.	4950000	5625	58.40	3.10	.....	38.50	.....
7–10–13	11.96 gr.	6262500	5000	42.43	1.38	0.19	.....	0.19

CASE No. 10.

Before Injection of Radium.

Date	Haemoglobin	Red Cells	White Cells	Neutrophiles	Eosinophiles	Basophiles	Lymphocytes	Monocytes
7– 4–13	15.96 gr.	6650000	7500	46.00	2.25	1.25	50.00	0.50
	7–14–13	100 micrograms radium (element) intravenously.						
7–15–13	13.44 gr.	6050000	9750	50.50	4.00	1.00	44.50	.....
7–21–13	14.36 gr.	5900000	8750	59.23	1.90	0.23	38.41	0.23

CASE No. 11.

Before Injection of Radium.

Date	Haemoglobin	Red Cells	White Cells	Neutrophiles	Eosinophiles	Basophiles	Lymphocytes	Monocytes
7– 8–13	10.76 gr.	6875000	13000	71.97	2.81	0.70	20.78	3.74
	7–8–13	100 micrograms radium (element) intravenously.						
7– 9–13	11.64 gr.	6400000	9500	74.25	1.16	.....	21.11	3.48
7–10–13	13.76 gr.	5700000	7750	68.37	3.40	0.28	22.55	5.40
7–13–13	11.96 gr.	5700000	10000	78.62	1.86	0.93	15.34	3.25

CASE No. 12.

Before Injection of Radium.

Date	Haemoglobin	Red Cells	White Cells	Neutrophiles	Eosinophiles	Basophiles	Lymphocytes	Monocytes
8–11–13	14.36 gr.	4875000	9250	55.20	1.60	0.80	39.00	2.00
	8–11–13	50 micrograms radium (element) intravenously.						
8–13–15	14.04 gr.	4500000	7750	53.03	1.11	0.44	41.99	1.77
8–14–13	13.24 gr.	4700000	12000	65.44	1.76	0.07	32.54	.....
8–15–13	8.96 gr.	4100000	8250	60.59	2.33	0.58	32.14	1.36
8–16–13	14.04 gr.	4300000	9250	63.36	1.49	0.99	34.16	.....
8–18–13	12.24 gr.	5400000	13750	62.50	1.80	0.25	37.25	0.05
8–20–13	14.96 gr.	5650000	9750	53.63	0.63	0.21	27.02	0.42
	8–20–13	100 micrograms radium (element) intravenously.						
8–21–13	13.16 gr.	4850000	7000	58.95	0.85	0.85	38.08	1.27
8–22–13	13.76 gr.	5250000	8250	62.57	1.97	0.49	34.97	.....
8–23–13	16.16 gr.	5500000	9740	63.70	1.34	1.34	32.95	0.67

CASE No. 13.

Before Injection of Radium.

Date	Haemo-globin	Red Cells	White Cells	Neutro-philes	Eosino-philes	Baso-philes	Lympho-cytes	Mono-cytes
8–13–13	13.16 gr.	5900000	10500	59.41	4.67	0.98	32.24	2.70
	8–13–13	100 micrograms radium (element) intravenously.						
8–14–14	13.44 gr.	5800000	11500	74.75	1.75	0.25	22.75	0.50
8–15–13	13.76 gr.	5950000	16500	69.35	2.33	1.00	26.32	1.00
8–16–13	14.64 gr.	6400000	12750	71.08	1.87	0.91	26.14	.....
8–18–13	13.16 gr.	5600000	12250	70.00	1.60	0.80	25.20	.....
8–20–13	13.16 gr.	5600000	12250	70.85	1.38	0.55	27.22	.....
8–21–13	13.04 gr.	5200000	11250	73.32	0.93	0.93	24.82	.....
10–11–13	16.16 gr.	6400000	15250	72.74	0.72	0.36	26.18	.....

CASE No. 14.

Before Injection of Radium.

Date	Haemo-globin	Red Cells	White Cells	Neutro-philes	Eosino-philes	Baso-philes	Lympho-cytes	Mono-cytes
8–11–13	14.36 gr.	4875000	9250	55.20	1.60	0.80	39.00	2.00
	8–11–13	100 micrograms radium (element) intravenously.						
8–12–13	14.04 gr.	4500000	7750	53.03	1.11	0.44	41.99	1.77
8–14–13	13.24 gr.	4700000	12000	65.44	1.76	0.07	32.54	.....
8–15–13	8.96 gr.	4100000	8250	60.59	2.33	0.58	32.14	1.36
8–16–13	14.04 gr.	4300000	9250	63.36	1.49	0.99	34.16	.....
8–18–13	12.24 gr.	5400000	13750	62.50	1.80	0.25	37.25	0.05
8–20–13	14.96 gr.	5650000	9750	53.63	0.63	0.21	27.02	0.42
	8–20–13	100 micrograms radium (element) intravenously.						
8–21–13	13.16 gr.	4850000	7000	58.95	0.85	0.85	38.08	1.27
8–22–13	13.76 gr.	5250000	8250	62.57	1.97	0.49	34.97	.....
8–25–13	16.16 gr.	5500000	9740	63.70	1.34	1.34	32.95	0.67
8–28–13	13.16 gr.	5250000	6500	57.30	2.66	0.66	37.32	2.00
9–25–13	13.76 gr.	6376000	8560	60.62	1.29	.....	37.60	0.49

CASE No. 15.

Before Injection of Radium.

Date	Haemo-globin	Red Cells	White Cells	Neutro-philes	Eosino-philes	Baso-philes	Lympho-cytes	Mono-cytes
8–15–13	14.96 gr.	4950000	6000	61.04	1.00	0.66	34.97	.....
	8–15–13	100 micrograms radium (element) intravenously.						
8–16–13	14.64 gr.	5000000	6750	73.54	0.99	1.23	24.24	.....
8–18–13	14.96 gr.	4950000	6500	61.00	1.00	0.25	36.75	0.25
8–20–13	15.84 gr.	4350000	5500	62.76	0.63	0.31	36.30	.....
8–21–13	14.96 gr.	5000000	6750	62.37	3.92	0.46	33.25	.....
9–29–13	16.44 gr.	6025000	7000	66.71	.....	0.66	30.65	1.98

CASE No. 16.

Before Injection of Radium.

Date	Haemo-globin	Red Cells	White Cells	Neutro-philes	Eosino-philes	Baso-philes	Lympho-cytes	Mono-cytes
9–25–13	16.40 gr.	5840000	8400	51.43	6.88	0.28	40.79	0.57
	9–25–13	100 micrograms radium (element) intravenously.						
9–26–13	16.44 gr.	5850000	8750	56.31	.....	.....	35.01	8.68
9–29–13	16.04 gr.	6250000	7500	57.40	3.40	0.80	38.40	.....
9–30–13	17.04 gr.	5900000	8750	52.40	3.40	0.20	44.04	0.40
10– 1–13	16.76 gr.	6650000	5000	53.78	2.51	0.19	43.52	0.19
10– 2–13	17.04 gr.	6250000	8750	62.00	3.80	0.80	30.60	2.80
10– 3–13	16.84 gr.	6200000	8250	47.50	2.75	0.25	48.25	1.25
10– 7–13	16.16 gr.	6350000	7250	60.25	2.50	0.25	35.50	1.50
10–10–13	16.44 gr.	6050000	8000	54.60	6.15	0.75	37.75	0.75
10–14–13	16.16 gr.	6150000	6750	47.14	12.20	0.66	33.00	7.00
10–29–13	15.56 gr.	5800000	7500	50.68	8.66	.....	38.66	2.00

In subsequent articles will be given the effects of intravenous injections of radium salts upon the blood pressure in these cases of arthritis, following which will be a summary giving the general conclusions from the observed results.

NOTES AND COMMENTS

Dr. Ernest *Rutherford*, Langworthy professor of physics in the University of Manchester, has been made a knight.

* * * * *

At a meeting of the Academy of Sciences at Vienna, December 13th, 1913, Prof. St. *Meyer* of the Vienna Radium Institute spoke of the "Secondary Radium Standards Prepared at the Vienna Radium Institute". The decision of the international committee for a Radium Standard was that each government which officially made application, should be provided with a "secondary radium standard" which would be compared with the Vienna and the Paris (international) radium standards. The Vienna Institute for Radium Research has undertaken the preparation of these standards, comparisons being made, independently, with the Vienna and the Paris standards, the accuracy of comparison being estimated at 0.5 per cent. Including one standard for Mme. *Curie* to replace the "international standard" which she prepared, there have been seven such secondary standards made, the following being a description of these standards:—

Country	Date Sealed	Vienna Mgm. Ra	Paris $RaCl_2$	Selected Value
France(Mme. *Curie*)	October 4, 1912.	22.47	22.42	22.45
Germany	"	19.73	19.74	19.73
England	"	21.10	21.16	21.13
United States	July 1st, 1913	20.29	20.28	20.28
Sweden	"	9.74	9.71	9.73
Japan	"	9.80	9.80	9.80
Portugal	"	9.07	9.11	9.09

The accuracy of measurement is probably greater than specified. The standards are accompanied by official certificates of the Commission, giving the quantity of the salt, the date of sealing, the radium content and the estimated accuracy of the measurement (0.2 to 0.3%). These certificates are signed by St. *Meyer*, certifying for the Vienna measurements, by Mme. *Curie* for the Paris measurements and by the president of the Commission, Ernest *Rutherford*.

* * * * *

The United States Bureau of Standards has received its secondary radium standard and now is prepared to make gamma ray determinations of quantities of radium in radium salts. For a schedule of fees charged for such measurements and other information address the Director, Bureau of Standards, Washington, D. C.

* * * * *

Mr. T. Thorne *Butler* in an interesting lecture before the Royal Society of Arts, of London, on the application of electricity and radium in agriculture said that a great deal of experimental work was going on with radio-active material, which gave in some cases such remarkable results that radium must be taken into consideration from an agricultural view. The residues resulting from radium extraction were sufficiently active to produce marked effects on germination and to greatly increase the size of the plants and crops. In some cases an increase of 300 and 400 per cent. had been obtained.

In the Berlin letter to the Journal of the American Medical Association for January 10th, 1914 a mention is made of a loan offered for the purchase of radium.

"A few days ago a conference took place in the department of the interior, under the presidency of the director of the Prussian Medical Bureau, of the representatives of numerous communes of greater Berlin, which was called at the request of Professor *His*, the director of the Radium Institute of the Charite. It was announced that certain insurance companies, the Landesversicherungsanstalten of Berlin and Brandenburg, had stated that they were ready to place at the disposal of the communes of greater Berlin a capital of $125,000 (500,000 marks), at a relatively low rate of interest, for the purchase of two grams of radio-active substances. The right is reserved to the communes participating to collect fees for radium treatment from patients who are able to pay. The representatives of the communes gave their consent, but the final decision naturally lies with the various communal corporations."

* * * * *

In giving a decision in regard to whether duty would need to be paid on a radium drinking water preparation, General Appraiser Brown says:—"When the Congress inserted in the act of 1909 the provision of the free list, using simply the word "radium", they must have meant to include more than the pure metal. According to the testimony in this case, radium does not occur in nature as the uncombined metal, and is not marketed for use as a medicine in that form but only in the form of its various salts, either dissolved in water, as in this case or mixed with some solid container. To hold in these circumstances that Congress meant only to admit free the pure metal radium, uncombined, would in our opinion render the provision in the free list meaningless.

Assuming that the salts of radium were intended to be allowed free entry, including the bromide, this plainly should not be excluded from the free list because dissolved in water".

* * * * *

Mrs. Lucy *Henderson* of New Castle, Pa., has donated a sum to the Jefferson Hospital, Philadelphia, Pa., the income of which is to be used in studying cures for cancer with special emphasis on the use of radium. The yearly income will approximate $3,500 and the fund will be known as the Lucy Henderson Foundation. The work of investigation for which the donation has been made will be carried on under the direction of Drs. J. Chalmers *DaCosta*, W. M. Late *Coplin* and Hobart Amory *Hare*.

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The Crocker Research Cancer Laboratory at Columbia University has been completed and turned over to the commission headed by Dr. Frances Carter *Wood*, which will begin its work this month. The building is three stories and a basement in height and 100 by 35 feet.

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According to the Chemiker Zeitung for December 23rd, 1913, the first Swiss Radium Institute has been founded in Geneva, the formal opening of this institute to take place in February, 1914.

RADIUM AND RADIUM SALTS

The following is reprinted from page 41 of the January 3rd, 1914 number of the Journal of the American Medical Association.

"Radium is a bivalent metallic element closely related to barium. It is exceedingly reactive, making it difficult to isolate in its metallic state and after isolation to keep it in a pure state, as it reacts with air, forming the oxide, nitrite and finally the carbonate. On account of this activity it is only produced in the form of its salts, principally as the bromide, chloride, sulfate and carbonate.

The most important property of radium is its radio-activity upon which depends its therapeutic value. Radio-activity is defined as "the property of spontaneously emitting radiations capable of passing through plates of metal and other substances opaque to ordinary light and having the power of discharging electrified bodies". A spontaneous disintegration of the atoms characterizes all the radio-active elements and it is in this transmutation or splitting of the atom that the rays are shot out, some being material in nature, others electrical or of the nature of light. The spontaneous transmutation of radium is going on at a regular rate, which is independent of the state of combination of radium in the molecule of its compounds.

To determine the radio-active value of radium, use is made of its property of ionizing gases. Thus when radium is allowed to act on the air in a charged gold-leaf electroscope the air becomes ionized and therefore a conductor of electricity and allows the charge to leak out, causing the leaf in the electroscope to move. By observing the rate of movement of the leaf in a calibrated apparatus the radio-activity can be determined.

Quantities and concentrations of radium emanation are expressed in terms of "curies" and mache units. A "curie" is the amount of emanation in equilibrium with 1 gram of radium; a microcurie, one millionth of a "curie", is the amount of emanation in equilibrium with 0.001 mg. radium and is equivalent to about 2,500 mache units.

Relation of Radium, Radium Emanation and Rays.—The rays are largely derived indirectly from radium through the formation of its "active deposit", according to the following scheme:

Radium { alpha particle
emanation { alpha particle
active deposit { rays.

These rays are divided into three groups, the alpha, beta and gamma, which differ in their velocity and penetrative power. The alpha and beta rays consist of minute particles of matter electrically charged and moving with a velocity almost equal to that of light. They are for the most part of relatively feeble penetrating power. The gamma rays are vibrations in the ether, very similar to X-rays, and of high penetrating power. Therapeutically the last group is the most useful.

Radium emanation is continuously given off from aqueous solutions of radium salts. It can be collected as it escapes from the solution, drawn off through the use of the mercury pump, or by other suitable means, quantitatively determined by either the alpha or gamma ray electroscope, brought into solution in water for internal or external

use or to be set free in an emanatorium for inhalation treatment. It may be collected into small glass containers and this used in place of the applicators described under surgical use.

Actions and Uses:—Radium emanation is said to increase the excretion of uric acid in the urine and to decrease its concentration in the blood; to increase somewhat the number of red blood-corpuscles; to cause temporary leukocytosis early in the course of treatment, the mononuclear increase being relatively greater; to lead frequently through long-continued use to leukopenia, although no appreciable benefit is observed in leukemia. It is said that radium increases general metabolism, and in vitro activates certain enzymes, pepsin, pancreatin, rennin, autolytic ferments, tyrosinase and diastase.

It has been claimed that radium emanation is of value in all forms of non-suppurative, acute, subacute and chronic arthritis (luetic and tuberculous excepted), in chronic muscle and joint rheumatism (so called), in arthritis deformans, in acute and chronic gout, in neuralgia, sciatica, lumbago, and in tabes dorsalis for the relief of lancinating pains. Its chief value is in the relief of pain.

Surgical Use:—The efficiency of the treatment is due to the beta and gamma rays. The quantity of ray is proportional to the amount of radium element represented in the salt or the emanation. Pure gamma rays may be employed when the apparatus is surrounded by at least 3 mm. of lead. Nearly all pathologic tissues are more sensitive than normal tissues. There is, however, a wide variation in the normal tissues; e. g. the ovary and the sexual organs are very sensitive, the eye and nervous tissues very unsensitive. In skin diseases marked results are obtained with epitheliomata, birth marks and scars.

Technic:—Usually heavy doses with epitheliomata, light doses with other conditions. New growths, benign and malignant, of the pelvic organs, the breast, the neck and other parts of the body have been most favorably influenced in some cases. The growths of the mucous membrane of the mouth are quite resistant. There is a remarkable sedative effect in true neuralgias, as well as those due to tumor pressure. The dosage for internal work is heavy, "hundreds of milligrams", and always with the pure gamma rays. The technic of filtration, of length of application and of amount is still in an experimental stage.

The radium salts and the emanation can be placed in any sealed container, but preferably in glass.

Dosage:—It may be administered as baths, by subcutaneous injection in the neighborhood of an involved joint (0.25 to 0.5 microcurie in 1 or 2 cc. distilled water), by local application as compresses (5-10 microcuries), by mouth as a drink cure (in increasing doses of from 1-10 to 10 microcuries three or more times a day), by inhalation, the patient for two hours daily remaining in the emanatorium, which contains 0.0025 to 0.25 (average 0.1) microcurie per liter of air.

RADIUM CHLORIDE.—Radium chloride is the anhydrous radium salt, $RaCl_2$, of hydrochloric acid. While nearly pure radium chloride, containing 76.1 per cent. radium (ra), is said to be obtainable, the market supply is a mixture of radium chloride and barium chloride and is sold on the basis of its radium content.

Actions and Uses:—See Radium.

Dosage:—See Radium.

Non-Proprietary Preparation:

Radium Chloride, Standard Chemical Company—Radium chloride is supplied in the form of a mixture of radium chloride and barium chloride for use in radium baths, radium drinking water and inhalatoriums. It is sold on the basis of its radium content.

Manufactured by the Standard Chemical Company, Pittsburgh, Pa. (The Radium Chemical Company, Pittsburgh, Pa.)

Pure anhydrous radium chloride occurs as a white or slightly brownish crystalline substance, soluble in water.

The presence of radium can qualitatively be demonstrated by electroscopic or by photographic methods.

The quantitative determination of radium is carried out according to the method of *Rutherford* and *Boltwood* (*Rutherford's* "Radio-active Substances and their Radiations").

RADIUM SULPHATE.—Radium Sulphate is the anhydrous radium salt $RaSO_4$, of sulphuric acid. While nearly pure radium sulphate, containing 70.2 per cent. (Ra), is said to be obtainable, the market supply is a mixture of radium sulphate and barium sulphate and is sold on the basis of its radium content.

Actions and Uses:—See Radium.

Dosage:—See Radium.

Non-Proprietary Preparation:

Radium Sulphate, Standard Chemical Co., Pittsburgh, Pa. (The Radium Chemical Co., Pittsburgh, Pa.).

Pure radium sulphate occurs as a white substance insoluble in water and dilute acids.

The presence of radium may be qualitatively determined by electroscopic or by photographic means.

The radium content may be determined as in the case of radium chloride."

REPORTS ON THE THERAPEUTIC EFFECTS OF RADIUM IN CANCER.

Presented at the 85th meeting of the German Scientists and Physicians at Vienna, September 25, 1913.

Prof. G. *Riehl*, director of the radium station in the General Hospital at Vienna, speaking on the subject "Carcinoma and Radium"* described the equipment which is there available for the therapeutic use of radium. Founded in June 1912, a half gram of radium (element) was available for use, part being used as a source of emanation, the greater part being available in the form of applicators for the local application of radium rays. After the meeting at Halle, where the results of *Kroenig* and *Gauss*, *Bumm* and *Doederlein* in the treatment of cancer of the uterus with massive doses of radium excited the wonder of the medical world, the requests for larger quantities of radium became so pressing that in June 1913 an additional gram of radium was given to the Hospital. The radium station is not a separate institution but forms a center which makes it possible to use radium or emanation in all the sections of the Hospital, and for physical and

*Wiener klin. Wochenschrift, Vol. 26, p. 1645 (1913)

biological experiments. The treatment of the resident patients is wholly under the direction of the chiefs of the various clinics, which gives the patient the advantage of being treated by specialists in their various lines. By action of the Government it was made possible to lend the applicators to physicians for ray treatments. Complete physical data as regards each applicator was carefully recorded, according to the measurements of Prof. St. *Meyer* of the Vienna Institute for Radium Research, making it possible to carefully control the dosage applied. *Riehl* suggests that in the future the following data be given in describing the action of radium;

1.—the radium (element) content of the applicator.
2.—the extent and kind of screening.
3.—the size of the surface from which the rays come.

Unless the area over which the radium is spread and the area rayed is specified, the term "milligram hours" is a very unsatisfactory expression.

Beginning in July the additional gram of radium was available being placed in Dominici tubes, each containing 30, 50 or 100 mgm. of radium (element). Since these had to "age" for a month the maximum activity was not attained until in August. So the results with larger quantities are limited to the few weeks between this time and the latter part of September. However, the results attained in this brief time are so important from the standpoint of radium therapy that they are presented.

Unfortunately the first results with new therapeutic agents often lead to too great expectations and then shortly follows a pessimistic period of doubt. The results of a great many independent workers and of many series of experiments will most rapidly bring out the truth.

Riehl recommends aluminum and platinum filters since the secondary rays from these metals are less irritating than those from other metals frequently used.

Lately the view has prevailed that the action of the gamma rays on the tissues depends on the production of secondary rays. Experiments made to sensitise the carcinomatous tissue to the radium rays by the injection of various colloidal metals have so far been without satisfactory results since it has not been possible to infiltrate the tumor without getting the material into the surrounding tissue.

In order to make results comparable it is necessary to state the exact radium content of the preparation according to the International Standard.

Large skin cancers can be successfully influenced by means of lengthy intensive raying.

A purely selective action on carcinomatous tissues depends only upon sufficiently large doses, however, with long powerful raying even healthy tissues may become affected.

For superficial cancers, heavy screening as used in gynecology is of limited use, as the quantity of radium must be increased as well as the length of application.

*Wertheim** speaking on the subject of "Radium Treatment of Cancer of the Uterus" describes his results in 19 cases of cancer treated with radium and 3 cases treated with mesothorium. Of the nineteen cases, nine were inoperable, one case was on the border line

*Wiener klinische Wochenschrift, Vol. 26, p. 1648. (1913)

and nine were considered operable. Seven of the nine were operated upon, while in two cases due to the production of a retrovaginal fistula and a stricture of the rectum operation became impossible. The results of radium treatment in the inoperable cases were not so satisfactory. In all the cases however, *Wertheim's* results show that radium has an effect on cancer of the uterus, as could be demonstrated macroscopically and microscopically. The radium treatment led to a complete disappearance of the growth, that is, a cure, only in those cases in which probably other operative treatment would achieve the same end. However, it is not to be said that radium treatment does not present certain advantages in such cases.

There is no doubt that radium produces rather far reaching effects. However, in very advanced cases the radium treatment is unlikely to cause complete disappearance of the growth. Effects on regional lymph glands that may be involved are not claimed but it is not impossible that there may be such an action. The bad action of intense raying expressed itself in weakness, emaciation, headaches, cardic weakness, diarrhea, elevated temperature, irritability and insomnia. *Wertheim* thinks that by careful screening and by improvement in the technic of application that these difficulties will be minimized. The experiments will be continued, however extraordinary care will be used, and two to three mm. of lead screening will be placed over the radium, the secondary rays from the lead being absorbed in thicknesses of paper, etc.

*Peham** discussing "Radium Treatment in Gynecology" told of twelve cases of carcinoma which he has treated since June 1913, working with 32 mgm. of radium (element). One case of carcinoma of the clitoris in which the tumor was the size of a small apple was completely cured, the tumor being replaced by a smooth scar tissue. In a case of carcinoma of the perineum the growth was reduced to a spot less than 0.5 cm. in diameter, a burn requiring the treatment to be discontinued for the time. Three cases of recurrences in cancer of the uterus following radical operations were little affected by the radium although in two cases the infiltrations became smaller. The remaining seven cases were of carcinoma of the uterus in which the local effects of the raying was proven both clinically and microscopically.

In conclusion *Peham* says that the direct ray treatment of cases of carcinoma of the female genitals is effective. It is not possible on the basis of present knowledge to say that radium is a specific in carcinoma and radium treatment is not to be recommended to replace the present operative methods. To treat an early cancerous growth with radium is not to be recommended as thereby the chances of recovery by an operation are lessened. In inoperable cases and recidives radium is to be recommended.

Ranzi, Schueller and *Sparmann*‡ speaking on the "Results of Radium Treatment of Malignant Tumors" reported on fifty-three cases. Of six cases treated with radium after operation, "preventive raying", three showed no recurrences and three showed recurrences. In the three cases where there was a recurrence, the radium was screened with 1 mm. thickness of gutta percha tissue and there was applied in toto, 133, 39 and 173 milligram hours of radium. These were three cases of tumor linguae. Of the 47 other cases treated all were inoperable save one case of carcinoma of the skin of the hand which was operated

*Wiener klinische Wochenschrift, Vol. 26, p. 1650 (1913)

‡Wiener klinische Wochenschrift, Vol. 26, p. 1651 (1913)

upon after the radium treatment had gone on for a while. Of the remaining 46, ten cases did not continue the treatment and so need not be considered. Of the thirty-six remaining, seven were recognized as utterly hopeless, because of the rapid growth of the tumors and the formation of metastases. Six other patients died during the treatment and in four of these cases only small doses had been applied. In three cases there was observed a disappearance of the carcinomatous nodules. In six other cases there was local improvement but the general condition of the patient became worse, and in three further cases the growths only increased as a result of the raying. These latter cases were a tumor colli, a carcinoma penis recidive and oesophageal stenosis, treated with 16920, 2400 and 937 milligram hours of radium respectively, using 2 mm. of silver in the first and third cases, the screening not being stated in the second case. In eleven cases still under treatment a beneficial effect of the rays was observed. These results lead the authors to conclude that in the action of radium there is not always the fulfilling of the hope that it would act selectively on the neoplasm, and care must be exercised not to cause perforations of hollow organs or hemorrhages due to erosion of blood vessels. The danger of infection after the perforation of the oesophagus, rectum, etc. is great. The general results of these fifty-three cases are rather disappointing. In spite of this it must be admitted that radium has improved eleven out of thirty-six cases of inoperable tumors. In any case radium is a valuable substance for the prevention of recurrences, when used post operatively. The use of radium in operable cases is not considered advisable.

*Dautwitz** in an article on "Radium Treatment in Surgery and Dermatology", draws the following conclusions from the radium treatment of hopelessly inoperable cases of cancer. Where all other means fail radium treatment benefits if only to make the suffering of the patient more endurable. The earlier a case is recognized as inoperable, the better the chances with radium treatment. Because of the specific effects of the radium rays on the cells of malignant growths it is well to use these rays after operations to prevent recurrences and metastases.

The necessarily large doses of rays required in inoperable cases may cause severe burns and other undesirable actions on the general condition of the patient, of which the patient should be warned. Radium should only be used in operable cases when the patient refuses operation.

REVIEWS AND ABSTRACTS

C. J. *Gauss*. Technic of Mesothorium Therapy as Applied in Gynecology. Strahlentherapie. Vol. 3, pp. 348-364. Description of the various forms of applicators, screens and safety devices used in the application of the rays of radium or mesothorium in the University Gynecologic Clinic, Freiburg in Br. (Director, Dr. *Kroenig*).

Anton *Sticker*. Radium and Mesothorium Radiations. Theoretical Considerations and the Practical Therapeutic Application of These Rays. Strahlentherapie. Vol. 3, pp. 1-63. From the Surgical Clinic of the University of Berlin; Director, Dr. *Bier*, and the Radium Institute of the Royal Charite; Director, Dr. *His*. The author devotes thirty pages to a general discussion of the physical nature of the rays of the radio elements and their various physical and chemical effects. The

*Wiener klinische Wochenschrift, Vol. 26, p. 1662 (1913)

remainder of the paper is given to a discussion of the biologic effects of these rays and their practical application in therapeutics.

* * * * *

L. *Wickham* and P. *Degrais*. Can Radium Aid Surgery in the Treatment of Malignant Tumors. Strahlentherapie. Vol. 3, pp. 457-472, 1913.

Lecture given at the 17th International Congress of Medicine in London, August 1913. "Our answer is wholly affirmative. Most assuredly radium can give valuable aid to Surgery in the treatment of malignant tumors." Immediate operation is recommended in all operable cases, raying the area afterwards to completely extirpate the last cells of the growth. This is a preventive measure against recurrence or metastases. In certain cases where an operation would be undesirable, radium alone can be used to remove the growth. In difficult operable cases, the use of radium before and after the operation is valuable. Tumors may be inoperable though accessible, or they may be inaccessible. This latter group is growing smaller day by day. As an example of the first group the tumors of the uterus may be cited, and in the second group cancerous growths in the larynx. Intensive raying with radium makes the first group operable, and can lead to the destruction of the growth in the second group. However, to put radium in the high place which it should have in aiding surgery in the fight against cancer many points must be kept in mind. Intensive raying through-out the whole of the neoplasm is necessary. This raying should be of equal intensity in all parts, particularly at the base and periphery of the growth. To attain this, surgical interference is of value. In addition to raying all the cells it is necessary that they be given adequate dosage so as to lead to their destruction. If this is not done the effect simply may be stimulating. Often poor results are due to a neglect of this point.

The quantity of radium to be used is a most important matter and must always be determined upon according to the radio-sensitibility of the tissue that is being rayed. We think that by an association of surgery and radium therapy a new science is constituted which will bring new aid to the sick by widening the field of surgery and of radium therapy.

* * * * *

H. *Dominici*. The Receptivity of Normal and Pathological Tissues for Radium Raying. Strahlentherapie, Vol. 3, pp. 379-387, 1913.

Written as an introduction for *Barcat's* "Compendium of Radium Therapy". Maloine, Paris, 1912. By the word "receptivity" the author designates the ability of organic tissues to be acted on or changed by the action of the radium rays. This receptivity varies with the age and race of the cells and also many other fortuitous conditions. Embryonal or undifferentiated cells are destroyed by the action of the radium ray, whereas older further developed surrounding tissues simply undergo a simple or metabolic change. The different living elements show varying sensibility towards therapeutic raying. These effects of age and the species of the cell are to be seen in considering the effects of the rays on tumorlike neoplasms. Some of the growths are radio-sensitive such as the ectodermal baso-cellular epitheliomata of *Darier* and *Krompecher*, lymphadenomata, the pure sarcomata, and fibromata. In the other class of growths which are more or less resistent to the effects of raying are the squamous celled epitheliomata,

the fibro-sarcomata, chondro-sarcomata and osteosarcomata. The radium rays acting upon neoplasms cause a retardation of cell growth, a destruction of the cells and in some malignant cells a change which leads to the cell becoming normal. This latter change occurs in the cells which are least carcinomatous in nature. The involution of external or internal benign tumors and of superficial epitheliomata under the effects of radium rays when proper technic is used is generally quite definite.

With the carcinomata involving mucous surfaces of the inner organs the tendency is towards recurrences after an apparent cure which may last for several months or years. The recurrences are due mainly to cells of the original growth which were only lamed and not destroyed or to those cells which apparently became normal under the action of the rays. The author thinks as the technic improves that the number of refractory forms of carcinomata will diminish.

* * * * *

P. *Degrais* and *Pasteau*. The Treatment of Prostatic Tumors with Radium. Strahlentherapie. Vol. 3, pp. 542-45, 1913. Operative treatment of carcinoma of the prostate has not given any too satisfactory results. Usually after a time the growth again develops, metastases form and there is a generalization of the carcinoma. The danger in an operation for the total extirpation of the prostate is also great. These considerations led the authors to try the effect of radium in such cases. Of 15 cases treated, six are still in the course of treatment. Among the cases treated were some which four years ago were considered hopeless.

Today, as a result of the radium treatment, the prostate is smaller in size, and movable. That these were malignant forms and not chronic prostatitis is not certain in all cases. In some however, there was the concomitant softening of the inguinal glands. One patient died later as a result of general metastases. In one case a very large and immovable prostate which could not be treated operatively, diminished under the influence of the radium treatment and became soft and movable. Operative treatment was then possible and sections showed the marked effects of the raying on the tissue, and confirmed the malignancy of the growth. The treatment with radium is simple, not dangerous, and if complete cures do not result, the improvement makes prostatectomy possible which before was impossible.

* * * * *

Foveau de *Courmelles*. Roentgen and Radium Rays in Gynecology. Strahlentherapie. Vol. 3, pp. 388-407. The first part of this paper, dealing with the action of the X-rays, was given at the International Congress of Medicine, London, August 1913.

In this is summed up the work of the author and of many others on the use of the Roentgen rays in the treatment of myomata and fibromata. A brief summing of the author's work with radium in the treatment of uterus carcinomata, myomata, metritis, salpingo-ovaritis. The author in conclusion says that it must be understood that the X-rays and radium rays are not panaceas, and they can do damage. But rightly used, they are very valuable, and often a last resource.

* * * * *

L. *Renon*, P. *Degrais* and L. *Dreyfus*. Radiumtherapy of Myelogenic Leukemia. Strahlentherapie. Vol. 3, pp. 551-52, 1913. Re-

ported at the 17th International Congress of Medicine, London, August, 1913.

Four cases of myelogenic leukemia which were not favorably influenced by X-ray or benzol therapy, and one case which had not been treated before, all responded in the same way to the following radium treatment. 300 to 330 milligrams of radium sulfate, covering an area of 500 to 600 sq. cm., screened with 2 mm. of lead, were applied for from 24 to 48 hours. The effect of the radium continues for 8 to 14 days after the application. The enlarged spleen diminishes to its normal size. The leucocyte count falls from 330,000 to 70,000 in five to ten days, the myelocytes disappearing. After three to four applications the leucocytes are normal, or even subnormal. The red blood cells increase, fever disappears, and the patient gains weight and becomes stronger. The patient is apparently cured, but only apparently, since in from 2 to 18 months after the treatment, the symptoms of leukemia reappear. When the radium treatment is again started the results obtained are different. The leucocytes count is not much changed, and the enlarged spleen diminishes only slowly. A tolerance to the radium seems to have been established. The patient succumbs; in two cases which the authors treated it was two years after the first radium treatment. The mechanism of the radium treatment is not known and the authors suggest that perhaps larger dosage and longer treatment at first might prevent the recurrence.

Perhaps a combined radium, X-ray and benzol treatment may give more permanent results. Certainly for rapid effects at first, radium gives remarkable results.

* * * * *

L. *Wickham*, P. *Degrais* and A. *Bellot*. The Action of Radium upon Certain Hypertophic Conditions of the Skin. Strahlentherapie, Vol. 3, pp. 527-30, 1913.

Flat juvenile warts and senile warts were successfully treated by means of the unscreened rays from 1 centigram of radium sulfate (ca. 7 mgm. radium element), spread over an area of one square cm. in a varnish applicator. Five to ten minutes application caused the disappearance of the juvenile warts, whereas longer applications were required in the ordinary warts which usually resist most other forms of painless treatment. Warts and callous growths on the soles of the feet which often make walking very painful, if not impossible, can be successfully treated with radium. Thirty milligrams of pure radium sulfate (ca. 21 mgm. radium element) on an applicator having an area of six sq. cm., screened with two mm. of lead were applied on six nights for a total of sixty hours. In every case the result was good and the treatment painless.

* * * * *

W. S. *Lazarus-Barlow*. The Action of Radio-active Substances and their Rays on Normal and Pathological Tissues. Strahlentherapie. Vol. 3, pp. 365-78. 1913.

A lecture given at the International Congress of Medicine in London, August, 1913—A resume of the author's work and that of his associates and others in this field. Too detailed to admit of a brief abstract.

* * * * *

Paul *Lazarus*, Radium Therapy in Carcinoma. Berlin. klin. Wochenschrift, No. 28, July 14, 1913, pages 1304 and 1305. The author gives

his opinions as regards the treatment of carcinoma, particularly of the uterus. He advises the use of not less than 30 mgm. of radium sulfate (21 mgm. of radium element) nor more than 100 mgm. (70 mgm. radium element) radium sulfate, when one mm. of silver or lead is used to filter the rays. Smaller quantities of radium serve to stimulate growth, and the massive doses, unless heavily filtered, may injure the surrounding tissues. The author also worked with intravenous injections of thorium X and thorium X administered per os in cases of pseudo leukemia and sarcomatosis in abdomine. In the former the normal blood picture was restored and in the latter case, in spite of the multiple tumors still present, the patient has been working during the past 2½ years. The permanent value of thorium X therapy still remains to be demonstrated.

* * * * *

Mache and *Suess*. The Absorption of Radium Emanation by the Blood in Inhalation and Drinking Cures. IV International Congress of Physiotherapy, Berlin.

The authors conclude from their work, which was carried out in the Vienna Radium Institute, that the inhalation of radium emanation or the taking of radium emanation drinking water, will cause emanation to pass into the blood, and remain there for some time. The decision as to which method is more advantageous must be made rather on the basis of medical and practical reasons. The inhalation method affords the possibility of a more exact dosage, and does not have the effect of causing a localized accumulation of radium emanation, as is the case with the drinking cure. This latter recommends itself because of its convenience and low cost of application.

* * * * *

Ramsauer and *Holthusen*. The Absorption of Radium Emanation in Blood. Strahlentherapie Vol. 2, p. 503–532. The authors find an absorption coefficient for radium emanation of from 0.295 to 0.325 in normal blood. This is about twice the absorption coefficient for radium emanation in water of the same temperature. The discordant values of the absorption coefficient of radium emanation in blood previously given have varied from less than the value for water up to thirty times this value. The authors find that the absorption coefficient varies with the composition of the blood—falling to 0.22 in anemia, and rising as high as 0.37 in hyperglobulia.

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VOL. II MARCH, 1914 NO. 6

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FORBES AND MEYRAN AVENUES, PITTSBURGH, PA.

We shall be glad to receive for publication from our subscribers and readers articles pertaining to the subject of radium and its application. All inquiries for information will be accorded prompt attention, and will be answered either by letter or through the columns of this paper.

VOL. II MARCH, 1914 No. 6

THE INTRAVENOUS INJECTION OF SOLUBLE RADIUM SALTS. III.

By FREDERICK PROESCHER, M. D.

Director of the Laboratory for Experimental Therapy, Standard Chemical Company.

In the following are presented the results of the intravenous injection of soluble radium salts upon the blood pressure in the polyarthritis cases.*

The blood pressure was estimated with a Faught aneroid sphygmomanometer by the palpation method, and by the asculatory method with the sphygmometroscope (Prendergast). The term systolic blood pressure (maximal pressure) means the degree of arterial pressure in the arterial system during the cardiac systole; diastolic blood pressure (minimum pressure) the degree of arterial pressure existing in the arterial system preceding the systole. The difference between the systolic and diastolic pressure represents the pulse pressure, indicating the amount of periodic variation in blood pressure within the arterial system as the result the intermittent action of the heart. The average maximum blood pressure for males at all ages is 127.5 mm., for females 120 mm. All determinations were made with the patient sitting in a reclining posture.

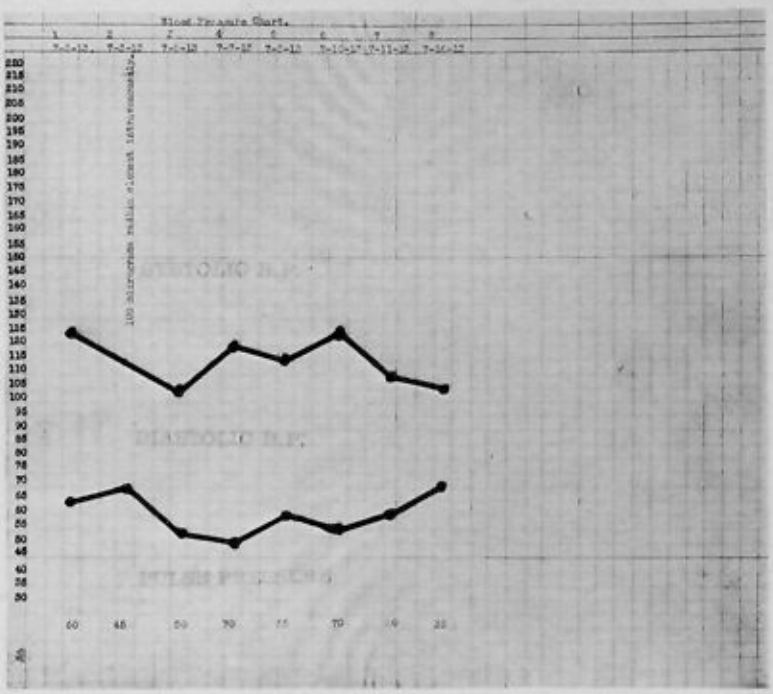
CASE No. 2†.

BLOOD PRESSURE.

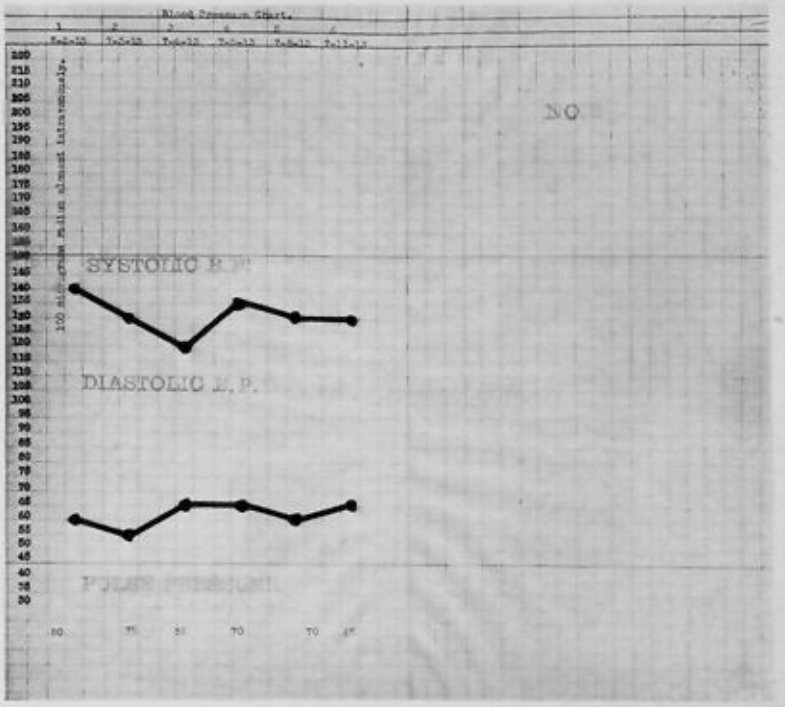
Date	Systolic	Diastolic	Pulse Pressure
7- 2-13	125	65	60
7- 3-13	115	70	45
	100 micrograms radium element intravenously.		
7- 5-13	105	55	50
7- 7-13	120	50	70
7- 8-13	115	60	55
7-10-13	125	55	70
7-11-13	110	60	50
7-16-13	105	70	35

*See preceding articles by Dr. Proescher, in January and February numbers of RADIUM, in which reports were given on sixteen cases of arthritis treated by the intravenous injection of soluble radium salts.

†In case No. 1 and case No. 16 no blood pressure was taken.



Case No. 2.



Case No. 3.

CASE No. 3.

BLOOD PRESSURE.

Date	Systolic	Diastolic	Pulse Pressure
7- 2-13	140	60	80
	100 micrograms radium element intravenously.		
7- 3-13	130	55	75
7- 4-13	120	65	55
7- 5-13	135	65	70
7- 8-13	130	60	70
7-11-13	130	65	65

CASE No. 4.

BLOOD PRESSURE.

Date	Systolic	Diastolic	Pulse Pressure
7- 3-13	120	75	45
	100 micrograms radium element intravenously.		
7- 4-13	115	70	45
7- 9-13	110	65	45
7-10-13	105	65	40
	100 micrograms radium element intravenously.		
7-11-13	105	65	40
7-12-13	100	55	45

CASE No. 5.

BLOOD PRESSURE.

Date	Systolic	Diastolic	Pulse Pressure
7- 6-13	125	90	35
	100 micrograms radium element intravenously.		
7- 8-13	105	70	35
7- 9-13	105	75	30
7-13-13	105	75	30

CASE No. 6.

BLOOD PRESSURE.

Date	Systolic	Diastolic	Pulse Pressure
7- 3-13	110	70	40
	100 micrograms radium element intravenously.		
7- 4-13	130	80	50
7- 5-13	115	70	45
7- 7-13	120	80	40
7- 8-13	105	65	40
7- 9-13	115	65	50
7-10-13	105	65	40
7-11-13	115	75	40
7-12-13	110	85	25
7-14-13	110	85	25

CASE No. 7.

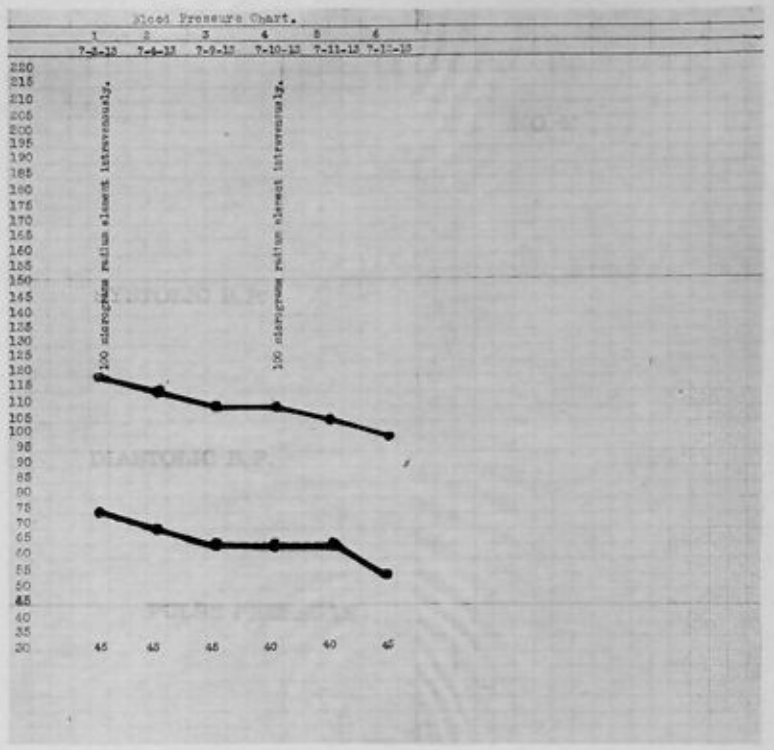
BLOOD PRESSURE.

Date	Systolic	Diastolic	Pulse Pressure
7- 8-13	105	80	25
	100 micrograms radium element intravenously.		
7- 9-13	110	70	40
7-19-13	110	75	35
7-20-13	105	75	30
7-24-13	105	75	30

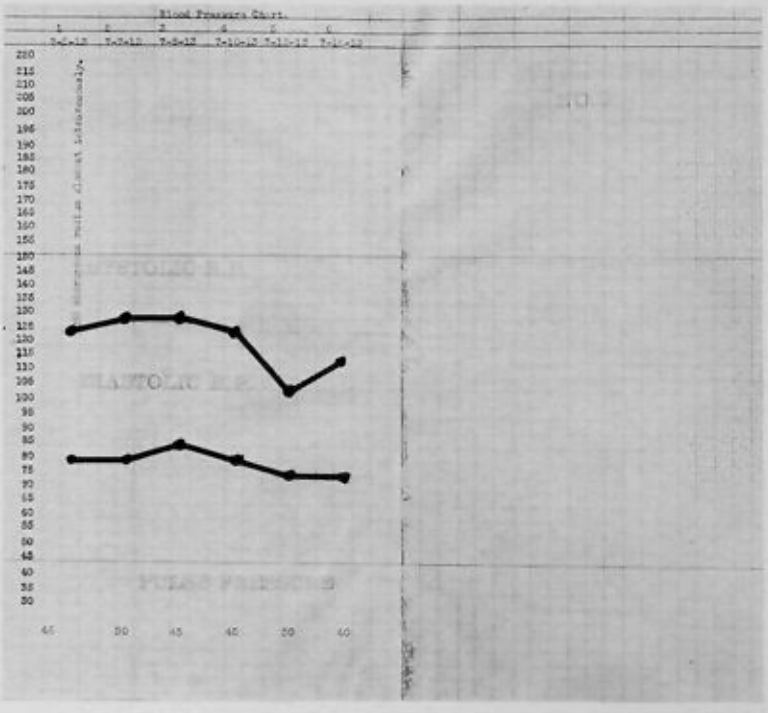
CASE No. 8.

BLOOD PRESSURE.

Date	Systolic	Diastolic	Pulse Pressure
7-19-13	155	60	95
	100 micrograms radium element intravenously.		
7-21-13	125	65	60
7-23-13	135	60	75



Case No. 4.



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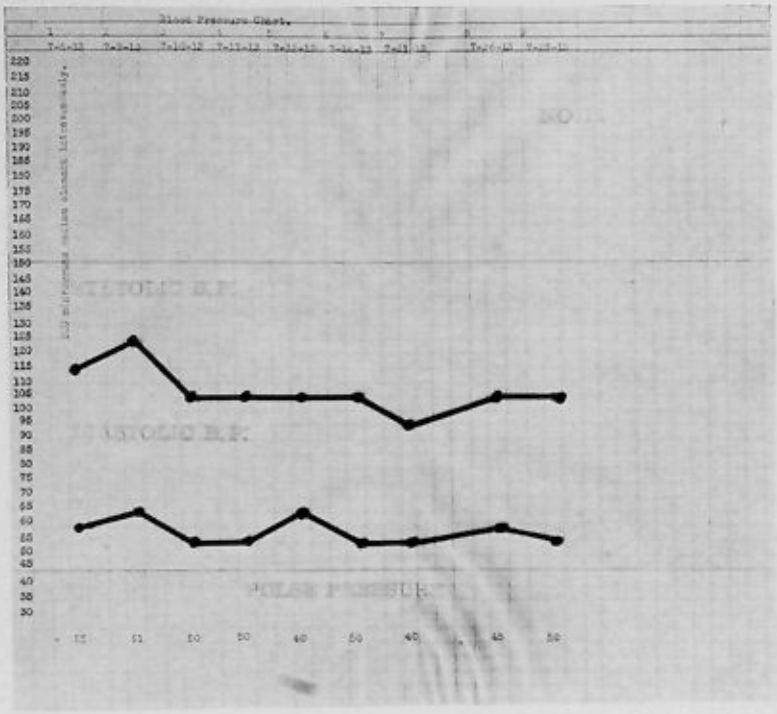


Case No. 11

CASE No. 9.

BLOOD PRESSURE.

Date	Systolic	Diastolic	Pulse Pressure
7- 5-13	125	80	45
	100 micrograms radium element intravenously.		
7- 7-13	130	80	50
7- 8-13	130	85	45
7-10-13	125	80	45
7-12-13	105	75	30
7-14-13	115	75	40

CASE No. 10.

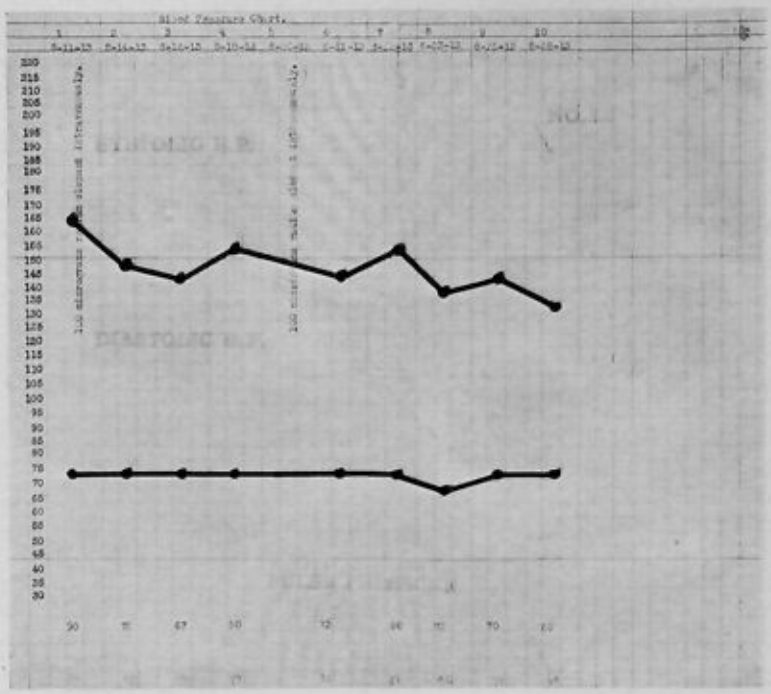
BLOOD PRESSURE.

Date	Systolic	Diastolic	Pulse Pressure
7-14-13	110	75	35
	100 micrograms radium element intravenously.		
7-21-13	115	75	40

CASE No. 11.

BLOOD PRESSURE.

Date	Systolic	Diastolic	Pulse Pressure
7- 8-13	115	60	55
	100 micrograms radium element intravenously.		
7- 9-13	126	65	61
7-10-13	105	55	50
7-11-13	105	55	50
7-12-13	105	65	40
7-14-13	105	55	50
7-21-13	95	55	40
7-26-13	105	60	45
7-28-13	105	55	50



Case No. 12

CASE No. 12.

BLOOD PRESSURE.

Date	Systolic	Diastolic	Pulse Pressure
8-11-13	165	75	90
	100 micrograms radium element intravenously.		
8-14-14	152	77	75
8-16-13	145	77	67
8-18-13	155	75	80
	100 micrograms radium element intravenously.		
8-21-13	145	72	73
8-22-13	155	75	80
8-23-13	142	70	72
8-25-13	147	77	70
8-28-13	135	75	60

CASE No. 13.

BLOOD PRESSURE.

Date	Systolic	Diastolic	Pulse Pressure
8-13-13	102	50	52
	100 micrograms radium element intravenously.		
8-15-13	97	65	32
8-18-13	97	62	35

CASE No. 14.

BLOOD PRESSURE.

Date	Systolic	Diastolic	Pulse Pressure
8-11-13	127	77	50
	100 micrograms radium element intravenously.		
8-14-13	117	72	45
8-16-13	132	77	55
8-18-13	130	77	55

	100 micrograms radium element intravenously.		
8-21-13	120	75	45
8-22-13	125	70	55
8-23-13	112	70	46
8-25-13	120	85	35
8-26-13	125	75	46

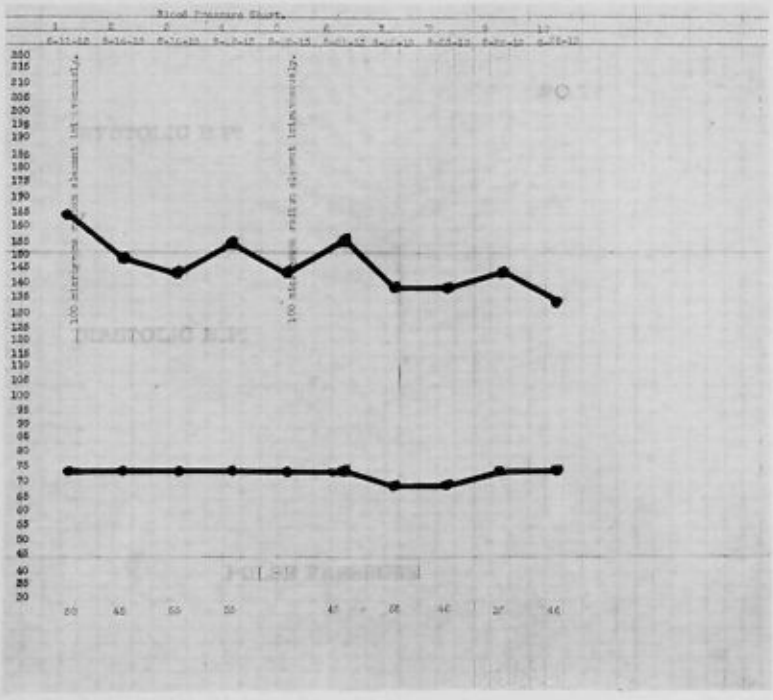
CASE No. 15.

BLOOD PRESSURE.

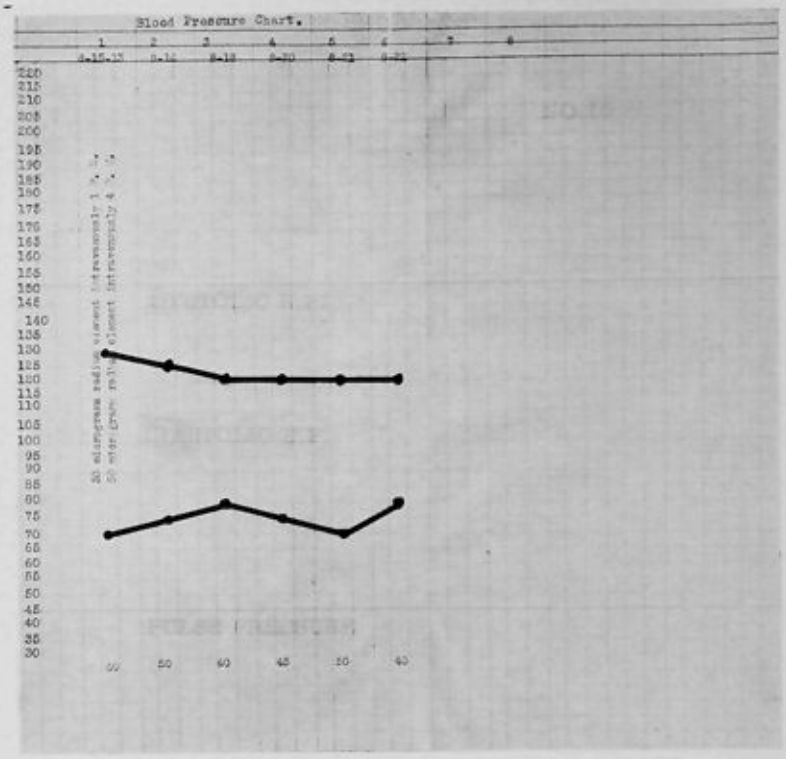
Date	Systolic	Diastolic	Pulse Pressure
8-15-13	130	70	60
	50 micrograms radium element intravenously 1:00 P. M.		
	50 micrograms radium element intravenously 4:00 P. M.		
8-16-13	125	75	50
8-18-13	120	80	40
8-20-13	120	75	45
8-21-13	120	70	50
8-22-13	120	80	40

In twelve cases (80% of all the cases) the blood pressure was reduced on an average of about 20 mm. in from one to eight days. In two cases (13⅓% of all the cases) no reduction was noticed. The effect of the radium on the circulatory system will be discussed in a later paper.

CONCLUSIONS. It is rather early from the relatively few cases of polyarthritis treated to draw any definite conclusions as to the therapeutic value of the intravenous application of radium. Considering the more or less chronic course of the polyarthritis with its periods of



Case No. 14



Case No. 15.

aggravation and at other times improvement without any medication, makes it very difficult to establish the true value of a new therapy. The clinical observation can very easily lead to a deception, if one is not thoroughly acquainted with the course of the disease process. To exclude errors it is necessary to keep the patient under constant observation, and make repeated examinations over longer periods, after medication is stopped. The foregoing reported therapeutic results with the intravenous radium therapy are only preliminary, because the time of observation is too short to make a definite statement as to the permanence and protection against recurrence.

I have used the terms "temporarily cured", "considerably improved", and "improved" to classify achieved results. Temporarily cured cases are those which are entirely free from all subjectve and objective symptoms and have no limitation in the movement of the joints. Such results can only be obtained in such cases in which the morbid process exists only for a short time and no degenerative changes have taken place. In the more advanced cases with objective changes in the joints, I used the terms "much improved" and "improved" because these cases show only an improvement consisting in a decrease or disappearance of pain and retrogression of the inflammatory swelling, as degenerative changes in the cartilage cannot be influenced. We are at present not informed as to the etiological agent causing the polyarthritis, we therefore do not know whether the radium has any direct specific effect upon the unknown cause or whether it has only a symptomatic one, acting as an analgetic and antiphlogistic agent upon the diseased joints. Without doubt radium has a specific selective effect

upon rheumatic diseased joints which is shown by the increased pain and inflammatory reaction after a radium injection. I presume that under the influence of the rheumatic cause a chemical change in the diseased cartilage takes place, probably in splitting of chondritin-sulphuric acid, which on account of the sulphuric acid radical has an increased affinity for the radium.

The soluble radium salt is probably deposited as an insoluble sulfate in the diseased joints. The theoretical hypothesis could be experimentally proved by estimation of the radium content found in the diseased cartilage.

Reaction, namely pain and stiffness, in the joints was noticed in fifteen cases. In eight cases inflammatory swelling was observed which subsided in from two to twenty-two days after the injection. In three cases the patients claimed that they had slept unusually well, and in ten cases the marked general improvement was claimed by the patients between two and twenty-two days after the injection. No alarming symptoms were observed in any of the cases. The temperature and pulse did not show any considerable change. In a few cases the patients noticed an increase in the urine secretion.

In the following tables we compare the results of the radium emanation therapy as obtained by *Gudzent* in 247 cases of polyarthritis, with the intravenous radium therapy:

Radium Emanation Therapy.			Radium Injection Therapy.		
Considerably improved	62	25%	Temporarily cured	4	25%
Improved	81	33%	Considerably improved	8	50%
Slight improvement	52	21%	Improved	2	12.5%
No improvement	52	21%	No improvement	2	12.5%

It will be noted that the intravenous radium injection has a more marked therapeutic effect than radium emanation therapy. The most favorable cases for radium treatment are the acute and subacute and the not too far advanced cases of chronic polyarthritis. Very little or no effect was noted in the arthritis deformans except in one case which showed a fairly good improvement. As to whether intravenous radium therapy in acute cases with high fever is indicated, is an open question. In one case of acute polyarthritis which I have treated recently I gave 50 micrograms during a temperature of 102° without injurious effect. About 24 hours after the injection the pain in the joints entirely subsided. Further experience with a larger number of acute cases is necessary in order to prove whether radium is indicated in all acute cases.

According to our experience 100 to 200 micrograms of radium element should be a sufficient dose in the treatment of polyarthritis. It seems to be advisable to give radium in fractional doses, for instance 100 micrograms in four doses of 25 micrograms, or two doses of 50 micrograms each, given every other day or 200 micrograms in 50 microgram doses given every other day.

In cases of recurrence radium injection can be repeated without any fear of danger as to the accumulative effect of the radium. According to our latest animal experiments the lethal dose for a human being would be about 60 milligrams.

THE INFLUENCE OF RADIUM ON THE BLOOD. In twelve cases (80% of all the cases) an increase of from 250,000 to 1,175,000 in the red cells was noticed. It is striking to note that the case injected with only 40 micrograms showed the highest increase of the red cells. Two cases (13⅓% of all the cases) showed a decrease of the red cells, one 450,000 and one 750,000. The haemoglobin was increased in 11 cases, (73⅓% of all the cases), and in four cases (26⅔ % of all the cases) no increase was

observed. The haemoglobin showed a marked decrease in eight cases, (3, 4, 5, 6, 7, 9, 12, 14) twenty-four hours to a few days after the injection with a subsequent return to normal or an increase in haemoglobin. The number of red cells in spite of the low haemoglobin content was not altered very much. Whether this quantitative change in the haemoglobin content is due to a chemical alteration of the haemoglobin by action of radium which changes the color so that exact determinations cannot be made with the haemoglobinometer or to an output of premature red cells with less haemoglobin, has not yet been determined.

The microscopic examination of the stained blood films of these cases did not show any morphological changes in the red cell (polychromasie macro or microcytosis or punctated red cells). No neucleated red cells were found. It would appear from this that the low haemoglobin content which was observed in half of the cases after the injection of radium is more likely due to a change in the color and not to a rapid destruction of the red cells, as we should find in the latter, premature red cells. Whether the numerical increase in the red cells in the circulating blood stream is due to an increased production of the red cells or a temporary chemotactic effect which introduces into the blood stream the reserve fund of the mature red cells I leave open for further investigation. The increase of the red cells is only temporary as they slowly return to normal.

The leucocytes were slightly reduced in ten cases, the lowest count observed being 4000. In five cases there was no decrease but a slight leucocytosis. The variations in the differential count are not very pronounced, the neutrophiles are more or less slightly increased. The same is observed in the eosinophiles, which show very little variation from the normal, save in one case where an increase of nearly 6% was noted.

The lymphocytes show more or less slight decrease followed in some cases by a slight increase. The monocytes and also the basophiles show a tendency to a slight increase. No morphological changes in the leucocytes in the stained films were observed.

I herewith give the following results obtained after intravenous injection of radium in sixteen cases of polyarthritis:–

Temporarily cured	4	25%
Considerably improved . . .	8	50%
Improved	2	12.5%
Unimproved	2	12.5%

TABLE SHOWING THERAPEUTICAL RESULTS OBTAINED.

Temporarily Cured Cases.

Acute polyarthritis, 18 days duration.
Chronic progressive polyarthritis, four years duration.
Subacute polyarthritis, three months duration.
Chronic polyarthritis, two and one half years duration.

Considerably Improved Cases.

Chronic polyarthritis 1, four months duration.
Chronic progressive polyarthritis 7, two months to forty years duration.

Improved Cases.

Chronic progressive polyarthritis 1, six months duration.
Chronic progressive polyarthritis 1, one year duration.

Unimproved Cases.

Oligoarthritis deformans 2, from four to nineteen years duration.

TABLE SHOWING THE AMOUNT OF RADIUM INJECTED IN THE ARTHRITIS CASES.

CASES	Amt. radium injected	Total amt. radium
No. 1 Acute polyarthritis . . .	10, 20, 20 micrograms	40 micrograms
No. 2 Chronic progressive polyarthritis .	100 "	100 "
No. 3 Chronic polyarthritis . .	100, 50 "	150 "
No. 4 Subacute polyarthritis . . .	100, 100 "	200 "
No. 5 Chronic progressive polyarthritis .	100, 50 "	150 "
No. 6 Chronic progressive polyarthritis .	100, 50, 50 "	200 "
No. 7 Oligoarthritis deformans . . .	100, 250 "	350 "
No. 8 Oligoarthritis deformans . . .	100, 30 "	130 "
No. 9 Chronic progressive polyarthritis	100 "	100 "
No. 10 Chronic progressive polyarthritis	100, 50 "	150 "
No. 11 Chronic progressive polyarthritis	100, 50 "	150 "
No. 12 Chronic progressive polyarthritis	50, 100 "	150 "
No. 13 Oligoarthritis deformans . . .	100 "	100 "
No. 14 Chronic progressive polyarthritis	50, 50 "	100 "
No. 15 Chronic progressive polyarthritis	50, 50 "	100 "
No. 16 Chronic polyarthritis . . .	100 "	100 "

TABLE SHOWING THE AMOUNT OF RADIUM INJECTED AND EFFECTS ON THE BLOOD PRESSURE.

	Amount of radium injected	Systolic pressure before injection	Systolic pressure after injection	Reduction
Case No. 2	100 micrograms	123 mm.	105 after 1 day	20 mm.
3	100 "	140 "	120 " 2 "	20 "
4	200 "	120 "	100 " 3 "	20 "
5	100 "	125 "	105 " 4 "	20 "
6	100 "	110 "	105 " 3 "	20 "
7	100 "	No reduction.		
8	100 "	155 mm.	125 " 1 "	30 "
9	100 "	125 "	125 " 4 "	20 "
10	100 "	No reduction.	105	
11	100 "	115 mm.	95 " 6 "	20 "
12	200 "	165 "	135 " 8 "	30 "
13	100 "	102 "	97 " 1 "	5 "
14	200 "	127 "	112 " 6 "	15 "
15	100 "	130 "	120 " 3 "	10 "

NOTES AND COMMENTS

One of the most interesting sessions of the Clinical Congress of Surgeons of North America was the symposium upon radio-active treatment of various kinds, the subject that was discussed Wednesday and Thursday nights. Among those taking part were Profs. Bernhard *Kroenig* and C. J. *Gauss*, of the University of Freiburg, Germany and Prof. Howard A. *Kelly*, of Baltimore. The German physicians demonstrated their technic of radiotherapy in the treatment of cancer at Wesley Hospital.

In the discussion on this subject, Doctor *Kelly* told of the treatment of forty cases of cancer. He declared that two cases of carcinoma of the breast seemed to have been cured by the use of radium. This substance also is sometimes curative, he declared, in cancer of the nose, eyes, and lips; and it will produce good cosmetic results where surgical measures would mutilate and disfigure. Doctor *Gauss* said that the

X-ray, radium, and mesothorium had all been used in Freiburg with excellent results, both temporary and permanent.

Dr. Thomas S. *Cullen*, of Baltimore, sounded a word of warning, saying that nothing is more to be feared than the use of radium in nostrums of any kind. "Radium should be standardized, so that the buyer knows what he is paying for," he continued: "and only time will tell what percentage of cases can be cured with radium." At present early surgical operation affords the best chance for cure. However, the results obtained from radium must be taken into consideration.

* * * * *

Consul Milo A. *Jewett*, of Kehl, in the Daily Consular and Trade Reports for January 29th, 1914, notes that the Strassburg (Germany) Hospital and University some time ago bought 200 milligrams of radium (bromide) at $76 per milligram, and has bought 100 milligrams more, which will cost at present prices $98 per milligram. This is at the rate of about $183 per milligram of radium element contained in the radium bromide.

* * * * *

T. *Nogier*, reports on the Biological Action of Radium, in the "Lyon Medical", December 7, 1913. He exposed the seeds of four different plant species to various concentrations of radium emanation, and observed the subsequent effects on growth when they were planted. The larger doses caused a complete loss of sprouting power, though the different seeds showed variations in the amount required, small seeds proving more resistant than the larger. A dose just insufficient to sterilize the seed resulted in a stunted growth, soon followed by signs of senescence and death of the plant. Intermediate doses caused slow and incomplete growth, with delay in blooming. Small doses caused initially retarded, scanty growth followed in two months by growth so rapid that the plants eventually became larger than the untreated controls, though flowering was somewhat delayed. These last observations demonstrate the excitant effect of small doses of radium, and probably, by analogy, may be said to imply danger in the clinical use of radium where the amount available is insufficient and the exposures too brief.

* * * * *

The Chemiker Zeitung for January 16th, 1914 (p. 70) says of radium that the commonest radium salts when pure (100%) have the following radium (element) content: radium bromide ($Ra\ Br_2\ 2H_2O$) 53.6%, radium sulfate ($Ra\ SO_4$) 70.2%, radium chloride ($Ra\ Cl_2$) 76.1%, radium carbonate ($Ra\ CO_3$) 79.0%, and as sold these salts are usually from 50% to 60% pure. In the sale of such radium salts, the price is always based upon the radium element content or the content of pure (100%) radium salt.

* * * * *

Charles H. *Viol*, Ph. D. and William H. *Cameron*, M. D. of Pittsburgh, Pa., addressed the Philadelphia Clinical Association, February 2nd, on the subject of "Radium". Dr. *Viol* told of the physical properties of radium, its decay products and the rays, and demonstrated these, 270 milligrams of radium element in the form of various salts being shown. Dr. *Cameron* spoke of his experiences in the internal use of radium and the local application of radium in cancer.

* * * * *

An anonymous donor has presented the University of Buda Pest with $30,000 for the purchase of two hundred milligrams of pure radium bromide.

The Harvard Alumni Bulletin for January 28th, 1914 contains an article on the Harvard Investigation of Radium, from which we give the following extracts:–

"The Cancer Commission of Harvard University, working in conjunction with the Harvard Medical School, has been experimenting for some time with radium and its derivatives as a cure for, or alleviation of, cancer, and from these experiments, a number of valuable observations have already been recorded. The Harvard authorities at present take a conservative view of the value of radium, but able men are on the commission, and they plan to pursue their investigations indefinitely, with the hope of determining eventually just what radium and its derivatives can do."

"Harvard is the first college in the country to take up this study in this thorough way; for the experimentation is being conducted in its laboratories and a considerable number of patients are being treated by radium at the Collis P. Huntington Memorial hospital, where careful records, illustrated by photographs, tracings and measurements are kept, that the benefit of radium therapy may be determined. Correlation of the clinical and pathological data and careful observation of all cases for final results of treatment are necessary for accurate clinical work."

"In each case, which comes under observation, exact microscopic evidence is obtained, for it is important to know with certainty whether a true cancer, or something which superficially resembles a cancer, is the subject for treatment."

"The commission has the resources of Harvard University behind it in this work, and that ability and experience are not lacking is apparent in the personnel of the commission, of which the members are as follows:—Dr. J. Collins *Warren*, chairman; Dr. Henry P. *Walcott*, of the Harvard Corporation; Dr. Edward H. *Bradford*, dean of the Harvard Medical School; Dr. Theobald *Smith*, professor of comparative pathology and Dr. William T. *Councilman*, professor of pathology, Harvard Medical School; Dr. Henry K. *Oliver*, trustee of the Caroline Brewer Croft Fund; Dr. Robert B. *Greenough*, secretary and consulting surgeon; Dr. Henry A. *Christian*, consulting physician; Arthur *Adams*, treasurer; Dr. E. E. *Tyzzer*, director; Dr. Thomas *Ordway*, physician in charge of the Huntington Hospital, and Dr. William *Duane*, Physicist."

"Dr. *Duane* was for six years an assistant in the Curie Laboratory in Paris, and is one of the foremost men in radium experimentation in this country. Dr. *Ordway* has recently investigated the status and methods of radium therapy in London and on the continent. Dr. *Tyzzer* supervises the biological and pathological work in which radium is used."

The Harvard Cancer Commission makes the following statement:—"In certain limited cases, treatment by radium seems to be curative, while in others, not cured by this agent, local results are good and such distressing symptoms as pain, hemorrhage and discharge may be greatly benefitted. At the present time, however, the most satisfactory treatment of cancer is generally admitted to be the complete removal by surgical operation at the earliest possible moment. The best, or curative results from radium therapy, are obtained in cases of various skin diseases, including certain types of skin and other localized forms of cancer."

"In many cases of true cancer which have advanced beyond the operable stage, or cases recurring following operation, improvement after radium treatment may follow not only symptomatically, but in the local condition. Such cases, however, are rarely cured. Occasionally large growths are much reduced and even disappear under the influence of radium, but matastasis, or spreading of the growth to other parts, is not usually prevented, or the patient may succumb from toxemia during the process of absorption."

"Great variations occur in different types of cancer in the same and in different individuals. In some cases the entire duration of the disease is short-months; in others it may last for years, as many as twelve or fifteen, and there may be periods of great temporary improvement. But the fact cannot be too strongly emphasized that this variability in the natural history of new growths may account for many of the favorable results supposedly due to therapeutic procedures."

"Owing to the possible exaggeration and misinterpretation of the result of radium therapy, it is deemed most important that ample and accurate clinical data be secured and the results recorded in a form suitable for critical analysis. It is to obtain such accurate observation of the effect of radium treatment, to devise new and more effective methods of administration and to give to the public the unprejudiced result of these investigations that the Cancer Commission of Harvard University is devoting its energies."

* * * * *

In the January 31st, 1914 number of the Scientific American Supplement, Prof. C. F. *Brown* gives evidence from geological data to show that the element sodium is undergoing radio-active disintegration.

"By the usual test for radio-activity, i. e., the continued ionization of a gas independent of other physical conditions, sodium as an element does not display any activity that is definitely greater than that found in all matter. And the ionizing activity of ordinary matter is so slight that it cannot be stated with definiteness whether or not the matter is of itself radio-active. But radio-activity implies a more fundamental change than that of emitting matter and energy continuously. It implies an atomic disintegration. If alpha particles are emitted the atoms go by leaps and bounds to new atoms of other properties, while if beta and gamma radiations are emitted the wearing away of the atoms must be just as certain, though no one has been able to conjecture by what steps the changes may take place."

"The fact that a given element does not give out a measurable ionizing radiation is not necessarily evidence that it is not radio-active."

"If sodium is a radio-active element we may at present look for other evidence than direct radiations. We shall inquire whether in past geologic time sodium has accumulated radio-actively from other matter or on the other hand whether sodium has disappeared or disintegrated into other forms of matter."

"The best evidence that we have for considering sodium a radio-active element is from geology. If the age of the earth is determined from radio-active data, and the value accepted, we find that there is not accumulated in the ocean basin as much sodium as there would have accumulated during this time."

The present estimated annual outputs from rivers of chlorine and of sodium (in metric tons x 1000) are 155,350 and 158,357 respectively, whereas the amounts of chlorine and sodium in the ocean (in metric

tons multiplied by one million million) are 25,538 and 14,138 respectively."

"The geologists do not believe that the rivers carried on the average any less sodium previously than they do now. But if they did, they should have also carried less chlorine. We may, therefore, for checking purposes say that nothing concerning the annual river output further than it should have varied alike with sodium and chlorine. On this assumption the above figures show that there is not as much sodium in the ocean as there should be. We see that the above evidence favors the radio-active decay of sodium as an element."

REVIEWS AND ABSTRACTS.

Isaac *Levin*. Radium and Roentgen Therapy in Cancer. Medical Record. Vol. 84, pp. 1064-68, (1913). A paper read at the meeting of the Section of Medicine of the New York Academy of Medicine, October 21st, 1913. *Levin* compares the action of the X-rays and the radium rays upon cells to that of the salvarsan used in syphilis. The latter substance kills the spirochetae pallidae without injuring the normal tissues of the organism of the host and in the case of the rays there is a selective action on the cancer cells. The advance in technique in the past several years has been remarkable.

"In order to place a true valuation on the radiotherapy in cancer a comparison with salvarsan may be again in place. A true radical cure of cancer with every cell destroyed is as rare as the therapia magna sterilisans in salvarsan therapy. One must not forget that the initial lesion in syphilis during the first few days does not penetrate any deeper than an epithelioma of the skin, and the latter can be radically cured by radiotherapy. But in the deeper conditions by no means every case responds as promptly and as well. I have seen cases of carcinoma of the uterus where the action of the radium was marvelous, and I have seen again cases which seemed to be identical clinically and microscopically, and still do not respond to the action of radium."

"I have also seen cases where the patient after treatment with radium appeared to be clinically well and the microscope showed only a few islands of carcinoma cells remaining. The treatment was discontinued for a couple of weeks, and the patient returned with a local recurrence of the carcinoma."

"Radiation undoubtedly accomplishes as much as the knife in certain localized superficial conditions like the epitheliomata of the skin and ulcus rodens. It may even have certain advantages over the operative treatment inasmuch as it may reach microscopically small islands of cancer cells which the knife would have left behind. Furthermore, it does not open the lymph and blood channels and allow freed cancer cells to enter the circulation as an operative incision may do. On the other hand, the size and extent of the tumor growth may be such as to preclude the possibility of its being influenced in its entirety by the rays. Should the main mass of the tumor be removed surgically then the rest can be easily influenced by the rays."

"Figs. 4 and 5 * present schematic drawings of a carcinoma of the breast and one of the uterus. One radium tube is shown over the skin of the breast, and this tube will not be able to influence the whole of the tumor. Another radium tube is shown on the wall of the chest after the tumor has been removed surgically. This tube will have to influence the remaining islands of carcinoma, which is surely easier of accomplishment. The rays may also be brought in better contact

*Not reproduced here.

with all the parts of the tumor by inserting the tube in the center of the growth, but a preliminary radical removal of the tumor is certainly a better procedure. In the case of a cancer of the uterus the tube can be placed in nearer contact with all the parts of the tumor, as is seen on the illustration, and in a certain number of cases all the cancer cells within the uterus may be destroyed. But even in this case a few islands of cancer cells may remain and give rise subsequently to recurrence."

"In view of all of these considerations the advisability of radiation as an only method of treatment of inoperable cases of cancer appears to me to be very questionable. In the present state of our knowledge I must emphasize strongly that the radical operative removal remains the paramount method of treatment in cancer whenever practicable."

"But in certain cases it may be advisable to radiate before the operation. The cases reported that were made operable through a preliminary radiation indicate the advantage of such a mode of procedure. Certain cases have also been reported where the radiation did not diminish the size of the malignant growth and still the condition seemed to have become more benign and the life of the patient was prolonged from a few months to a few years. A preliminary radiation may then improve the ultimate results of the operation. The same reasoning indicates clearly the absolute necessity of prophylactic radiation following every operation for a malignant growth. Inoperable cases belong indisputably to the domain of radiotherapy. But here another extreme must be guarded against. Cases with metastases in the liver and lungs and general dissemination should not be turned over as an ultimum refugium for radium therapy. This will serve only to discredit the method of treatment and demoralize scientific work. Barely 20% of the cases referred to me for radium treatment are suitable. The attending physician or surgeon should begin to consider radium early in his treatment of cancer cases, and not when the patient is moribund."

"The radio-active substances are the most powerful chemical agents of any that we know at present, and a wildly proliferating cancer cell is the most treacherous enemy to handle. Too small a dose of radium may irritate and increase the growth of cancer, instead of arresting it. Too large a dose may necrotize the cancer tissue too rapidly and produce perforations into vital organs (esophagus, stomach, colon, etc.), or erode the blood vessels and produce a fatal hemorrhage. Very large doses may produce, also, alarming general symptoms—fever, nausea, and even collapse. Correct and scientific methods of radium and Roentgen therapy, methods which will lead to real progress in the future treatment of malignant growths, imply the correct selection of cases, correct dosage and filtration of the rays, and constant clinical and microscopical control of the patient under treatment. In other words, the physician who takes up radiotherapy as his life work and wants to protect himself and his patients against great disappointments and serious mishaps should not only be well acquainted with the physical and biological properties of the rays, but must also be a trained clinical surgeon and a pathologist."

"To recapitulate:—The radium and Roentgen rays are no more of a cancer cure than salvarsan is a syphilis cure, but these rays are therapeutic agents deserving at least as much consideration as surgery. Over-enthusiasm is as injurious to scientific work as over-pessimism is. Sober joint research in this field of the physicist, biologist, and the clinic, will surely be fruitful of far-reaching results in the therapy of malignant tumors.

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