that sufficient platinum is present. The method gave good results with the organisms of botulismus and malignant oedema, but with tetanus the growth was slow and poor.

METHOD 3.—Colloidal Platinum and Sodium Formate.

An attempt to dispense with hydrogen was made by adding to broth excess of sodium formate and colloidal platinum. In a system of this kind it was expected that all the free oxygen would be used up in oxidizing the formate owing to the vigorous catalytic action of colloidal platinum. This expectation was not fulfilled completely. The addition of colloidal platinum to a solution of sodium formate in water containing a little methylene blue brings about complete destruction of all the free oxygen in a short time, and this whether the solution be acid, neutral, or alkaline. The anaërobic state of the solution will continue for some time, for as soon as there is any oxygen absorbed it is used up in oxidizing the formate. But when the method is tried on broths the results are not nearly so good. Some constituent, in some specimens of broth, interferes with the reaction. Bouillon made with Witte peptone, for example, does not give good results. Broth made with a tryptic digest instead of Witte peptone (Douglas) was more suitable. To this medium there was added a trace of methylene blue, sodium formate up to 1 or 2 per cent., and just before infecting 2 c.cm. of colloidal platinum, or platinum black suspension. The infected tubes were plugged with cotton-wool, and thus there was free access of air to the medium. The tubes remained anaërobic for twenty-four to forty-eight hours, and, in cases where growth occurred, for all the time that growth was taking place. *B. botulinus* grew extremely well and regularly, the bacillus of malignant oedema less regularly, but when it did grow it gave a luxuriant growth. *B. tetani* did not grow well, and occasionally did not grow at all. It formed little toxin, and the bacilli stained badly.

After these methods had been devised, my attention was drawn to a paper by Pfühl,¹ who describes some methods of growing bacteria with free access of air. In one of these methods he adds 1 gram spongy platinum to bouillon, and boils out all air just before infecting. Care is taken not to shake the tube, and so allow the medium to take up oxygen. In this way anaërobic bacteria would grow. The exact part played by the platinum in his experiments is not quite obvious, as he does not seem to have added a reducing agent in order to make the reaction continuous. Moreover, the amount of platinum used is prohibitive, although it can be recovered.

In Methods 2 and 3 the platinum is never recovered, but as the weight of the metal thrown away is extremely small, the cost is not great. The platinum sol is made by making an arc between platinum electrodes under water. The sol is protected by the addition of a small amount of gelatine, and sterilized by repeated boiling and incubating.

The last two methods require further work to endeavour to get over the uncertainty and the poor growth of *B. tetani*. Moreover, the fact that some specimens of broth give poor results is a serious objection; and as the colloidal platinum is easily aggregated, and thus its efficiency as a catalyst destroyed, it may be that the difficulties will never be overcome. The colloidal metal seems to have no deleterious effects on the growth of the organisms, unless it is on this account that *B. tetani* does not grow very well. In the case of organisms of botulismus and malignant oedema, on the other hand, the growths are very good, and a rich crop results.

It seems from all the experiments so far carried out that the first method will prove the best, and the facts that it is so simple, can be used with all kinds of media, and that no addition or alteration of the medium is made in any way, seem to show that it will give the best results in the end.

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THE Pennsylvania Society for the Protection of Scientific Research has opened a campaign for the education of the public concerning medical research. The organization will include a branch consisting of medical practitioners who contribute £2 or more to further the objects of the society. Dr. William Pepper of Philadelphia is the Chairman of the Finance and Membership Committee.

THE THEORY AND TECHNIQUE OF TREATMENT BY RADIUM EMANATION NEEDLES.

By WALTER C. STEVENSON, M.D., B.Ch., D.P.H.,

SURGEON AND X-RAY OFFICER, DR. STEEVENS'S HOSPITAL;
SURGEON, ORTHOPAEDIC HOSPITAL, DUBLIN;
CAPTAIN, R.A.M.C. (TEMPORARY).

BRIEFLY, it may be stated that, for therapeutic purposes, radium *per se* is of no value; it is not till it breaks down and the third and fourth generations of the series of elements that come into existence are reached that therapeutic effects are produced. The therapeutic agents are the penetrating beta and gamma rays which are given off during the disintegration of radium B and radium C. The disintegrating radium atom at ordinary temperatures turns into a gaseous element—radium emanation—a gas that can be collected by means of a mercury vacuum pump and utilized as a much more convenient source of radium B and radium C than the solid radium salt.

The disadvantage of using a radium salt is that, owing to its great costliness, it cannot be changed from one form of receptacle to another to suit the requirements of different cases without serious loss of time and valuable material. This latter loss is more obvious when we consider that 50 mg. of radium chloride, which is at present worth at least £1,000, has approximately the same bulk as a grain of calomel.

The only serious disadvantage of radium emanation as a source of radiation is that, owing to there being no parent radium present to go on producing it, it is dissipated comparatively rapidly, its activity being reduced to half in 3.85 days.

At the end of any and every hour there is 0.75 per cent. less emanation present than at the beginning of that hour. This works out as a loss of 4.4 per cent. per six hours, or 16.5 per cent. per day, and of 71.6 per cent. per week. It must not be lost sight of that for the first four hours after emanation—without radium—is confined in a receptacle its activity increases—that is, till radium C equilibrium is established.

The advantages of radium emanation are: (1) It has a much smaller bulk than the parent radium salt. (2) It can be supplied from institutions at a reasonable cost, while for general use the price of radium is prohibitive. (3) It can be collected in capillary tubes, or flat applicators, or in any shape or size of glass or other vessel suitable for the requirements of the case to be treated, and this without risk of loss or permanent diminution of the value of the parent radium. (4) The loss of a tube of emanation is of comparatively little consequence.

Rationale of Radium Therapy.

In the treatment of deep structures, and especially malignant growths, the great advantage radium possesses over x rays is that the source of radiation can be inserted among the actual cells to be treated, and the rays, therefore, are not expended on the skin and healthy tissues before they reach their goal. By burying radium the cells that require radiation are primarily and principally affected, and protect the skin and healthy tissues by screening or filtering off from them the less penetrating rays. With the surface application of radium, or by using x rays, the reverse is the case: the skin receives a greater dose than the deep parts because it is nearer the source of radiation. For example, by using a soft and unscreened x-ray tube the skin may be burnt, while the deep structures, being so effectually screened by the superimposed tissues, may not be radiated at all.

In x-ray therapy this undesirable state of affairs is to some extent overcome by using a hard tube which will give off for the most part hard or penetrating rays, and also by interposing filters of various density and thickness, according to the depth of the tissues to be radiated. The filter cuts off the soft rays which would otherwise act on the superficial structures alone. The same consideration obtains in the surface application of radium, with this difference, that the quality or penetrating power of the rays from a given amount of radium is constant. The beta rays (corresponding to cathode rays) and gamma rays (corresponding to x rays) of radium B and radium C

may be roughly divided, according to Rutherford, into three groups:

1. Very soft gamma rays, softer than the softest x rays.
2. Beta rays and gamma rays, which will penetrate 3 mm. of lead (or about 3 cm. of human tissue).
3. The very hard rays of radium C (some of which will not be stopped by several human bodies).

In treating deep structures by the surface application of radium, only Group 3 can be used. Groups 1 and 2 are cut off by filters of 3 mm. of lead, or about half that thickness of platinum.

Surface application of radium is very wasteful, as the rays go in every direction, and only about one-third of them would be directed towards the deep structure.

Filtering is also necessary when radium is buried—that is, when one or two tubes containing anything from 25 to 400 milligrams of radium are inserted in the tissues—as, should the soft rays not be filtered off, the parts nearer the tube will be greatly over-exposed if the more distant parts are to be sufficiently radiated.

The deduction I wish to draw from these considerations is that all filtering in radio-therapy is simply and solely a method of obtaining uniformity of radiation.

I have attempted very diagrammatically to illustrate my contentions in Figs. 1, 2, 3, and 4.

Fig. 1.—Diagram of a tumour treated by unfiltered rays from an x-ray tube. The softer rays are stopped by the skin and superficial tissues, which are over-exposed, and do not reach the tumour, which is under-exposed.

Fig. 2.—Diagram of a tumour being x-rayed, with a filter in use to cut off all but the hardest rays. There is greater uniformity of radiation than in Fig. 1. The skin that is nearer the anode still receives a larger dose, per unit area, than the tumour.

Fig. 3.—Diagram of a tumour radiated by (A) a radium or emanation tube in platinum case, with wall 2 mm. thick to cut off all but the hardest gamma rays of radium C; (B) a tube which will allow beta rays and the gamma rays of radium B to pass. Radiation will not be uniform. If the tubes are left in long enough for the tumour to be sufficiently radiated by (A), there will be over-exposure from soft rays round (B) in the area indicated by heavy lines. If (B) were filtered to the same extent as (A), there might still be sloughing round both tubes, though, at the same time, it would be possible for the periphery of the tumour not to be sufficiently radiated.

Fig. 4.—Tumour treated with six emanation needles placed parallel to and within "soft ray range" of one another. Much greater uniformity of radiation is obtainable than in Fig. 3, without screening off and wasting any of the rays it is possible to use. The softest beta and gamma rays, which it would be impracticable to use without local over-exposure, are intercepted by the 0.3 mm. steel walls of the needle. An almost perfectly uniform radiation of the tumour can be obtained by withdrawing the needles and re-inverting them in intermediate positions. This procedure, which is quite practicable with fine needles, is hardly justifiable when the incisions necessary to bury comparatively large tubes have to be made at frequent intervals of time and space.

Filtering or screening is not an ideal method of obtaining uniformity of radiation, because the intensity of radiation is, approximately, inversely proportional to the square of the distance from the source of radiation. It is not an economical method, as it cuts off the soft, generally considered the "injurious rays," which compose a large proportion of the total rays given off by radium B and radium C. It is not economical either because these soft rays are the most active therapeutically. Every x-ray worker knows the reaction of the skin produced by a soft

tube. This reaction is undesirable in a healthy skin which we do not want to treat, but it is just what is required in diseased cells which we do want to treat.

There is no innate objection to using soft rays, as they are employed in a routine manner for surface conditions. In addition, as pointed out by Professor Joly, it is probable that hard gamma rays do most of their therapeutic work by means of the secondary soft beta rays which result in the cells they traverse.

Screening is merely a method of obtaining uniformity of radiation, and if soft rays are not in themselves injurious, it is obvious that they may be utilized legitimately, provided that there is not over-exposure near the source of radiation, that is, that uniformity of radiation is secured. It is obvious also that a method which will allow the soft rays to be used will greatly increase the therapeutic value of a given quantity of radium. The principle of such a technique, namely, the use of a number of sources of "illumination," was suggested by Professor Joly,¹ and the detail worked out in conjunction with the present writer.²

I shall briefly contrast the method of burying radium or radium emanation in general use with that which I have been employing for the last ten months, as described in the BRITISH MEDICAL JOURNAL of July 4th, 1914. In the former one or two tubes containing at least 25 mg. of radium, usually a great deal more, or an equivalent quantity of emanation, in each instance surrounded by a metal case, are buried. In the latter six, twelve, or any number suitable for the size of the tumour, of fine serum needles, with 1.4 mm. external diameter, each containing 4 or 5 millicuries of radium emanation in glass capillaries of 0.75 mm. external diameter, are utilized. In the former the soft rays are wasted; in the latter they are not only not wasted, but play an important part in the treatment. In the former, uniformity of radiation is obtained by screening off the soft rays; in the latter, by using a number of sources of radiation within "soft ray range" of one another (the very soft rays of Group 1 are cut off by the walls of the needle—that is, by 0.3 mm. of steel). I may add that in the former method the patient has usually to be anaesthetized and an incision made into the tumour, a procedure which is not without risk of causing dissemination and septic infection. In the latter the skin is only punctured by fine needles, which transfix the tumour, and the patient can immediately go home with the emanation needles *in situ*.

The twenty-eight patients I have treated with inoperable malignant disease during the last ten months have convinced me at least that a great deal of good can be done in malignant growths by the use of such small quantities of radiant matter as would be of little service if other methods were employed. The general opinion expressed by those who work with radium is that very little can be effected in the treatment of malignant disease, excluding superficial conditions, with less than 50 mg. of radium. I have never used more than 24 millicuries. Four of the patients were shown at the Surgical Section of the Royal Academy of Medicine in Ireland on January 29th last. As the Royal Dublin Society were good enough to supply me with the emanation to investigate a new method, I was particularly glad to have the opportunity of permitting others to judge of the efficiency or otherwise of this method for dealing with cancer. I value the kindness of members of the various hospital staffs for opportunities of treating their inoperable cases with emanation needles, which treatment I have carried out in several Dublin hospitals, though most of my work was done at Dr. Stevens's Hospital. I am much indebted to Professor McWeeney for his histological reports on the cases, as an independent opinion as to whether the tumour was malignant or not increases the value of the investigation of this method of treating cancer.

The Royal Dublin Society, aided by the munificence of some of our citizens, especially Lord Iveagh and Sir John Griffith, has recently started a radium institute for supplying emanation to the local medical profession. We are also very fortunate in having Mr. Moss, the Registrar of the Society, who has taken unlimited trouble to devise and make suitable apparatus for collecting emanation in fine capillary glass tubes which he makes to fit the fine needles used. Personally, I am most grateful to him for his invariable kindness and for the great interest he has taken in the work.

The price the Radium Committee have at present fixed for emanation is 4d. per millicurie for free hospital patients and 1s. 6d. per millicurie for private patients.

If the result of the method which I have been employing appeals to others the cost of treatment will be less and more patients can be dealt with.

Emanation is so valuable that I endeavour to keep it in constant use until it is practically exhausted. For instance, in a case of cancer of the cervix uteri with involvement of the vagina, I have used an initial dose of 24 millicuries in six needles for four days. I leave them in the first position—usually the posterior lip, as it is the hardest to get at—for twenty-four hours, in the anterior lip for thirty hours, and, lastly, in the vaginal wall for forty hours. The emanation will be reduced by that time to twelve millicuries, so that the patient would receive an average dose roughly equivalent to 18 milligrams of radium for ninety hours, or 1,620 milligram hours. I have then used the same needles for malignant glands, or a large rodent ulcer, for two days, and for a small rodent ulcer for two more; so that the capillaries are in constant use for eight days, until only five millicuries remain. Frequently, when treating such a structure as the cervix, I collect the capillaries a week old into a cannula and insert it into the os uteri, using them for three or four days longer.

From the practical point of view, needles are most convenient to work with, as they are so easily inserted, withdrawn, and reinserted. They give great facilities for suiting the requirements of a case. For instance, a row of needles placed close together enables the thorough and systematic radiation of a growing edge, which is often of vital consequence when an important structure tends to be invaded. The dose, which of course is a matter of experience, is under perfect control. A short capillary and needle is used for the tonsil, or palate; long ones for a large tumour. The risk of over-exposure is at a minimum when only small quantities of emanation are used in each needle, as there is a considerable margin of safety in the length of exposure. It is somewhat like comparing the latitude of exposure which is permissible in taking a photograph in very strong sunlight and in a dull diffuse light—in the one case the exposure must be measured in tenths of a second, while in the other half a minute might not make any great difference.

The exploring needle is charged by slipping the capillary glass tube containing emanation into it, and then placing the needle in a dish of melted hard paraffin. The needle is taken out, its outside wiped and the paraffin allowed to set inside. The needle is then examined with a fluorescent screen to make certain of the position of the capillary, which should be towards the sharp end, and to see that it has not slipped out, as sometimes happens with a new needle. I use a glass tube of willemitite to see the glow, but have found that the needles immersed in boric or carbolic lotion, or if placed on a white marble slab, will show fluorescence also.

The needles are then inserted into the tumour parallel to one another and not more than one inch apart, usually a good deal closer. The length of time for which the needles are left in depends on the size of the tumour, the amount of emanation in each capillary, and their distance apart, but is independent of the number of needles used if the area is correspondingly larger; because using more needles at the same distance apart simply means that a larger area is being simultaneously treated.

The different localities in which cancerous affections have been attacked shows how convenient the method is. I have used emanation needles in growths of the floor of the mouth, tongue, tonsil, pharynx, palate, antrum of Highmore, orbit, frontal sinus, glands in the neck, abdomen, vagina, and cervix uteri. No surgeon would have had any hesitation in saying that the cases I have treated were quite beyond operative interference, and indeed they were sent to me, as a last resort, to see if, by radium treatment, anything could be done to relieve their distress. Under such circumstances, and with this small amount of radium available in Dublin, it was hopeless to expect dramatic cures; but it is a great satisfaction to me to have been able to bring about the local and general improvement, prolongation of life, and relief of pain exhibited in practically every patient treated.

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SMOKE AS A FACTOR COMPLICATING CARBONIC OXIDE POISONING IN COLLIERY DISASTERS.

By E. EMRYS-ROBERTS, M.D.,

PROFESSOR OF PATHOLOGY AND BACTERIOLOGY IN THE UNIVERSITY OF WALES.

It is well recognized that, following explosions of fire-damp and coal dust, and underground fires, the chief danger lies in the in-breathing of CO. For this reason, much attention has been directed to the symptoms and treatment of CO poisoning.

It is also true that many divergencies in the symptoms of CO poisoning have been observed from time to time, and that these have rightly been attributed to the admixture of other gases.

But the part played by smoke, produced at the time of the explosion, or fire, does not appear to have met with the consideration its importance deserves. In addition to CO and CO₂, smoke contains numerous irritant gases, comprising sulphurous and nitrous fumes, acetic acid and ammonia. These dangerous and irritant gases when met with, especially as a result of underground fires, in dense volumes in a confined space give rise to immediate symptoms of a profuse running at the eyes, and coughing, accompanied by a sensation of choking.

These immediate symptoms may give place to those of CO poisoning, if the latter gas has been inhaled, and may thus become virtually masked in the more evident state of CO poisoning.

The irritant gases present in smoke, however, when inhaled under such circumstances, produce after a certain lapse of time, generally a few hours, a well-marked remote effect upon the lungs. In the more fortunate cases bronchitis is superadded to the symptoms of CO poisoning, but in severe cases acute oedema of the lungs, or even bronchopneumonia, may develop.

The development of these complications may naturally increase the dangers of CO poisoning very considerably, and cases are on record in which the greatest difficulty has been encountered from this cause.

That these complications are due to the action of the irritant gases present in smoke is abundantly proved—first, by the fact that in cases of CO poisoning uncomplicated by smoke pulmonary symptoms, such as have been described above, never develop; secondly, that in those cases in which the pulmonary symptoms described have developed there is an invariable history, when such is obtainable, of exposure to smoke; and, thirdly, that in cases of poisoning by nitrous fumes following the use of explosives, whether in the mine field or on the battlefield, precisely similar pulmonary symptoms are met with.

Since the irritant gases present in smoke are freely soluble in water, it might be advantageous to emphasize the value during exposure of tying a wet cloth over the mouth and inhaling through it, and at the same time to point out the fallacy of employing a dry cloth for the same purpose.

THE *Medical Record* of January 30th notes that over two years ago Dr. Little described a form of neuritis rather common in Newfoundland and the coast of Labrador, where many of the natives live on a restricted diet consisting to a great extent of highly milled white flour. He was of opinion that the disease was true beriberi, and more recently Ohler, in the *Journal of Medical Research*, 1914, reports experimental results that bear out Little's conclusions. Chickens fed exclusively on white bread, either with or without yeast, hominy or milled rice, developed polyneuritis gallinarum within six weeks. It is not settled that this disease is identical with beriberi in man, but it would seem that the two conditions are sufficiently alike in their course and etiology to permit of satisfactory conclusions. Control experiments indicated that Ohler's conclusions were worthy of acceptance. The evidence would indicate that white bread as a sole article of diet is undesirable, as it lacks the necessary vitamins.