- Lennox, W. G. (1931). *Epilepsy and the Convulsive State*, p. 475. Baltimore.
- Levine, S. (1936). *Clinical Heart Disease*. Philadelphia and London.
- Lewis, Sir T. (1932). *British Medical Journal*, **1**, 873.
- and Cotton, T. F. (1918–20). *Heart*, **7**, 23.
- Lyon, D. M., and Dunlop, D. M. (1933). *Edin. med. J.*, **40** (N.S.), 266.
- Morgagni, J. B. (1761). *De Sedibus et Causis Morborum*, Venetiis, Ep. **24**, Art. **33**, p. 263.
- Oppenheim, H. (1911). *Textbook of Nervous Diseases*, **2**, 1217. Edinburgh.
- Oppenheimer, B. S., and Fishberg, A. M. (1928). *Arch. int. Med.*, **41**, 264.
- Penfield, W. (1936). *Arch. Neurol. Psychiat.*, Chicago, **36**, 449.
- Prinzmetal, M., and Bloomberg, W. (1935). *J. Amer. med. Ass.*, **105**, 2051.
- Russell, A. E. (1909). *Lancet*, **1**, 963.
- Ryle, J. A. (1931). *Ibid.*, **1**, 737.
- (1934). *British Medical Journal*, **1**, 89.
- Spens, T. (1793). *Med. Commentaries for the Year*, **7**, 458. Edinburgh.
- Starr, I., and Collins, L. H. (1931). *J. clin. Invest.*, **9**, 561.
- Stokes, W. (1846). *Dublin Quart. J. med. Sci.*, **2**, 73.
- Sutherland, G. A. (1927). *Lancet*, **1**, 1221.
- Walker, A. E. (1936). *Arch. int. Med.*, **58**, 250.
- Weiss, S., and Baker, J. P. (1933). *Medicine*, **12**, 297.
- Wilson, S. A. K. (1928). *Modern Problems in Neurology*. London.

AN INVESTIGATION OF INTERNAL RADON THERAPY

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In this country the use of radium has been largely confined to its local action in the treatment of malignant conditions in which the objective is a destructive or deterrent effect upon the growth. In America and on the continent of Europe radium and other radio-active substances have been administered internally in small doses spread over long periods as therapeutic agents in a wide field of medicine, and considerable claims have been made as to their value. Apparatus capable of producing radio-active solutions for oral administration, injections containing small quantities of radium salts, and radio-active pads for external application have, however, appeared on the market here, and there is some evidence that their use is on the increase. Many of these are available not only to the medical profession but also to the public.

It was thought worth while at this stage, therefore, to investigate certain aspects of the subject under complete hospital routine, and the present paper is an account of the results obtained during the last five years. Although, as will be seen, the therapeutic results have been largely of a negative character, this is thought to be no reason for omitting to publish the data.

The objects of this investigation were: (1) to determine what physiological or biochemical changes might be induced in patients by such comparatively small doses as those generally used; (2) to assess the value, if any, of such treatment upon various diseases; and (3) to ascertain the effects of stronger dosages than those hitherto employed and to find when they become dangerous. Before recording the results of our experiments the following brief survey of what is sometimes known as "mild radium therapy" and of the literature available upon the subject is given.

Mild Radium Therapy

The first disintegration product of radium is the radio-active gas radon. From the point of view of therapy it is important to distinguish clearly between the internal uses of radium salts and of radon.

The salts of radium may be given by the mouth or may be injected intravenously or subcutaneously. Both methods are attended by definite risk. If given by the mouth considerable damage may be done to the mucous membrane of the intestines, especially if the patient undergoing treatment is constipated and the salts are held up. When injected intravenously it is stated (Oloff) that 80 per cent. is retained in the tissues, principally in the bone marrow, and that it disappears from these situations only very gradually indeed. Thus deposits of radium are formed from which radon may be produced for a long time.

There is not enough evidence to determine the exact quantity of radio-active salts which constitutes a lethal dose in man, but it is obvious that the internal administration of radium is attended with the gravest risks. According to Gudzent, a single dose of salt containing the equivalent of 0.5 mg. of radium element can prove fatal. Among the women who have lost their lives working with luminous radium paint the total amount of radium found in the body at the time of death ranged from 0.01 to 0.18 mg. The death of an American citizen was caused by the self-administered and repeated use of a solution containing one-thousandth of a milligramme each of radium and mesothorium per ounce of water.

The introduction of radon into the body, however, presents a totally different problem from that of radio-active salts. Its activity does not last long, declining to one-half in 3.85 days and diminishing to less than 1 per cent. in a month. When radon is taken by the mouth about 90 per cent. of the gas is eliminated through the lungs within an hour or two, and no more is exhaled after five hours. It remains in the urine for a longer time, but very little stays in the body to form "active deposit" (Flinn).

There is, however, another important distinction between the uses of radon and radium salts. Radon is a soluble gas, so that when swallowed it can be absorbed from the alimentary canal, and may, through the circulation, reach every tissue in the body. In this way it may be anticipated that there will be very free action by the alpha rays, which are known to have an intense local effect, not necessarily the same as that produced when radium is applied in platinum or other containers which exclude the alpha rays entirely.

The unit of radon is the millicurie, which is the amount of the gas in equilibrium with one milligramme of radium element. This unit has often been considered much too high for the measurement of very weak concentrations, and the Maché unit has accordingly been substituted; 2,500,000 Maché units are equivalent to 1 millicurie, or 1 Maché unit (M.U.) = 4×10^{-7} millicurie.

Some spa waters are radio-active, and one of the strongest of these is the spring at Joachimstal, which has a content of 600 M.U. per litre. Most radio-active springs contain weaker solutions than this, that of Baden-Baden, for instance, being 104 M.U. per litre. It will be seen, therefore, that the radio-activity of natural waters is exceedingly small, though perhaps not negligibly so.

Artificial radio-active waters can be prepared in very high concentration, but most of the work published on the subject has been done with daily dosage of from 8,000 to 30,000 M.U. per day, usually contained in one litre of water, although some (Bickel) have worked up to

100,000 M.U. From a search in the literature on the subject it appears by far the highest concentration which has as yet been used was in the treatment of six cases at the Radium Institute, London; in one of these the daily dose was as high as 1.5 millicuries.

Some experimental work has been done on animals. Jansen and Schultzer (1926), using the continuous inhalation method in high concentration, found that rats lost weight and died. The coagulation time of the blood was increased, and there was a marked leucopenia. At the post-mortem examinations haemorrhages were found in the lungs, the spleen was enlarged, and there was glandular atrophy.

known spas, but no statistical evidence has been adduced to show that treatment at those spas in which the radium content is relatively high is accompanied by any enhanced therapeutic effect.

The Present Investigation

Preparation of the Radon Water.—A simple apparatus was required to provide aqueous solutions of radon having a wide range of strength, the mean being about one millicurie in 10 oz. of water. The apparatus to be described has been found to satisfy these requirements.

DESCRIPTION OF APPARATUS

The source of radon is an aqueous solution of radium bromide. It is contained in the small flask A, which has a volume of about 50 c.cm., and which is approximately half full of a solution which contains radium bromide equivalent to about 25 milligrammes of radium element. The flask communicates through glass tubing with the Woulfe's bottle D, which has a capacity of about 250 c.cm., and can be shut off by the stopcock C. A second tube carrying the stopcock B enables radon to be swept out of the apparatus, when the occasion arises, by bubbling air through the solution. The bulb A rests on a rubber pad contained in a stout glass jar, which serves to retain the radium solution in the event of breakage of the bulb. The jar is at floor level, and the flask with its connecting tubing is supported on a wooden framework fitted through the top of the table, upon which the Woulfe's bottle D rests. This arrangement permits heavy screening blocks of lead to rest on the floor and surround the whole table for the protection of the personnel. Further lead blocks are placed close to the jar containing the radium bulb. The supply of water comes from a large Woulfe's bottle K (capacity 12 litres), which is supported on a wall bracket at about a foot above H. It acts as a reservoir, and is fed from the water main, which can be shut off at the tap G. The reservoir is open to the air through the stopcock F, which is provided with a filter of cotton-wool to prevent entry of dust and micro-organisms. The two Woulfe's bottles are provided with scales in order to be able to repeat any particular water level. By varying the level in H it is possible to work with concentrations of radon ranging from 0.02 to 4 millicuries per 10 oz. The actual content of radon is found by measurements on a gamma ray electroscope. With the smallest concentrations the measurements are made by means of the beta ray electroscope devised and described by B. A. Spicer.

METHOD OF OPERATION

The normal positions of the stopcocks are shown in the diagram, but it is well to close C during the initial filling of the bottle H. The bottle H is filled to a mark predetermined by experiment, for it is the water level in this bottle which determines the concentration of radon that is obtainable. Once set, the water level in this part of the apparatus remains sensibly constant. With the tap E shut, the upper reservoir K is filled from the mains to any convenient scale mark selected as a working level. With the main tap shut off the taps E and C may now be opened, and the whole apparatus is left for the radon to diffuse into the vessel H, a proportionate part of it diffusing throughout the water, the coefficient of solubility of which is 0.3 at 14° C. When the steady state has been attained the radon solution is drawn off into any suitable vessel (such as a bottle which can be corked) by opening the tap D. The water in H is automatically replenished from the upper reservoir, the water level in which is maintained by admitting water from the main.

The Clinical Tests

The cases selected for our observations were mostly patients suffering from various forms of rheumatism, such as osteo-arthritis, chronic rheumatoid arthritis, fibrositis, and neuritis, although other diseases were also included in the series. They were separated into the two categories out-patients and in-patients.

Apparatus for the supply of radon solutions of varying concentration.

The basis of the claim made for the administration of radon in general therapeutics is that small quantities have a stimulating effect upon cell activity. In addition to this general cell stimulation it is further claimed that radon "has a selective action, promoting the growth of healthy cells, whilst being inimical to morbid ones, that it stimulates the production of erythrocytes, lowers the blood pressure, produces diuresis, and increases the excretion of uric acid" (Saubermann).

From published clinical reports it appears that the most favourable results have been obtained in various forms of rheumatism, although improvement has also been reported in hyperpiesia, in endocrine disturbances, and over a wide field of pathological conditions. Successful clinical results are undoubtedly obtained at many well-

OUT-PATIENTS

These patients were given small doses of radon, equivalent to the larger doses referred to in the literature. They came to the hospital daily, and drank measured quantities of radon water. The treatment was begun with one-thirtieth of a millicurie (80,000 M.U.) in 15 oz. of water. Treatment was continued daily for four to six weeks in each case. There were twenty cases in this series.

Clinical notes were taken, including the weight and blood pressure of each patient and also of the general reaction to treatment. Blood analyses were also made. In the arthritic cases the degree of limitation of movement in the joints was also noted, and in some cases x-ray photographs were taken both before and after treatment.

In assessing the value of any treatment on purely clinical observation it is important to bear in mind the following pitfalls.

1. *The Psychological Factor.*—Sufferers from chronic disabilities such as rheumatism are extremely susceptible to suggestion. Every physician who is accustomed to dealing with chronic disease is aware of the eagerness with which patients are apt to embrace any new treatment; particularly is this the case when any enthusiasm is shown on the part of the prescriber. Such enthusiasm may be of considerable therapeutic value, but it may obscure the true merits of the remedy. In this instance the very word radium engendered hope. For this reason the patients were not for the most part told the nature of the fluid they were drinking; other steps were also taken to ensure that any effect upon the patients produced essentially by the radon in the water could be substantiated.

2. *Intercurrent Factors.*—All chronic conditions normally run a variable course, with a tendency to remission. The story told by a patient at any given moment, say at the end of a course of treatment, does not necessarily give a fair impression of the trend of events. In the case of arthritis such factors as damp, alteration of temperature, and particularly mental strain and physical fatigue have a temporary but considerable adverse effect. For this reason the symptoms were not only noted during and at the termination of the treatment, but they were also seen at intervals during two years after its cessation.

3. The difficulty of withholding other forms of treatment during the investigation, particularly in cases where local pain is evident. It is frequently impossible to satisfy a patient solely with a general measure, and in cases of increasing pain or stiffness it would be wrong to do so. Such accessory treatments obscure the value of the remedy under investigation.

Taking all these facts into consideration we were unable to find any change in the clinical condition of these patients as the result of ingestion of radon in doses ranging from 80,000 to 240,000 Maché units.

IN-PATIENTS

These were subjected to strict hospital routine, and in them it was possible to make a more detailed investigation, including various pathological tests. They were given much higher dosages, ranging from 1 millicurie (2,500,000 M.U.) to 4 millicuries (10,000,000 M.U.) per day in 10 oz. of water. Various conditions were treated, including chronic rheumatism and hyperpiesia. As controls three cases were given the same diet and general conditions as the treated cases, and the same investigations were undertaken, using tap-water instead of radon water.

In the rheumatic group male patients representing various types of the disease were selected, and these were all admitted to the same ward, so that conditions of diet, fluid intake, and exercise could be controlled to the same standard. Notes were taken of the clinical condition, and general investigations, including radiographs of the joints, were made before treatment began. Initial blood counts and analyses and urine analyses were also made, and these were repeated at weekly intervals during the radon treatment. The following pathological investigations were undertaken.

The blood.: The erythrocyte count and haemoglobin index, differential white counts, and, in addition, the blood uric acid, urea, and calcium values were estimated. *The urine*: A routine examination was made, and the uric acid, urea, and creatinine contents were determined. The following results were obtained.

Results

In the majority of cases the blood counts of both red and white cells were uninfluenced. In certain instances, however, the erythrocyte count showed a marked tendency to fall, particularly when a dosage of 2 to 3 millicuries was reached and maintained; in two of these the fall amounted to one million red cells per cubic millimetre.

The differential white cell count was not appreciably altered except in the cases of gout, where there was an eosinophilia. The results of the blood and urine analyses were all within normal limits, with the exception of the gouty cases (vide Table).

GOUT (THREE CASES)

In three patients the administration of radon in large doses caused a definitely increased output of uric acid in the urine, but it was impossible to correlate this with the blood uric acid levels. Two of the cases (Nos. 3 and 5) showed a slight increase in blood uric acid during the early stages of treatment which later returned to the original value, but Case No. 5 developed a subacute attack of gout just as the treatment began, thus obscuring the value of the results. The third case (No. 6) showed a slight fall in blood uric acid level, later returning to the original value.

CONTROL AND RHEUMATIC CASES

In certain of the control and rheumatic cases with the same fluid intake there was a slight increase in the uric acid output, but not, however, commensurate with that seen in the gouty cases. In the controls and rheumatic cases the blood uric acid fell within normal limits.

All the other biochemical investigations, including the estimations of blood urea, calcium, and phosphorus, gave results within normal limits.

Clinical Findings

No improvement was noted in any of the cases of chronic arthritis, whether of the atrophic or degenerative type. No increase in the movement of the joints was obtained, and no relief of pain in the muscles. The general condition remained unaltered. In certain cases of chronic gout, however, there did appear to be an improvement in the general symptoms, and in one instance at the end of treatment there was a marked reduction in the size of the tophi.

A few cases of hyperpiesia were treated. In these an initial fall in the blood pressure was sometimes obtained, particularly when large doses were employed, but this fall

was not maintained, and the final readings were not lower than would have been expected as a result of prolonged rest in bed.

Case Histories from the Rheumatic Group

Case 1.—A patient, aged 30, with spondylose rhizomélîque, had had ten years' history of increasing pain and stiffness in

the back, spreading to other joints. On admission there was general muscular atrophy and joint fixation, but no focal sepsis or history of gonorrhoea. The temperature, pulse, respiration, and nervous system were normal. An x-ray examination of the spine showed complete ankylosis with ligamentous calcification. In both hips and the right shoulder there was complete ankylosis; in the left shoulder and knees there was less complete ankylosis. The bones of the carpus

Case 1

[illegible]

Case 2

Case 2																							
5,2.35				6,250		52	3,260	41	2,580	3	2		2	32	34.7	43	1.96	148	480	10.8	5.24	3.36	
11.2.35	2 mc.	4,040,000	92	5,650	1.5	46.5	2,630	47.5	2,690	1	4		1	32	34.5	43.4	1.74	155	487	10.5	4.91	3.39	
18.2.35	3 mc.																						
26.2.35		4,260,000	81	10,100	0.98	67	6,750	26.5	2,680	3	1	0.5	2	30	32.4	43.2	1.58	160	495	10.1	4.97	4.07	
6.3.35		4,450,000	89	11,350	1.01	70	7,940	20	2,270	8	2												
11.3.35		4,365,000	86	8,700	0.99	69	6,000	29	2,520	3	1	1	1	37	33.2	52	2.17	152	560	10.75	5.30	3.45	
22.3.35	stop red	4,460,000	85	7,300	0.96	56	4,100	37	2,700	4	1.5		1.5	33	33.7		2.36	155	388	10.6	6.26	2.84	
5.4.35		4,590,000	86	6,500	0.94	48	3,120	44	2,850	2	2.0	1	1.5	31	34.5		2.34	161	545	10.7	4.98	2.97	
19.4.35		3,870,000	90.5	8,900	1.17					Transitional cells 1.5								1.84		413	10.9		

Case 4

19,3.34		6,250,000	110	7,500	0.89	67	5,020	30	2,250	2		0.5	0.5	37	36	48	3.04	150	487	11.45	6.10	3.04
26,3.34	1 mc.													34	36	44	3.66	155	479	11.45	6.20	2.87
10,4.34		5,610,000	104	8,800		59.5	5,220	32.5	2,860	3	2	1	2	28	34	38.6	3.76	139	478	11.65	5.08	3.16
23,4.34		5,520,000	110	8,600	1.0	59	5,080	31	2,660	3	4	1	2	26	25	48.5	3.80	124	445	11.15	4.82	2.84
4,5.34		4,645,000	99	8,000	0.9	75	6,000	18.5	1,480	2.5		1.5	2.5	26	23	53	3.68	129	512	11.25	5.34	2.41
28,5.34	After	5,370,000	116	10,000	0.99	62	6,200	32	3,200	2	2		2	32	33	45	4.66	148	365	11.30	7.00	3.34
26,11.34	After	5,190,000	105	10,500	1.02	72	7,580	23	2,420	2	1.5		1.5	31	30	48.3	3.04		495	10.80	5.94	2.96

Case 3

[illegible]

Case 5

Date	Blood Counts			Colour Index	Polymorpho-nuclears		Lymphocytes		Monocytes	Eosinophils	Basophils	Hyaline	Blood Urea	Uric Acid	Calcium	Urine Output	
	R.B.C.	Hb	W.B.C.		Per cent.	Total	Per cent.	Total								Uric Acid	Creatine
22 5 36	4,420,000	90	9,700	1.02	52.5	5,400	40	4,120	2	2.5	/		47	4.90	11.7	0.33	1.17
29 5 36	4,690,000	93	7,600	1.00	56.5	4,300	30	3,280	7	3	1					0.49	1.16
5 6 36	3,970,000	71	10,150	0.89	79	8,000	18	1,820	3	1			46	5.05	10.2	0.97	1.14
12 6 36	4,160,000	76	11,900	0.91	64.5	7,650	27	3,210	0.5	7	1		47		10.4	0.52	1.19
19 6 36	4,490,000	76	8,550	0.85	56	4,780	39.5	3,380	1.5	2	0.5		53	5.30	10.3	0.504	1.07
26 6 36	4,160,000	74	8,650	0.89	72.5	6,280	20	1,730	4	3	0.5		57	5.60	12.1	0.48	1.25
3 7 36	3,930,000	71	9,900	0.91	62	6,120	25.5	2,530	7.5	3			55	4.25	12.1	0.40	1.02
13 7 36	4,499,000	77	10,000	0.86	64	6,400	29	2,900	6				40	4.15	12.0	0.218	1.23
25 9 36 Out-patient	4,860,000	95	6,300	0.98	50	3,150	39	2,460	9	2			57	5.32	10.6		

Case 6

19 6 36	4,240,000	76	4,650	0.90	52	2,420	39	1,810	3	4	2		60	4.37			
26 6 36	4,500,000	80	5,250	0.88	49.5	2,600	39	2,100	4	5	2.5		66	4.04	11.0	0.266	1.14
4 7 36	4,420,000	79	8,000	0.89	61.5	4,900	32	2,560	3.5	2.5	0.5		58	3.40	10.9	0.290	1.11
10 7 36	4,630,000	84	9,550	0.91	55.5	5,300	34.5	3,300	3	7			48	3.44	10.8	0.425	1.18
20 7 36	4,700,000	83	9,750	0.88	69.5	6,750	21	2,040	5	4	0.5		48	3.90	10.6	0.404	1.14
29 7 36	4,790,000	84	10,300	0.88	72	7,420	24	2,480	2	2			40	4.15	11.0	0.300	1.06
25 9 36 Out-patient	3,870,000	81	9,200	1.05	62	4,450	24	1,720	10	2	2		44	4.40	10.95		

and hands were rarefied, but there was no ankylosis. Radon was given for two days at 2 millicuries, and for sixteen days at 4 millicuries. The clinical condition remained unchanged.

Case 2.—In a patient, aged 55, with spondylitis the pain in the back had begun eighteen years previously, with progressive stiffness. On admission the nutrition was poor, but there was no obvious infective focus. The arthritis was of the degenerative type, with limitation of movement in the spine, right hip, and right shoulder. There was coincident fibrositis and right brachial neuritis. The blood and urine were normal. Radon was given for six days at 2 millicuries and for twenty-eight days at 3 millicuries. The clinical condition remained unchanged.

Case 3.—A patient, aged 59, had fibrositis and early osteoarthritis. On admission the nutrition was fair and there was no evidence of infection. There was generalized muscular pain, which was increased on movement. The heart and blood pressure were normal. An x-ray examination revealed some lipping of the thoracic and lumbar vertebrae. The blood and urine were normal. Radon was given for six days at 1 millicurie and for twenty-two days at 3 millicuries. The clinical condition was unchanged, but eighteen months later gouty tophi were found.

Case 4.—In a patient, aged 19, with fibrositis there had been a history of two years' increasing pain in upper thoracic region. On admission the nutrition was good, but there was a tendency to dorsal kyphosis, with inability to flex the neck. An x-ray examination revealed a possibly normal spine, but there was irregularity of the ninth, tenth, and eleventh dorsal vertebrae. The other joints were normal. There was no evidence of infection or of tuberculosis, and the nervous and cardiovascular systems were normal. There had been no improvement under diathermy and other physical treatments. Radon was given for thirty-seven days at 1 millicurie without benefit. The spine was manipulated later with some improvement.

Case 5.—A patient, aged 49, with tophaceous gout, had had the first attack nineteen years previously in the right foot. Acute attacks followed at intervals of three to six months. On admission large gouty tophi were seen on the knees and ears. One, which had been removed from the finger seven weeks before admission, had left a septic focus.

The x-ray examination showed a general rarefaction of all the bones of the hands suggestive of coincident rheumatoid arthritis. The blood uric acid figure was 4.9 mg. per cent., and the sedimentation rate was 30 mm. in the first hour. The value of the pathological tests was somewhat obscured by a subacute attack occurring just before treatment. Radon was given for six days at 1 millicurie, for six days at 2 millicuries, and for twelve days at 3 millicuries. Some improvement was noted in the general condition, and there was definite reduction in the size of the tophi.

Case 6.—In a patient, aged 59, with gout, pain began in the left hand and left foot, and there was a four-years history. Other joints had since been affected. On admission there was swelling of the right wrist and left ankle. The x-ray examination disclosed the typical punched-out gouty areas and slight rarefaction of bone. The blood urea figure was 60 mg. per cent., and the blood uric acid 4.37 mg. per cent. There was no obvious infection, and the other systems were normal. Radon was given for six days at 1 millicurie, for six days at 2 millicuries, for six days at 3 millicuries, and for six days at 4 millicuries. On discharge the pain and swelling in the affected joints had diminished, and there was some general improvement.

Conclusions

In the series of cases (out-patients) in which radon was given in small doses, such as those obtainable from apparatus in present use, no demonstrable change was found in the clinical condition. Subjective improvement, due to the psychological stimulus and to other factors operating during the experiment, was neither more marked nor more frequent than in the controls. Patients seen two years after treatment did not ascribe any permanent amelioration of symptoms to the treatment. On the other hand the blood counts were not affected, and no injurious results were encountered.

In the series of cases (in-patients) in which radon was given in very much larger doses no improvement was noted in the clinical condition, except in certain cases of chronic gout. The chemical analyses of the blood were unaffected, again with the exception of the uric acid readings in this latter group. More work remains to be

done to determine exactly what value radon has in the treatment of gout.

The erythrocyte count, however, showed a tendency to fall when large doses were employed, in certain instances to a serious degree. It appears, therefore, that with large dosage the administration of radon is attended by definite risk, and it should be administered with great caution.

BIBLIOGRAPHY

- Bickel, A. (1927). *Med. Welt*, 1, 423.
 Flinn, F. B. (1934). *Amer. J. Roentgen.*, 31, 830.
 Gudzent, F. (1922). *Klin. Wschr.*, 1, 1658.
 Jansen, H., and Schultzer, P. (1926). *Acta Radiol.*, 6, 631.
 Martland, H.S. (1929). *J. Amer. med. Ass.*, 92, 466.
 Oloff, A. (1925). *Fortschr. Ther.*, 21.
 Report of the Radium Institute (1913). *British Medical Journal*, 1, 149.
 Saubermann (1913-14). *Arch. Roent. Ray*, 18, 99.
 Spicer (1936). *J. Sci. Instruments*, 13, No. 8.

PSYCHOLOGICAL FACTORS IN RHEUMATISM

A PRELIMINARY STUDY

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PART I

Psychological factors play an important part in initiating and maintaining illness, especially those forms of illness which are grouped under the heading of general medicine. This is widely accepted, but is vaguely understood. This paper is therefore prefaced with a brief account of the ideas underlying the term "psychological factors" as related to illness.

Psychological Factors

An individual enters the world with a particular structure, a particular chemical and physical make-up, and a particular mode of behaviour. This idea is sometimes put in another way by saying that he inherits a certain constitution (which refers especially to structure), a certain diathesis (which refers especially to chemistry and physics), and a certain pattern (which refers especially to behaviour). Among the patterns which he inherits from his ancestors, his race, and his species are those which drive him to behave as a human being. These patterns of behaviour are often called instincts. They include the deep-seated instincts common to all animals—namely, those of self-preservation—with the drives to eat, to drink, to fight, and to escape; and those of sex—with the drives in the earlier years to love the mother, and later to mate and to succour the offspring. The more distinctively human tendencies include the drives to create and to construct in the physical world of things or in the mental world of ideas.

As an individual grows in time he meets things, forces, and happenings to which we give the name "environment." As he meets new factors in his environment he reacts to them, and sometimes he reacts in such a way that he is described as ill. Illness is not an external object which a person "catches," but is a reaction on the part of the individual to factors of his environment. The environmental factors which provoke a reaction of illness belong to two groups. First, there are those which the individual meets by direct contact of his body tissues. These include the physical agents of mass (which causes trauma); of light, heat, wet, and cold; chemical agents such as drugs, poisons, and foodstuffs; and biological agents such as micro-organisms. Secondly, there are the factors which frustrate, or threaten to frustrate, the instincts and drives of the individual, as, for example, the death of a loved person, being jilted, financial loss, or

unsuitable occupation. The individual does not encounter such factors by direct bodily contact but through his mind, and because of this they may be called psychological to distinguish them from physical factors. The study of how the individual reacts by illness to psychological factors is called psychopathology. This science is still in its infancy, and is complicated. However, from the standpoint of general medicine it is convenient to consider the problem in simple terms, and we can increase our understanding of illness enormously if we realize that when the instincts are frustrated emotion is manifested.

Emotional Reaction

The bodily mechanism of emotion consists of the triad of the primitive brain, the autonomic nervous system, and the endocrine glands. By means of this mechanism psychological factors may affect an individual profoundly, bringing about changes in chemistry, rhythm, secretion, and even structure in the whole of the body or in any part of it. This may be illustrated by considering the emotion of grief, which is the response to the loss of a person or object that has been loved.

The acute phase of grief may last for days or for weeks, and is spasmodic or paroxysmal in its effects. The symptoms are numerous, and vary from person to person. They may involve every vegetative system of the body. The classical symptoms include tears, sobs, choking sensations, twitching of the lips and hands, pulling down of the corners of the mouth, obliquity of the eyebrows, a general sense of coldness, distaste for food (especially flesh foods and milk), with a feeling of the food sticking in the gullet, and the "heart turning to stone" or "breaking." This last is a feeling as if some foreign body like a lump of rock or iron lay heavily under the left chest wall, and with each movement, or even with each respiration, dull jags are experienced as if the heart were a stone with broken edges. Also, and this is a point of importance to the subject-matter of this paper, the sufferer between the paroxysms of grief feels sore and stiff as if he had been thrashed.

With the passage of time these bodily disturbances may subside; on the other hand, one or more of them may be maintained in the original or in a modified form. For example, in the respiratory system the chokings and sobs may merge into asthma; in the cardiovascular system the pain of the broken heart into angina and palpitation, and the coldness into vasomotor disturbances of the extremities; in the alimentary system the loss of appetite and the sticking of the food may merge into anorexia, regurgitation, vomiting; and in the locomotor system the soreness and the stiffness may merge into "rheumatism." I have seen examples of all these among insured patients who had never suffered from any of those disorders until they had encountered a bereavement and reacted with the emotion of grief.

In such instances the patient's attention was no longer focused on his bereavement, but was dominated by his symptoms, which he interpreted as evidence that he was diseased in the part of the body affected. It may be added that it is doubtful if grief ever occurs in pure form. It is almost always accompanied by anxiety, which is associated with other emotions, such as fear (for example, concerning the future), resentment (for example, against a person, an institution, or even a mental concept such as justice or the idea of God), and a sense of guilt. Regarding the last, Charles Darwin (1872) wrote: "Under the sudden loss of a beloved person one of the first and commonest thoughts which occurs is that something might have been done to save the lost one—'It was my fault, and I should never have left him.' . . ." Similarly also Groddeck (1929), a German physician who was one of the first medical men to take an interest in psychological factors in organic disease, wrote: "In our civilized society everyone whose mother has died believes that he or she is guilty of her death, believes it even when the mother has died in a place far removed." The bodily effects of anxiety are not infrequently found in psychoneurotic