continual direct influence of the rails, which make it easier for the train to travel in the right direction than to jump them and go astray. We might, if we chose, admit that the path was laid down or determined by the mentality of the surveyors and designers of the route; but a Martian spectator with partial information might still wonder at the apparent intelligence which guided one part of a train to Manchester, and another part to Liverpool, in accordance with the wishes of the passengers or the labels on the coaches. If told that an invisible guardian angel switched over the points to produce this result, he might resent the suggestion as absurdly unscientific and preposterous; as on a purely mechanistic view it would be.

After having studied trains for some time, our spectator might begin to notice the novelty of a motor-car. His first tendency would be to look for the rails in that case also; and, finding none, he might superstitiously but correctly surmise that a guardian spirit was guiding the car to its destination. In this case, moreover, further experience would soon persuade him that he had to allow for an element of caprice. But even that is not fatal to the truth: he need not throw up his hands in despair. As soon as we introduce the activity of life and mind we get out of mere mechanism, and the results are not easily formulated or predicted. The activities of an animal cannot be expressed in mathematical terms, and yet animal instincts and behaviour are subject-matter for scientific investigation. It is assumed that they obey laws of some kind.

Science is not limited to the accurate data and laws of mathematical physics: and to claim that a hypothesis is unscientific because we cannot formu-

late it completely, or because we do not understand the method of working, or even because there is a certain amount of capriciousness about it, is more than we have any right to claim. Anthropology and sociology are less advanced sciences than physics and chemistry; they have to get on as best they can, with a profusion of data, and with the inevitable complications appropriate to live things. Let us not be put out of our stride by the fear of retaining, in modified form, some of the animistic guesses of primitive man. Experience may lead us, as it led him, to contemplate stranger modes of existence, and more whimsical phenomena, than our long study of mechanism has led us to expect. We must put aside prejudice, be guided by the evidence, and strive for truth. The superficial simplicity of materialism has served us well, as a comprehensive covering, for three centuries, and we have made good progress under its protection; but it is beginning to be threadbare and inadequate, it is not co-extensive with reality, and unsuspected influences are peeping through.

To sum up. A working hypothesis can be followed and developed rationally, without being metrically exact in its early stages. The important question about the spiritistic hypothesis is not whether it is simple or complicated, easy or puzzling, attractive or repellent, but whether it is true. Its truth can be sustained or demolished only by the continued careful critical and cautious method of inquiry initiated by the S.P.R. under the presidency of a guiding spirit or guardian angel called Henry Sidgwick, with the active (and I believe continuing) co-operation of Edmund Gurney and Frederic Myers.

The Supply and Therapeutic Uses of Radium.

By Prof. S. Russ, The Middlesex Hospital.

THE law of supply and demand is as true for radium as other commodities. Production has often almost ceased owing to lack of demand, only to be renewed as the demand returns, while sudden demands have sent up the price to prohibitive levels until either competition or diminished requirement has brought it down again.

The three main sources from which radium has been mined on any scale are Czechoslovakia, the United States of America, and the Belgian Congo; Cornwall and Portugal have also been producers, though on a smaller scale. The low grade of the carnotite deposits in U.S.A. made it impossible for America to compete with production from the large deposits of pitch-blende located by the Union Minière du Katanga in its property in the Congo since this rich source has been developed. Czechoslovakia still produces radium, and in Great Britain there is very little difference in the price of radium coming from there or from the Belgian Congo. Unless the amount bought is as much as several grams, the price is at present £12 per milligram of radium element, with extra charges for certificates of measurement and other services connected with the supply. This price is doubtless one

which yields a very big profit to the producers, and it is worth while mentioning that the price of the Belgian radium is graded according to the national purse of the buyer—Britain pays more than do her continental neighbours, and America pays more than Britain. There is radium enough in the earth for the world's needs if it can be paid for.

The therapeutic uses of radium are mainly in connexion with cancer, though it is also used for certain other conditions and some dermatological diseases. The outstanding medical interest in radium-therapy is in determining its value and the best methods of application in the treatment of cancer.

Radium-therapy has gone through several phases. In its earliest years, about 1900, success often attended its use in superficial cancers of low malignancy; this was followed by attempts at dealing with internal growths by implanting radium in platinum or other metal tubes into them. Dominici from 1909 onwards insisted on the necessity of avoiding the use of easily absorbed beta and gamma rays when radium was actually inserted into the tissues, and said that only "les rayons ultra-pénétrants" should be used.

By the year 1914 radium-therapy had already made some progress. The principle of selective action was recognised, and there were several laboratories where the effects of the rays on normal and malignant structures were being investigated. All this work received a set-back during the years of the War, but the ten years that have passed since have been a time of great activity and progress in the subject.

France is the home of radium-therapy (Curie-thérapie they prefer to call it), and it is in no small part due to the systematic researches carried out at the Institut du Radium in Paris, organised by Prof. Regaud, that radium-therapy has reached its present phase. This phase is one in which the definite gains of the past give rise to the belief that radium may be looked upon as a means whereby certain localised growths of cancer can be removed as surely as, and generally with less danger than, by surgery. This is a big claim, and it is one now generally acknowledged, but it cannot seriously be suggested that radium is a cure for generalised cancer. Although a primary localised growth often disappears with radium treatment, in cases where the disease has already spread to glands it is generally true to say that the disappearance of growth in one part of the body has little recognisable effect upon the spread of the disease outside the range of action of the radium.

One of the most important principles that has been recognised during the last five or six years is the significance of the time factor. It is certain that the effect of radiation upon a tumour depends not only upon the dose of radiation absorbed by the tumour and the surrounding normal structures, but also upon the time over which the radiation is spread. This is nowhere exemplified better than in the treatment of cancer of the tongue. For many years these growths, often heavily infected with bacteria, were the despair of those who attempted to treat them by inserting one or two radium tubes, containing perhaps as much as 50 milligrams of the element, and leaving them *in situ* for twenty-four hours. With this treatment it often happened that the local condition was actually aggravated. Since the treatment has been altered and a number of smaller tubes containing only a milligram or two have been inserted and allowed to remain for a week or ten days, so great has been the improvement in the results that, to-day, radium combined with surgery is looked upon as the most suitable treatment for cancer of the tongue and buccal cavity.

An explanation of this difference in biological reaction has been sought on various lines, for while some think that it lies in the greater probability of cells in the vulnerable state of division being irradiated in the longer exposure, others believe that cell growth is more affected by prolonged than by short period irradiations, while the opinion is also held that the effect is largely due to the ability of the host to support a low intensity of radiation more easily than a high one. It must not be lost sight of, however, that the two types of treatment are fundamentally different in the distribution of the radium in the tissues. In the second case the

radiation of the region involved is much more uniform and there is more prospect of treating the whole of the growth than in the first case, where one or two tubes containing a large quantity of radium are embedded. This distribution necessarily gives a much too heavy dose to the tissues surrounding the tube, while at the same time much of the growth may be outside the lethal range of action.

Radium is now an acknowledged agent in the treatment of localised cancer, and every year new methods are being devised in order to deal with the more inaccessible varieties of growths (for example, stomach, oesophagus, brain, etc.). But the radium in Great Britain is not enough to treat the numbers of cases of cancer who would probably benefit from its use. It is true that the supplies, especially in the London area, have been considerably increased in the last five years, but in Great Britain generally there is a real shortage. From a national point of view, if an agent is known to be of remedial value in the treatment of any disease, then it would naturally be urged that it should be got, provided there are people enough who know how to use it to the best advantage. These two objects are doubtless in the minds of those who have not only to gauge the nation's radium needs but also to find the means of satisfying them. It is unthinkable that Great Britain cannot really afford the radium that it requires, but the administration of a quantity, let us say a gram per million of population, calls for a good deal of consideration in medical economics. Is the present moment the time for starting a radium centre on the broadest lines where treatment, research, and the teaching of therapy can be carried out? Would it be better to supplement the resources of centres in Great Britain which have already earned a certain reputation? Or would it be better to aim at putting the technique of radium-therapy into the hands of the general practitioners of the country?

The final result, in so far as the economic and efficient treatment of cancer by radium is concerned, is very largely bound up with the decisions of a national character which are likely to be taken in the near future.

In the House of Commons on April 16, Mr. Winston Churchill announced that the Government has arranged for the publication of the report of the Sub-Committee of the Committee of Civil Research on Radium. This Sub-Committee, under the chairmanship of Lord Rayleigh, expressed the opinion that in order to meet the medical requirements of England, Scotland, and Wales, twenty grams of radium should be acquired before the end of 1930. It also recommended the election of 'National Radium Trustees' whose duty it should be to hold the funds provided and to purchase and hold radium for the use of an expert body; this expert body to be called the 'Radium Commission.' Mr. Churchill further stated that the Government has accepted the financial recommendation of the Sub-Committee and that it will be prepared to contribute from public funds, up to a maximum of £100,000, to the extent of £1 for every £1 of private subscription.