Observations

ON

THE THERAPEUTIC ACTION OF ULTRA-VIOLET LIGHT UPON THE EYE.

BY

W. STEWART DUKE-ELDER, M.A., M.D., F.R.C.S.

(From the National Institute for Medical Research, and the Ultra-Violet Clinic, Royal London Ophthalmic Hospital.)

OF late years, owing largely to the work of Leonard Hill and his co-workers, the treatment of general disease by ultra-violet light is being rapidly put on a scientific basis, but hitherto no serious attempt has been made in this country to investigate how far it might be utilized in the treatment of diseases of the eye. To this paper, which is a preliminary report of the experience gained at the Ultra-Violet Clinic of the Royal London Ophthalmic Hospital, I must prefix an acknowledgement of my indebtedness to the Medical Research Council for opportunity and financial aid in this work, and to Professor Leonard Hill and Sir John H. Parsons for much stimulating help and encouragement. The preliminary nature of the paper must be emphasized. The method of treatment cannot as yet be said to be altogether out of the experimental stage, and sufficient experience has not yet been obtained to dogmatize absolutely on its indications and limitations, or to assign to it its ultimate value in our therapeutic armamentarium. The present paper is based on the treatment of seventy cases, and it is hoped that later, when larger statistics have been gathered, fuller and more authoritative reports will be published. At the present moment, however, it is felt that results of sufficient interest have accumulated to warrant publication, largely in the hope that the knowledge of them may stimulate others to supplement them out of their own experience.

At present the therapeutic action of ultra-violet light is largely a mystery which presents theoretically many interesting and elusive problems. The clinic has outrun the laboratory, for the stimulating effect of this form of radiant energy upon the normal individual, and its therapeutic influence in many diseased states, cannot be denied. It is already well known that ultra-violet light, particularly of wave-lengths 2,500 to 3,000 Angström units, exerts a very definite biological action on the skin, whose apparent signs are the production of an erythema followed by death and desquamation of the outermost layers, and that thereby activities of great therapeutic value are called into being. These activities are comprised partly of electrical forces set free in the change of potential involved in atomic disintegration, and partly of chemical factors, the result of the destruction or partial destruction of the cell proteins, the products of whose death and disruption, being set free into the general circulation, increase the non-specific immunity of the body, much in the same manner as the production of homoproteins presumably plays the leading part in the chemical mechanism of defence and immunization against disease generally. In the benefits of these activities the eye shares in common with the rest of the body.

In the treatment of eye diseases ultra-violet light may be utilized in two ways: applied as general light baths to the skin of the body generally, or applied locally to the eye itself. We shall refer to the first as "general phototherapy," to the second as "local phototherapy."

GENERAL PHOTOTHERAPY.

The technique employed by the writer in the administration of general light baths is based on that elaborated by Leonard Hill and Eidinow⁷ at the National Institute for Medical Research. This method of procedure aims at giving the optimum intensity of radiation over the optimum area of body surface as gauged by the estimation of the bactericidal power of the blood. So far as we are aware at present, this is the only systemic effect of radiation which submits itself to scientific estimation on whose basis we can regulate our treatment. Hill, Eidinow, and Colebrook⁸

have shown that after exposure to ultra-violet light this property of the blood is increased, sometimes to a marked degree, the effect being due in large measure to the formation and biological action of photochemical products liberated from the leucocytes. Further, Colebrook⁸ has demonstrated that excessive dosage diminishes the haemo-bactericidal power, an effect which can be correlated with the mental and physical depression which too large doses of ultra-violet light almost invariably produce. The total effect produced varies with the intensity of the radiation and the area of skin exposed; and, going a step further, Eidinow⁴ has shown that the optimum effect is obtained with radiation of such intensity as produces a mild erythema extending over an area of about one-quarter of the body surface.

Individuals vary largely in the degree of their susceptibility to light, and therefore the routine procedure adopted is to estimate first the reaction of the patient by a determination of the duration of exposure required to produce the faintest recognizable erythema. This "minimal erythema dose" is obtained by exposing small areas of the inner surface of the arms or of the back to the mercury vapour lamp at about one metre distance for periods of two, three, and eight minutes. The following day the areas are observed, and dosage commenced whose duration is judged from the standard thus obtained. Thereafter, during the course of the treatment, the body is divided into four areas—the chest and front of the abdomen, the back, the front of the legs, and the back of the legs—and each of these is irradiated on alternate sittings. The patient attends the clinic on three days a week, and in this way practically the whole body is irradiated once in ten days. The object of each dose is to produce the faintest perceptible erythema, after which there is a fine desquamation of the cuticle. This desquamating skin is very opaque to the ultra-violet rays, and to irradiate it would be largely a waste of time; further, the newly exposed skin is extremely sensitive, and gives a strong reaction. The ten days' interval between successive treatments of the same part brings the alternating areas up for re-exposure after the stage of desquamation has passed, and when fresh but not too sensitive skin is exposed. By this routine an optimum reaction is obtained automatically over an optimum area; an optimum increase of the haemo-bactericidal power is induced; and with this—as far as we can judge—an optimum general effect is obtained from the course of treatment.

Sensitiveness varies largely with individuals, and moreover with different parts of the body in the same individual; the back and hams are practically always more easily affected than the front of the body. The dose is therefore regulated for the individual, and varied with the area exposed to suit the case. After some time a certain amount of immunity develops. As a general rule the initial dose is two to three minutes with the mercury vapour lamp (K.B.B., atmospheric, 200 volts, 2 to 3 amperes), and works up fairly rapidly to twelve or fifteen minutes, where it remains for a very long time, since the small dose given and the method of alternately resting the skin keeps it in a condition of "light sensitiveness."

CLINICAL CONDITIONS.

As in the other parts of the body, so in the eye, the diseases most amenable to treatment are the chronic inflammatory. This, in fact, is one of the most satisfactory aspects of phototherapy in ophthalmology, for in many of these cases little can be done by the ordinary methods of treatment at our disposal. The experience gained points to the view that in the earlier acute stages general phototherapy very frequently does more harm than good, and that relapses are prone to occur. The best time to commence treatment appears to be immediately after the acute symptoms have passed off, before the disease can be definitely labelled "chronic," and before the lesion is complicated by the accumulation of massive organized deposits, or restoration rendered impossible by extensive tissue degeneration and destruction.

In the eye cure, from the patient's point of view, is placed on a much higher standard than elsewhere in the body. By him the end-result is interpreted in terms of the vision finally obtained, and whereas elsewhere the

formation of a cicatrix is welcomed as a desirable termination deserving to be considered a satisfactory cure, in the eye such a culmination too often renders the organ useless, and is therefore interpreted as a failure. For this reason it is important to get the cases under carefully supervised treatment as early as is safe. In many chronic cases improvement has been slow, and, although in some the rate of progress has been astonishing, in others the treatment has been a question of weeks or months, calling for no little patience on the part of all concerned. Experience has shown that this should never be allowed to tempt one to increase the dosage beyond the limits already outlined. With the ease with which it lends itself to examination, and the importance the patient places upon slight changes in subjective symptoms, the eye lends itself to the appreciation of slight changes for better or for worse more readily than most organs of the body; and I am convinced that the best results are obtained by rigidly refraining from "pushing" the treatment, but rather allowing what is really a natural cure of the disease to act slowly, and gradually, and naturally.

In all cases, almost from the commencement, the marked general tonic effect is evident. Almost invariably, whether the eye condition clears up or not, one is told that the patient feels better and stronger and is generally more fit, that the appetite increases, sleep improves, and weight is put on. Particularly is this seen in children, and more especially in the sun-starved creatures that the hospital largely caters for. Not only is the stimulation confined to the physical state, but usually the mental state responds as well—indeed, in the assessment of the progress of treatment this factor leads one easily astray: the influence of the undoubted psychological effect of the treatment at the clinic, the unfortunate popular belief that ultra-violet light is a cure-all for everything, and the general mental and physical tuning up, delude the patient into thinking that rapid progress is being made, and it is easy for the observer to be led to share in his enthusiasm.

Tuberculous Lesions.

The affection which gives the readiest response is ocular tuberculosis in any of its forms. The importance of this is realized when it is remembered that tubercle of the eye is one of the most depressing and hopeless diseases in ophthalmology. With the methods of treatment ordinarily used the history of such a case is too often one of gradual and relentless deterioration, ending ultimately in blindness or in the excision of the eye for pain. The effect of light treatment at the clinic has been most encouraging, and the patients have uniformly improved from its commencement—as a general rule slowly, sometimes with remarkable rapidity. No case would seem to be too bad to be altogether despaired of, and it would seem not unreasonable to hope that the prognosis of this disease may be completely altered.

Of the 70 cases on which this paper is based, 9 were labelled clinically as tuberculosis—that is, they showed lesions which appeared typically to resemble tuberculosis, had a positive von Pirquet reaction, and other sources of infection were excluded. Eight cases of irido-cyclitis have made, or are making, most satisfactory progress; two examples may be cited.

A woman, aged 37, had had recurrent attacks since 1914; the disease was steadily progressive in spite of all methods of treatment—tuberculin, arsenic, etc.; the left eye was excised in 1920 for pain and raised tension. When ultra-violet light treatment was commenced vision of the right eye was reduced to bare perception of light. After ten weeks' treatment (general and local), intermitted with rest periods, the massive keratitis punctata has completely disappeared, the eye is quiet and white, she can see to get about the streets of London unaided, and is rapidly improving.

A woman, aged 23, who had massive keratitis punctata, ciliary injection, and nodules on the iris, has, after thirteen treatments, a perfectly quiet and white eye, with no clinical pathological evidence.

The remaining case of the nine, a woman aged 23, was of tuberculous dacryocystitis. Five years ago she was under the care of Rollier in Switzerland, under whose treatment the disease cleared up. A relapse occurred eight months ago, and in spite of surgical treatment an open discharging wound persisted. After four weeks' treatment the wound has healed, and all signs of activity have disappeared.

Phlyctenular Kerato-Conjunctivitis.

The other disease in which startlingly good results have been obtained is phlyctenular ophthalmia, especially the type which is met with in so chronic and recurrent a form

in the debilitated and sun-starved children of large cities. The ready and rapid improvement in these cases is remarkable; after a few days' treatment most of the distressing symptoms have disappeared and the photophobia has gone; after a few weeks' treatment a child whose eyes have been in a chronic state of intermittent irritation for years will clear up, and the general health will improve in a remarkable manner. Relapses, however, have occurred in a few cases, and the end-results have not been sufficiently long observed to allow one to dogmatize on the permanency of the improvement derived from one course of treatment; but the relapses are easily controlled by a repetition of another course of irradiation. The most satisfactory method of dealing with these cases would appear to be the establishment on a large scale of municipally owned centres in the more congested and badly housed areas of the large cities, where these children could receive at regular intervals throughout the year some of the benefits of the open air and sunshine which they so sadly lack.

Infective Irido-Cyclitis.

Cases of infective irido-cyclitis show on the average a much less dramatic response to ultra-violet light treatment, and a response which varies very much from case to case. Excluding the tuberculous lesions, the series comprises 29 cases, all of which were of considerable severity, and the majority of which were of very long standing before they were referred for treatment at the clinic. Of these, 5 have improved so rapidly as almost to be considered as cured within a few weeks; 12 have shown a slow and steady betterment; in 8, apart from the usual improved general condition, the eye lesion appears to have made little or no progress; and 4 have definitely got worse during treatment. In 3 of these 4 the reason is now obvious—that treatment was undertaken while the disease was too acute. Thus 60 per cent. showed an improvement, of which proportion in 30 per cent. it was extremely satisfactory; 40 per cent. have reacted disappointingly, but the majority of these, it must be admitted, were of very long standing; all were considered as quite intractable to the ordinary methods of treatment, and most were sent only as a last resort. On the average, therefore, the results of treatment, as judged on a statistical basis, are to a high degree unfair. At the present stage sufficient experience has not been accumulated to lay down any definite rules of general value as to the indications or contraindications—if any—on which to base a selection of cases.

Sympathetic Ophthalmitis: Choroiditis.

The one case of sympathetic ophthalmitis which has been treated improved so rapidly that in three weeks the eye looked quiet and the injection and practically all the keratitis punctata had disappeared. Three cases of choroiditis have been treated. One, a case of many years' standing, showed no apparent change; the other two rapid and marked improvement.

It is to be remembered that in all these cases the usual routine treatment with atropine, etc., was persisted in throughout; tuberculin was given to some of the tuberculous cases, arsenic to the sympathetic, and in the infective iritis any focus which could be detected was dealt with, and its removal attempted in the usual manner.

LOCAL PHOTOTHERAPY.

The media of the eye share the property of all living matter of being transparent to some wave-lengths of the energy spectrum and opaque to others. Those waves to which the eye is practically transparent pass through the media without exerting more than a correspondingly negligible effect upon them, either pathologically or therapeutically; it is only those waves which are absorbed which can have any action—a generalization which applies here as elsewhere in the physical universe. In the ultra-violet region of the spectrum it may be taken that all waves shorter than 2,950 Angström units are completely absorbed by the cornea, and that above this level an ever-increasing percentage is transmitted, until at the region 3,100 to 3,150 A.U. practically all are transmitted to the underlying lens and iris. The lens absorbs all radiation incident upon it below 3,200 A.U., practically all that below 3,500,

and continues to absorb an ever-diminishing amount up to a limit which varies with the age and the degree of sclerosis, but which may be taken to average 4,000 A.U.; the retina is reached, therefore, by practically all the incident radiation in this spectral region above 4,000, and by some of the incident radiation down to wave-lengths as short as 3,200. The pigment in the iris absorbs all wave-lengths that fall upon it, and degrades the energy into heat.

That part of the incident energy which is absorbed produces a reaction which may be either thermal or abiotic, depending on the length of wave. By the use of suitable filtering screens it has been determined that in the cornea² the upper limit of wave-length for abiotic response is about 3,050 for the intensities of radiation that can be used clinically, but since comparatively great intensities are required to produce any observable reaction with rays above 3,000, the latter figure may be taken for all practical purposes as the liminal wave-length. Radiation with rays above this produces a thermal lesion, resulting in a burn if sufficient intensities be used; waves shorter than this produce, after a definite latent period, the characteristic symptoms of photophthalmia, with a typical abiotic tissue reaction of desquamation of the epithelium and destruction or partial destruction of the underlying cells. Not only is there a critical threshold of wave-length, but also of energy intensity required to produce a response, which I have found to be on the average, for the production of a mild reaction, slightly under 2 I.K. (infusoria killing) units—that is, such an amount as is obtained from a mercury vapour lamp (K.B.B., atmospheric; 200 volts, 2 to 3 amperes) at a distance of half a metre in two and a half minutes, which corresponds to slightly less than the intensity required to produce a minimal erythema on the skin. In doses under this intensity, short-waved radiation, while it produces no irritant action, seems to have some therapeutic, and certainly some analgesic, action; doses of this intensity produce a temporary abiotic reaction; higher intensities involve a marked photophthalmia, and may, in extreme cases, result in the production of an opacity, which, although becoming highly vascularized and to a large extent disappearing in a few weeks, is often to some degree permanent.

In the lens³ the radiation which is absorbed causes changes of exactly similar nature in the proteins of its fibres, the long thermal rays more readily than the shorter abiotic. These changes result in the coagulation of its proteins or in an increase in the lability of their colloid system, so that they are more easily coagulable by other influences—an occurrence which involves the formation of an opacity, or the production of a state wherein an opacity may be induced more readily than normally. In the iris, owing to the absorption of the pigment, a thermal effect is easily produced, which completely masks any abiotic action, and involves hyperaemia, congestion, and even the production of an iritis if sufficient intensities be employed; but when the pigment is lacking, as in the albino, or where very mild intensities are used, an abiotic effect can be obtained, since most of the incident energy above 2,950 A.U. reaches it. The lens protects the retina³ so completely that an abiotic reaction here is very difficult to elicit within reasonable limits of intensity of radiation; but the absorption of the pigment makes it easy to produce a marked thermal lesion even with the shorter visible rays.

In radiating the eye directly, therefore, when an irritant effect on the cornea, conjunctiva, or lids is aimed at, rays shorter than 3,000 A.U. are used, or, in practice, the whole of the spectrum from the mercury vapour lamp. When a mild abiotic effect or an analgesic action on the cornea is desired, rays of 3,000 and longer are used; the mercury vapour lamp has two strong bands at 3,020 and 3,050 A.U. In radiating the interior of the eye the infra-red rays are inadmissible in any quantity, owing to their potent action in causing opacity in the lens and destructive thermal lesions in the retina and iris. The visible rays are also inadmissible on account of their discomfort, due to glare, and, when in great intensity, of their heating effect on reaching the pigment of the retina. The region of the spectrum between 3,000 and 4,000 would appear to be the least noxious, since here the heat effect is at a minimum, the luminosity

is low, and there is still a considerable amount of abiotic energy, although not of a strength so great as to exceed the threshold for producing the distressing symptoms of photophthalmia. It might be argued that to use these indiscriminately would be reasonably safe, especially in the relatively small and intermittent doses used clinically, derived from sources of small extensity subtending a small solid angle, and therefore involving no great energy concentration in the lens; but these waves are to a large extent absorbed by this tissue, and it is very probable that in the formation of all forms of cataract the common and fundamental process is the absorption of radiant energy⁴; moreover, in the present case we are dealing with pathological eyes wherein lenticular degeneration readily occurs. All rays, therefore, should be controlled so that the lens is excluded from their path of incidence.

Passow¹¹ has recently sought to overcome the difficulty of obtaining a strong abiotic effect without the attendant photophthalmic symptoms by the use of visible light with sensitizers (Bengal blue, etc.), and Löwenstein¹⁰ and others have used fluorescein in a similar manner. Our knowledge, however, of the action of sensitizers is at a stage when their use should be resorted to with caution, for, although good results may be obtained at the time, unpleasant after-effects may possibly ensue. The formation of cataract by the injection of these substances has been referred to elsewhere,⁵ and Leonard Hill and Campbell,⁶ on similar treatment of the mesentery, constantly found the formation of capillary thromboses. Even on the local application of such substances to the surface of the cornea it is more than probable that they will be rapidly absorbed into the interior of the eye, when we consider the rapidity with which substances such as atropine, when administered externally as drops, are found to act upon the iris. Until, therefore, substances with a higher selective bacterial affinity are elaborated, the use of sensitizers would appear to be fraught with possible immediate danger to the retina, and probable ultimate danger to the lens.

The technique I employ is as follows. The mercury vapour lamp is used in preference to any form of carbon or metallic arc, owing to the smaller emission of heat rays. In diseases of the lids and conjunctiva, where an irritant abiotic effect is desired, a screening apparatus bearing a quartz director 8 in. long and curved half an inch from the tip at an angle of 140 degrees, concentrates all the emittent rays from the mercury vapour lamp into a parallel beam issuing from the director tip. The director is carried by a flexible spring holder, so that there is considerable play at its distal end, with which the cocainized and everted lids are slowly massaged, sufficient pressure being applied at the same time to render the parts temporarily anaemic. It has a rounded end, so that it can be inserted into the recesses of the fornices. In conditions such as trachoma, where a stronger effect is desired, the lids are everted and held so as to cover up the cornea completely, and the direct light of the lamp concentrated on the conjunctiva at a focus by a lens system of quartz. In the treatment of corneal lesions, where a similar irritant action is required, the director is held obliquely almost touching the cornea, its bent tip being at such an angle that none of the rays reach the pupillary aperture. Where an irritant effect is not required, but a mild abiotic and sedative action, filtered light is obtained by passing it through a Chance's filter and concentrating it to a focus with an ordinary glass lens, rays above 5,000 A.U. and below 3,000 being thus excluded.

It has been shown that the dose of light necessary to produce pathological effects visible microscopically on the cornea is slightly less than that required to produce a minimal erythema on the skin. The latter standard is therefore first obtained, and the local dose thus gauged. In conditions where the urgency of the case forbids waiting for the twenty-four hours necessary to obtain this standard (as in corneal ulcers) the average dose of two and a half minutes at the working distance (1/2 metre) is given, and the individual dose calculated in the usual way in the meantime. Local treatment is usually accompanied by a course of general light baths should the condition at all seem to require it, these reinforcing its action, and giving the patient the benefit of the general tonic effect.

We propose to differentiate the treatment of the external

eye (the cornea and conjunctiva) and the lids from that of the internal eye by the terms "external" and "internal" phototherapy.

EXTERNAL PHOTOTHERAPY.

Diseases of the Lids.

Chronic blepharitis, squamous or ulcerative, has been found to respond extremely well to ultra-violet therapy, especially the type so commonly met with in debilitated children, which is characterized by continual relapses, and lack of response to the usual local medicaments. In young children the quartz director is used to the everted lid margin; in older people light is concentrated thereon by the quartz lens. In some cases complete healing results from one or two applications of ten minutes to a quarter of an hour; in all those treated cure was eventually obtained. In the more chronic cases, after some months, lashes which have fallen out regrow.

Diseases of the Conjunctiva.

In the treatment of diseases of the conjunctiva the reaction aimed at is one of tissue irritation and destruction, and coincidentally of bacterial destruction. Initial doses of five minutes are given, and the patient is seen the next day and the effect observed. If the reaction is good its subsidence is awaited; if not, a dose of ten, fifteen, twenty, or even thirty minutes is given, depending on the lesion. In doses of five minutes' duration an acute conjunctivitis starts in about eight hours, and lasts for forty-eight hours; after high doses of thirty minutes the latent period is shorter, and the inflammatory symptoms may remain for a week. A whitish-yellow false membrane forms which, if an attempt is made to remove it, re-forms during the first few days, but which ultimately falls off, leaving fresh unscarred conjunctiva exposed. The absence of corneal damage does away with the distressing symptoms of photophobia, and the patient is little inconvenienced.

Chronic catarrhal conjunctivitis, in the two cases treated, cleared up after six and eight sittings. Three cases of *trachoma* have given most satisfactory results. An acute exacerbation in one case cleared up after two applications; the other two have very much improved after six sittings, the effects of which compare very favourably with the deep scarring caused by prolonged copper applications. One case of *vernal catarrh* showed slow but very satisfactory progress.

Diseases of the Cornea.

In the treatment of corneal lesions one of two effects may be aimed at—an irritating effect on the tissues produced by the shorter waves, or a sedative effect produced by the milder abiotic influence of rays over 3,000 A.U.

Corneal ulcers have been found to respond very favourably to treatment by radiation; especially is this so in the case of marginal ulcers. The two cases of hypopyon ulcer so far treated became quite quiet after the third exposure. The quartz director is used, and a beam of unfiltered light is played obliquely over the ulcer, the time of exposure being regulated to be slightly less than that required to produce a minimum erythema on the skin of the back or the inner surface of the arm. If the condition appears so urgent that it is not desirable to wait for this, an average initial dose is given arbitrarily of two and a half minutes at the distance worked at (1/2 metre), and the individual dosage calculated in the usual way in the meantime. The ulcer heals with a considerable amount of localized opacity formation, which becomes highly vascularized, and to a large extent clears up, thus corresponding in its behaviour to the opacities produced on the experimental irradiation of the cornea of the rabbit.³ It is possible that the therapeutic action is largely one of irritation and increased vascularity, but it is also probable that abiotic action, involving the production of photochemical products from the injured corneal cells, play a part also. Hertel⁵ demonstrated that bacteria suspended in a quartz cell in the anterior chamber were rendered immobile by ultra-violet light; but Verhoeff and Bell,¹² on the other hand, showed that these rays cannot kill bacteria within the cornea without causing severe injury to that structure. Confirming this, I have found that the freshly excised cornea of the rabbit completely protects staphylo-

cocci sown on agar from the lethal action of light, and also that if the anterior chamber is injected with a culture of the same organism, and thereafter the eye be exposed to radiation of an intensity which causes the formation of a definite opacity, the aqueous shows on culture a growth no less abundant than that obtained from unirradiated controls. It is probable, therefore, that direct killing by ultra-violet light of the bacteria responsible for the ulcer does not enter largely into the question, and it is here especially where a sensitizer—could a safe one be found—which would attach itself to bacterial protein in preference not only to the corneal tissue but also to blood, would be of immense advantage.

Corneal opacities have been reported as partially clearing up with ultra-violet radiation. While it is possible that the increased vascularity which follows radiation might have this effect in a recent condition, I have so far been unable to substantiate this claim.

Phlyctenular keratitis, in addition to being treated with general baths, is much benefited by the local application of light. One striking feature is the almost immediate, although temporary, relief which radiation with the filtered rays brings on in the photophobia and blepharospasm.

Interstitial keratitis, to judge from the ten cases treated, is little influenced either by general or by local treatment, although the photophobia is relieved, and the general condition much improved.

Acne, on the other hand, responds very favourably to the treatment. In the two cases treated, the distressing and damaging lesions on the cornea were greatly benefited, and recurrences have been so far warded off. Short exposures with the quartz director, or longer exposures to filtered rays, together with skin baths directed especially to the associated lesions on the face, have been found to clear up both the eye and the facial condition. Where, however, dense corneal opacity and infiltration have been caused by repeated attacks, these residua have remained while the active process has died down.

One case of *episcleritis* of unknown etiology completely resolved after three radiations of five minutes' duration of unfiltered light concentrated by a quartz lens.

INTERNAL PHOTOTHERAPY.

A number of writers on the Continent have reported very favourably upon the treatment of *iritis* and chronic *irido-cyclitis* by local radiation alone; Koeppe,⁹ using filtered and concentrated long ultra-violet rays, is particularly enthusiastic over this method of treating tuberculous lesions, and with its use he has obtained very satisfactory results. I have never yet relied upon this method alone, since it seems reasonable to add to any effect it may have the undoubted aid of general baths. In three cases of *iritis* which were being treated by general phototherapy, periods of a fortnight were selected, when, in addition to the general treatment, filtered rays were focused upon the iris for periods of ten minutes three times a week. In each case the patients asserted that considerably more improvement followed than by raying the skin alone, and the appearance of the eyes certainly did not belie their statements.

Chorioiditis and *chorio-retinitis* have been similarly treated locally by Koeppe,⁹ Poyales,¹² Birch-Hirschfeld,¹ and Stock,¹³ and they report good results. It would seem, however, that caution is to be observed in such treatment; general light baths do such patients good, and it seems that to focus light of an abiotic nature into the eye in such intensity that it will have any marked action is running an unjustified risk of laying down future trouble in the lens.

Up to the present the procedure adopted has been to accept for treatment any case that promises to do well at all, and all cases wherein the usual methods of therapy have failed. Such a method of selection obviously involves a proportion of disappointing results, since advanced and almost hopeless cases predominate; but the failures are no less valuable than the successes. Later, when methods of technique have been standardized, and results of greater statistical value have been collected and are compared with those of others, it would seem reasonably safe to predict that an agent of considerable value will have been added.

to our therapeutic armamentarium—an agent which, although not by any means a general panacea, is the more valuable in that many of its successes are those very chronic and difficult cases in which the prognosis has hitherto been so hopeless.

A bibliography of the literature of ultra-violet therapy in ophthalmology is appended.

It is a pleasure to thank the members of the staff at Moorfields for their cordial assistance and advice, and for according me the privilege of making use of and reporting their cases.

REFERENCES IN THE TEXT.

- ¹ Birch-Hirschfeld: 100 Versamm. deutsch. Naturforscher u. Aerzte, Leipzig, September, 1922.
² Colebrook, L.: *Lancet*, 1923.
³ Duke-Elder, W. S.: *Ibid.*, 1925 (to be published).
⁴ Eidinow, A.: *Ibid.*, August, 1925, p. 320; *ibid.*, 1926 (to be published).
⁵ Hertel, E.: *Ber. u. d. xxi Versamm. d. ophthalm. Gesell.*, Heidelberg, s. 144, 1903; *Arch. f. Ophthalm.*, lxxvi, 257, 1907.
⁶ Hill, L., and Campbell, A.: *Brit. Journ. Exper. Path.*, v, 317, 1924.
⁷ Hill, L., and Eidinow, A.: *Practitioner*, August, 1925; Eidinow, A.: *Lancet*, August, 1925, p. 320.
⁸ Hill, L., Eidinow, A., and Colebrook, L.: *Brit. Journ. Exper. Path.*, v, 24, 1924.
⁹ Koeppe, L.: *Diathermie u. Lichtbehandlung des Auges*, Leipzig, 1919.
¹⁰ Löwenstein, A.: *Die Tuberculose des Auges*, Berlin, 1924, s. 30.
¹¹ Passow, A.: *Arch. f. Augen*, xciii, 95, 1923; xciv, I, 1924.
¹² Poyales, F.: *Archiv. de Ophthalm. Hispano-Americ.*, xxv, 559, 1925.
¹³ Stock, vide Bach: *Kunstlicht Hörsenonne*, 1922, s. 127.
¹⁴ Verhoeff and Bell: *Proc. Amer. Acad. of Arts and Sciences*, li, No. 13, 630, 1915.

BIBLIOGRAPHY OF PHOTOTHERAPY IN OPHTHALMOLOGY.

- Diseases of the Lids.*
 Lomholdt: *Brit. Journ. Dermatol.*, xxxvi, 112, 1924.
 Passow: *Med. Klin.*, No. 51, 1913; *Heidelberger Ber.*, s. 243, 1920; *Strahlenther.*, xii, 441, 1921.
 Poyales: *Arch. de Ophthalm. Hispano-Americ.*, xxv, 559, 1925.
 Schanz: *Arch. f. Ophthalm.*, lxxxvi, 568, 1913; *Muench. med. Woch.*, lxxiv, 525, 1917; *Zeit. f. Augen*, xxxvi, 22, 1918; *Klin. Woch.*, 2568, 1922; *Deut. Ophthalm. Gesell.*, Jena, 229, 1922; *Muench. med. Woch.*, lxxix, 1341, 1922.
 Strebel: LXXV Versamm. deutsch. Naturforscher in Kassel, 1903.
- Diseases of the Conjunctiva.*
 Birch-Hirschfeld: 100 Versamm. deutsch. Naturforscher u. Aerzte, Leipzig, September, 1922.
 Löwenstein: *Die Tuberculose des Auges*, 1924.
 Lundsgaard: *Hospitaltidende*, 1905; *Klin. Monat. f. Augen*, xlv, 191, 1905; *Arch. f. Ophthalm.*, lxxvi, 578, 1907; *Klin. Monat. f. Augen*, xlvii, 1, 386, 1909; xlix, II, 763, 1911; lxi, II, 369, 1918; lxxviii, 103, 1922; *Acta Ophthalm.*, I, 39, 1923.
 Passow (1921).
 Seefelder: *Heidelberger Ber.*, s. 243, 1920.
 Werther: *Muench. med. Woch.*, lxxiv, 527, 1917.
- Chronic Simple.*
 Mohr u. Baumm: *Klin. Monat. f. Augen*, xlix, 629, 1911.
 Passow (1919).
- Spring Catarrh.*
 Birch-Hirschfeld (1922). Passow (1919). Poyales (1925).
- Trachoma.*
 Chotzen u. Kuzintzy: *Klin. Monat. f. Augen*, lx, 198, 1918.
 Grönholm: *Arch. f. Ophthalm.*, lxxx, I, 1911; with Heiberg, *ibid.*, s. 47.
 Hegner u. Baumann: *Berl. klin. Woch.*, No. 29, 1910.
 Hunsel: *Nederl. Tijdschr. v. Geneeskunde*, No. 6, 1911.
 Isaak: *Westnik. Ophthalm.*, xxx, 988, 1913-14.
 Lundsgaard (1907).
 Mohr u. Baumm (1911). Poyales (1925). Schanz (1917). Strebel (1903).

Diseases of the Cornea.

- Phlyctenular Keratitis.*
 Birch-Hirschfeld (1922).
 Hippel: *Vide Thedering, Das Quarzlicht*, Oldenberg, 1923, s. 127.
 Lundsgaard (1917).
 Nutt: *Brit. Journ. Ophthalm.*, x, 138, 1926.
- Interstitial Keratitis.*
 Birch-Hirschfeld (1922).
 Menacho: *Ann. d'Oculistique*, cxi, 150, 1908.
 Poyales (1925). Schanz (1917). Strebel (1903).
 Stock: *Vide Bach, Kunstlicht Hörsenonne*, 1922, s. 127.
- Tuberculous Keratitis.*
 Koeppe: *Diathermie u. Lichtbehandlung des Auges*, Leipzig, 1919; *Arch. f. Ophthalm.*, xcii, 115, 1916; *Muench. med. Woch.*, lxxvi, 743, 1920.
 Löwenstein (1924). Lundsgaard (1918). Passow (1921).
 Seidel: *Arch. f. Ophthalm.*, xcii, 357, 1917.
- Corneal Ulcers.*
 Birch-Hirschfeld (1922).
 Hertel: *Arch. f. Ophthalm.*, lxxvi, 275, 1907.
 Nesnamoff: *Westnik. Ophthalm.*, xviii, 1901.
 Passow (1921); also *Arch. f. Augen*, xcvi, 74, 1925.
 Poyales (1925). Schanz (1913).
 Schinck: *Zeit. f. Augen*, xlvi, 292, 1922.
 Schwarzkopf: *Zeit. f. Augen*, xlvi, 77, 1922.
- Corneal Opacities.*
 Menacho (1908). Passow (1921). Schanz (1922).
 Sulzer: XVII Internat. Cong. Med., London, 1913, Sect. xi, Pt. 2, p. 71.

Diseases of the Sclera—Episcleritis.

- Seidel (1917).
- Iritis and Irido-cyclitis.*
 Birch-Hirschfeld (1922).
 Fleming and Krusius: *Deut. med. Woch.*, 1600, 1911.
 Hippel (1923). Koeppe (1921).
 Kraupa: *Ber. d. Versamm. deutsch. Naturforscher u. Aerzte*, September, 1922.
 Löwenstein (1924). Lundsgaard (1905). Passow (1921). Poyales (1925).
 Schanz (1918). Seidel (1917). Stock (1922).

Chorioiditis.

- Birch-Hirschfeld (1922). Koeppe (1921). Poyales (1925). Stock (1922).

DEATH FROM FULMINATING PNEUMONIA AFTER BRIEF NITROUS OXIDE ANAESTHESIA.

BY

ERNEST GLYNN, F.R.C.P.,

PROFESSOR OF PATHOLOGY, UNIVERSITY OF LIVERPOOL; PATHOLOGIST TO THE ROYAL INFIRMARY, LIVERPOOL; HONORARY PATHOLOGIST, CLINICAL DENTAL SCHOOL, LIVERPOOL.

An apparently healthy lad was anaesthetized with nitrous oxide and the stumps of a molar tooth extracted. He never recovered consciousness and died in thirty-seven hours. The main features of this remarkable case are as follows.

A.B., aged 17, the brother of a dental student of Liverpool University, was seen by a dentist in June, 1923; he unsuccessfully attempted to remove two stumps of a lower molar tooth. A local anaesthetic was used. Six months later the jaw was x-rayed at the Liverpool Dental Hospital and an appointment made for extraction. On Saturday, January 26th, 1924, the patient came to the hospital as arranged. At 11 a.m. he was anaesthetized with pure nitrous oxide, and the stumps extracted without difficulty. The administration of the anaesthetic and the extraction took a minute or slightly more.

The patient began to recover from the anaesthetic, but soon went a "nasty colour, then black," and collapsed. As air failed to enter the lungs properly he was placed on the floor and artificial respiration resorted to; 15 minims of ether were injected subcutaneously. A few minutes later Dr. Earlam, a house-surgeon at the Liverpool Royal Infirmary, was summoned. He found that the patient was cyanosed. There was a gag in his mouth; but owing to an unusual deformity of the lower jaw the chin was pressing on the larynx. On removing the gag and pulling the chin forward, breathing became much freer.

At 1.30 the patient appeared to be progressing satisfactorily, but was still drowsy, so he was put to bed in the Royal Infirmary under the care of Dr. Douglas Bigland; the temperature was then