lying just above the pubes, and intestinal contents were issuing from these holes. A large gall-stone ($1\frac{1}{2} \times 1'$) was found lying free in the recto-vesical pouch. There was a large mass of carcinoma in the rectum (1st part), and just above this a ragged hole in the wall of the bowel, from which the stone had evidently escaped. The gall-bladder was small and contracted, and the hepatic flexure of the colon and the duodenum were adherent to it. There were holes between both colon and duodenum and gall-bladder, and a gall-stone in the latter projected slightly into both parts of the bowel. No other stone was found in any part of the bowel. The liver was enlarged and markedly cirrhotic.

The specimen from this case was put aside labelled "Carcinoma Rectum with impaction of gall-stone and escape of gall-stone by ulceration." Amid an abounding wealth of pathological material it was neglected until the year 1908 when I was especially interested in this question of gall-stone ileus. On re-examination I found that the supposed growth was simply inflammatory thickening associated with a typical diverticulitis, as is well shown in the illustration (Fig. 15).

ULTRA-VIOLET LIGHT.

ITS PROPERTIES AND THERAPEUTIC USES.*

(ABSTRACT.)

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In a brief talk such as this it is not possible for me to cover the whole field of light therapy, but I shall endeavour to place before you as concisely as possible what I consider to be the main principles underlying the subject.

In order that we may appreciate fully the therapeutic values and limitations of such an agent as ultra-violet light it is essential that we should first understand something of its nature and of its physical and biological properties.

Ultra-violet radiation is of the same nature as light—i.e., visible light—X rays, gamma rays of radium and Hertzian (wireless) waves. These are *all* due to electro-magnetic disturbance of the ether—which disturbance is transmitted in the form of waves. The velocity of transmission is the same in each case—namely, the velocity of light (186,000 miles per sec. or 300,000 km. per sec.)—but the wave-lengths differ widely, ranging from the long waves of wireless telephony of 20 km. in length or more down to the heat waves and the infra-red rays—i.e., those rays just above the red end of the visible spectrum—followed by one octave of what we appreciate as visible light (an octave being so called because the waves at one end are twice the length of those at the other), then three octaves of ultra-violet light gradually merging into the X rays, of which there are 14 octaves, and, finally, the extremely short waves of radium.

As all these rays travel at the same velocity, it follows that the short waves repeat themselves much more frequently than the long—i.e., the frequency is greater. The frequency of a gamma ray is indicated by a figure stretching to 21 units, and that of wireless wave by five figures only.

Hertzian waves	..	..	20 km.
Heat waves—infra-red	..	..	8000 Au.
Visible light	..	..	7900–3800 Au.
Ultra-violet light	..	..	4000–1000 Au.
X rays	..	..	12–0.15 Au.
Radium rays	..	..	0.1–0.015 Au.

(Au = 1 ten-millioneth of a mm.)

It may be of interest to consider briefly the steps by which this long series of waves has been built up. Newton made the first discovery when he named the colours of the visible spectrum in 1666, and for over 100 years these were the only rays known, until Herschell announced the existence of the infra-red in 1800. Shortly after this, in 1801, the first mention was made of ultra-violet rays by Ritter, who noted the effect produced upon silver chloride by the violet end of the spectrum. Maxwell, in 1868, stated that there were rays beyond the infra-red, and Hertz shortly afterwards discovered how to generate them. Then in 1895 came the great discovery of X rays by Rontgen, leaving a gap between these and the ultra-violet, which was finally filled by Millikan as recently as 1921. The gamma rays were brought into use by the discovery of radium by Becquerel and the Curies in 1896 and after. Even now fresh discoveries are being made, and as recently as last year Prof. Millikan has stated that there are rays capable of penetrating 6 feet of lead.

The band of radiation which we make use of in our work extends from 4000–1500 A.U. approximately—the various wave-lengths being determined by analysis through quartz and fluorite prisms. These rays obey the same laws as light rays—namely, they are transmitted in straight lines in a uniform medium—they are capable of reflection and refraction, and they can be polarised. Again, the intensity of radiation on a given surface varies inversely as the square of the distance from the source—that is, the radiation falling on a surface at two-feet distance is one-quarter of that falling on the same surface at one-foot distance from the source of radiation. This is of great importance.

The natural source of ultra-violet light is, of course, the sun, but the pure sunlight contains only half an octave of this kind, and we have, therefore, to resort to artificial means to produce the rays in greater quantity. The use of sunlight as against that of ultra-violet light has been somewhat aptly compared to the use of crude drugs and their synthetic products, for instance, opium and morphia.

When we consider that only a fraction of the sun's radiation ever reaches the earth's surface, and that of this fraction only 75 per cent. on a clear day reaches an altitude of 18,000 feet, and 50 per cent. reaches sea level (according to Leonard Hill), it is seen that systematic heliotherapy is

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quite impossible in the cities of this country. The various impurities and natural constituents of the atmosphere—smoke, dust particles, water vapour and ozone in the higher altitudes—all absorb a certain proportion of the ultra-violet radiation, and the daily readings of ultra-violet intensity show all too clearly what a negligible quantity falls on the inhabitants of our great cities.

PHYSICAL PROPERTIES.

These are brought into use in the estimation of the intensity of radiation, and are therefore of great importance. There are several methods employed, but we need not go into them in great detail here. The power of blackening silver chloride is one of these properties, and a simple form of photometer, using this or some sensitised paper, can be devised, the change of colour being compared with known standardised tints. Again, ultra-violet light of certain wave-lengths has the power of liberating the charge on a suitably charged metal plate, the rate of discharge being detected by a gold-leaf electroscope, and thus affording a measure of the intensity of radiation. This or the photo-electric effect is also employed in the Furstineau aktinometer, which depends on the changes in electrical conductivity of selenium when exposed to light. The power of liberating iodine from solution of potassium iodide, and of bleaching a solution of acetone methylene-blue, are also properties employed in different methods of estimating dosage.

The absorption of ultra-violet light constitutes one of its most important properties and to which most of its effects are due. The absorption by various substances of ultra-violet light depends largely on the wave-length of the disturbance, the absorption increasing directly with a decrease in wave-length. Water vapour, smoke, dust particles all absorb these rays; certain gases such as oxygen and ozone do likewise, whilst others, such as hydrogen and nitrogen, transmit. Of solids the most transparent is fluorite—the pure crystalline variety of fluorspar (CaF_2). This is rare, and made use of only for laboratory instruments and spectroscopes. Quartz transmits all the more useful of the ultra-violet light, the natural crystalline variety being considerably more transparent than the fused. Ordinary window-glass absorbs all ultra-violet rays below 3300 A.U., so that these are all cut out of the sunlight by our windows. “Vita-glass,” a new variety of glass, transmits down to 2700 A.U., so that its value is at once apparent. Whilst talking of absorption we must not forget what is to us the most important phenomenon of all—namely, that living cells have the power of absorbing ultra-violet light. The transmitted waves have no effect on the cells through which they pass, as in the case of X rays, whilst the absorbed waves give rise to the biological effects, which we will now consider.

The first noticeable effect of exposure to ultra-violet light is the development within four to eight

hours of erythema. This is accompanied by all the typical signs of mild inflammation—namely, heat, redness, and swelling—the degree, of course, depending upon the intensity of radiation and the length of exposure. We commonly recognise four degrees of erythema: first, in which only a mild blush results, fading within 12 hours; second, equivalent to a mild sunburn and followed by branny desquamation; third, equivalent to severe sunburn and followed by peeling of large flakes or strips of epidermis; and, fourth, a severe degree, accompanied by destruction of the superficial layers of the skin with exudation of serum and blister formation. The desquamation which follows often does not commence for three to four days after irradiation. The trophic condition of the skin improves noticeably, as do also the condition of the underlying muscles, the tone of which improves, as after massage.

If persisted in, irradiation produces pigmentation in a large number of cases, the rays of 3000 A.U. being credited with the power of producing this condition. General metabolism is improved, as evidenced by the increased output of carbon dioxide and of nitrogenous waste products. The work of Leonard Hill and Eidinow has shown there to be a definite rise in the bactericidal power of the blood within certain limits. The nerve-endings in the skin are markedly affected, dosage of a mild degree producing a definite analgesia. This is very noticeable in the treatment of pruritus.

The effects on the skin of ultra-violet radiation from artificial sources is very much what we should expect from our every-day observations of the effects of sunlight. Fair types are affected more than dark, young people more than old. Parts normally exposed show much less response than parts covered, and normal skin is more sensitive than morbid.

In the blood the effects are no less marked; platelets and hæmoglobin both show an increase, as do also the calcium and phosphorus content. The white cells vary, sometimes a lymphocytosis, sometimes leucocytosis, whilst at other times there is a diminution in the number. To the clinical observer perhaps the most striking feature of this form of treatment is its effect on the nervous system. Almost from the first exposure a feeling of exhilaration results, and a course of treatment over a period effects a definite improvement in the mental outlook of the patient. Especially is this the case with the peevish and fretful child, of which one sees such large numbers in the out-patients' departments of our large hospitals.

The effect of ultra-violet light on the eye is of importance, as the question of the protection of the eyes is one which arises both for the patient and operator. The retina is protected from the injurious effects of short ultra-violet waves by the absorptive powers of the cornea and lens, but the cornea and conjunctiva suffer by this absorption with resultant cloudiness of the cornea, conjunctivitis, and sometimes iritis.

One other very important biological property of this light is the action upon cholesterol. Recent work by Leonard Hill tends to show that cholesterol in the skin when activated by ultra-violet light becomes vitamin D. This substance enables the absorption from the alimentary canal of minimal quantities of phosphorus and lime salts deficient in the diet, so that what was previously wasted is now absorbed and goes to build bone. The importance of this in the treatment of rickets is obvious.

TREATMENT.

From the fact that ultra-violet radiation is so readily absorbed by the skin, it will necessarily follow that many morbid conditions of the skin can be readily treated by this agent, and often with remarkable benefit. Among these are furunculosis, alopecia, lupus, psoriasis, impetigo, sycosis, herpes, and pruritus. Of these, lupus often yields surprisingly good results, especially if the local treatment of the lesion is combined with general body radiation. The widespread or generalised type of lupus improves very much with general light treatment alone. Psoriasis of the type where the patches are of long standing and indurated often yields good results if the dosage is pushed far enough. A judicious alternation of ultra-violet radiation with X rays will almost always relieve the most obstinate cases.

Of general conditions rickets is, of course, the disease par excellence which can always be attacked with sure hope of success.

Tuberculosis, again, in all its forms calls for the use of sunlight, both natural and artificial. The use of surgery in tuberculosis of bones and joints can now in most cases be discarded, or if employed finds a ready ally in its attack upon the disease in ultra-violet light. Tuberculous glands, if treated sufficiently early, are often arrested—if seen, only after breaking down with pus formation, the healing stage can be much hastened by a course of local treatment after aspiration or evacuation of the pus. With carefully graduated dosage of light marked improvement in cases of tuberculous peritonitis can often be obtained.

Recent research suggests that advances in the treatment of the anæmias may result, the value of arsenical preparations being much enhanced by the coincident application of ultra-violet light. General debility and marasmus, especially in children, form a large proportion of cases sent for treatment in our general hospitals, and these all show marked improvement in both mental and physical condition. To enumerate all the conditions which can be treated with benefit would occupy more time than is at my disposal, so we will now pass to the consideration of the various sources of artificial light.

TYPES OF LAMPS.

These may be roughly classed as (a) open arcs and (b) enclosed arcs. Of the former the earliest used was that devised by Prof. Finsen in 1893, and used with modification since. The arc in this case is struck between carbon poles and the light

emitted contains only a small proportion of ultra-violet rays with a large amount of visible light and heat rays—these are not made use of and are therefore filtered out by a series of quartz lenses surrounded by a water-cooled jacket. The time required to give an erythema dose with this lamp is, of necessity, very long.

Other types of carbon arc lamps now in use have electrodes of carbon impregnated with metallic salts—these burn at a voltage of 90–50 volts and consume 30–75 amperes of current.

The Arnold lamp consists of four pairs of carbon electrodes, each at a pressure of 50 volts.

The Tungsten arc, which gives an exceedingly intense ultra-violet spectrum, is struck between poles of pure Tungsten—an erythema dose may be obtained with this lamp in two minutes at a distance of 2 feet. An arc light with iron electrodes is sometimes used on account of its cheapness.

The second type of lamp is the *enclosed arc*—these are the mercury-vapour lamps. They consist essentially of a quartz chamber partially filled with mercury, in which the arc is struck, and are of two main patterns, the air-cooled and the water-cooled. The quartz chamber in the air-cooled lamps is sometimes partially exhausted and sealed off, while at other times it is left unsealed and at atmospheric pressure. The latter type is easier to clean, and is free from the possibility of leaking seals, but the intensity of its output is said to be slightly less than that of the vacuum lamp. All these lamps are delicate in their construction and require gentle handling. On no account should the quartz chamber be touched with the bare fingers, as the finger-marks become etched into the quartz and cause dispersion of the light. After considerable use the quartz becomes less transparent to ultra-violet rays, the high temperature converting a layer of the quartz into tridymite. In consequence the life of these lamps is limited, but the burners can be cleaned and used again.

The water-cooled lamp is of a smaller type and consists of an inverted U-shaped arc tube surrounded by a quartz jacket, which is cooled by an enclosing metal water chamber, in the front of which is a quartz window. This lamp is extremely useful for local treatment. The fall of intensity in the output of all these lamps should be measured from time to time, as the time required for therapeutic doses necessarily increases with the fall in output of the lamp.

It is of interest here to compare the output of the different ranges of wave-length from different sources of radiation—this is well shown by the following table (Pacini):—

	Infra-red.	Light.	Ultra-violet.
	%	%	%
Mercury-vapour lamp ..	52	20	28
Sunlight	80	13	7
Arc (carbon)	85	10	5
Incandescent lamp ..	93	6	1