the tubes, thereby indicating that the compound even in a concentration of 1 in 1,333 has no bacteriostatic action.

Discussion

From the table it is evident that *p*-aminobenzenesulphonamide when administered in the doses used in this investigation is capable of prolonging and in some cases of saving the lives of mice infected intraperitoneally with a strain of *Staph. aureus*. Thus four out of twelve mice (Group C), or 33 per cent., were found to survive; while 50 per cent. were alive up to forty-eight hours and 80 per cent. up to twenty-four hours after the infection. A similar treatment with the combined antitoxic and antibacterial serum (Group B) shows a 25 per cent. survival among the infected animals. It appears, therefore, that in the relative doses employed in the present investigation the efficacy of *p*-aminobenzenesulphonamide is slightly greater than that of the specific serum. The data from Group D again point to the fact that much better therapeutic results may be obtained by a combination of serum and drug, as under this condition a 100 per cent. survival among the infected animals occurred. But as the drug has no bacteriostatic action in culture media, it would now be of additional interest to discover the mode of action of the drug *in vivo*, particularly as a combined chemotherapeutic and biological treatment has been found to be far more efficacious against staphylococcal infections in mice. Work in this direction is already in progress.

Conclusion

From the preliminary experiments it would be unwise to make any definite conclusions. It may, however, be said that the subcutaneous administration of *p*-aminobenzenesulphonamide is capable of prolonging and in some cases of preserving the lives of mice infected with staphylococci. A better protection against staphylococcal infections in mice is obtained by combination of serum and the drug treatment.

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The second of the series of leaflets issued by the Department of Scientific and Industrial Research describing standard methods for the detection of toxic gases in industry deals with hydrogen cyanide vapour. It is pointed out that the danger of the absorption of this gas through the skin is intensified by the presence of sweat or other fluid: it may also be introduced into the body by inhalation. Slight symptoms of prussic acid poisoning will be noticeable after several hours' exposure to a concentration of 1 part in 50,000, while a concentration of 1 part in 500 will be fatal. The faint almond-like smell is quite easily missed, and is therefore useless as a method of detection. A sample of the suspected atmosphere should be drawn by a hand exhausting pump through a piece of specially prepared test paper impregnated with Congo-red-silver nitrate or benzydine-copper acetate. Two charts are supplied with the pamphlet to show the colorimetric reactions with various concentrations, and in this way a sufficiently dependable index to the relative safety of the atmosphere can quickly be obtained. It is remarked that this test will not indicate the danger in cases in which the oxygen content of a closed chamber is dangerously deficient. The price of the leaflet is 5s. 6d., owing to the high cost of reproduction of the colorimetric charts. It is obtainable from H.M. Stationery Office, Kingsway, W.C.2.

DAYLIGHT IN RELATION TO CLIMATE AND HEALTH*

BY

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Daylight is derived from the radiation of the sun as modified by the interposition of the earth's atmosphere, and is perceived by the eye. Much of the sun's radiation is not thus perceived, but on account of its other effects may be properly considered here.

Measurements have been made of the radiation from the sun, throughout the whole spectrum, by Dr. C. G. Abbot and his co-workers at the Observatories of the Smithsonian Institution of Washington. When extrapolated to its value outside the earth's atmosphere what is termed the solar constant of radiation, as received on a surface set normally to the sun's rays, is 1,940 calories a square centimetre a minute, the scale of radiation being that of the Smithsonian Institution of 1913. For the sake of uniformity, measurements continue to be given on this scale, but the latest results of Abbot and Aldrich lead to a value which is 2.3 per cent. less, and closer to the Angström scale, and agrees to one part in a thousand with that of the British National Physical Laboratory (Guild).

The value given for the solar constant of radiation relates to the mean distance of the earth from the sun. The earth is closest early in January and furthest away early in July. The variation in the square of the solar distance causes a 6.6 per cent. increase in January as compared with July. The solar constant, however, undergoes irregular fluctuations and periodic variations, which usually amount to about 2 per cent. but may be as much as 8 per cent. of its mean value. These are probably of great importance for the climate of the earth.

Abbot, Fowle, and Aldrich determined the relative energy at various wave-lengths for pure sunlight. These results have been extrapolated to give the curve outside

TABLE I.—Solar Energy—Spectrum (Abbot)

Wave-length	Mean intensity in Arbitrary Units, k	Transmission, Fraction of Column 2	
		Washington	Mt. Whitney
μ 0.39	3,614	0.445	0.800
0.43	5,321	0.600	0.844
0.45	6,027	0.640	0.875
0.47	6,240	0.671	0.902
0.50	6,062	0.705	0.919
0.55	5,623	0.739	0.930
0.60	5,042	0.760	0.940
0.70	3,644	0.839	0.964
0.80	2,665	0.865	0.976
1.00	1,657	0.901	0.975
1.60	532	0.930	0.963
2.50	43	0.870	0.945

the atmosphere, and the fraction transmitted and received normally is given in Table I, as calculated with the sun vertically overhead at each station. Fig. 1 has been constructed with the help of these data. Wave-lengths are

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given here in microns (millionths of a metre, symbol μ) or in millimicrons ($m\mu$).

To compute the transmission for other than a vertical sun—namely, zero zenith distance—the coefficients given in Table I must be raised to a power equal to the secant of the zenith distance, for the path of the light through the atmosphere is proportional to this. The results are shown in Fig. 2. With a declining sun the more oblique path of the rays results in the almost complete cutting off of the shortest wave-lengths; this effect is often greatly enhanced by the presence of mist or dust, so that a low sun may appear a fiery red.

FIG. 1.—The ordinates denote arbitrary energy units, k_λ , and the abscissae wave-lengths. The curves A, B, and C refer, respectively, to outside the atmosphere, Mt. Whitney, and Washington, and relate to zenithal sunlight received at normal incidence. The vertical lines denote the approximate limits of visible radiation.

FIG. 2.—The ordinates are transmission factors and the abscissae wave-lengths. Curve B refers to Mt. Whitney and C to Washington at zero zenith distance. Curves D, E, F, H refer to Washington at zenith distances 40, 60, 75, and 78.5 degrees.

FIG. 3.—Values of $k_\lambda f \sec z \cos z$ plotted against wave-lengths, for Washington at zenith distances 0, 20, 40, 60, 75, and 78.5 for curves C, d, D, E, F, and H respectively. Dotted lines: using factors for potassium photo-electric cell.

In Fig. 3 the arbitrary energy units are taken as ordinates, and k_λ is multiplied by $f \sec z$ to allow for the additional atmospheric distance traversed for different values of z , the zenith distance; the expression is then multiplied by $\cos z$ to correct to incidence upon a horizontal surface. The curves then are $k_\lambda f \sec z \cos z$ and relate to Washington. For Plymouth, latitude 50 degrees, $z = 40$ degrees at noon on April 16 and August 21; $z = 60$ degrees at noon on February 23 and October 18, and $z = 75$ degrees approximately at noon on December 22; at 10 a.m. and 2 p.m. on December 17 to 27 inclusive $z = 78.5$.

It may be seen that in curves A, B, and C, Fig. 1, the maximum lies at 0.47, 0.47, and 0.50 $m\mu$ respectively, and in Fig. 3 the maximum becomes flattened and shifted towards longer wave-lengths, so that in E the maximum is at 0.55 in the green, and lies in the deep red at about 0.7 μ with $z = 75$ degrees. There is therefore in the course of the year a shift in the maximum from red to blue and back again.

The extra-atmospheric solar radiation may be thus divided between the limits 0.3 and 3.0 μ : ultra-violet 0.3 to 0.4 μ , 6.6 per cent.; visible 0.4 to 0.76 μ , 52 per cent.; infra-red 0.76 to 3.0 μ , 41.3 per cent. There is radiation of longer wave-length, stopped by glass but transmitted by certain crystals, also radiation of shorter wave-length about which we know little, as its absorption by oxygen in the upper air causes a very abrupt falling off. According to the work of Fabry and Buisson, under the best conditions in the South of France the relative intensities in sunlight are as follows:

TABLE II					
In $m\mu$					Relative Intensities
314	..	..	..	..	22,400
299	..	..	..	..	1,320
292	..	..	..	..	22
290	..	..	..	..	0.02

Diffuse Daylight

As sunlight passes through the atmosphere certain wave-lengths are absorbed and their energy used up in effecting a chemical change, as in the production of ozone from oxygen. Much of it is scattered and reflected. Droplets of water, relatively large as compared with the wave-length of light, scatter and reflect all wave-lengths; thus a cloud directly illuminated by the sun is white, as is also a sea fog. The reflection of light from a cloud is very

high; according to Aldrich it amounts to 78 per cent., as observed from a balloon above a level layer. According to calculations made for the whole of the earth's surface no less than 43 per cent. of the total incoming solar radiation is reflected by clouds (Simpson).

But scattering by particles, small relative to the wave-lengths of light, affects the radiation inversely as the fourth power of the wave-length. Thus light of wave-length 0.38μ , which is taken as being the extreme limit of the visible violet, is scattered sixteen times as much as light of 0.76μ , the extreme limit of the visible red. So the scattered light, some of which reaches the earth, is relatively richer in blue, violet, and ultra-violet as compared with sunlight. Thus the unclouded sky looks blue.

Measurements of the energy of a source as a whole may be made with electrical instruments having blackened receiving surfaces, so that energy of all wave-lengths is almost totally absorbed. Of these instruments thermopiles are the most widely used, but bolometers, in which a change in resistance is produced by the energy absorbed, have found useful applications. By reducing the dimensions, and so the heat capacity, of both bolometers and thermopiles, a high sensitivity and a quick response have been produced. By placing the receiving surfaces in a spectrum, or by using light filters with due precautions, measurements can be carried out upon portions of the spectrum. But for comparative measurements in certain portions of the spectrum photo-electric cells have advantages, inasmuch as they have an instantaneous response, a high sensitivity, and a relatively low cost, coupled with a certain degree of wave-length selectivity, which can be rendered more highly selective by means of filters. Photo-electric cells serve to compare radiation received on a horizontal plane surface from sun plus sky, and from sky alone, when direct sunlight has been shaded off. The cells should be covered with a diffusing disk of opal-flashed glass, and colour filters, if used, should be placed below this. The spectral sensitiveness of several types of photo-cell are shown in Fig. 4 (Atkins and Poole), in which is

FIG. 4.—Curve M shows the distribution of energy in mean noon sunlight as a percentage of the maximum, and all sensitivities relate to this spectral energy distribution. N denotes vacuum sodium cell under opal. SO denotes selenium cell under opal. SG denotes selenium cell under special green filter; as this lies so close to the VM and SGO curves it has been omitted, but is denoted by the crossed circles; SGO shows the foregoing under opal, taking into account that the filter is now traversed by oblique light. VM denotes the international relative visibility factor of the eye, as for mean noon sunlight.

also shown the spectral sensitivity curve for the light-adapted human eye. This is not very different from that of the selenium rectifier photo-cell, and may be closely matched by the latter under a special greenish filter. The sodium cell, on the other hand, is most sensitive in sunlight—around 0.41μ where the eye is of low sensitivity. It has been shown, however, that for mixed sunlight, white clouds, and blue sky the ratio of the readings of a sodium to those of a selenium cell remains nearly constant over a wide range of intensities; but atmospheric conditions exist under which a considerable divergence becomes manifest.

The difference between sunlight and sky light may be seen from the following. At noon on May 26, in Dublin, the blue light from sunlight was only 1.28 times as intense as that from the sky. That for yellow was 5.4 times and for red 6.2 times as intense. In the anti-rachitic ultra-violet of sunlight (namely, from $313 m\mu$ to the extreme limit received, about $297 m\mu$ —frequently longer and rarely shorter in appreciable amount) Dorno has shown that the radiation from the whole sky exceeds that from the sun unless the altitude of the latter exceeds 45 degrees.

The Daylight Factor

When considering diffuse daylight the most useful index of the illumination in a room is the "daylight factor." It was shown by Paterson and Walsh that in absence of sunlight the illumination at a point inside a building bears a very nearly constant ratio to the illumination at a point outside, the receiving surface being set horizontally in each case. This percentage ratio is termed the "daylight factor." Owing to the great intensity of sky light, situations with a factor of 1 per cent. are adequately lighted for reading throughout the greater part of the day: even immediately inside large north windows the daylight factor is only about 6 to 16 per cent. Photo-electric cells serve well for such determinations; if the sun is shining its rays should be screened off from the open-air photometer, or a correction be applied by the determination of the sunlight/sky light ratio.

It is obvious that a person exposed in the open for six minutes in the middle of the day will receive far more light than when inside for ten hours with a 1 per cent. daylight factor. It is therefore uneconomical to fit glass transparent to ultra-violet light in windows other than those that receive direct sunlight, save in buildings specially constructed to admit a far larger proportion of sky light than is customary.

Daily and Seasonal Changes in Light

As the altitude of the sun increases, the illumination received upon a horizontal surface rises from about 700 metre candles (lux) at sunrise to about 90 kilolux for 45 degrees and 145 kilolux for 90 degrees altitude, with a clear sky (Atkins, Ball, and Poole). The illumination at various solar altitudes is shown in Fig. 5, as obtained by using a selenium rectifier cell, corrected for curvature of the intensity-current relation. The cell was standardized in artificial mean noon sunlight and, as previously shown, its scale is fairly close to that of the eye. With the sun at 90 degrees its rays are less scattered in reaching the earth and its incidence is normal. With the selenium cell, sensitive throughout the spectrum, the ratio of zenithal sunlight to sky light is usually between 4 and 8; whereas with a sodium cell, sensitive only to the blue end of the spectrum, the sun/sky ratio is about 2 to 4. The upper limits are far beyond what is found in England,

where the sun reaches an altitude of about 63 degrees in summer. Owing to the variation in the scattering of light of different wave-lengths the daily and seasonal changes are not the same for different portions of the spectrum.

An elaborate study of the alterations in the composition of daylight has been made by Ornstein, Eymers, Vermeulen, and Postma, measuring the energy in various narrow wave-length bands under different atmospheric conditions. By means of a sodium cell daily records

FIG. 5.—Vertical illumination at Colombo, for different altitudes of the sun, with clear sky or but few clouds. The ordinates denote vertical illumination in kilolux.

FIG. 6.—The ordinates denote percentages of the light received in each year, as measured in kilolux-hours.

have been obtained by the author for the last eight years at Plymouth, using a Cambridge Instrument Company "thread recorder." The records are of the blue-violet end, around 0.41μ , and by measuring the areas of the daily curves the total amount of light received has been found, expressed in kilolux-hours—namely, that received when an illumination of one kilolux persists for one hour. The daily illumination integral varied from 14.5 to 1,323 kilolux-hours, and the monthly means from 45.6 in December, 1934, to 781 in July, 1930, that year being exceptionally bright. For it the daily average was 414 kilolux-hours, but five other years averaged 309. In Plymouth the six summer months receive from three-quarters to four-fifths of the annual daylight; of this the brightest month—May, June, or July—receives 15 to 18 per cent. and December 1.5 per cent. (see Fig. 6).

The Physiological Effects of Daylight

The effects may be classified primarily under two headings:

(a) The Purely Photo-Chemical, in which the resultant action is proportional to the energy of the effective wave-length absorbed.—Thus when ergosterol is irradiated and thereby converted into vitamin D the action is purely chemical, and exact proportionality exists unless too great an intensity or time of exposure introduces a secondary destructive action.

(b) The Physiological Stimulation of Living Cells.—In this the effect decreases with time, which is a perfectly general result from the application of any stimulus. Thus the eye when exposed to bright light reduces its sensitivity first of all by decreasing the pupillary diameter. This, however, only decreases the area of the pupil to about one-fourth or one-fifth, approximately the variation between the illumination on a horizontal surface from full daylight and that from sky alone when the sun is obscured by a small cloud. There is then a slower diminution in sensitivity due to an alteration in the quantity of unbleached visual purple and to the variation in nervous response. A similar decrease in sensitivity is observed when the skin is subjected to the extreme solar ultra-violet, which appears to be almost the same in range as the antirachitic region.

The action of radiation takes place only where it is absorbed, so the effect of ultra-violet is primarily quite superficial; but a secondary result, such as increased calcification, may be found when the blood stream has carried away the activated products.

The major successes of light therapy appear to be the treatment of rickets, including tetany, of lupus and "surgical" tuberculosis, also of certain types of wound and ulcer. But on the healthy population the mental effect of bright daylight is so cheering that one is compelled to regard it as of significance for the body also, especially when—as usual in our land—it is a very variable stimulus.

In the treatment of tuberculosis and of wounds it appears that the whole solar radiation is effective, and not the ultra-violet only. The longer wave-lengths penetrate more deeply, the maximum penetration being that of the deep red and short infra-red, about 0.7 to 1.4μ . The longer infra-red is so heavily absorbed by water that its penetration is less and its causation of superficial burning is greater, though erythema is produced by the ultra-violet below $313 m\mu$ without contemporaneous sensation.

I am indebted to my brother, Lieutenant-Colonel R. R. G. Atkins, R.A.M.C., for a discussion on heat-stroke, commonly though less correctly termed sunstroke. Its incidence is mainly confined to tropical and semi-tropical regions where the small amount of water vapour in the atmosphere allows much infra-red to penetrate, and where a dry earth, especially a sandy or rocky situation, is heated by the sun; were the ground moist much of the solar energy would be expended in evaporation. Thus at Singapore, with the sun vertically overhead twice a year, heat-stroke is far less common than in the North-West Provinces of India and in Mesopotamia. Thick turbans and sun-helmets—especially those provided with thin aluminium foil as recommended by Crowden—serve to protect the head, but may fail unless the whole skin is acting efficiently as an evaporating and radiating surface. There are descriptions in Lawrence's *Seven Pillars of Wisdom* of the extreme conditions of

unmitigated sunlight, baked reflecting surfaces, and hot winds in which well-trained men can yet endure great muscular exertion and fatigue. But they eat sparingly and drink water of varying degrees of brackishness, which provides against salt depletion. Moreover, through long exposure their bodies are provided with larger skin capillaries than in the shielded bodies of Europeans. In erythema the surface capillaries become dilated, but with constant exposure, as on faces and hands, they become larger. No one can see the splendid general tone of the skin of those who take even short regular sun-baths on the sea front in Plymouth without realizing that an un-sunned skin is unnatural and may consequently be expected to fail when extreme calls are made on its heat-regulating powers. The function of the skin in heat regulation may be considered as of prime importance to health, and we need probably look no further than a pure heat effect for the stimulation of the powers of the body resulting from exposure to sunlight, which is capable of raising the tissues to well above their normal temperature to a depth of over one centimetre, as shown by Sonne, also by Loewy and Dorno.

Figs. 4, 5, and 6 are reprinted from the *Proceedings of the Royal Society* by permission.

Clinical Memoranda

Volvulus of Pelvic Colon in a Young Person: An Unusual Complication of Appendicectomy

Volvulus of the pelvic colon rarely occurs in young people. L. E. C. Norbury in an article on left iliac fossa pain describes a personal case of a girl aged 25 in whom the gut twisted a second time almost exactly a year after the first occurrence. At her second operation the pelvic loop was resected after Paul's method. A definite degree of megacolon was present. Other cases are recorded complicating pregnancy and labour, including Jellinghaus's case following Caesarean section, though the age of the patient was 37. Foote records volvulus of the pelvic colon in a mentally deficient male aged 22. My case is of interest not only from the point of view of the youth of the patient but also because it presented itself as an acute obstruction on the ninth day after an otherwise uncomplicated appendicectomy.

Four months ago a domestic servant aged 20 was admitted and operated upon for an attack of acute appendicitis typical except for the lack of the initial central abdominal pain. Through a lower right paramedian incision an acutely inflamed appendix, stiffened with oedema and covered with lymph, was removed. The appendix was unperforated and the abdomen was closed without drainage and without exploration of any other viscus. Convalescence was normal in every way until the ninth day—that is, thirty-six hours before her proposed discharge from hospital. In the evening of that day she was seized with acute lower abdominal pain and had vomited some four times before I saw her five hours after the onset of the complication. She was obviously ill and distressed, with a subnormal temperature and a pulse rate of 116. Her tongue was furred and she had passed no flatus since the onset of the pain, though the morning bowel action had been regular since operation. The abdomen was tensely distended; this seemed to be most marked beneath the incision, which had by now healed. The rectum was empty and even somewhat ballooned.

Upon a diagnosis of acute intestinal obstruction, probably from rupture of the deeper layers of the wound, she was taken to the theatre and the original incision reopened. It was

soundly healed, and the cause of the obstruction presented itself as the familiarly large loop of sigmoid colon. The bowel was decompressed with a trocar and cannula, and a twist of 180 degrees undone. The attachment of the mesocolon did not appear unduly narrow and no fixation was attempted. A long rectal tube was passed up to the splenic flexure and the peritoneum closed around a pelvic drain owing to the fact that free fluid was present in the peritoneal cavity. The bowels acted copiously on the table and regularly after operation. Peritoneal drainage was rather more copious than was expected and the peritoneal infection prevented an uninterrupted recovery. The patient was transferred to the country eleven days after her second operation, and she has remained symptom-free since then.

A radiograph of a barium enema taken after convalescence shows that the rectum and colon up to the splenic flexure are rather wider in calibre than normal and the haustrations are less well marked. A condition of megacolon is not present.

I am indebted to Mr. Eric Crook, on whose behalf I treated the case, for his help in the after-care following the second operation, and for his permission to submit these notes.

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Cervical Pregnancy

I would like to bring to notice two recent cases of cervical pregnancy on account of their rarity.

Case 1.—On December 11, 1937, a patient was admitted with a history of four months' pregnancy. She was in a state of toxæmia, with face drawn and haggard, tongue coated brown and cracked, a pulse of 140, and a temperature of 103°. The bladder was distended, and the urine on removal was found to be fetid and dark in colour, containing traces of albumin, blood, and pus. The level of the uterus was to just below the umbilicus, and she was having violent contractions. Examination showed a globular swelling, pressing outside the vagina and obliterating it. A small dimple was visible about its centre, representing the cervix. The appearance was that of a typical hæmatoma. A longitudinal incision was made over the cervix, and a four-months foetus and placenta were removed. The placenta was found partly in the bulging cervix and partly in the uterus, and the whole foetus was in the cervix. The patient developed white-leg, was treated with prontosil and sulphonamide-P, and left the hospital well.

Case 2.—On December 21, 1937, this patient was admitted with a history of ten months' pregnancy. She was toxic and her tongue was furred; her pulse was 130 and temperature 102°. Her bladder was distended, and the urine on removal contained pus. On examination a large contracting uterus was found, and in place of a cervix a globular mass was felt, but no opening was apparent. With a speculum a small dimple was seen in the centre of the swelling. A Caesarean section was performed. The walls of the uterus were dark in colour, thickened, and almost fibrous in texture; there was no bleeding on cutting into the uterus. A large over-mature dead child was removed. The mucous membrane lining the uterus was thick and oedematous, and the membranes had to be peeled off. The placenta, dark and sodden, was found in the distended cervix down below. The uterus contracted fairly well, but owing to the septic condition of the walls of the uterus it was considered advisable to perform hysterectomy. This was done. An opening was made in the lower dilated portion of the cervix, and a tube was left in position, draining into the vagina. The patient was treated with prontosil and sulphonamide-P, and after a fairly stormy convalescence returned home well.

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