

seen them literally blossom forth in good health, with ruddy complexions and plump bodies, can fail to be struck with the resemblance they bear to flowers in a springtime garden.

We have need for sunshine, and we are benefited by it. The facts we have observed so definitely in rickets and tuber-

culosis are but indices of many other beneficial effects of sunshine. A hundred obscure and elusive evidences of its action upon other diseases and upon normal metabolism await investigation. Let us seize the evidence we have and preach the gospel of the outdoor life and sunshine in every community.

SUNLIGHT AND HEALTH

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A STUDY of the importance of sunlight as a factor in the health of the community until recently has been sadly neglected. This neglect has not been due to any fault of the public health organizations, but rather to a lack of scientific investigation by the medical profession. Although from the time of Hippocrates physicians have observed in a vague manner the importance of light and fresh air in the treatment of disease, until 4 years ago no scientific proof had been noted of a definite effect of light on the metabolism of the body. Since then extensive investigations have been undertaken in this country, in Canada and elsewhere which have yielded results of the greatest importance. It is now not only the duty but the privilege of our public health organizations to disseminate and apply this knowledge in a practical manner for the benefit of the people at large.

Before speaking of the importance of light in the growth, development and general metabolism of the body, we must first consider exactly what we mean by the term "light" or "light rays." Light is still generally regarded as a form of ether-wave energy the character of which is dependent on the length of the wave. Sunlight, or, to use the correct term, solar radiation, is composed of invisible heat rays which have wave lengths longer

than 760 millimicrons (a millimicron is one-millionth of a millimeter in length), visible light which varies in length from 760 to 380 millimicrons, and invisible ultra-violet rays which range from 380 to 290 millimicrons in length. Although strictly speaking the term light should be restricted to the visible rays, the term light or sunlight is here used as meaning the total solar radiation.

It was first shown some 50 years ago that sunlight retarded the growth of bacteria. Later it was observed that this action was not due to the heat of sunlight or in other words to the infra-red rays, nor to the visible rays with the exception of some of the shorter ones, but almost entirely to the ultra-violet rays. It was also observed that the shorter the ultra-violet ray the greater was this lethal effect on bacteria. It is obvious on account of this action of sunlight that it is of inestimable value to mankind from the hygienic standpoint. This is one effect of sunlight to which I wish to draw your attention.

Our knowledge of the effect of light on the growth, development and metabolism of the body has been gained largely through the study of one disease, namely, rickets. It is therefore necessary for us to consider this disease in some detail, not only on account of the importance of the

disease itself, but because its reaction to light gives us practically our only biologic test of the efficacy of different light rays. Rickets is a disease of infancy which occurs chiefly during the winter and spring months and in distribution is confined almost entirely to the temperate zones. It involves not only the osseous system but also other parts of the body, particularly the nervous and muscular systems. The earliest manifestations of the disease are restlessness, sweating about the head, the development of soft areas at the back of the skull and enlargement of the junction of the bony and cartilaginous portion of the ribs, the so-called rachitic rosary. Later the muscles lose their tone and the long bones become soft, which results in the development of the well known bow-leg and knock-knee deformities. The blood is characterized by a marked reduction in the concentration of the inorganic phosphorus, and a slight reduction in the concentration of calcium. The most important change produced by rickets, however, and one which is usually overlooked, is a general lack of resistance of the individual to infection. This is by far the most important result of the disease.

Rickets can be cured or prevented by the administration in the food of the so-called antirachitic vitamin which is present in large quantities in raw cod liver oil. The chemical composition of this vitamin is unknown. The beneficial effect can be accurately followed by the appearance of characteristic bone changes readily shown by X-ray examination, and by an increase in the concentration of the inorganic phosphorus of the blood. Rickets can also be cured or prevented by the exposure of the individual to ultra-violet rays.

The effect of ultra-violet rays on rickets was first observed about 7 years ago in Germany. The criterion of cure was the appearance of the characteristic bone changes as shown by the X-ray. No studies were made of the effect of light on the metabolism of the body, however,

until 4 years ago when it was shown almost simultaneously at New York, at Johns Hopkins and at Toronto, that ultra-violet rays produce in infants with rickets a marked increase in the inorganic phosphorus content of the blood. It is indeed remarkable in view of the fact that sunlight is the source of energy on this planet that this change in the phosphorus metabolism is the first undisputed effect of sunlight on the human organism which has ever been observed.

THE SHORTEST RAYS THE MOST ESSENTIAL

The shortest ultra-violet rays in the sunlight which reach the surface of the earth are 291 millimicrons in length, all rays shorter than this being absorbed by the layer of ozone in the outer limits of our atmosphere. This means that the ultra-violet rays of sunlight extend from 380 to 291 millimicrons in length. All these rays, however, are not equally effective from the metabolic standpoint. It has been shown, largely by the work of a New York investigator, that the effective rays are of a shorter wave length than 313 millimicrons. Therefore the rays in sunlight which are most essential for the well-being of the human organism range only from 313 to 291 millimicrons in length and constitute less than 1 per cent of the total solar radiation.

There are a number of factors which influence the percentage of essential ultra-violet rays which reach us. One of the properties of these rays is that they possess very little power of penetration and the shorter the wave length the more readily is the ray absorbed. The shorter rays which are the most essential ones, are readily cut off by the smoke dust and moisture in the air. One need only note the amount of smoke which hangs over all our large cities to realize what an important factor this is. Unfortunately no statistics for American cities are available, but in the city of London, England, as compared with the country of England, and as compared with the Swiss Alps, the highest daily percentage of ultra-violet

rays was found to be in the proportion of 6 to 23 to 41. In other words the smoke dust and moisture in the air of London, compared with the Swiss Alps cut off over 85 per cent of the rays which are so essential to mankind. In Toronto we have so realized the importance of this factor that we are building a half-million dollar addition to our Hospital for Sick Children in the form of a convalescent home situated twelve miles outside the city.

The height of the sun in the sky is another factor which influences the percentage of ultra-violet rays which reach us. It is quite obvious that when the sun is low the rays pass through a greater distance of our atmosphere and in this way a larger proportion are removed. We find that the percentage of ultra-violet rays in the early morning or late afternoon sunlight is practically negligible. Also in the winter in the temperate zone the sun is so low that the percentage of ultra-violet rays even at midday is very small. Actual measurements show that in the northern part of the United States and the southern part of Canada only about one-tenth of the ultra-violet radiation is found in the noonday sunlight of January as compared with that of July. The importance of this reduction of ultra-violet radiation may be even greater than the figures indicate as the shortest and therefore the most effective rays are those diminished the most.

GLASS AND CLOTHING IMPENETRABLE

The prevalence of the use of glass in our modern life must be considered in this question of ultra-violet radiation. Ordinary window glass stops all rays shorter than 330 millimicrons in length. Although the light, which has passed through glass, is of the greatest importance from the standpoint of vision and retains all the appearance of ordinary sunlight, it contains none of the potent ultra-violet rays. This fact cannot be too strongly emphasized because so few people realize that light which has passed through ordinary glass has been robbed of practically all the rays which are essential for health.

The last important factor to be considered is the effect of clothes. Ultra-violet rays cannot penetrate ordinary clothing. Even an open mesh removes over 50 per cent of these rays. It is evident that to be effective the ultra-violet rays must fall on the unprotected skin:

We may conclude from all these facts that the effectiveness of solar ultra-violet radiation is dependent on:

1. The clearness of the atmosphere
2. The height of the sun in the sky which is in turn dependent on the time of the day and the season of the year
3. The absence of glass between the individual and the source of sunlight
4. The amount of the body directly exposed to the rays of the sun

THE ANTIRACHITIC VITAMIN

We have stated that rickets can be cured or prevented by two means, first the administration of the antirachitic vitamin and second by the exposure of the individual to ultra-violet rays. At first glance these curative agents appear to have no connection with each other, but recent experiments reported simultaneously from Wisconsin and New York have shown that their action is the result of a common factor. It was found that exposure of different food substances to ultra-violet rays resulted in the production in the food of some substance which possessed the same properties as the antirachitic vitamin. There is no doubt that this substance actually is the antirachitic vitamin itself. It was soon found, however, that in order to produce the vitamin it was necessary for the irradiated substance to contain either cholesterol, an essential constituent of animal cells, or phytosterol, the corresponding plant constituent. In other words, the antirachitic vitamin may be produced by exposure of cholesterol or phytosterol to ultra-violet rays. What chemical change is produced in these substances is unknown. We can make the antirachitic vitamin but we still do not know its composition.

We have to go but one step further to link up the common effect of ultra-violet rays and the antirachitic vitamin. Cholesterol in inert foods can be so changed by exposure to ultra-violet rays that the antirachitic vitamin is actually produced. There is ample proof that cholesterol in the living body is activated in the same manner. Observations have been made that milk from irradiated cows and eggs from irradiated hens contain more antirachitic vitamin than when the animals or birds have not been exposed to ultra-violet rays. Another suggestive fact is that the part of the body exposed to ultra-violet rays, the skin, has a very high cholesterol content. We may conclude therefore that the ultra-violet rays of sunlight produce in the skin the antirachitic vitamin which is carried by the blood throughout the different organs to exert in some manner a vital influence on the metabolism of the body.

CHOLESTEROL IN COD LIVER OIL

The antirachitic vitamin of cod liver oil owes its efficacy to the ultra-violet rays of sunlight. The sea contains a great deal of vegetable matter and as water is comparatively permeable to ultra-violet rays a large quantity of this matter no doubt contains activated phytosterol. Small fish eat this vegetable matter and change the phytosterol into cholesterol. The cod then eat these small fish and store the activated cholesterol in their livers from which it is extracted in the manufacture of cod liver oil.

SUNLIGHT SUPERIOR TO COD LIVER OIL

If the antirachitic vitamin and ultra-violet rays produce the same effect in infants and children are the ultraviolet rays necessary? Can they not be entirely replaced by cod liver oil? I think not. One reason is that the amount of cod liver oil which can be assimilated without the production of a gastrointestinal disturbance is limited. Although immeasurable benefits are obtained by the routine administration of 1 to 2 drams of cod liver oil 3

times a day to infants and children throughout the winter, the beneficial effect of summer sunlight is much greater. It is just possible that if the same amount of the antirachitic vitamin could be given in cod liver oil as is produced in the skin by the ultra-violet rays the effect might be the same. On the other hand, it is not positively known whether ultra-violet radiation does not increase the resistance of the individual regardless of the production of vitamin. It is very difficult to come to a definite conclusion as other factors must also be considered such as the greater amount of fresh air and exercise which children obtain in the summer. Also there is considerable indirect evidence that the visible and infra-red or heat waves of sunlight produce a beneficial effect on the body. In view of these facts it is reasonable to consider that although the antirachitic vitamin can produce the same vital effect on the metabolism of the body as is produced by some of the ultra-violet rays of sunlight; nevertheless sunlight if not absolutely essential for life is of the greatest importance.

Another question which may be legitimately raised is whether we get too much ultra-violet radiation in sunlight. Pigmentation or tanning of the skin which is produced largely by the ultra-violet rays act as a protective measure. In the tropics it is well known that prolonged exposure to sunlight produces deleterious effects but it has been shown that this is the result of the heat rays and not the ultra-violet rays. From the evidence at hand it is extremely doubtful that we can get too much ultra-violet radiation in sunlight.

DISSEMINATING INFORMATION

All mothers should be told of the importance of sunlight as a factor in the production of healthy infants and children. The difference between sunlight and fresh air must be clearly explained as comparatively few mothers will follow instructions unless this is done. They will put their children out each day on the

verandah or in the yard *but carefully protected from the direct sunlight*. We have found that the best results are obtained by telling mothers that they must get their children sunburnt. The objection will be raised that sunlight will hurt the baby's eyes. This is a tradition that has been handed down from generation to generation. In strong light infants close their eyelids which cuts off all the ultra-violet rays and most of the visible and heat rays. In Toronto we have exposed patients daily to sunlight for periods as long as 4 hours and have never observed any ill effects on the eyes.

In the winter it is practically impossible to expose more than just the face of the infant. As ordinary window glass cuts off all the vital rays it is useless to place the patient before a closed window. Certain American, English and German glass works have been experimenting in the manufacture of glass which will transmit these rays. It is expected that this type of glass will soon be on the market at a reasonable price.

Whenever possible even in the middle of winter the infant should be taken out on bright days for a time between the hours of 11 A.M. and 2 P.M. and the sun allowed to shine directly on its face. By April definite sun baths may be given. The infant should be protected from the wind, but the bonnet should be pushed well back to expose as much of the face and forehead as possible. It is advisable to turn the baby slightly on one side so that it may open its eyes without looking directly into the sun. Ten or 15 minutes is quite long enough for the first sun bath as the skin of the infant burns very readily. The duration should be increased about 5 minutes daily until exposure to the direct sunlight lasts 1 hour in the morning and 1 hour in the afternoon. As soon as possible the hands, the arms and legs should be exposed. In the hot summer days the head should be protected from the heat rays and on very hot days it is advisable to give the sun bath between 9 and 10:30 A.M. If these instruc-

tions are carefully carried out a surprising degree of tanning will be obtained as early as the first of April. The amount of tanning or sunburn may be taken as a rough estimate of the effectiveness of the treatment.

So far the value of sunlight from the pediatric standpoint only, has been considered, but the beneficial effects are not limited to infants and children. Rickets practically does not occur in adults but there is no doubt that ultra-violet rays are intimately concerned with the vital processes of the adult organism. As has been stated, the great mortality in rachitic infants is due not to the bone changes but to the marked lowering of the resistance to infection. These infants die of bronchopneumonia and other similar conditions and constitute our greatest factor in infant mortality during the winter and spring months. There is no doubt that ultra-violet rays increase the resistance to infection of the adult as well as the infant and child. Experiments undertaken in England in which blood was removed from adults before and after exposure to ultra-violet rays show a marked increase in the bactericidal power of the blood after the individual had been exposed to the rays. The blood platelets, which are now considered to be connected in some way with the resistance of the individual, were also increased in number. These experiments constitute a direct proof that ultra-violet rays can increase the resistance of patients against infection.

There is no doubt that the whole population of our communities suffer from a lack of ultra-violet radiation during the winter months. As a result of this there is an increasing lack of resistance to disease which results in the production during the late winter months of our greatest mortality rate of the year.

It is beyond the scope of this paper to consider other specific effects of ultra-violet radiation as in the treatment of bone tuberculosis or the various skin diseases. The subject of artificial ultra-violet rays from the mercury vapor quartz

lamp has not been considered, as it is very unlikely that these lamps will ever be of general use from the public health standpoint on account of their expense. A discussion of the value of artificial ultraviolet radiation would constitute a separate address. The mercury vapor quartz lamp has not only its advantages but its disadvantages, and it is not out of place to issue here a word of caution against its present-day indiscriminate use in the treatment of almost every known pathological condition. This in time will minimize its real value and bring discredit to the medical profession.

CONCLUSION

Sunlight is essential to life. The rays which apparently are the most essential are the shortest invisible rays. They constitute less than 1 per cent of the total solar radiation. They are readily absorbed by the smoke, dust and moisture of our atmosphere and on this account are markedly diminished in our cities. They are also diminished in the winter and in the early morning and late afternoon, due to the sun being lower in the sky and the rays consequently passing through a greater distance of our atmosphere. They are absolutely cut off by glass and clothes. These rays apparently act on a substance in the skin known as cholesterol and produce what was formerly known as the antirachitic vitamin. This is carried by the blood to the various organs and produces a vital effect on the metabolism of the body. No doubt many changes are produced but the ones we have definitely been able to measure are an increase in the calcium and phosphorus in the blood (the cure of rickets), an increase in the blood platelets, and an increase in the resistance of the individual to infection. If a knowledge of these facts can be disseminated throughout our communities, and applied by the people particularly during the late winter and spring months, it will

result in a marked reduction in the incidence of disease and also will be the means of saving thousands of lives.

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