GROWTH UNDER VITA GLASS.

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(With 5 Charts.)

While, within the past few years, recognition of the therapeutic value of ultra-violet rays has been spreading, the mode of action is in most cases obscure or disputable. So frequently are the results of exposure dramatic—as in the production of erythema, or the cure of rickets—that treatment by ultra-violet radiation has been attempted in many diseases; and the reported results have shown the widest variations. Inasmuch as many of the experiments have been, from their nature, uncontrolled, one is often not entitled to draw definite conclusions; and further, the pathological subject is not always the best for what are largely preliminary investigations.

Medical and lay opinion has shown a decided tendency to insist on the value of the ultra-violet part of the spectrum to such an extent that the procuring of a due meed of these rays for children is now a plank in the hygienist's platform. Concurrently the means for the provision of ultra-violet rays have been developed, and one has the choice of genuine heliotherapy, "artificial sunlight" baths, or, as a compromise, the fitting of windows which allow a modicum of the sun's ultra-violet to pass through. From many points of view, this last would seem the most practicable measure, and interest in this country was stimulated by the publication, some years ago, of the results obtained in the school children of Smethwick. The earlier experiments(1) on 30 boys working in a room glazed with vita glass during the winter of 1925–26 showed quite definite increases in weight and height, also in haemoglobin, as compared with a control group; the results being of such interest the experiment was repeated with much larger numbers (about 240 all told) over a period of a year; but in this last series the only positive finding(2) was a relative increase in haemoglobin of the order of 5 per cent.

It is difficult to establish a "normal" for any mixed group of human beings, as pointed out in the Smethwick reports and elsewhere. Interest was therefore diverted to the effect of ultra-violet radiation on experimental animals; but, perhaps owing to the clinical importance of rickets and tuberculosis, attention has been largely bestowed on the value of radiation in these and other subnormal conditions. It seemed at the time that an investigation of the result of exposure of healthy animals to ultra-violet rays might prove of some interest, and the experiments detailed hereunder were therefore performed.

Colonies of rats were maintained in specially constructed hardwood boxes

on the flat roof of the building: these boxes were 3 ft. long by 1 ft. broad by 7 in. high, the roofs recessed to hold a sheet of glass approximately 3 ft. by 1 ft. A continuous light-trapped ventilating opening $\frac{1}{4}$ in. deep was provided under the glass, and a hole drilled in the side of each box for the supply of tap water by the usual inverted bulb tube. Every evening a small inverted box was put into the larger box, this small box having an entrance cut out: and in it the animals passed the night, with reasonable protection from cold. The bedding was fat-free cotton-wool. For each box roofed over with ordinary window glass, one was roofed with vita glass of the same thickness, artificially solarised by exposure to the rays from a mercury vapour lamp.

The animals used were pedigree albino rats, and groups were formed as follows:

(1) 12 males under ordinary glass;
(2) 12 males under vita glass;
(3) 12 females under ordinary glass;
(4) 12 females under vita glass;
(5) 6 males and 6 females under ordinary glass;
(6) 6 males and 6 females under vita glass.

The initial age of the animals was 30–32 days, and the experimental period 245 days (except for those litters reared by the females of groups 5 and 6). The previous nutritional history of the animals was good, and all were maintained on the stock Sherman B diet(3) during the experimental period, the diet being given *ad lib.* The composition of this diet is:

Whole wheaten meal	100 parts
Dried whole milk	50 parts
Sodium chloride	2 parts

Weighings were made every alternate day, including weighings of the litters of groups 5 and 6. The experimental period was from the beginning of March to the end of October.

Results.

The accompanying growth curves are self-explanatory. It has been found that the stock rats (which are derived originally from Wistar Institute stock) grow in fairly exact correspondence with the Donaldson curve(4), and the relevant portion of this curve is therefore included in each chart. It will be seen at once that one can draw no distinction between the rats kept under vita glass and those kept under ordinary window glass.

Discussion.

Assuming that those rats kept under ordinary glass grew at "normal" rates, any acceleration under vita glass will have to be described as "supernormal." The production of supernormal growth in animals has already been achieved in various ways, *e.g.* by exceptionally good housing and provision

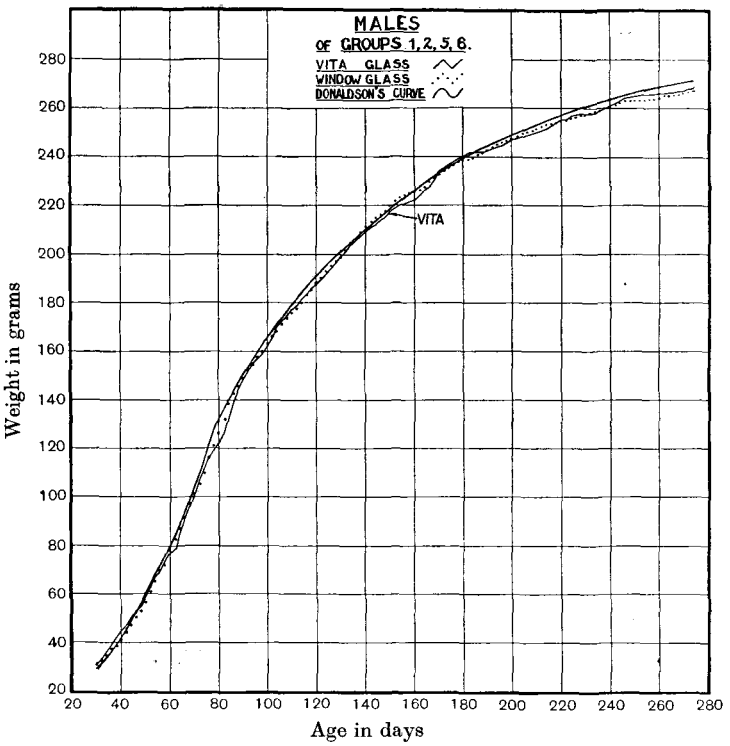

Chart I. Average Growth Curves.

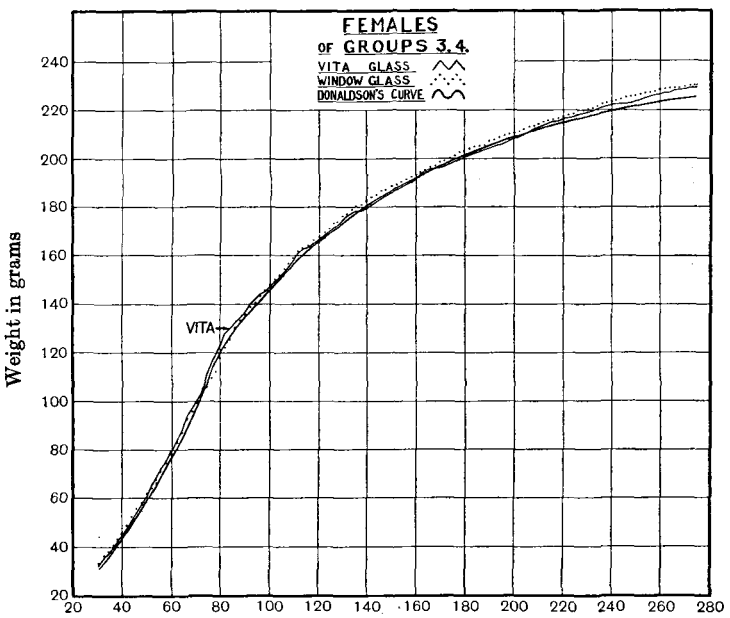

Chart II. Average Growth Curves.

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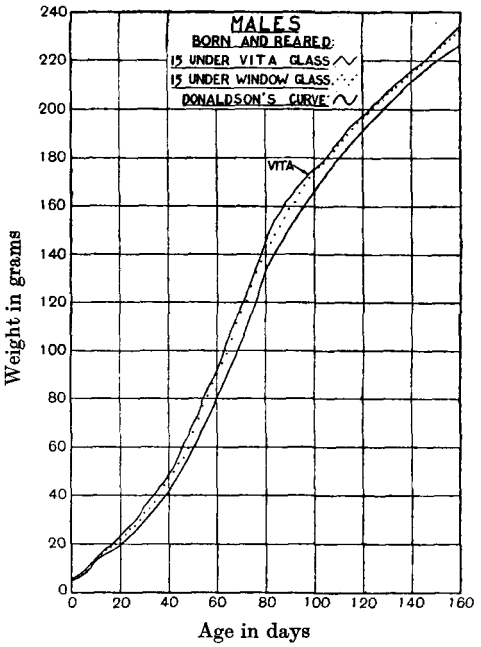

Chart III. Average Growth Curves.

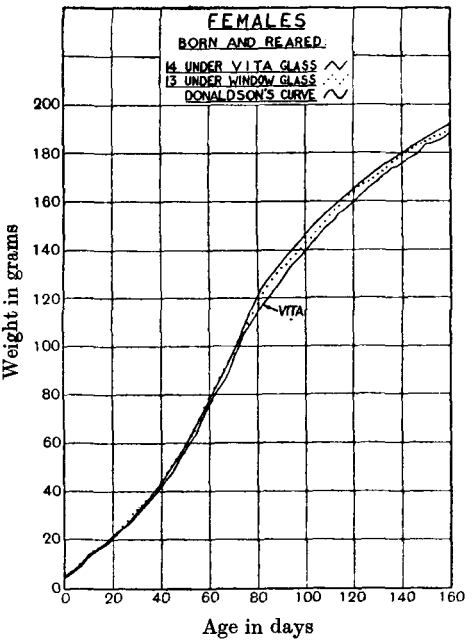

Chart IV. Average Growth Curves.

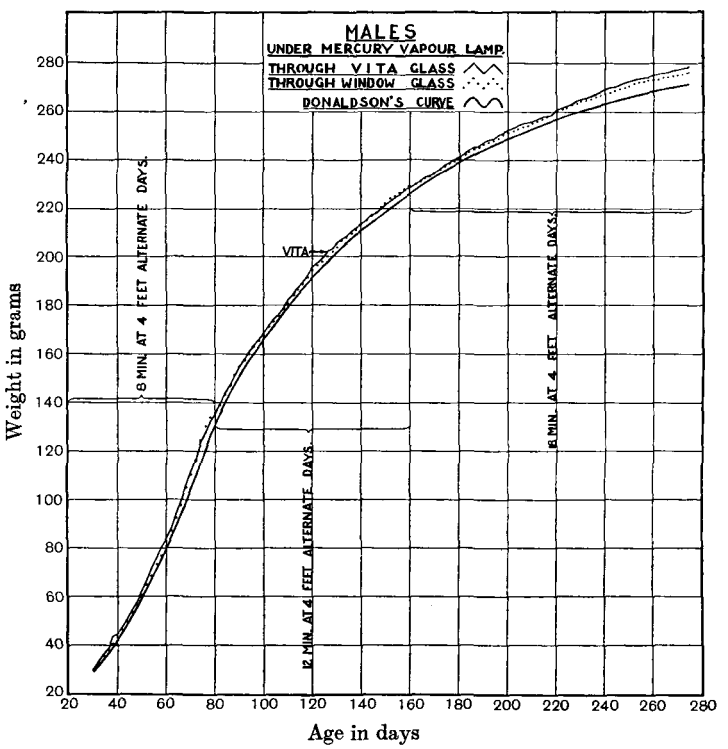

Chart V. Average Growth Curves.

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for exercise(5), by feeding on diets of high protein content(6), and by many other means of less direct interest. An admission of the possibility of supernormal growth is, nevertheless, no admission of its biological value, and one fails to see what advantage the overgrown animal (or child) has over its "normal" brother. It may be that normal growth is optimal growth.

Even in growth experiments on healthy subjects, as in so many aspects of this therapeutic problem, reports are at variance: for while in one instance(7), using normal rabbits, some growth acceleration was achieved and maintained by the use of long ultra-violet rays, the preponderance of evidence, in the human subject, is on the negative side(2, 8, 9, 10). Visible light may play some part (7, 11), and perhaps one may explain divergencies on the count of dosage, but this paper is concerned only with sunlight filtered through glass, where the range of dosage is strictly limited. It is in no way cognate to this argument that ultra-violet rays may stimulate growth in pathological subjects; for growth is the result of the integration of many factors, and to one especially—the growth-permissive "factor" of vitamin D—may be traced the happy result of much work on the human subject and experimental animal.

Were it the case that, in the proper wave-lengths, intensity and dosage, ultra-violet rays could stimulate growth, one would expect them to have an effect on metabolism: and yet, while recognising some positive results(12, 13 *et alia*), one must concede the comparative failure of so many experiments to show any change(14, 15, 16).

It is recognised that the negative result of this investigation must be accepted, if at all, in conjunction with the nature, intensity and dosage of the ultra-violet rays. When this work was begun, there was no method in regular use for the estimation of the intensity of ultra-violet radiation. The duration of bright sunshine during the experimental period was for groups 1 and 2, 1150 hours, and for groups 3 to 6, 1075 hours, representing in each case over 80 per cent. of the year's sunshine. The altitude of the sun was for 7 months out of the 8 more than 35°, Gage's "critical angle" for rickets(17). The experimental period covered those months when there is appreciable ultra-violet in the sunlight of Edinburgh; during November to February, measurement by Hill's method shows that the ultra-violet, though present, is of low intensity, and indeed often absent. Even in full sunshine one has to realise that the energy of the biotic ultra-violet is only 0·01 per cent. of the total radiant solar energy(18). In appreciating which rays of the ultra-violet range actually reached the animals under vita glass, one has to assess (*a*) the ultra-violet content of sunlight, and (*b*) the transmission factor of the glass. The range and intensity of shorter ultra-violet rays in sunlight is not large, and even at high altitudes the position of the "cut-off" is liable to considerable secular variation(19), but a useful guide is the statement(20) that it is in the region of $\lambda = 3000$ Å. Tests of solarised vita glass show that the transmission factor varies slightly according to the observer (*see* 21, 22, 23), but, taking the curves of Coblentz(24) as a basis, the transmission factor falls from 0·62 at λ3200 to

0·23 at λ3000 (and 0·17 at λ2950, the uttermost limit of the solar spectrum at sea level). For the region between λ3100, the site of the cut-off of window glass, and λ2950, the lower limit of the solar ultra-violet, the average transmission factor is approximately 0·27.

Thus those animals under vita glass received an increment of ultra-violet rays of an intensity approaching that of sunlight in the longer wave-lengths (about λ3100) but rapidly diminishing to zero at about λ3000 owing to the weakening of the sun's radiation and the increased opacity of the glass.

A further point in transferring any results to everyday use is that in these, as in most other experiments, the animals were exposed to direct sunshine through the glasses, an achievement rarely possible in house construction. Even allowing for the mediocre biological action of the ultra-violet rays of skyshine (25), the ultra-violet of diffuse daylight indoors is very small; and, granting that reflection of ultra-violet radiation may be surprisingly large (26), up to 45 per cent. at λ3200 for suitable reflectors, it may well be that indirect exposure under special glasses is, as suggested by Eddy (27), optimistic, or, as stated by Clark (28), futile. Experiments at this Institute by Col. J. du P. Langrishe (unpublished), even with wide open windows, do not give much hope. It will be recalled that, because of the shallow construction of the glazed boxes used for this series, a maximum of direct and scattered ultra-violet was secured for the animals. The animals were in fact over-illuminated by ordinary standards of indoor lighting.

It may be questioned whether sunlight passing through any special glass satisfies the criteria of Eidinow (29, 30) for deriving the greatest benefit from irradiation.

In the daily cleaning of the glass roofs of the boxes a large amount of deposit was often removed. It would seem that dirt does not absorb ultra-violet rays selectively (21, 31, 32); yet, when one considers that sometimes 75 per cent. of visible light is obstructed by dirty windows, this further toll on the ultra-violet is of practical importance.

The difficulties in the path of the user of any specially permeable glass are many: the niggardly supply of ultra-violet radiation in winter, when, if necessary, it is most needed; the inevitable loss in transmission through the glass; the practical necessity for frequent cleaning; the importance of exposure to directly transmitted sunshine; the need for casting off clothing; and the prime cost—all make a strangely sad story for those of us whose hopes of a new preventive technique were high. Perhaps the perfect source may be found in the newer artificial light sources, which supply ultra-violet light in those seasons when it is naturally deficient.

I must express my most sincere thanks to Prof. Lelean for his interest and help in my work.

SUMMARY.

White rats reared from the age of 30 days to 275 days under vita glass, and properly fed, do not grow at a different rate from those reared under ordinary glass.

The offspring of these rats, kept in the same environment, grow at the normal rate when compared with controls born and reared under ordinary window glass.

A short discussion of these results is given in the text.

Addendum. The temptation to use an artificial source of ultra-violet rays having proved irresistible, a further experiment was performed with 20 males, 10 under vita glass and 10 under window glass. These were exposed to the radiation of a Hanovia quartz mercury vapour lamp[1] on alternate days, at a distance of four feet from the burner. The growth curves are shown on Chart V, and the lengths of exposure have been entered on this chart: it will be seen that the results are the same as with natural sunlight.

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