

or even from the eyes of the small number of persons whose visual function has been minutely tested, to the properties, as optical instruments, of the eyes of mankind in general. "La position," writes Helmholtz, "des foyers, des points principaux et des points nodaux de l'œil est assurément soumise à des variations individuelles assez importantes, puisque la plupart des mensurations de l'œil et de ses diverses surfaces réfringentes présentent, chez différents sujets, des différences plus grandes qu'on ne paraissait devoir les attendre pour un organe dont les fonctions semblent réclamer une si grande exactitude de construction."

As a matter of fact, the theoretical limit of resolving power assigned by Lord Rayleigh, to which he tells us that civilised physicists "approach," is one which civilised physicists have considerably exceeded. The mean of twelve observers, as quoted by Helmholtz, gives resolving power under a visual angle of 101 seconds; and this mean is reduced by two cases in which the angles were 124 and 147 seconds respectively. The minimum was 51 seconds, the most frequent angle was about 80 or 90 seconds. The commonly accepted standard of normal vision among civilised people is satisfied by deciphering letters the parts of which subtend visual angles of one minute, while each letter as a whole subtends a visual angle of five minutes.

I cannot say, however, that I think any such tests are very material to the issue. The eyes of civilised physicists, or of such of them as have undertaken practical research in physiological optics, are probably very highly cultivated, and I doubt whether resolving power, which must greatly depend upon the functional activity of the central depression of the retina or, in the case of stars, upon the functional activity of the zone which immediately surrounds the yellow spot, furnishes any accurate test of acuteness of vision in the sense in which I employed the phrase.

Assuming the civilised man and the savage to have eyes of precisely equal optical value, the latter might yet possess an acuteness of vision greatly in excess of that of the former; and this excess might be due to conditions of the percipient elements of the retina which, in the case of the savage, permitted the optical powers to be utilised to the fullest extent. The savage might have greater sensitiveness to variations of light, greater sensitiveness to colour, and acuteness of vision over a larger retinal area. All these advantages might be conferred by better formation or higher development of the retina, and such higher development might at once be promoted by exercise and handed down by descent. I support the "commonly-received view" that the vision of savages is more acute than that of civilised men, because this view seems to me to be established by abundant testimony, and to be in perfect harmony with physiological knowledge. I feel very strongly that the conditions of town life are unfavourable to the evolution of the eye and favourable to its involution or degradation; and I believe that a moderate amount of attention might greatly modify these conditions, and might do for the eyes what is done by athletic games and exercises for the muscles.

With regard to the improvement of Lord Rayleigh's own vision, in a dim light only, by concave glasses, I think his Lordship cannot fail to see that the case, as stated, does not contain all the data which would be required in order to arrive at an explanation of the phenomenon.

R. BRUDENELL CARTER

IN a short article on Civilisation and Eyesight which appeared in NATURE of February 12, Lord Rayleigh expresses the belief that the greater visual acuity of savages "is a question of attention and practice in the interpretation of minute indications" and is not ascribable to any possible inherent superiority in their eyes, regarded simply as optical instruments. With this conclusion probably most who have had opportunities of testing the sight of uncivilised races or read the account given by those who have undertaken such examinations, will agree. The same difference in making more or less out of an imperfect retinal image is met with in different individuals with the same degree of short sight, and otherwise subjected to similar conditions according as they have or have not been in the habit of resorting to constant optical correction of their defect. Such a cerebral elaboration of the retinal image, as it might be called, constitutes also probably the main reason for the difference between the visual acuity of children who have only just learnt to read the letters of the alphabet and adults, which our ordinary tests so frequently show.

The question of the increasing prevalence of short sight has for a considerable time been the subject of much investigation and speculation in Germany, the results of which have been in many cases to give rise to predictions of rather an alarmist tendency. These, again, have led to legislation in the shape of regulations with respect to school appliances which might meet the theoretical requirements of the most energetic and influential agitators. It is to be hoped that, as the question is now being brought forward in this country, it will be viewed in a more comprehensive manner. The numerous statistics from German schools have shown that the proportion of short-sighted boys continually increases from form to form, and from this fact it is very generally argued that the continued use of the eyes for the perception of near objects is the essential if not the only factor in the production of short sight. This view appears, again, to be supported by statistics which allot the largest proportion of short-sighted individuals to those branches of industry or those pursuits which constantly call for near vision. Two points, however, appear to be forgotten, or at all events fail to receive sufficient consideration, in arriving at such a conclusion. In the first place, there is an undoubted tendency to increase in the degree of short sight with age alone up to the period of cessation of growth. This has been shown to be due to the elongation of the antero-posterior axis of the eye, which carries the retina further and further from the principal focus of the dioptric media, and is in the vast majority of cases no more a disease than is the attainment of a greater than average height by a certain number of individuals. It is merely a type, and as such is governed by the laws of heredity. A small proportion of cases of short sight are, however, due to disease. These differ from the ordinary cases in that they are seldom hereditary and are not more frequently present in the learned than in the absolutely illiterate classes, besides which the pathological changes to which they are due can often be detected with the ophthalmoscope. The second point which has to be taken into consideration is how far the greater proportion of short sight amongst literary men, or artisans whose daily work necessitates close vision, is actually due to their occupation, or depends on the circumstance that, being originally short-sighted, they have drifted into pursuits which are more attractive to them, owing to their not being able to enjoy out-door work or sports to the same extent as others whose eyes are more fortunately focussed. That the choice of a life-occupation is often influenced by the condition of the sight is a matter of every-day experience, and it would be interesting to have statistics showing to what extent this occurs in the case of myopia. Further, as a man's circle of acquaintance is, for the most part, amongst individuals having similar interests in life, intermarriage in myopic families must frequently occur, and would tend to perpetuate, and perhaps increase, the defect. In savages, on the other hand, where the great principle of the survival of the fittest is not frustrated to the same extent as among civilised races, everything would evidently be against the perpetuation of the myopic type. The question comes to be, then, Is not the absence, or comparatively great infrequency of short sight amongst savages due rather to the requirements of such races being antagonistic to the circumstances which would be most likely to perpetuate the myopic type, than to the fact that young savages are not subjected to compulsory education? The pages of NATURE are perhaps hardly the place to develop very fully a question of this kind; suffice it to say, therefore, that the conclusion which such reflections, as well as the result of every-day examination of cases of short sight, appear to justify, is, that *the increase of myopia is due mainly to the perpetuation of a type through the requirements of civilisation, and, though not a disease in the ordinary sense, it is desirable to attempt to check its progress.* This will assuredly not be an easy matter, but it is not likely to be much influenced by such school reforms as have been introduced into Germany.

Lord Rayleigh mentions, as an interesting subject for further investigation, the slight myopia which he finds not uncommon when the light is lowered in a room, until objects begin to be indistinctly seen. He finds, e.g., that though in a good light he sees rather worse with a concave lens of 36 inches focus than without it, yet, when the illumination is diminished, the same lens increases his visual acuity. Altogether, the influence of illumination on visual acuity, and the relation between light-sense and form-sense, are points which have not yet received adequate attention. If the phenomenon described by Lord Rayleigh be really one of short sight occurring under the circumstances mentioned, it is evident that it can only be due to involuntary accommoda-

tion for a nearer point than that on which attention is directed—a kind of spasmodic myopia, and, as such, would disappear when the power of accommodation was paralysed by atropine. On the other hand, it may not be myopia at all, the improvement given by the weak concave lens being perhaps due to the contraction of the pupil, which would occur along with the accommodation necessary to neutralise the effect of the glass. If this were the case, the improvement would also take place by the use of a suitable diaphragm held in front of the eye. Still another possible explanation suggests itself, viz. that the new dioptric combination made up of the concave lens and partially accommodated crystalline might introduce conditions of chromatic and spherical aberration which were more favourable to distinct vision. The disturbing effects of such aberration are probably greatly neutralised by the arrangement of the retinal elements, but the degree of the neutralisation is, not unlikely, dependent on the amount of absolute and relative illumination of contiguous elements.

GEO. A. BERRY

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The Fall of Autumnal Foliage

THE paper by Mr. Sorby in *NATURE* for December 4, 1884 (p. 105) opens up an unpursued inquiry into the cause of leaves falling in autumn. While Mr. Sorby has had his attention drawn to the subject by looking at the actual trees and leaves “of the fine display of autumnal tints which we have lately seen” in England, there is much of both positive and negative evidence to be drawn in two extreme directions—the tropics and the pole.

Being, in the year 1881, home from India, where, it is not necessary to say, nearly all the trees retain their green foliage throughout the year, the writer indulged in a long curiosity to see the counties of Caithness, Orkney, and Shetland. He went there with reference to the luminosity, which reaches its maximum in them for Great Britain, and is very marked and exceedingly striking and beautiful as a feature all over the north of Scotland in the month of June, when it is daylight all through the hours of night, sufficiently clear for reading distinct print at twelve o'clock midnight.

A peculiarity of Caithness and the Orkney and Shetland Islands is that no forest-trees can be got to grow. Setting on one side a remark “that it was because nobody had tried,” the suspicion had already occurred to my mind that there must exist some other causes than those usually asserted—the high sea winds, bleakness in winter, and extreme cold—for this want of trees.

Any one who has been much in the north of Scotland, and is at all acquainted with the optical sciences, cannot fail to have noticed the immense amount of polarised light there is from the sky; almost all the diffused daylight, except for an hour or two in the middle of the day, being plane or elliptically polarised.

The attention of readers of *NATURE* may with advantage be specially directed to the possibility, from the phenomena of the north, that leaves fall in autumn from trees growing above a certain latitude—about 30° —through loss of vitality in the more or less highly polarised light.

The first thing a traveller from India notices in Alexandria is the American fall of the leaves in the Grande Place, or, as a fellow-passenger once put it, pointing to these, “It is here trees first become deciduous.” It is worth being remarked that, not until reaching Cairo or Alexandria, can sun-protection be done without.

So far Mr. Sorby has to refer to the action of light in the last resort, as he says, with regard to leave, “slight frosts reduce their vitality in such a manner, that the chlorophyll is changed by the action of the light into a red product.”

Chlorophyll is composed of carbon, hydrogen, oxygen, and a trace of iron. Chemically it is $C_{18}H_{20}N_2O_8 + O_{18}$, resulting from the action of carbonic acid and ammonia on a fat, $C_8H_{14}O$, under the influence of light, as given by a different authority; but the composition of its products and combinations have not been traced. Still there is almost every constituent of the animal frame present except the earthy salts, and it must be a substance very sensitive to rays of light, or to what light probably is, electro-magnetic forces.

The weakening of the plant is supposed by Mr. Sorby to have occurred, for the leaves of a tree to have lost the vitality which counteracted the chemical degradation of the chlorophyll. Now in India or Ceylon, if a stalk were injured, the leaves

would wither into brown. Trees remain, however, when living, constantly green, the leaves dropping off gradually one by one almost, and are immediately replaced. Indian leaves of trees are much thicker, and more of the texture of parchment than those of foliage in European countries, and the phenomena of change can be studied in evergreens without going there, Indian observation merely serving to draw attention that might not otherwise be given to the matter.

The Rothamsted experiments of Sir J. B. Lawes and Dr. Gilbert, F.R.S., bear closely on the question. They found (Swansea, 1880, address) that plants assimilate chlorophyll not only during but a small portion of the year, but the action is limited to the hours of daylight, while during darkness there is rather loss than gain. The experiments, however, both there and in Norway by Prof. Schübeler, were made in ordinary unpolarised solar or electric light.

On the other hand, in India the light is intense owing to its tropical position, and, from the altitude of the course of the sun, very slightly polarised. It is only for an hour at dawn and another hour of sunset that the Indian is at all the same sort of daylight that it is in England. It accords with the Rothamsted and Norwegian experiments under the continuous exposure of vegetation to daylight and electric illumination during the night that the trees in India are large and evergreen. Of course in time leaves have done their work and fade, but as they have not been unfolded simultaneously, they drop off gradually in batches.

Where, accordingly, the light is polarised, trees are scarce or absent, mown by a swathing light; and in the tropics, where there is little polarisation, they are luxuriant, and green all the year round.

This is not inconsistent with fact. To begin with, plane polarised light has half the intensity of ordinary white light, the set of vibrations at right angles to the plane of polarisation being absorbed in the reflecting matter of the sky. Besides, circularly or elliptically polarised light must largely prevail, to judge from the metallic glow there is on the Pentland Firth, Orkney, and Shetland in midsummer, and what effect circularly polarised light has on the assimilation of carbon in the leaves of plants and decomposition of chlorophyll is unknown.

At any rate, Caithness, and the northern islands have a number of hours in the daytime of a wintry darkness, and scarcely any light in the summer months and its long days that is not polarised. From this cause, which could in the leisure of their winter be put in arithmetical units of force, combined with cold winds and a thin soil, without alluvial deposits, resting on stone, it is no wonder that, though the inhabitants are not strangers to the pathos of the fall of the leaf, the Caithness-shire landscape, and the sward and heather of Orkney and Shetland are lustrous day and night with polarised light, and bare of autumnal foliage.

A. T. FRASER

India, January 22

Erosion of Glass

IN reference to the letter of Dr. Ord in last week's *NATURE*, glass is by no means proof against the action of either acids or alkalis, indeed its resisting seems to depend merely on its colloidal, at any rate non-permeable, nature. It may not be generally known that water alone very rapidly acts on glass, especially when it is in a finely divided state, extracting both alkalis and silica in quantity. It would be rash to put down the action of substances on glass to “molecular coalescence” to the exclusion of chemical action, or under the idea that acids or fluorine are necessary to etch glass. Alkaline salts, especially phosphates, act, either wet or dry, very vigorously on glass. One class of salts, the potassium salts of phenol sulphonic acids, have been noticed to literally tear a glass bottle in pieces, whilst crystallising out of an acid solution. Ordinary gum is often acid in reaction; but the ordinary mechanical action of sticking and then contracting is probably quite sufficient to cause an abrasion or etching, especially with soda-glass. This purely mechanical action is often noticed in the distillation of tarry substances which solidify at a high temperature, the whole interior surface of the retort being torn off and cracked in all directions.

W. R. H.

A Lantern Screen

THE optical lantern has come to be so much used for scientific and educational purposes, that you may perhaps think it useful