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HUMAN PHYSIQUE AND CLIMATE

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Abstract: The analysis of the geographic distribution of human body height and body weight, as well as that of the anthropometric parameters correlated with it, reveals, without a doubt, clear distribution patterns: In all of the main racial groups — with the notable exception of the Negroids — the populations of cooler biotops are characterized by taller, heavier, thus, in general, bulkier somatotypes, while within populations of warmer biotops, a smaller lighter (thus generally more slender) somatotype predominates. So far the wellknown BERGMANN rule can be regarded as being valid also for man. Nevertheless, on account of still lacking satisfying evidence it seems to be rather problematic to interpret these associations as the result of selective acting forces leading to different thermoregulating adaptations to the various climatic conditions present on earth, though, of course, certain differences between somatotypes in their response to climatic stress are quite known. Considering the results of the modern growth research, it seems to be much more likely to recognize these climatic associations in the geographical distribution of anthropometric variables (like body height, etc.) in connection with the geographical distribution of nutritional factors, in particular with geographical differences in protein and calorie supply during childhood and adolescence. It remains an open question, however, whether merely selective adaptations to gross insufficient food supply are alone responsible or whether both qualitative and quantitative food deficiencies during the growth period effected long-lasting modifications. In addition, it is quite possible that the anthropometric differences found in various populations may also be dependent upon still-to-be-defined genetic variations concerning different growth capacities as well as the degree of socio-economic development of a population.

Key words: Human physique, climate, height, weight, Rohrer-index, weight/surface ratio, surface/weight ratio, mean annual temperature, protein intake, nutrition, adaptation.

It is a well documented fact that numerous anthropometric, dermatoglyphic, serological and biochemical variables of man are not distributed inhomogeneously all over the world, but are showing more or less characteristic distribution patterns or gradients, which are in many cases clearly connected with particular environmental factors such as climate, altitude, infectious diseases, etc. A detailed discussion of all these distribution patterns and its possible causes has been given by WALTER (1974a), to which it may be referred here. As for blood group polymorphisms, haemoglobin variants or skin pigmentation it is relatively easy to explain the present distribution patterns of gene or phenotype frequencies as the results of genetic adaptation processes via natural selection. Thus the ABO gene distribution is without doubt influenced by selection via smallpox and plague, some haemoglobin variants like Hb S and Hb C proved to be of considerable advantage in malaria burdened areas,

and, last but not least, dark skin colour seems to be an effective protection against high doses of ultraviolet radiation as they are found in tropical and high mountain areas. Against that, it is much more difficult to give a plausible explanation for the likewise apparent coherencies between human physique (respectively the anthropometric variables by which it is composed), on the one hand, and certain environmental factors on the other hand. Without any doubt there are e.g. associations between human physique (and its components) and climate, which has been pointed out first by RENSCH (1935), and insofar the wellknown BERGMANN (1847) rule can be regarded as being valid also for man. However, at the present stage of research it seems to be not admissibe to explain these associations between human physique and climate too decidedly as the result of selectively controlled genetic adaptation to various climatic conditions on the earth, as it was pointed out by ROBERTS (1952, 1953, 1960, 1973) or SCHREIDER (1950, 1951, 1963, 1966). It seems that these authors have not considered sufficiently the fact that all the anthropometric variables composing human physique are not only controlled by genetic factors, but are also influenced essentially by a good number of non-genetic factors, among which nutrition is playing an important role.

Thus in the following the problem "human physique und elimate" should be discussed again. By this, and by offering an own hypothesis to explain the association between human physique and climate, further research should be stimulated in order to approach to a more satisfying solution of this problem than it has been possible up to now. — For methodological details see WALTER 1974b, 1976.

From Figs 1—5 it is seen that body height, body weight, Rohrer-index, weight/surface ratio and surface/weight ratio — some major components of human physique — are not distributed inhomogeneously over the world, but are showing clear distribution patterns. Generally one can state from these

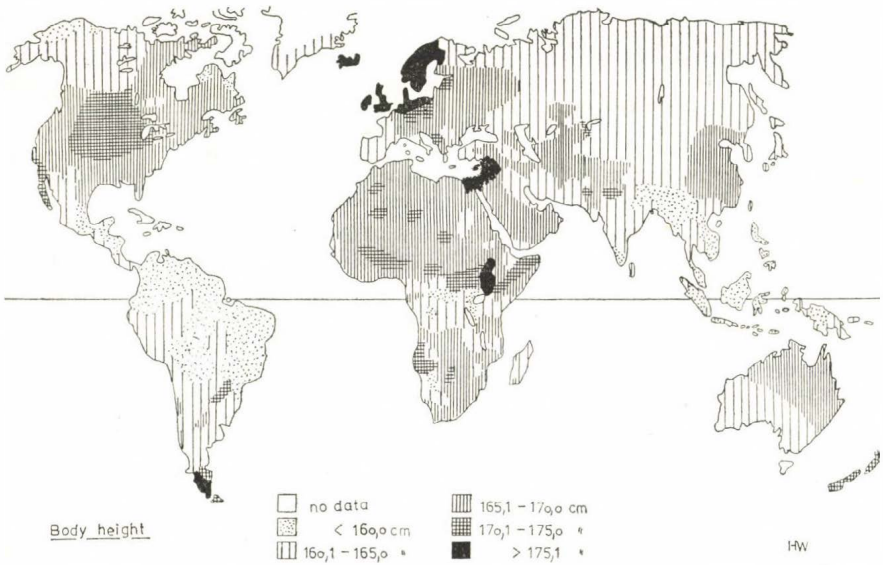

Fig. 1. Geographical distribution of body height

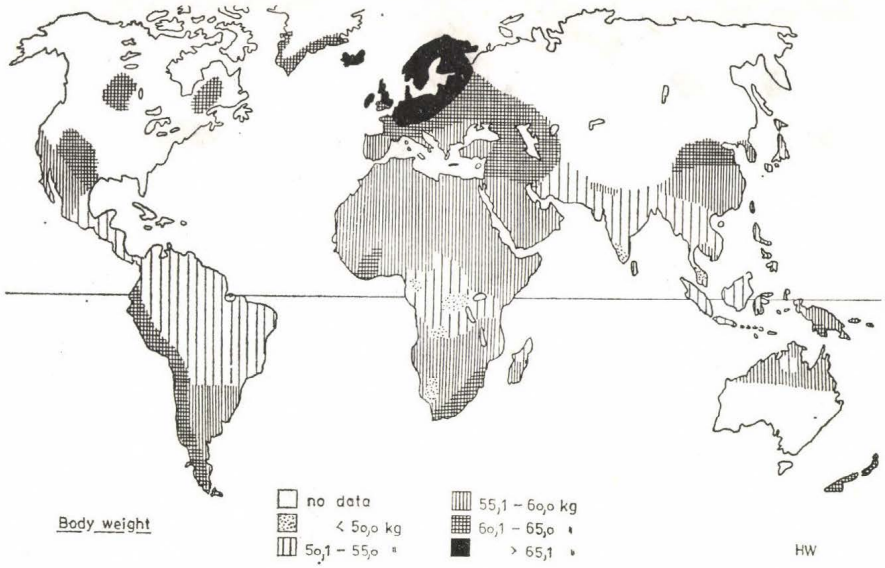

Fig. 2. Geographical distribution of body weight

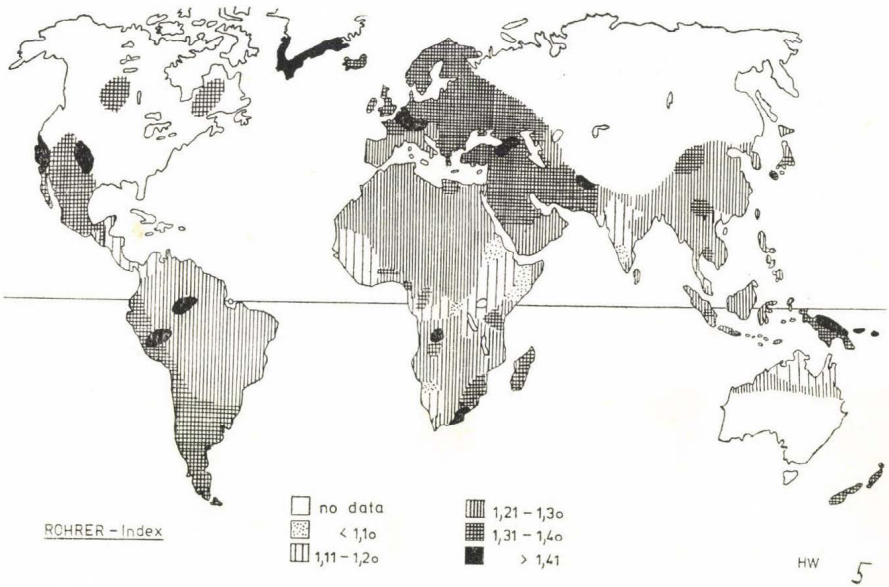

Fig. 3. Geographical distribution of Rohrer-index

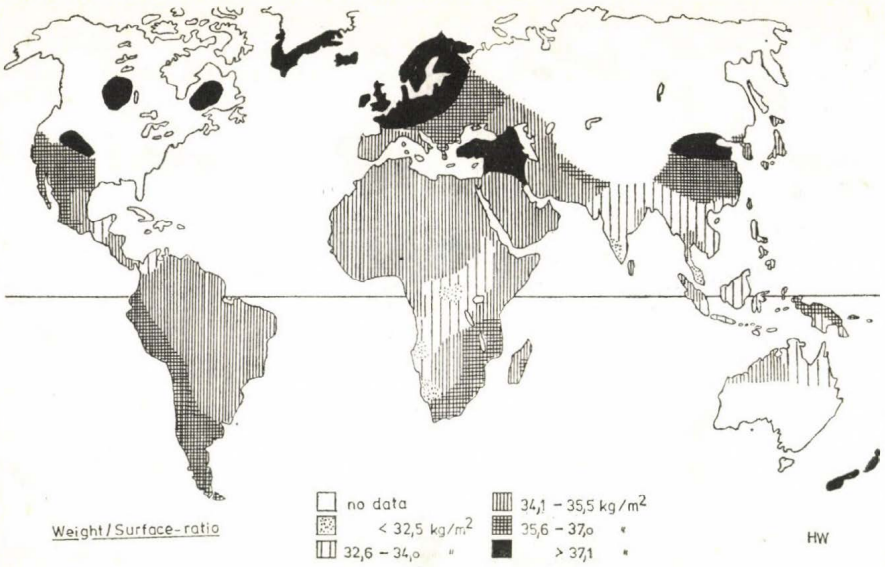

Fig. 4. Geographical distribution of weight/surface ratio

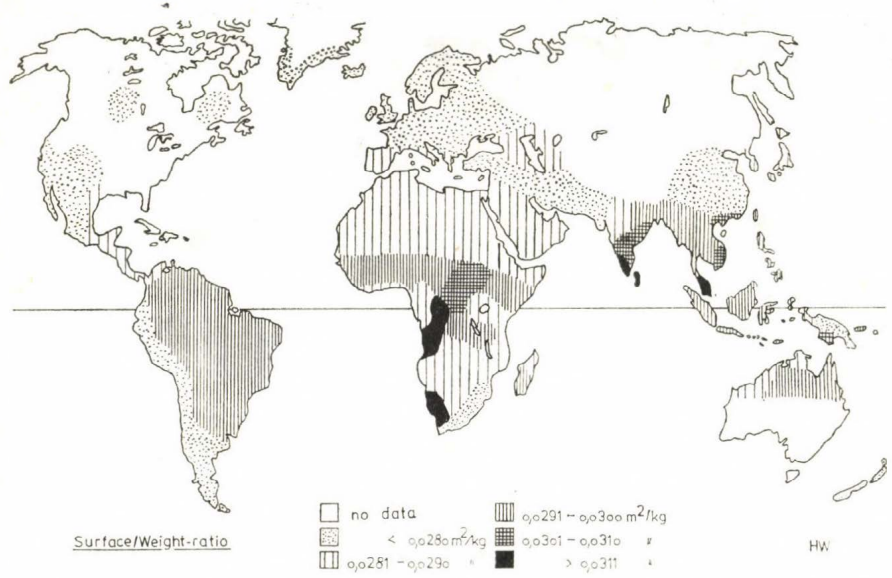

Fig. 5. Geographical distribution of surface/weight ratio

distributions patterns: Populations living in the warmer tropical and subtropical regions of the earth are averagely smaller, lighter, thus having generally more slender somatotypes as compared to those living in the cooler regions, who are characterised by generally taller, heavier and bulkier somatotypes. As the geographical distributions of weight/surface ratios and surface/weight ratios are also showing obvious relations to climatic conditions, one can say that *Bergmann's rule* — body size decreases as we progress from temperate regions towards the equator — holds true in man, too. The same can be said with regard to the *Allen rule*. As among the climatic factors the mean annual temperature is of considerable importance, body height, body weight, Rohrer-index, weight/surface ratio and surface/weight ratio of Caucasoid, Mongoloid and American Indian populations have been correlated with this climatic parameter. The results of these computations are shown in Figs 6—10. It is seen from these figures that in all these three racial groups mean body height, body weight, Rohrer-index and weight/surface ratio are decreasing with increasing mean annual temperature, whereas the surface/weight ratio is showing an opposite tendency. Thus human physique as a whole is without doubt anyhow related with climate. But how can this be explained?

The "classical" hypothesis runs as follows: Tall, heavy and bulky organisms with a for that reason relatively small surface are in cooler climates in advantage, because they have a greater heat production ability combined with a lesser heat loss. Small, light and more slender organisms with a for that reason smaller surface are in warmer climates in advantage, because they produce only relatively little heat combined with an effective heat loss because of a greater body surface. By this, life perilous effects of hypothermy and hyperthermy, respectively, would be avoided. Having such biological advantages

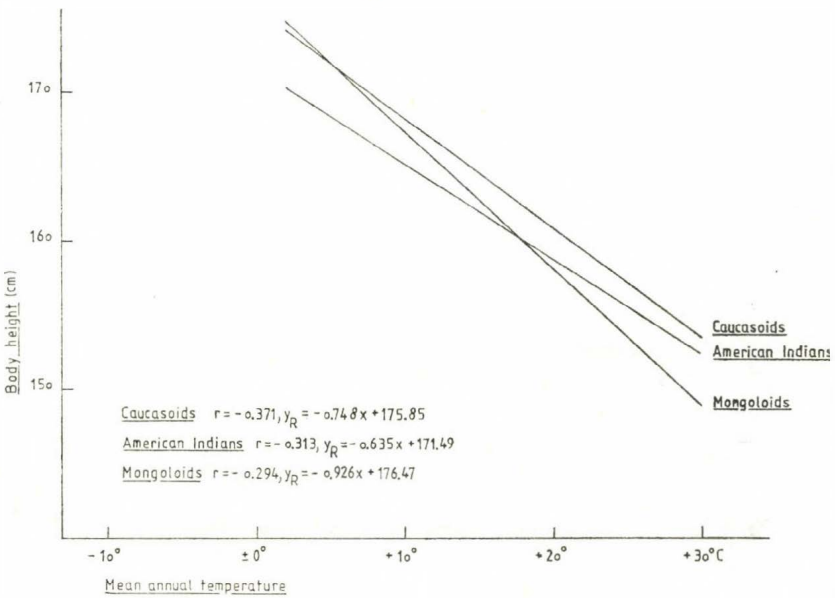

Fig. 6. Correlation between body height and mean annual temperature

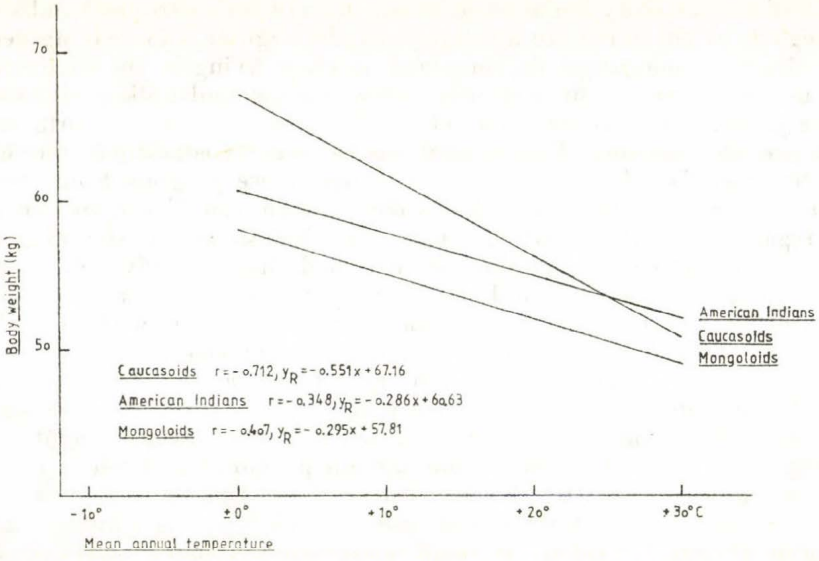

Fig. 7. **Correlation between body weight and mean annual temperature**

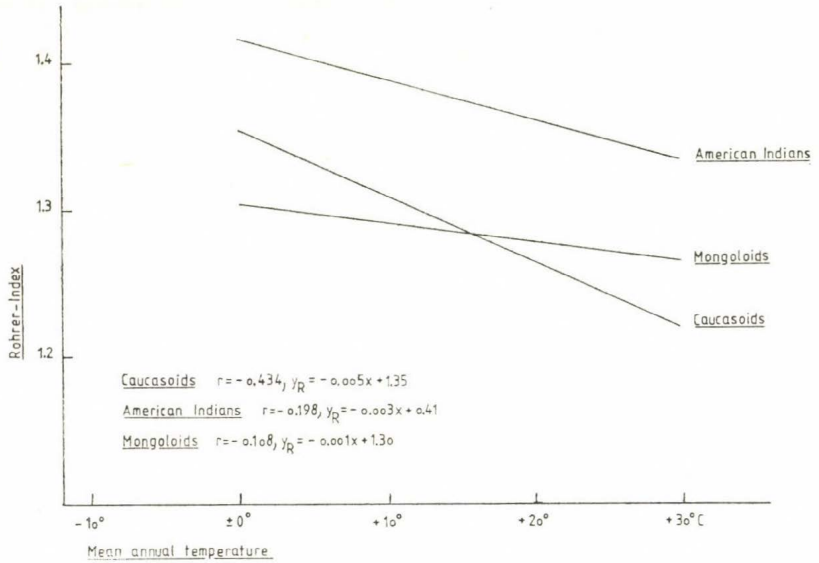

Fig. 8. **Correlation between Rohrer-index and mean annual temperature**

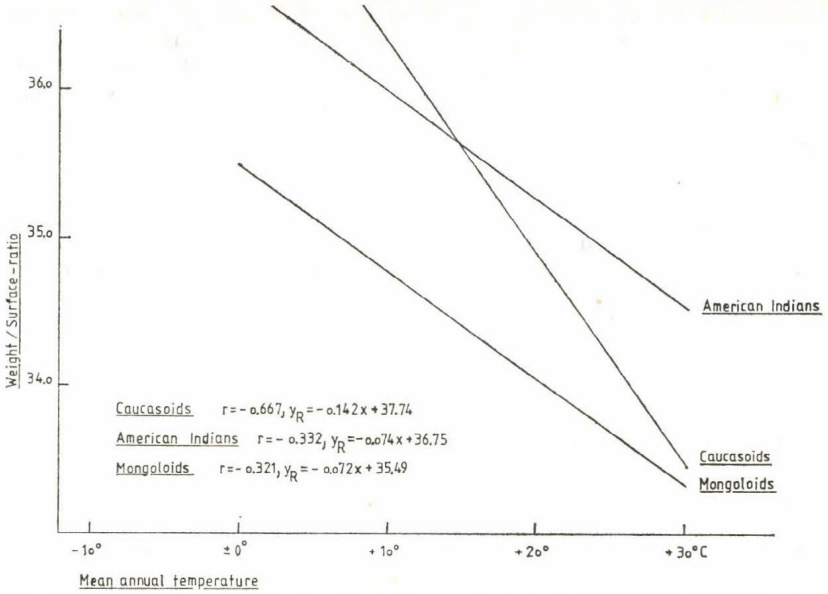

Fig. 9. **Correlation between weight/surface ratio and mean annual temperature**

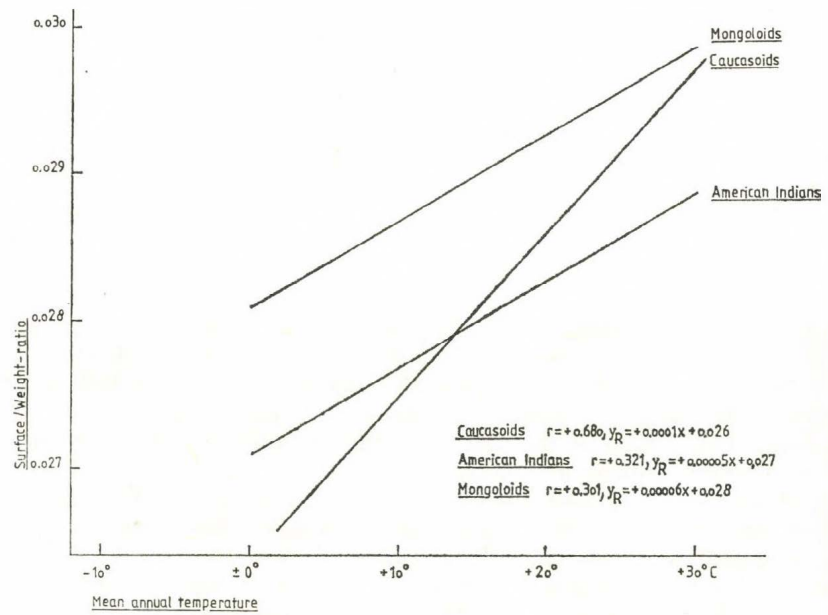

Fig. 10. **Correlation between surface/weight ratio and mean annual temperature**

the climate-related distribution of these somatotypes is supposed to came about in the course of man's evolution via natural selection.

Without doubt, this assumption appears to be plausible. However, is there any reliable evidence for that? None, as far as one can see. It rather has to be doubted considering the following questions:

1. Does the external form of human physique actually play the decisively role with regard to the thermoregulation of the human organism? As far as known up to now, no convincing evidence has ever been presented showing any climatic advantage or disadvantage of any somatotype. It rather has to be assumed that various physiological mechanisms independent from anthropometric factors are actually responsible for thermoregulation in man (and other mammals). This has also been emphasized by RÖHRS (1968), BRIGGS (1975), R. W. NEWMAN (1975b) and STEEGMAN JR. (1975).

2. Are there any indications showing that under specific climatic conditions specific somatotypes would have an effectively selective disadvantage, which must result in higher mortality rates of the non-adapted somatotypes before and during their reproductive phase? This is not the case. And furthermore it must be mentioned in this context that, up to now, all climate-associated variations of anthropometric variables were only seen in males, but never in females (SCHREIDER 1963)! And finally, hitherto no attempt has been made to study climate-associated variations of anthropometric variables on adolescents. R. W. NEWMAN (1975) points out in this connection: "Although a height/weight gradient in children from the tropics to temperate climates is well known, the influence of nutrition is so well established in subadult growth that it would be very difficult to correct for inequalities in nutritional background in a size-temperature comparison. Yet it is the subadult portion of a population that would have to be the prime target of selective pressure through differential mortality. Adult males represent a sample that has largely passed the screening process from a genetic standpoint. The emphasis on the adult surface/mass relationship ignores the fact, that every individual undergoes a remarkable change in its relationship from birth to adulthood. The ratio of surface area to mass changes threefold over this time because the mass increases twenty-fold, while the surface areas increase only sevenfold. Expressed another way, SCHREIDER (1963), who uses the reverse ratio (mass/surface), shows a total average ratio range of nine units from samples with the least mass per area (Bushmen and Semang) to samples with the most mass per area (Germans and Eskimos); this range is the same as that experienced by most individuals, at least in the United States, while maturing from age 2 to adulthood. The change is from a preponderance of surface area (heat adaptation?) to a preponderance of mass (cold adaptation?)". As these changes, without doubt, hold true for all human populations, even the subadult individuals living in cooler climates would be disadvantaged with respect to their thermoregulation, if anthropometric factors would actually be the most important ones. And this would be a biological absurdity.

3. Is it admissible to base the explanation of climate associations of human physique on a strong genetic control of its components as SCHREIDER (1966) does, writing: "The most plausible hypothesis is that these ecological gradients are the produce of natural selection. Nutritional habits cannot explain the gradients if they influence them. The wide differences revealed by the figures do not admit of this interpretation, as many gradients like the average body

mass of the populations are linked in the first place to the very marked variations in average sizes and anatomical proportions, which are largely, if not exclusively, hereditary."? This statement must be questioned, however, as it is known from many investigations that body height, body weight and thus all anthropometric parameters linked with them, are influenced to a not inconsiderable degree by environmental factors of different kind. In this context the secular changes of body height should be mentioned, which could be observed in Europeans (BACKMAN 1948, LENZ 1949, TANNER et al. 1966), in Japanese (SHIMAZONO 1973), and even in Bushmen (TOBIAS 1972). From all these studies it is known that growth and development in man are controlled by a great number of non-genetic factors, among which nutrition and also chronic diseases caused by infectious agents and parasites are playing a major role. How much under- and malnutrition, chronic diseases and especially the permanent combination of these growth disadvantaging factors can influence the whole body development, and how much they even can have "long lasting effects" until adulthood, could be demonstrated evidently by DUBOS et al. (1966).

Considering all these facts, especially those just mentioned, one should suppose an association between human physique and its anthropometric components, respectively, on the one hand, and the total of non-genetic growth controlling factors, on the other hand. Among these factors, without doubt, the daily protein intake is playing an important role. Fig. 11 is showing the world distribution of the average protein intake per capita and day, as it is known from FAO data. Comparing Fig. 11 with Figs 6—10 it becomes evident that populations living in areas with a high protein intake are generally taller, heavier, having also higher Rohrer-indices and higher weight/surface-ratios as compared to those living in areas with a low protein intake. The close

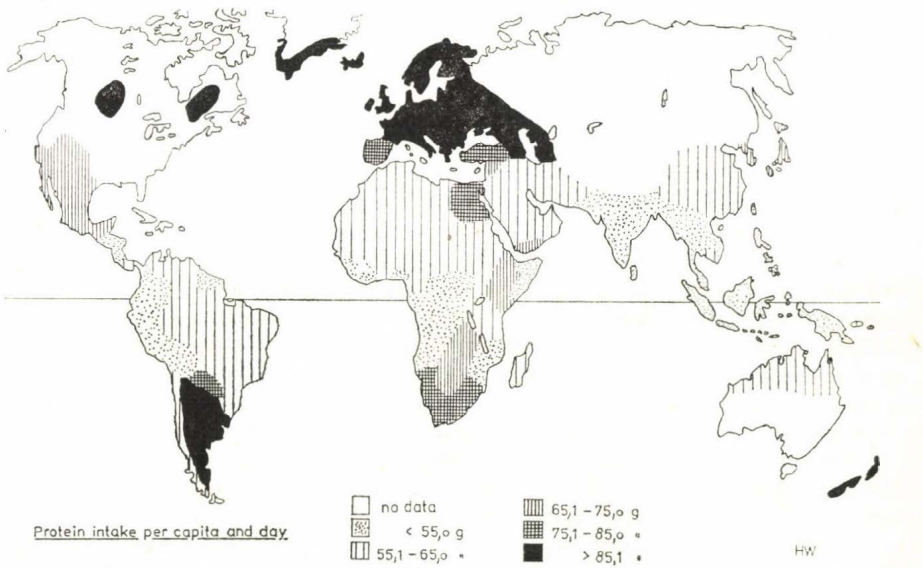

Fig. 11. Geographical distribution of protein intake per capita and day (data from FAO, 1964)

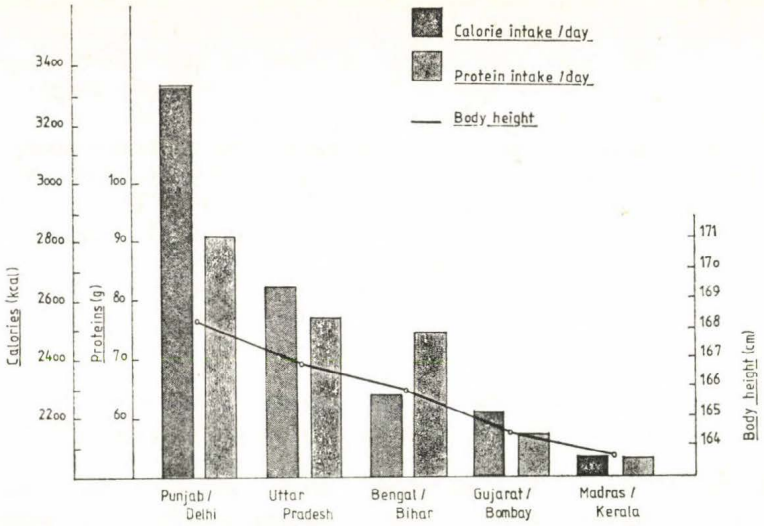

Fig. 12. **Nutrition and body height in India (20 year-old males; data from MALHOTRA, 1966)**

coherencies between protein and calorie supply and the average body height are also seen from Fig. 12, which is based on data from India. Further examples on the close coherencies between nutrition and anthropometric parameters such as body height and body weight have been given by MALHOTRA (1966) and M. T. NEWMAN (1975a).

As for the geographic distribution of the aver age protein intake, it is striking that the highest values are generally found in temperate and cool climatic zones, against that the lowest values are mostly seen in the warm and hot zones of the tropics and subtropics. According to FRISCH and REVELLE (1969) the same geographic distribution pattern is present regarding the caloric supply. Considering now the fact that protein and caloric supply during the human growth period are of high importance for the expression of anthropometric parameters even in adulthood, one can suppose that the climatic associations of body height, body weight as well as that of these parameters derived from them (Rohrer-index, weight/surface-ratio, surface/weight-ratio), are rather indirect ones. That means that these associations are to be seen less as the results of selection processes related to thermoregulation, for which at present no convincing evidence is in hand, but would rather reflect geographic differences in production and consumption of growth-important foodstuffs.

Are hence geographic differences in the distribution of somatotypes consequence of geographic differences in the facilities of production and thus consumption of growth important foodstuffs ? And would the anthropometric parameters, in particular body height and body weight, increase on a world-wide scale if a global nutrition improvement would happen as it has been the case in Europe since about 100 years, in Japan since about 50 years, and even in Bushmen since about 1935 ? Consequently, is it admissible to regard these geographic differences in body height etc. as modification effects, which would say that genetic endowments responsible for growth and development could be real-

ized in part only? Or might it be possible that the prevalence of smaller and lighter samototypes in the tropics and subtropics could be a result of selective adaptation to the chronic shortage of food being met here as compared to other climatic zones, in particular those of temperate climate? Such a hypothesis has been discussed already repeatedly, e.g. by THOMSON (1968) or by MALCOLM (1970). They argued as follows: In populations living for long periods under the conditions of mal- and undernutrition those individuals were in selective advantage who had a small genetic growth potential and hence a presumable small need of food, whereas individuals with a larger genetic growth potential and a consequently greater need of food are supposed to have been in selective disadvantage. Thus gene combinations effecting small and light somatotypes could spread in areas short of food, by which in the course of time climate associated distribution patterns came about. However, up to now, there is no conclusive evidence for such a hypothesis.

Without doubt, it is well a documented fact that anthropometric variables such as body height, body weight, Rohrer-index, weight/surface-ratio and surface/weight-ratio are associated with climatic conditions, in particular with the mean annual temperature. Insofar one can say that the geographic distribution patterns of all these variables are compatible with the so-called *Bergmann rule*. Against that, all attempts to explain these distribution patterns by selection, either via thermoregulation or via adaptation to chronic shortage of food, cannot satisfy, as they are starting from completely unproved assumptions.

After all, it seems that the geographic distributions of body height, body weight, etc. are associated only indirectly with climatic conditions, indirectly insofar as these conditions might be of significant influence on those environmental factors, which are growth advancing or disadvancing, respectively. These factors are quantity and quality of food as well as growth stunting chronic diseases caused by infectious germs or parasites. These are particularly found in tropical and subtropical areas, in which very frequently at the same time persistent shortage of caloric and protein rich foodstuffs is at hand. Hence one can point out, that possibly primarily the total of growth advancing or disadvancing factors, respectively is correlated with climate, whereas the climate associations of anthropometric variables would be of secondary importance, being so to speak indicators for the nature of those non-genetic factors, which are controlling human growth. How far the geographic differences in the distribution of anthropometric variables can be regarded as "long lasting effects" of unfavourable life conditions during childhood and adolescence or at least in part as the results of specific adaptation to chronic mal- or undernutrition, is for the time being not to be decided with certainty. There are at any rate many reasons to believe that the first assumption is more correct, last but not least the considerable increase of the body height among Europeans within the last century, which was without doubt caused by the improvement of the life conditions in particular, however, by the qualitative and quantitative improvement of the nutrition.

Summing up, it is not denied that the anthropometric differences seen among the various human races and populations are also caused by genetic factors. But this — in its extent unknown — genetic portion of these differences must not necessarily be considered as a climate associated genetic adaptation via selection. It is to be supposed that these differences are to a not inconsiderable

degree indicators of the total of growth conditions, which vary with the natural environment, but in addition to it also with the socio-economic situation, and this is generally in tropical and subtropical areas much more unfavourable as compared to that in temperate and cooler climates. Further investigations on the geographic and racial distribution of human physique and its components should consider therefore more than hitherto the impact of non-genetic factors for the coming about of these differences.

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