New Aspects in the Assessment of Physical Fitness.

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A Physician in a great city seems to be the mere plaything of Fortune; his degree of reputation is for the most part casual; they that employ him know not his excellence; they that reject him know not his deficiency.—SAMUEL JOHNSON.

THESE words might, with truth, have been written of Dr. John Hutchinson, one time physician to the Brompton Hospital for Diseases of the Chest. His earlier years devoted to the study of engineering, he later turned to medicine, and carried with him into his profession that enthusiasm for the accurate expression of scientific data which must have been engendered by his early training. In 1846 he published a paper "On the Capacity of the Lungs and on the Respiratory Functions" (1)¹, in which he showed that he possessed the inspiration which is ever the mark of true genius, combined with the ability for accurate observation and the patient collection of data. He made the earliest investigations into the physiological effects of "forced breathing"; by means of a mercurial manometer he examined "expiratory force"; but interest lies for the special ends of the present subject in the extensive series of observations which he made upon the "vital capacity"² of more than 3000 persons covering a wide range of body size, occupation, and mode of life.

Dr. Hutchinson claimed that he had shown that "vital capacity" increases in simple arithmetical progression with increasing height, and believed that he had disproved any relationship between "vital capacity" and body weight, trunk length, or circumference of the chest. The fact that his conclusions might be open to criticism, and that the fundamental principles underlying his investigation might yet have eluded his grasp, was present in his mind, and he concluded his treatise with the following remarkable sentences, which could well be taken as a model by any scientific worker:—

The matter of this communication is founded upon a vast number of facts—immutable truths which are infinitely beyond my comprehension. The deductions which I have ventured to draw therefrom I wish to advance with modesty, because time, with its mutations, may so unfold science as to crush these deductions and demonstrate them as unsound.

Nevertheless, the facts themselves can never alter nor deviate in their bearing upon respiration, one of the most important functions of the animal economy.

This prediction has, with the passage of time, been fulfilled.

Prof. G. Dreyer, of Oxford University, has made an extensive re-investigation of the whole subject, drawing upon Hutchinson's data as well as upon his own records. In a brilliant analysis

¹ The figures in brackets refer to the Bibliography at the end of the article.

² The term "vital capacity" is used to indicate the maximum amount of air the individual is able to expel from his lungs, by voluntary effort, after the deepest possible inspiration.

of this considerable body of observations, he has conclusively proved the existence of physiological laws which escaped the mind of the pioneer Hutchinson. On practically every point do these laws refute the conclusions reached by Hutchinson.

Prof. Dreyer (2) has shown that definite relationships do exist between "vital capacity" and body surface, body weight, trunk length, and the circumference of the chest, while no true relationship can be traced when "vital capacity" is regarded as a simple function of the standing height, as claimed by Hutchinson.

Hutchinson's misconception of the facts may be attributed in part to faulty mathematical analysis, in part to the fact that his observations were made upon subjects covering an insufficiently wide range of weight and size. It is obvious that physiological laws, if such exist, must be applicable over the entire period of growth of the individual, and must be inadequate if they can be established only over a limited range of variations of sex, age, stature, body weight, etc.

The scientific world is now familiar with the conception that certain physical, physiological, and anatomical attributes of the living organism are functions of the surface, and not of the volume, of that organism. Heat loss offers possibly the most familiar example, being relatively greater for the small body than for the large, by virtue of the relatively greater surface area presented by the small body for a given volume.

How can the surface of an animal be determined? It is simply necessary in this brief article to state that the surface can be determined indirectly from the body weight, of which it is a constant function. For justification of this procedure reference should be made to the original articles which describe the methods by which this relationship was determined (3 and 4).

Prof. Dreyer has in recent years shown that the blood volume (4), the cross-section of the aorta (5), and the cross-section of the trachea (6) are "surface functions" of the warm-blooded mammals, and not simply related to the body weight, as has often been maintained. It comes, therefore, as no surprise when he finds that "vital capacity" is also a "surface function," since this must represent, in one direction, the limit of the capacity possessed by the organism for oxygenating its blood and discharging the waste products of its metabolism, and consequently be a physiological expression of one most important aspect of respiration. It follows that this measurement gives us an index of the "vitality" of the organism, *i.e.* its ability to meet the various strains and stresses of its life.

If the "vital capacity" is a "surface function," there is the further difficulty to be faced: What

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is to be taken as the normal weight of the animal, if we are to determine its surface from its weight? This fundamental question has hitherto defied solution, but is now brought into the realms of exact science, since the work of Prof. Dreyer and Dr. Ainley Walker (2 and 7) has shown that in animals and man definite relationships exist between the trunk length, chest circumference, and body weight of individuals in health, while no accurate relationship, as has long been realised by those familiar with the subject, can be traced between standing height and body weight.

The value of these measurements is enhanced by the fact that, as anatomical data, they will be practically immune from change in diseases which may be accompanied by a loss of weight, and, further, that as they bear a constant relation to the body weight, so must they bear a constant relation to the surface area of that animal.

The relationships which have definitely been shown to exist between "vital capacity," body weight, trunk length, and the circumference of the chest can be expressed by the following formulæ (8) :—

(i) $\frac{W^n}{V.C.} = K_1$, where the power n is approximately $\frac{2}{3}$, though more accurately 0.72 ;

(ii) $\frac{\lambda^n}{V.C.} = K_2$, where the power n is approximately 2, though more accurately in males 2.26, in females 2.3 ;

(iii) $\frac{Ch^n}{V.C.} = K_3$, where the power n is approximately 2, though more accurately in males 1.97, in females 2.54 ;

while the relationships between body weight, trunk length, and circumference of the chest, respectively, can be expressed as follows :—

(iv) $\frac{W^n}{\lambda} = K_4$, where the power n is approximately $\frac{1}{3}$, though more accurately in males 0.319, in females 0.313 ;

(v) $\frac{W^n}{Ch} = K_5$, where the power n is approximately $\frac{1}{3}$, though more accurately in males 0.365, in females 0.284.

In all the above formulæ W = net body weight in grams, λ = trunk length in centimetres, Ch = circumference of the chest in centimetres, and $V.C.$ = vital capacity in cubic centimetres.

The procedures for taking the above-mentioned measurements, briefly described, are as follows :—

(i) Body weight = net weight, without clothes, in grams.

(ii) Trunk length in centimetres is taken by making the subject sit on a level floor with the knees flexed, the os sacrum, spine, and occiput being in contact with an upright measuring standard.

(iii) Circumference of the chest is taken at the

nipple level in males, and just under the breasts in females, the subject being encouraged to talk and breathe naturally while the measurement is being taken.

(iv) The "vital capacity" in cubic centimetres is obtained by taking five consecutive readings with a suitable spirometer. The subject is instructed patiently and carefully how to proceed, and encouraged to make the maximum effort, the highest reading of the five measurements being recorded as the "vital capacity."

The relationships established by Prof. Dreyer, by the examination of individuals in perfect health, provide standards with which an individual or groups of individuals can be compared as regards two fundamental attributes, namely, "physique" and "physical fitness." These two attributes have hitherto been subject to the widest possible individual interpretation, and even in the judgment of one individual are liable to undergo monthly, if not diurnal, variations, dependent upon humour and an infinity of changeable circumstances in observer and observed.

Applying the standards determined for individuals in perfect health, it is found, as might have been expected, that different persons exhibit considerable deviations from these standards, particularly in respect to their "vital capacity," dependent upon their occupation and mode of life. Thus persons living a healthy outdoor life exhibit a greater "vital capacity" than persons following a sedentary occupation, and when this deficiency is *not* due to fundamental bodily defects it can be remedied by properly regulated training and outdoor life.

Critical examination of the available data has enabled Prof. Dreyer to grade the community, for all practical purposes, into three classes, A, B, and C, representing conditions of perfect, medium, and poor physical fitness. A classification on such lines is essential when any degree of accuracy is required in the determination of the aberrations from normal met with in disease. It would obviously be unjustifiable in disease (9) to apply A class standards to the individual who, by reason of his occupation and mode of life, belongs in normal health to C class. The consideration of this aspect of the question, however, need not detain us longer, as being outside the scope of the present article.

It is extremely difficult in so brief an account to do full justice to the immense significance and the great possibilities which lie behind this recent work of Prof. Dreyer's, but sufficient, it is hoped, has been said to show that by systematic measurement of "vital capacity" and the body measures herein discussed, in adults and adolescents, it should be possible to ascertain what detrimental or beneficial effects environment and occupation exert upon the development and health of the individual. Further, it is clear that most important information, from the point of view of national health, should become available in connection with the methods employed to ameliorate the conditions

of those who show deficiencies from the standards obtaining in conditions of perfect health.

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The British Association at Cardiff.

THE eighty-eighth annual meeting of the British Association opened at Cardiff on Tuesday morning, in the very unfortunate circumstances of a general strike of tramwaymen and some other sections of the city workmen. It is to be feared that as, unfortunately, paragraphs about this found their way into the Sunday newspapers, this local trouble has had the effect of diminishing the attendance at the meeting. Members and intending members might have rested assured that the city of Cardiff would rise to the occasion. The local secretaries immediately arranged a British Association motor service for the use of members, but it appears that no inconvenience was felt by those who are attending the meeting, and most of the services have now been withdrawn.

It is not possible at the moment of writing to give exact figures of the membership, but it exceeded 1200 on Tuesday morning, so that a fair average meeting was even then certain, in spite of the strike. The weather, always inclined to be wet in this part of the country, and particularly atrocious during the present summer, has taken a turn for the better, and the visitors have had the opportunity of seeing the sun in Cardiff, when the residents had almost forgotten its existence.

The citizens' lecture on "Light and Life," by Prof. J. Lloyd Williams, of University College, Aberystwyth, in the Park Hall, on Monday evening, attracted a large audience, notwithstanding that many of those present had to face a long walk home.

At the inaugural general meeting on Tuesday evening, when Prof. Herdman delivered the illuminating address published in full elsewhere in this issue, the retiring president, Sir Charles Parsons, read a message which the council had sent to the King offering, at this meeting in Wales, the grateful congratulations of the Association for the inspiring work done for the Empire

by the Prince of Wales during his Australasian tour. Sir Charles Parsons read also messages of condolence sent to relatives of Prof. J. Perry and Sir Norman Lockyer at the loss sustained by the recent deaths of these two distinguished representatives of British science—one of whom was general treasurer of the Association from 1904 until his death, while the other was president in 1903-4.

At the meeting of the general committee on Tuesday, the report of the council was adopted nominating Sir Edward Thorpe as president of the Association for the meeting next year in Edinburgh, and Sir Charles Parsons as a permanent trustee, in succession to the late Lord Rayleigh.

The whole of the presidential addresses are this year published in volume form under the title "The Advancement of Science, 1920," at the price of 6s., or 4s. 6d. to members at the meeting. The volume makes a valuable record of the progress and position of many departments of science, and of authoritative conclusions concerning them.

Whilst the meeting is not likely to rank as a "record," the members present are very keen, and everything possible to ensure its success is being done by the city authorities and local Press.

The palatial apartments of the City Hall are being used for the reception room and other offices, whilst in the University College and Technical College near by all the sections are provided with excellent accommodation. The Park Hall, in which the president's address, the evening discourses, and the citizens' lectures are delivered, has a seating capacity of well above 2000, and everyone present has an uninterrupted view and hearing.

The numerous sectional and the two general excursions have not been interfered with by the strike, as they rely chiefly on road or railway transport.

R. V. S.