The number and the location of the incisions used in this method can be regulated without difficulty. When this is done, experiments indicate that the method is as accurate as any yet devised for mosaic transmission, and it has advantages over any other yet devised for studying fractions containing small amounts of virus.

The three inoculation methods under discussion are all useful for certain types of work and a virus-unit system is being developed for each of them.

As these studies progress it becomes increasingly evident that all the factors which influence the quantitative tests should be controlled as far as practicable. In this way the most satisfactory results are obtained with a minimum number of test plants.

It has been found advantageous to conduct some of the quantitative inoculation tests and certain other mosaic studies in rooms illuminated only by controlled electric light and held at 25 to 27° C. Mazda lamps, and also the Cooper Hewitt mercury vapor work-lamp with glass tube, have been employed as sources. The last-mentioned light is made up of yellow and green bands, also blue and violet bands. No red is present. The plants in these rooms grow more slowly than those receiving sunlight, thus causing the mosaic disease to develop more slowly. Mosaic-free plants grown under mazda lamps produce very long petioles and internodes. The leaves also tend to elongate. The color of the foliage is light green.

Plants cultured under the Cooper Hewitt work-lamp grow in a more nearly normal manner. The petioles and the internodes are comparatively short, the leaves are not excessively elongated, and the green coloration is more nearly normal than that produced by mazda lamps.

The methods commonly used for extracting virus are a source of error when determining the concentration of virus in different tissues. Bursting cells by freezing or by grinding, and the use of the hydraulic press, aid in removing the virus from the tissues. However, even when these steps are followed some virus remains in the press cake, especially if the tissue is of low water content.

To avoid part of this difficulty the following method of extraction is employed. Small representative samples of tissues are obtained. Samples greater than one gram of green weight are avoided if possible. If several samples are taken at one time each is placed in a stoppered weighing bottle. Duplicate samples are taken of each tissue to be tested.

All samples and duplicate samples are weighed to determine the green weights. The duplicate samples are dried to constant weight. In this manner water-content data are made available for the final calculations of the virus concentrations after the completion of the inoculation test.

Immediately after obtaining the green weights of the test samples, the tissue is very thoroughly pulped in a stoneware mortar. In some cases it is frozen before pulping. Sand is not employed unless woody or tough tissues are being studied. A known amount of sterile distilled water is added to the tissue to make a very soft pulp, and evaporation is reduced as far as possible during the pulping process. After the pulping process is completed, additional water of known volume is added to bring the volume in cubic centimeters up to 30 or more times the original weight in grams of the samples of tissue.

The extract contains very small pieces of tissue, plastids, starch grains and finer particles. With the exception of a few plastids and smaller particles, these materials are removed from the extract by means of a laboratory centrifuge. If necessary, the extract may be diluted further for use in the quantitative inoculation tests.

When the water content of the duplicate samples has been determined, the dilutions employed in the tests are corrected on the basis of the excess water added and the total water present in the tissue. After the completion of the inoculation tests, the concentration of the tested virus is calculated if a virus-unit system is used.

Although some extraneous solids remain in the test extract, the error introduced by their presence is relatively small.

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SPECIAL ARTICLES

HUMAN BODY-WEIGHT: I. CORRELATIONS BETWEEN BODY WIDTHS AND OTHER PHYSICAL MEASUREMENTS ON YOUNG MEN

ORIGIN OF DATA

IN October, 1927, the entering men students at Stanford, both freshmen and upper classmen, were given physical examinations under the immediate supervision of Dr. Thomas A. Storey, director of physical education for men. At that time Dr. Storey kindly offered me the opportunity of having certain physical measurements taken under very excellent and uniform conditions. As a result, nearly all the measurements were actually made with the assistance of Dr. Royce R. Long, assistant professor of hygiene and physical education at Stanford. Without the kind cooperation of these colleagues I could not have had these data to subject to statistical study.

THE MEASUREMENTS

In a former paper[1] which dealt with data secured from people who were fasting or on decreased rations and from a group of individuals measured before and after thyroidectomy, it was shown that there are certain body widths as well as heights which demonstrate relatively little change in the presence of rapid changes in body-weight. Notable among these measurements are (1) the maximal diameter at the iliac crests, and (2) the shoulder diameter at the acromions. Total height or stature as well as sitting height also proved to be (as was known) stable measures. Earlier[2] (1922) in connection with an analysis of physical measurements on diabetic patients it was found that body circumferences formed an erroneous basis for predicting normality of body-weight, and it was suggested that the bony diameters should be substituted. Hence in our present investigation it was decided to take measurements of only these four relatively unchanging features along with the body-weight. The men were measured nude after urination and an opportunity for defecation. They had not engaged in heavy exercise previously during the day.

Body-Weight: A carefully standardized, Toledo "No-Springs Scale" graduated in half pounds, was used for the taking of the body-weight measure. Under the conditions employed the weight measurements were probably accurate to one pound, as representing a particular individual's usual weight.

Height: The stature measurement was taken in millimeters. The scale consisted of two meter sticks placed end to end and fastened on a board about three inches wide. This in turn was fastened to a suitable place on the wall, giving vertical and firm support. A small sliding triangle[3] was held in the hand of the observer who slid it along the scale and brought it with proper pressure against the head of the man being measured. The values are probably a little greater than those gotten with the ordinary stadiometer.

Sitting Height: The measurement was made from the floor in the manner described by Dryer.[4] The subjects were required to flex the knees somewhat and to press the base of the spine firmly against the vertical scale before straightening up for measurement. All subjects do not do this equally well; however, the measure as taken on a chair or box is likewise variable, an effect especially due to variability in the voluntary tensing of the gluteal muscles by which the subject can lift the vertex as much as 1 cm. The scale and triangle used for stature were employed for sitting height.

Hip Diameter: The maximal diameter between the outside iliac crests against bony resistance was the measurement recorded. A twenty-four-inch caliper with curved arms (a modified Starrett's outside caliper) was used. The caliper tips were fitted with metal knobs five-sixteenths of an inch in diameter. The instrument was held about horizontal, its apex resting against the belt of the examiner, who, with a hand on each caliper arm, pressed the knobs of the instrument firmly against the bony resistance at the widest point on the iliac crests. The reading was taken *while* the pressure was being applied.

Shoulder Diameter: The caliper knobs were pressed firmly against the acromion processes and the distance measured, during pressure, between the superior external borders. It has been found convenient for the examiner to stand on a small stool so that he may look down on the shoulders of the examinee and on the scale of the caliper held about horizontally.

With the aid of a clerk to record the values as they are called off, and with the men coming up in line, this short series of measures requires a little less than 2′ per man.

THE RESULTS

Foreigners are not included in the results reported in the following tables. The report covers 552 young American men, active and in good health at the beginning of the autumn quarter of the university year, 1927–28. The theoretically equivalent sub-groups were made as follows: the names and data had been copied in one alphabetical list in a note-book of such size as to accommodate nineteen names per page. The men whose names occurred on odd numbered pages were taken as the Odd Group (280) and those found on even numbered pages as the Even Group (272). It was supposed that this would provide random sampling. As it turns out, although each sub-group is rather large, there are in certain instances differences between the groups that exceed the probable error values for the means of either group.

[1] Miles, W. R., and Root, H. F., "Weight and Physical Measurements after Thyroidectomy," *Arch. Inter. Med.*, 1927, 39, 605–617.

[2] Root, H. F., and Miles, W. R., "Physical Measurements of Diabetic Patients, with a Discussion of Normal Weight Standards," *Jour. Metab. Research*, 1922, 2, 173–197.

[3] Miles, W. R., and Root, H. F., "A Simplified and Trustworthy Means of Measuring Stature," *Boston M. & S. J.*, 1925, 192, 111–112.

[4] Dryer, G., and Hanson, G. F., "The Assessment of Physical Fitness," London, 1920. Reprinted by Hoeber, New York, 1921.

The Even Group shows the greater range (Table I) in weight, sitting height, shoulder breadth and age.

TABLE I

THE OBSERVED RANGES FOR CERTAIN PHYSICAL MEASUREMENTS TAKEN ON A GROUP OF UNIVERSITY MEN

Measurement	Odd	Even
Weight (pounds)	103–188	93–225[1]
Height (cm)	159–197	159–193
Sitting ht. (cm)	80– 98	78– 98
Shoulders (cm)	30– 42	32– 45
Hips (cm)	23– 33	24– 34
Age (years)	16– 41	15– 46[2]

1 Even range would be 103–188 except for one man at 93 and one at 225.

2 Many at 16 but only two at 15.

TABLE II

THE MEANS AND VARIABILITY VALUES FOUND FOR SOME PHYSICAL MEASUREMENTS ON YOUNG MEN

Odd 280 men	Mean	PE_M	σ	PE_σ	$V = \frac{\sigma}{M} \times 100$
Age (yrs.)	19.6				
Weight (lbs.)	140.3	± .63	15.7	± .45	11.2
Height (cm)	175.8	± .26	6.4	± .18	3.6
Sitt. ht. (cm)	88.7	± .13	3.1	± .09	3.5
Should. (cm)	37.3	± .08	2.1	± .06	5.6
Hips (cm)	27.9	± .06	1.5	± .04	5.5
Even 272 men					
Age (yrs.)	19.7				
Weight (lbs.)	142.4	± .68	16.7	± .48	11.8
Height (cm)	176.2	± .24	5.8	± .17	3.3
Sitt. ht. (cm)	88.9	± .13	3.2	± .09	3.6
Should. (cm)	37.5	± .08	2.1	± .06	5.5
Hips (cm)	27.9	± .06	1.5	± .04	5.5

TABLE III

THE INTERCORRELATIONS OF FIVE PHYSICAL MEASUREMENTS ON YOUNG UNIVERSITY MEN

Odd 280 men	Weight	Height	Sitt. Ht.	Shoulders
Height (cm)	.55 ± .03			
Sitt. ht. (cm)	.52 ± .03	.70 ± .02		
Should. (cm)	.44 ± .03	.33 ± .04	.26 ± .04	
Hips (cm)	.58 ± .03	.53 ± .03	.45 ± .03	.30 ± .04
Even 272 men				
Height (cm)	.53 ± .03			
Sitt. ht. (cm)	.50 ± .03	.71 ± .02		
Should. (cm)	.47 ± .03	.34 ± .04	.32 ± .04	
Hips (cm)	.51 ± .03	.45 ± .03	.42 ± .03	.24 ± .04

The range is the same (13 cm) for hips, but the Odd Group has some taller men, although the mean for height is a little greater for Even. The group averages and variability values are given in Table II. The men were about nineteen years old. There were a very few graduate students who were several years older. The two portions of Table II correspond closely with the exception of weight where there is a difference between group means of 2.1 pounds. This is seen to be three times the size of the probable error of either weight mean. The Even Group also has the larger mean for height, sitting height and for shoulders, but the means for the hip measurement are the same. Davenport and Love[5] for white American troops found an average weight of 144 pounds and height of 172.0 cm. The sitting height taken on a stool was 90.4, shoulder width 41.8 and pelvic diameter 29.4 cm. The two latter measurements were taken with a straight arm caliper. Gray and Mayall[6] for 229 white American men, average age twenty-six years, found the average height 171.0 cm and average weight stripped 141 pounds. The Stanford group is thus somewhat younger, taller, the same weight as the group measured by Gray and Mayall, but lighter than the average soldier.

Comparing the various means with their standard deviations we find in the extreme right hand column of Table II the coefficients of variability, which closely resemble the values previously published for such measures. Davenport and Love have found the following: body-weight 11.7; height 3.9; sitting height 3.9; shoulders 5.8 and pelvic diameter 9.7. The latter was not a bony diameter, hence its variability reflects more typically the weight and is considerably larger than the value we have found for hips. The two portions of Table II correspond quite closely in these variability values and are typical of all published data. Weight is always the most variable and usually height the least. The same relation applies to the human skull as shown by Pearl.[7] The skull capacity is more variable than linear skull measurements, such as breadth, height or length. My colleague, Professor Weymouth,[8] has shown the same

5 Davenport, C. B., and Love, A. G., "Army Anthropology," Washington, D. C., Gov't. Printing Office, 1921, p. 234, table 103.

6 Gray, H., and Mayall, J. F., "Body Weight in Two Hundred and Twenty-Nine Adults, Which Standard is the Best?", *Arch. Inter. Med.*, 1920, 26, 133–152.

7 Pearl, R., *Biometrika*, 1905–1906, 4, 31. Cited by Miner, our reference No. 9.

8 Weymouth, F. W., "The Life-history and Growth of the Pismo Clam," State of Calif. Fish and Game Commission, Fish Bulletin No. 7, Sacramento, 1923, see pp. 20–21.

fact in his measurement of clams. He was apparently the first to point out that the higher variability for weight was a result of the simple mathematical relation that weight is a three-dimensional character. From a series of clams measured in 1918 he got a mean weight of 41.2 grams, coefficient of variability of 18.5; for the length 6.3 cm, v. 6.3; height 4.7 cm, v. 6.7; thickness 2.9 cm, v. 8.3. The variability of length cubed is 19.5, and of length × height × thickness 18.9. Miner[9] follows something of the same reasoning in comparing variabilities of weight with linear measures. Nevertheless, as we have pointed out elsewhere,[10] it seems anomalous to take the least variable human measure and make it the sole basis for predicting normality in the most variable, especially when shoulders and hips stand fairly midway between height and weight in variability and therefore may reasonably be assumed as more representative of the body build and hence of the normal body-weight than is height alone. Professor T. Wingate Todd in a personal communication has pointed out the necessity that the measurement of the smaller linear distances will have somewhat higher variability due to the fact that the observational error, for example, from using a millimeter scale, will be a larger percentage of the mean. It appears doubtful if this alone can account for the difference, as shown in Table II, between shoulders and hips on the one side as against height and sitting height on the other.

Turning to the correlations given in Table III, we find in the first place, as indeed we could expect, that they are all positive. In the second place the two portions of the table approximately agree. The correlation between height and weight is about .54, a value which corresponds with what has been published. Sitting height apparently does not correlate with weight quite as well as does height. The correlation between height and sitting height is the highest value shown, .70. Shoulders and weight give a value of .45 or .46. However, hips and weight correlate more strongly for the odd group, indeed a little more strongly than between height and weight, while for the even, a little less. This discrepancy between the two portions of Table III, .58 and .51, can not be explained in the light of our grouping method. As mentioned before in reference to Table II, the means for hips were identical, but the other means show differences. Hips correlate more strongly with all the measurements than can be said for shoulders. The correlations of shoulders and hips with weight are stronger than those with height, sitting height or with each other. It is therefore apparent that both these measurements contribute something to the body-build and thus to the total body-weight that is not included in the other measurements. Each correlation value in Table III is several times the size of its probable error. So far as the author knows, these are the first correlations to be published for bony hip and shoulder measurements with weight and the other more usual measures on white male adults.[10a]

Following the suggestions of Miles and Root,[11] Gray and Walker[12] published a short note and gave one diagram for data from different sources which indicate some relationship between body-weight and intercristal diameter; and Gray and Parmenter[13] on one hundred candidates for a varsity football team took measurements and correlated the depth of chest, "nearly a bony measure," with weight. The result found was $.55 \pm .05$. They do not give the height-weight correlation for comparison.

CONCLUSIONS

(1) Two stable bony width measures, the maximal diameter at the iliac crests and shoulder diameter at the acromions, together with height, sitting height and body-weight, were applied to 552 young American men, average age about nineteen years, all entering students at Stanford in October, 1927.

(2) For statistical treatment the men were divided into two approximately even groups. These subgroups are found to compare quite closely. The average height is 176 cm; sitting height 89 cm; shoulder diameter 37 cm; hip diameter 28 cm and average weight 141 pounds. Average height is thus about 4 cm greater than ordinarily reported for white American troops.

(3) The coefficients of variability for the different measures are compared. Shoulders and hips give variability values fully 50 per cent. greater than height and sitting height (5.6 compared to 3.6), while weight shows 11.5 per cent. Weight being a cubic measure shows approximately three times the variability found for height.

[9] Miner, J. R., "The Variability of Skull Capacity," *Amer. Jour. Phys. Anthro.*, 1924, 7, 425–426.

[10] Miles, W. R., and Root, H. F., "Weight and Physical Measurements after Thyroidectomy," *Arch. Inter. Med.*, 1927, 39, 605–617.

[10a] Since this was written some data have appeared: Gray, H., "Weight, Body Diameters and Age; Correlation Coefficients," *Proc. Soc. Exp. Biol. and Med.*, 1928, *25*, 384–385.

[11] *Op. cit.*

[12] Gray, H., and Walker, A. M., "Applied Anthropometry," *Jour. Amer. Med. Assoc.*, 1924, 82, 628.

[13] Gray, H., and Parmenter, D. C., "Chest Depth as an Index of Body-weight," *Jour. Amer. Med. Assoc.*, 1923, 81, 2183.

(4) The correlation between height and weight is about $.54 \pm .03$. For one group, hips and weight correlated .58, for the other group .51. From these observations it appears probable that the bony hip diameter for young men bears as important a relationship to body-weight as does stature.

(5) The correlation between shoulders and weight is about $.45 \pm .03$. Shoulders and hips each correlate with weight more strongly than they do with each other or with height or sitting height. Therefore, they may be assumed to contribute a factor to total body-weight that is not wholly included in the height measurements.

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A PRELIMINARY REPORT ON STUDIES OF FIREBLIGHT OF APPLE[1]

FOLLOWING the classical studies of Burrill[2] and Arthur[2] in establishing the bacterial cause of fireblight of pomaceous fruits and of Waite[2] in discovering the relation of pollinating insects to its dissemination and in developing a method for combating it by excision of affected parts, many valuable contributions[3] have been made to the knowledge of this destructive disease. Nevertheless epidemic outbreaks of fireblight continue to take their toll and commercial pear culture has been abandoned in many sections because of the ravages of blight. In view of the lack of success which has attended numerous attempts of apple growers of Wisconsin to control fireblight by the excision method, it seemed desirable to investigate certain aspects of the epidemiology and control of the disease under local conditions. This work was begun by Brooks,[4] who contributed substantially to the knowledge of the overwintering of the blight organism and the seasonal development of the disease. For three years the investigation has been continued by the present writer[5] through field and laboratory studies.

A clear understanding of the modes of dissemination of the natural inoculum and of access of the organism to the host tissues seemed to be of primary importance to the adequate understanding of the epidemiology of the disease and further development of control measures. Special attention has, therefore, been directed to these aspects of the problem. For many years the prevailing conception has been that the primary inoculum is carried by insects from the cankers where the organism overwinters to susceptible parts of the current year's growth, notably the blossoms, where it induces blighting, presumably penetrating to the interior tissues through the nectaries. Once established in the blossoms, the bacteria have been supposed to be carried to other blossoms chiefly by the agency of pollinating insects, while their direct entrance from external sources to twigs and other susceptible parts has been considered to occur chiefly through wounds. An important modification of these earlier conceptions was necessitated by the valuable contributions of Gossard and Walton,[6] who showed that rain is a very important agent in the dissemination of the inoculum for fireblight. They concluded that from 50 to 90 per cent. of the blossom blight observed in their work was caused by rain-borne inoculum. They state, however (p. 107), that "raindrip does not become an agent of dissemination until primary centers of infection have been established, in nearly all cases by insects." In somewhat similar experiments which appear to have been conducted independently and near the same time, Stevens, Ruth and Spooner[7] showed that blossom clusters and young twigs which were carefully protected from visitation by insects were blighted approximately as much as similar unprotected parts. Access of air and of meteoric water was not precluded. The writers conclude that the disease must have been transmitted by some agency other than insects and state that "the only tenable hypothesis is that wind was the chief agent of transmission."

The exact mode of dissemination of the inoculum which first establishes the fireblight organism in the current year's growth is obviously of great potential importance in relation to control measures. The conception that insects are the agents of this dissemination seems firmly established, yet the writer has been unable to find in the literature of fireblight sufficient evidence to justify such a conclusion. The conditions encountered at Gays Mills, Wisconsin, in the seasons of 1926 to 1928, inclusive, have offered a very favorable opportunity to follow the details of dissemination of the primary inoculum under natural conditions. In each of these three years the earliest infections of both blossom clusters and young shoots have been ob-

[1] Published with the approval of the director of the Wisconsin Agricultural Experiment Station.

[2] Cited (pp. 368–369) in: V. B. Stewart, "The Fireblight Disease in Nursery Stock," Cornell University Agr. Exp. Sta. Bul. 329: 313–372, 1913.

[3] A fuller discussion of literature will be given in a later paper.

[4] A. N. Brooks, "Studies of the Epidemiology and Control of Fireblight of Apple," *Phytopath.* 16: 665–695, 1926.

[5] The writer is indebted to Dr. G. W. Keitt, under whose direction these investigations were conducted, for first suggesting the importance of the problem and for helpful criticisms and suggestions during the progress of the work.

[6] H. A. Gossard and R. C. Walton, "Dissemination of Fireblight," Ohio Agr. Exp. Sta. Bul. 357: 83–126, 1922.

[7] F. L. Stevens, *et al.*, "Pear Blight Wind Borne," SCIENCE, N. S., 48: 449–450, 1918.