is insignificant when compared with that in the heterosporous vascular cryptogam where the large spore may be as much as 30,000 times the bulk of the small one.

If excuse be sought for not making measurements where size is concerned it may perhaps be found in two things. The female spore of the seed plants (the embryo sac initial cell) does not look like a spore since it has a very thin wall, no storage products (such as starch, oil, etc.), and is in intimate contact with surrounding nutrient cells. In the second place, it does not long remain a spore, soon undergoing prothallial development and increasing very rapidly in size. The large size at this stage of development does undoubtedly tend to make one assume that the spore must originally have been large, without troubling to measure it. How different, however, is the true megasporous conditions. Nearly all, if not the whole, increase in size of the megaspore over the microspore occurs before prothallial development begins, and the food supply from the mother plant is stored in the spore, where it is protected against the vicissitudes of the free-sporing habit of the resting stage by a thick suberized coat. It can get no further supply from the mother plant, either during prothallial or embryonic development, whether the spore be shed at once or retained longer in the sporangium. In contrast to this, the enclosed spore of the seed plants starts out small, grows rapidly while undergoing its prothallial and embryonic development, and finally ceases growth and comes to its resting or storage stage only when the ovule has matured into the seed.

It is not intended in this statement to go farther into the *proof* that the seed plants are homosporous[1] but to refer briefly to some of the anomalous statements that are included in our text-books because of the assumption that the enclosed spore of the seed plants is a megaspore. In the first place the classic text-book choice for comparison with the seed plants is selaginella, although very often in some other part of the same text there is found a statement that the fern ancestry of the seed plants has been demonstrated beyond doubt. Perhaps if the text-book is an advanced one there may even be a statement that it is the eusporangiate ferns that show more relationship to the seed plants, the author often considering it necessary to apologize for drawing attention to these facts as the eusporangiate ferns are all homosporous, while the *Leptosporangiatae* contain many heterosporous forms.

In the text-book of the future, even if the author is still a confirmed megasporist, may we not at least ask that he insert a drawing to scale of the male and female spores of the seed plant, to give substantial and convincing visible proof of his view. He might also add to the ordinary comparison of seed plants and eusporangiate ferns a reference to such things as the similarity in mode of food absorption, organization and orientation of the embryo in the gymnosperms and certain of these eusporangiate forms. Perhaps an illustration of these pertinent features might be included, even if the ubiquitous figure of selaginella had to be omitted.

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WORK AND BODILY FATIGUE

The text-book of physics, which I studied as a high-school student, said that no work was done in carrying a load along a level path. I knew this was incorrect because as a boy I had carried large forkfuls of hay along the loft floor of the barn, to be thrown down to the cows and horses below, and had become weary in well-doing.

A similar concept of work holds in the statement that no work is done in holding a mass out at arm's length. Just let any one who believes this statement hold a kilogram mass in this fashion for eight hours (union labor) and see if he thinks he has not been doing work! What is the discrepancy between these statements in our physics text-books and our experiences in life? Is it not fair to say that they should check with each other?

The Milwaukee Road has electrified its railway over the Rocky Mountains. Powerful electric motors draw the heavy trains up one side of the range and by a so-called regenerative braking system, much of the energy used in going up is recovered on the down grade. "This is accomplished by reversing the usual function of the electric motors, utilizing the momentum of the train to drive them as generators." (Quoted from "Running Trains with Running Water," published by C. M. St. P. and P. Ry.). In harmony with our physics text-books, no work is done

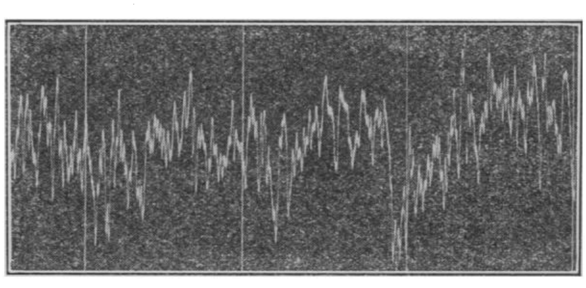

Fig. 1

[1] Those who desire measurements and further proof can find them in the writer's article on "Evolution of the Seed Habit in Plants," in the Transactions of the Royal Society of Canada. Third series, Vol. xxi, 1927, pp. 229–272.

in moving the train over the mountains. Indeed there is much more sense to such a statement than to say no work is done in holding out a mass at arm's length.

In Fig. 1 is shown the way in which the hand carries a kilogram mass at arm's length over an interval of time. The movement is magnified three fold, while the time interval between the vertical and parallel lines is 30 seconds. Involuntarily the arm sinks a short distance, lowering the mass, then the muscles contract and raise it again. Each time the mass is raised work is done, and unlike the Milwaukee system there is no regenerative process on the down slope. Thus from a purely physical standpoint work is being done in holding out a mass and this work must come from an expenditure of muscular energy which produces bodily fatigue.

It will be noted that at the bottom of each downward motion there is a sudden and quick return, making each low point in the movement sharper than those at the top where the beginning of the letting down process seems to be more deliberate.

Any one who carries a load along a level pathway is also unconsciously letting his load fall to be raised a moment later and so doing work. The swinging stride of one walking along a level path also raises and lowers the load carried and again energy is dissipated. The energy which is thus being utilized is not created out of nothing. It must come from bodily exertion and so we experience fatigue.

This relation between bodily fatigue and work could be amplified still more by the physiologist showing how energy is dissipated in the mere tension of the muscles.

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EFFECTS OF BREED ON EMBRYO SIZE IN THE DOMESTIC FOWL AND THE RABBIT

CASTLE and Gregory[1] have published recently a very ingenious interpretation of Byerly's[2] data on the effects of breed on the growth of the chick embryo. The validity of their interpretation seems to hinge on the soundness of their assumption that the average weight of the unincubated blastoderms in the eggs from Single Comb White Leghorn fowls, 0.0030 gram, is significantly greater than the average weight of the unincubated blastoderms in eggs from Single Comb Rhode Island Red fowls, 0.0028 gram. Byerly judged the difference between these weights to be obviously insignificant and treated his data in accordance with that assumption. Since Castle and Gregory have assumed that the difference in average blastoderm weight is significant, it has seemed necessary to make further measurements of blastoderm weight and to obtain a statistical measure of the variation.

Each blastoderm was washed as free from adherent yolk as possible and transferred to a weighing bottle. Water was removed with a capillary pipette. Some water remained and this accounts for the slightly greater average weights of the blastoderms in the present study than in those described in the writer's former paper[2] for the earlier weights were obtained by weighing several blastoderms at one time. It was possible to remove relatively more of the adherent water in the case of group weighings than in the case of individual weighings. All blastoderms were weighed to the nearest 0.0001 gram.

Twenty-one Single Comb White Leghorn blastoderms had an average weight of 0.00342 ± 0.000181 gram; 22 Single Comb Rhode Island Red blastoderms had an average weight of 0.00333 ± 0.000132 gram. The difference between the average weights, 0.00009 ± 0.000222, is less than half its probable error. Assuming the same variation in the earlier material, the difference between the average blastoderm weights, 0.0002, would be approximately equal to its probable error. Certainly no significance may be attached properly to differences of such magnitude. Byerly[2] was justified, therefore, in his subsequent treatment of his data and therefore in his conclusion that no consistent differences due to breed were present in his data for the first half of the incubation period. Subsequent investigations on growth of the chick embryo make that interpretation still more likely.

Henderson[3] concluded that there are slight, if any, differences in weight of embryos of the same age from matings of Single Comb White Leghorns, of Dark Cornish, and from reciprocal crosses of these breeds. Byerly[4] has shown that a hypothesis that the inherent rate of cell division is the same but that absolute rate of growth under uniform physical conditions of incubation is determined by food supply, is sufficient to account for differences in weight of embryos of the same age in eggs from matings of: Rose Comb Black Bantams; Bantam ♂ × Barred Plymouth Rock ♀; F_1 hybrids from the reciprocal crosses between the Bantams and Plymouth Rocks. The hypothesis is also sufficient to account for embryo size in small eggs, normal-sized eggs, and double-yolked eggs from fowls of breeds which normally produce eggs of standard weight.

Byerly[2] pointed out that different numbers of cells may be present in embryos of the same age, due to

[1] SCIENCE, n. s. 73, June, 1931.
[2] *Jour. Morphol. and Physiol.*, 50, December, 1930.
[3] *Missouri Agri. Exp. Sta. Bul.* 149, Sept., 1930.
[4] *Jour. Exp. Biol.*, in press, 1931.