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The structure of starch grains from wheat grown under constant conditions.

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This is a report upon the starch of the seed of Hard Federation wheat grown under continuous constant illumination by Mazda C lamps, the other external conditions such as temperature, humidity, water- and salt-content of the sand in the pots being kept as constant as possible.[1]

The starchgrains did not show the lamellation or rings that can be seen in the starch of ordinary wheat seeds. This difference is all the more striking if the two kinds of starch are compared, after heating to a temperature at which the grains begin to swell, while their border is still refractive. Inside the swollen unlamellated grains, very refractive radial needles can be seen, attached to the refractive border of the grain or to the circumference itself, while the rest of the grain may be quite translucent. On the upper and lower sides of the surface of the grains, the needles are seen in optical section as refractive globules; in the optical plane, between the upper and lower surface, they are seen at their full length. They are tapered towards the center, resembling pyramids with a base of 2-3μ. The lamellated starchgrains in the ordinary seeds also show needles after they have been heated to this temperature. These needles extend to the first distinct nonrefractive ring, and are much shorter absolutely and relatively. The needles in the ringless starch sometimes have a length of 17 to 20μ, which is about 45 per cent of the total diameter of the grain; in the field-grown seeds they are no larger than 5μ, or about 10 per cent of the diameter. Ten to twenty or more rings can be counted.

A suspension of ringless starch in water heated over a flame applied to the margin of the slide shows all graduations of swelling. In this way it was easy to follow the effect of different

[1] The observations upon growth and metabolism under these conditions will be presented later.

temperatures by studying the different stages of swelling. The unheated grains show some needles which are visible through the refractive border of the grain; these are the needles which are discussed above. They are the thickest and the most resistant to higher temperatures. If the temperature is raised, the refractive border of the grain loses its refractivity, so that the interior of the grain, *i. e.,* the needles can be more easily observed. There are both thick and thin needles, filling the interior of the starch-grain, except at the hilum. With increase in temperature, the thinner ones are the first to dissolve, so that only the thicker ones remain. These needles are not radial cracks. The bases of the thinner needles, which are their thickest parts, are still visible. The narrow, tapered ends of the thicker needles also begin to dissolve, so that the thicker needles become shorter as well. Finally, they lose their refractivity and the starchgrains become large, swollen sacks without much structure. These stages were followed throughout the heating and cooling process.

These operations leave no doubt that these ringless or unlamellated starchgrains are composed of masses of radially arranged refractive needles, thinner towards the center, thicker towards the circumference. At the circumference their bases are fused to form a very refractive border. This border obscures the radial structure of the unheated starch, so that only the thickest needles are visible.

The occurrence of large needles must be correlated with the absence of rings. This is also borne out by the following observation. If starch from field-grown grains is heated to the swelling temperature, the rings then consist of small particles, as pointed out in a previous paper.[2] Now, particles in successive rings may often be seen oriented in a radial direction, suggesting that needles had fallen apart on heating. The parts of the needles which correspond to the non-refractive rings have been dissolved by heat. The parts lying within the refractive ring, however, remain. Moreover, in ordinary unheated starch large needles can also be seen.

Careful examination under magnifications of 1300 to 1600 diameters shows that even in the ringless starch there is, in many grains, slight indication of the presence of one or two rings, which, however, are very indistinct. They cannot be followed all

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[2] PROC. SOC. EXP. BIOL. AND MED., 1925, xxiii, 195.

around the grain. It is very probable that these indistinct rings are due to fluctuations in external conditions. During ripening of the seeds, illumination was twice interrupted accidentally for periods of 2 and 2½ hours. The temperature decreased during that time 7° C. and 5° C. respectively. Some of the needles are interrupted by one of these very faint rings, so that they fall apart into two or three shorter portions. Some needles overlap such a ring and only a refractive spot can be seen at the place which corresponds to the ring.

Whether or not these needles are crystals will not be discussed here, but it is evident that Meyer is right when he states that the starch grains have a "radialtrichitische Struktur". In the ringless starch, the needles are nearly homogenous and probably all of them stretch from the border to the hilum in unheated starch. The starch grown under field conditions is composed of the same radially arranged needles, but these have a different refractivity at the places corresponding to the less refractive and more refractive rings.

As was discussed in the previous paper[2] the more and less refractive rings of the starchgrains have to be considered as composed of more and of less dehydrated amylose. The phenomena caused by heating to the swelling or gelatinization temperature consist of hydration. Partially dehydrated amylose loses its refractivity or goes into solution, according to the degree of its previous degree of dehydration. The thicker needles offer more resistance to hydration than the thinner ones. After cooling, dissolved amylose is again partially dehydrated.

If at a certain stage of growth of a starchgrain n needles cover 1 cm.^{2} of the inner surface of the grain, $4n$ needles have to develop per cm.^{2} if the radius of the starchgrain increases 100 per cent, or else the diameter of each needle has to increase 100 per cent. As the needles are actually wider at their bases, this phenomenon can only be explained on the assumption that new starch substance is added to the base of the needles.

The formation of rings of different refractivity has to be ascribed to different stages of hydration of the amylose during or after its apposition. The hydration of the amylose will depend on the hydration of the protoplast, *i. e.*, on the amount of turgescence of the cell. This depends (other conditions remaining constant) largely on the transpiration. It is, therefore, probable that not only the periodicity of the illumination will determine the periodicity of the dehydration of the amylose, but also to a large extent the periodicity of the transpiration. The transpiration factor has not been controlled by previous investigators.

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Alcohol and the sex ratio in mice.

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An animal heterozygous for a character produces two kinds of germ cells with respect to that character. Since these two classes of germ cells differ in their genetic potentialities, it is conceivable that they may also differ in their ability to react to varied environmental conditions. Critical tests of this question are difficult to devise, one of the best thus far being that introduced by Stockard[1] in his alcohol inhalation experiments. By use of Stockard's method evidence has been obtained which indicates that when alcohol is thus introduced into the tissue of the fowl, germ cells are differentially affected according to their general vigor,[2] as well as on the basis of some of their genetic differences.[3] In the mouse, in which the male is presumably heterozygous for the sex chromosomes, Bluhm[4] found a much higher sex ratio after administering alcohol to the male parent by subcutaneous injections. The difference was attributed to a differential effect on the two classes of sperm cells. Bluhm's work has been questioned[5, 6] because of the low sex ratio in the controls (80 males: 100 females in a total of 965 young, as compared with a ratio of 122:100 among those sired by alcohol-injected fathers). The

1 Stockard, C. R., *Amer. Nat.*, 1913, xlvii, 641.

2 Pearl, Raymond, *J. Exp. Zool.*, 1917, xxii, 125.

3 Danforth, C. H., *J. Exp. Zool.*, 1919, xxviii, 385.

4 Bluhm, Agnes, *Sitz. Ber. d. Preuss. Akad d. Wiss.*, 1921, xxxiv, 549.

5 Pearl, Raymond, *Eug. Rev.*, 1924, xvi, 1.

6 Hanson, Frank Blair, and Heys, Florence, *Genetics*, 1925, x, 351.