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THESIS

-- T H E S I S --

A Comparative Study of the Grain of our Most Important Cereals.

May 1899

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In making a comparative study of the grain of our most important cereals such as wheat, oats, rye, barley and corn, one finds that they have a marked similarity of structure. For instance. In all the cereals the endosperm, or the central portion of the fruit, makes up a large percentage of the whole grain. This central portion is composed of starch, varying in amounts from sixty to eighty per cent of the whole fruit, its function being to supply the germ with food during its early growth. The cells of the endosperm are large and irregular in shape generally with the length extending from the outside toward the center of the fruit. They are closely filled with starch grains which differ in size, shape and markings in the different cereals. At the outer edge of the endosperm we find the aleurone layer which extends around the rest of the fruit. When seen in a cross section these aleurone cells appear rectangular or nearly so in shape, but when seen in a tangential section they do not seem to have any definite shape, often appearing polygonal.

Outside of the endosperm we find the outer coatings which are generally divided into three layers. These outer coatings serve as a protection for the true seed, and in the wheat they form what

is known as bran. These coverings differ some in their make up in the different grains, but generally speaking they have quite a similarity of structure.

From the points of general similarity I will pass to a comparative study of the different cereals. As most of my time was given to an examination of the wheat I shall be able to give more concerning this, than of the others studied.

-- W H E A T --

Cross section of the grain seen on plate 3, Fig. 1. I first examined the wheat in a transverse section. In doing this I was able to distinguish the outer coatings, as they lay upon each other, their thickness, and was also able to ascertain the shape and size of the cells in aleurone layer. From a transverse section I was able to determine the size and shape of the starch cells and the size and shape of the starch granules.

In examining a tangential section of the epidermis, or outer covering of the wheat, we find that it is made up of a layer of long thick walled cells which have indentations in the cell walls and give them a wavy or sinuous appearance. Fig. 2, plate 4 illustrates this. As these cells approach the top of the kernel they become smaller and more nearly circular in shape and have fastened between them numerous small hairs with thick walls. Seen in Fig. 6, plate 4. In the center of the hair there is a small narrow space running part way up the hair. These spaces are called canals.

The coat under this outer covering is called the epicarp and

is made up of thin walled cells arranged parallel to each other and running at right angles to the cells in the layer above. Fig. 3, plate 4 shows these cells. They run around the grain while the cells in the outer coat run longitudinally. Under the second coat are found the canals of the wheat. Some appear simply as long tubes, while others have branches running from them.

The third or inner layer of the wheat is the aleurone layer, the cells of which appear cubical, square or nearly so when seen in a transverse section, but on examining them in a longitudinal section of the coat we find they have no definite shape. Fig. 1, plate 4.

A study of these outer coverings of the wheat gives one an idea of the make up of wheat bran.

Just inside of these outer coverings comes the endosperm. This part of the fruit contains the starch and also the embryo of the kernel. The starch cells of the endosperm have very thin walls and are difficult to see, unless a very thin section is examined. Besides being filled with starch in these cells, we may also find gluten present in considerable amounts. The starch granules of the wheat are exceedingly variable in size, some being very small, others larger with but few medium sized granules. They are circular, or nearly so, in form and have concentric rings over their surface. Fig. 2, plate 3 show granules of wheat starch. These rings are quite difficult to discover unless examined with high power. I examined the starch granules of wheat after germination and noticed the way in which the granules break

up after germination has taken place. Some were disintegrating in concentric rings, while others would appear to have a hole eaten out of the center of the granule, and others would have a check or cross in the center.

-- T H E O A T --

Cross section seen in Fig. 2, plate 1. The fruit proper is enveloped in quite a thick horny covering which can be removed from the fruit with but little trouble. In examining the oat in a cross section, we find the gluten layer is double instead of single as in the wheat. The outer layer of starch cells next to the gluten layer are very thick walled. The outer structure of the oat grain is thin compared with the epidermis of the wheat and corn.

The starch of the oat is easily distinguished from the starch of the other cereals. The markings of the granules are peculiar to that cereal. Over the surface of the granule we find small lines joining each other which divide the surface into many polygonal shaped divisions. Fig. 8, plate 3 represents such a granule. These markings are characteristic of oat starch.

-- R Y E --

Fig. 3, plate 1 represents rye as seen in cross section. The rye resembles wheat very closely in its make up. The gluten layer is composed of a single row of cells as in the wheat. The size and shape of starch cells and the size and shape of starch granules resemble very closely those of the wheat. The starch

granules are variable in size and have no distinctive markings. They are circular or nearly so in form.

-- B A R L E Y --

Fig. 1, plate 1 represents barley grain in cross section. The fruit of the barley is incased in a tough dense covering which adheres closely to the fruit. The gluten is found in large quantities in the barley grain. This layer consists of three rows of cells radially placed and considerable amount is also found in the starch cells.

The barley starch is quite similar to the wheat in that the granules have concentric rings. The grains are not so variable in size as those found in the wheat.

-- R I C E --

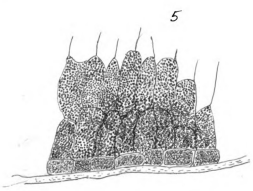
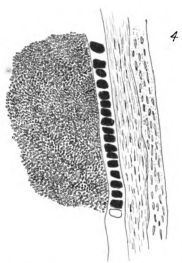
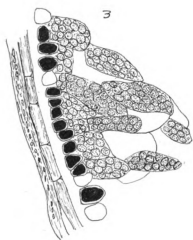
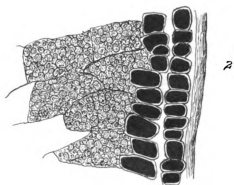
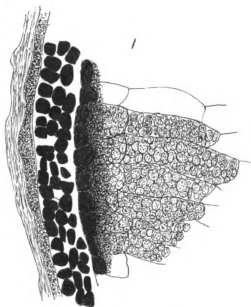
Fig. 5, plate 1 represents rice as seen in cross section. The rice is surrounded by a delicate husk which is not attached to the fruit as it is in the barley. The grain of the rice is unequally divided by a groove running down the side. On examining a cross section of the fruit, we find that the outer covering of the grain is very thin compared with the other cereals. The aleurone layer is sometimes double, but in most cases it consists of a single row of cells.

The starch grains of rice are very minute and do not vary much in size. They are mostly polygonal in shape, being five or six sided when seen in section. Fig. 7, plate 3 shows a group of rice starch grains.

--C O R N--

Cross section of kernel, Fig. 4, plate 1. A kernel of corn has a thick, horny epidermis not easily separated into its different layers. Under these outer coverings of the grain we come to the aleurone layer. this is a single layer of cells in the corn and the cells are not as large as those in the barley, but are more regular in shape.

The starch granules of the corn are small compared with the starch granules of other cereals excepting the rice, --those of the corn and rice being about the same size. They are hexagonal in section and are nearly uniform in size, resembling the rice granules in this respect. They have rings or markings which are scarcely visible. Seen in Fig. 4, plate 3.



1. SECTION OF GRAIN OF BARLEY
2. SECTION OF GRAIN OF OAT
3. SECTION OF GRAIN OF RYE
4. SECTION OF KERNEL OF CORN
5. SECTION OF GRAIN OF RICE
6. STARCH GRANULE FROM THE OAT

PLATE I.

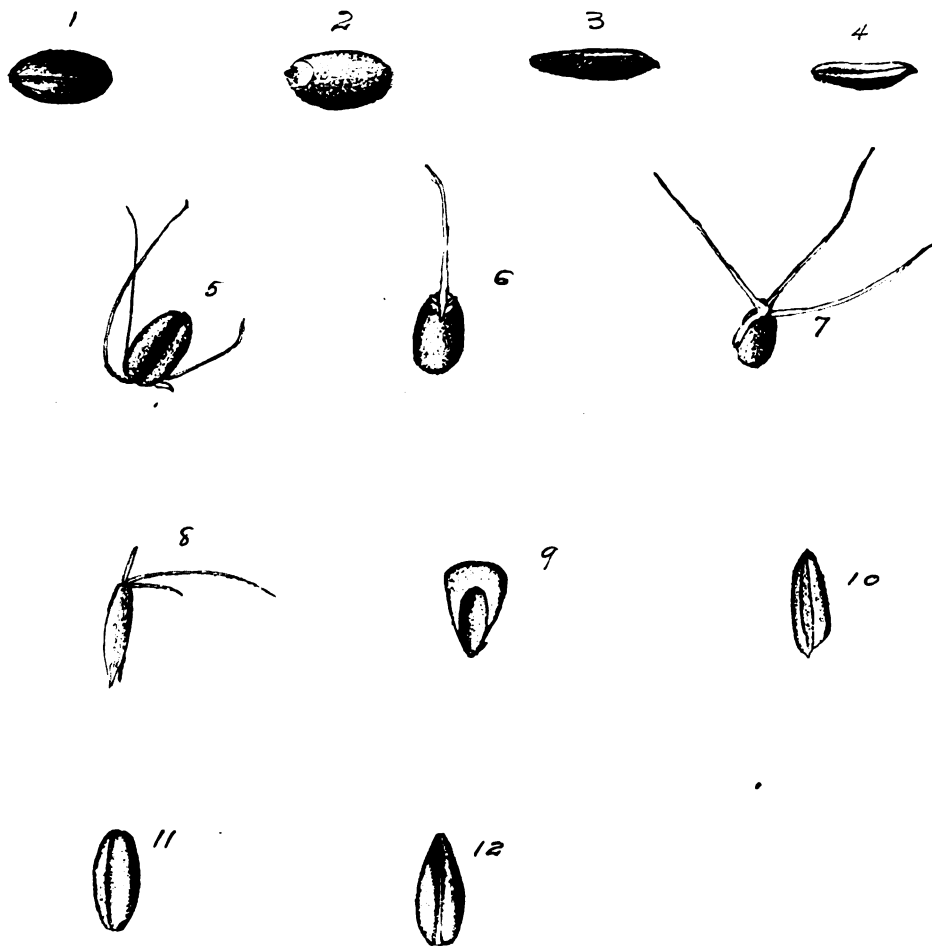
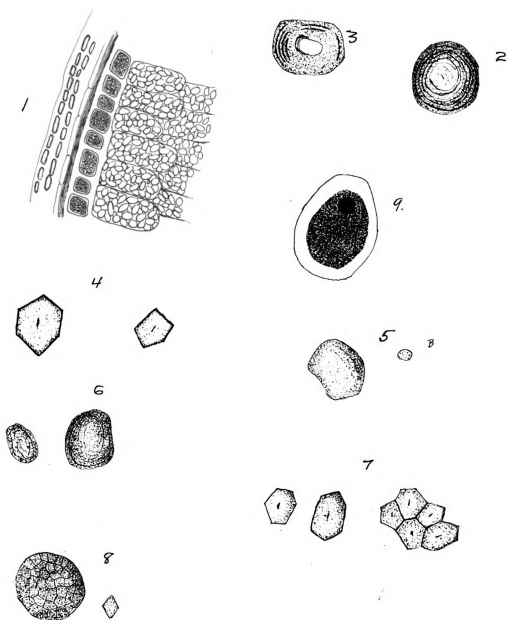


PLATE 2.

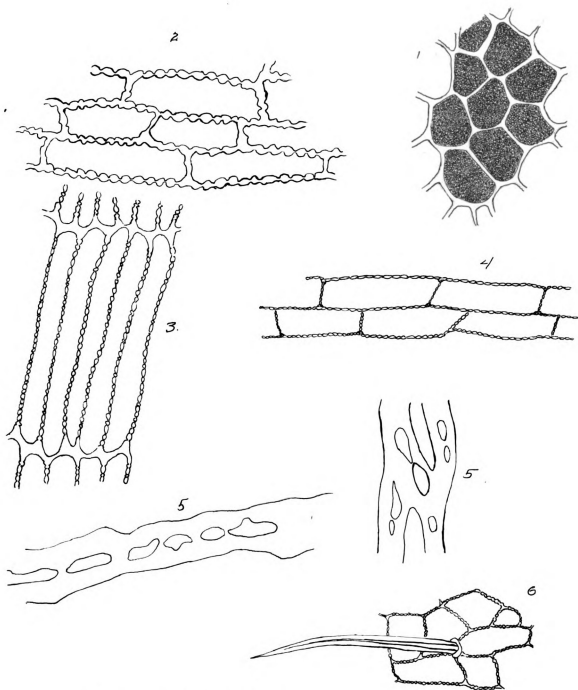


7 GROUP OF RICE STARCH GRANULES.

8. OAT STARCH.

9. GLUTEN CELL OF THE WHEAT.

1. RADIAL SECTION OF KERNEL OF WHEAT
2. GRANULE OF WHEAT STARCH
3. GRANULE OF WHEAT STARCH AFTER GERMINATION
4. GRANULES OF CORN STARCH
5. GRANULES OF BARLEY STARCH
6 GRANULES OF RYE STARCH
PLATE 3.



- 1, GLUTEN CELLS OF WHEAT
- 2, OUTER LAYER OF CELLS
- 3, SECOND LAYER OF CELLS
- 4, THIRD LAYER OF CELLS
- 5, CANAL JUST BELOW SECOND LAYER
- 6, HAIRS FOUND AT CROWN OF GRAIN

PLATE 4

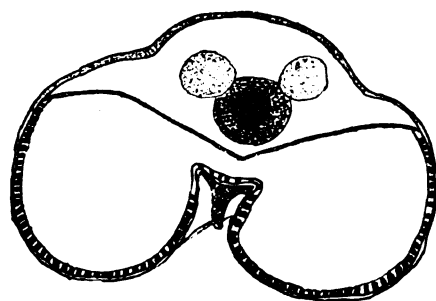
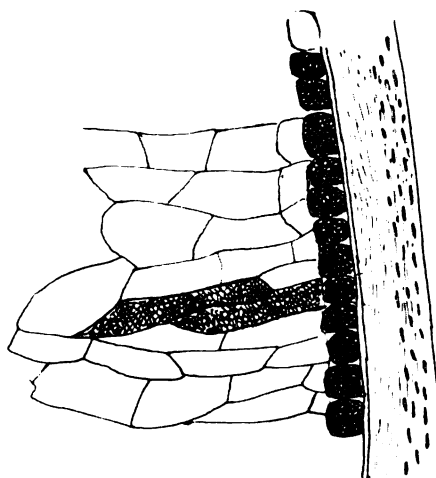


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