What is Starch?

The term starch is used to describe a biopolymer system comprising predominantly of two polysaccharides - amylose and amylopectin. The two polysaccarides are made of glucose monomers

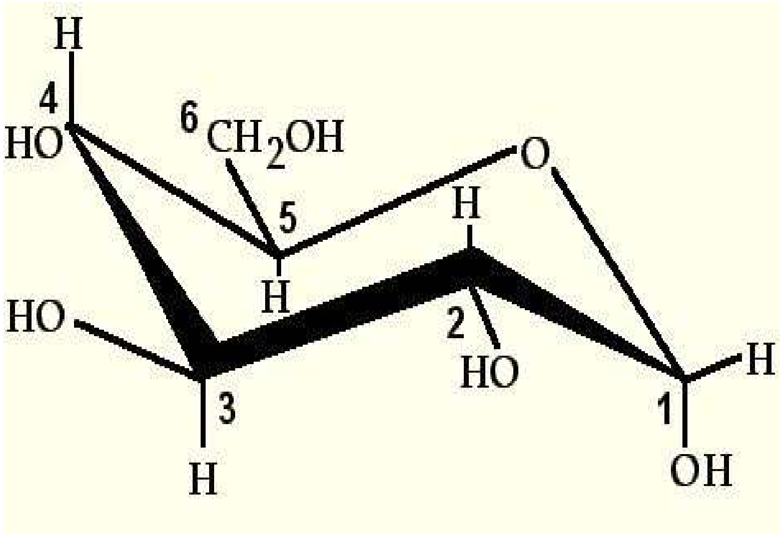

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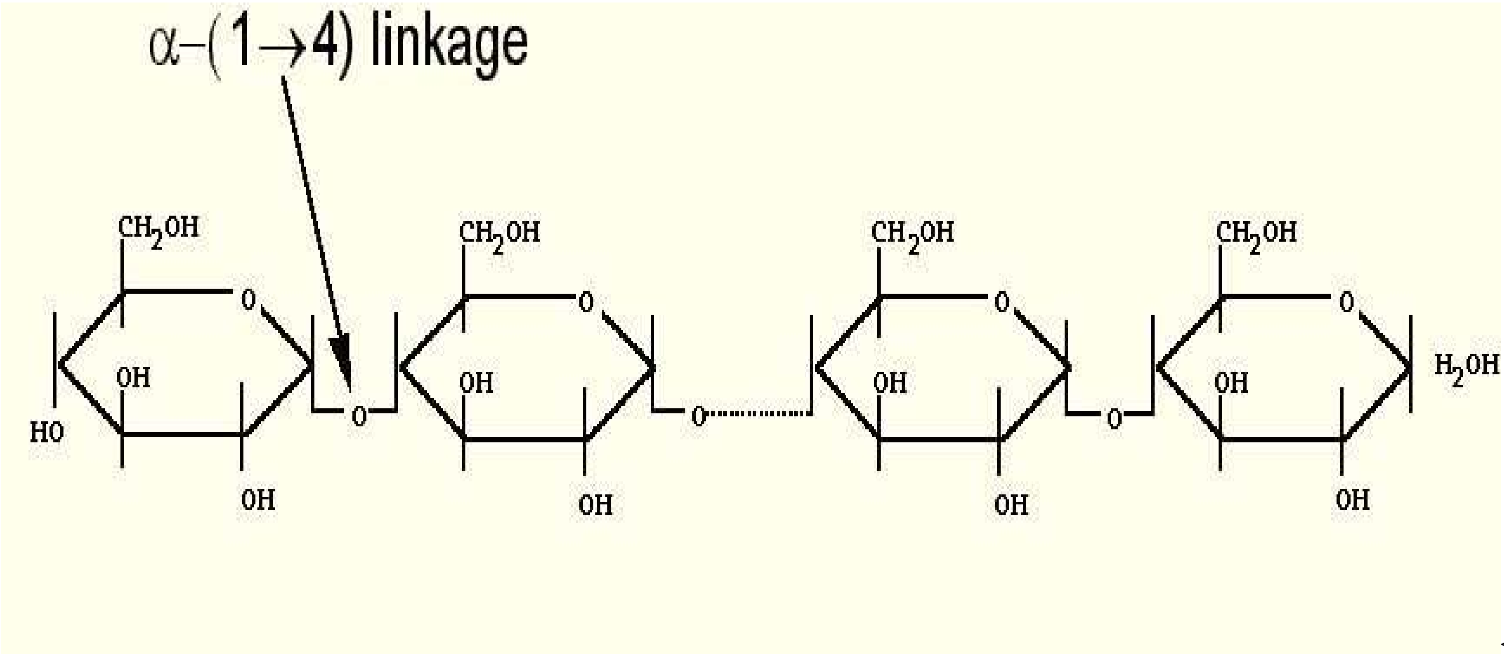
Figure 1 : A glucose molecule, the basic building block of starch

Starch is formed by a complex biological pathway involving photosynthesis. Much of this route still remains unknown. However once produced starch is held in granular storage bodies, which are usually deposited in the plastids of most higher plant species. Starch is the main energy storage system in most plants. Being insoluble there is no increase in the osmotic pressure within a cell, which would be the case if glucose itself was used. Starch is broken down in the body by a complex process of enzymatic attack. This is the process through which energy is absorbed when plants are consumed.

Amylose

The smaller of the two polysaccharides which make up starch, amylose is a linear molecule comprising of (1-4) linked alpha-D-glucopyranosyl units. There is a small degree of branching by (1-6) alpha linkages. This is shown below in Figure 2.



<>**Figure 2 : Amylose molecule**

Amylopectin

The larger of the two components, amylopectin is highly branched with a much greater molecular weight.

This structure contains alpha-D-glucopyranosyl units linked mainly by (1-4) linkages (as amylose) but with a greater proportion of (1-6) linkages, which gives a large highly branched structure (Figure 3).

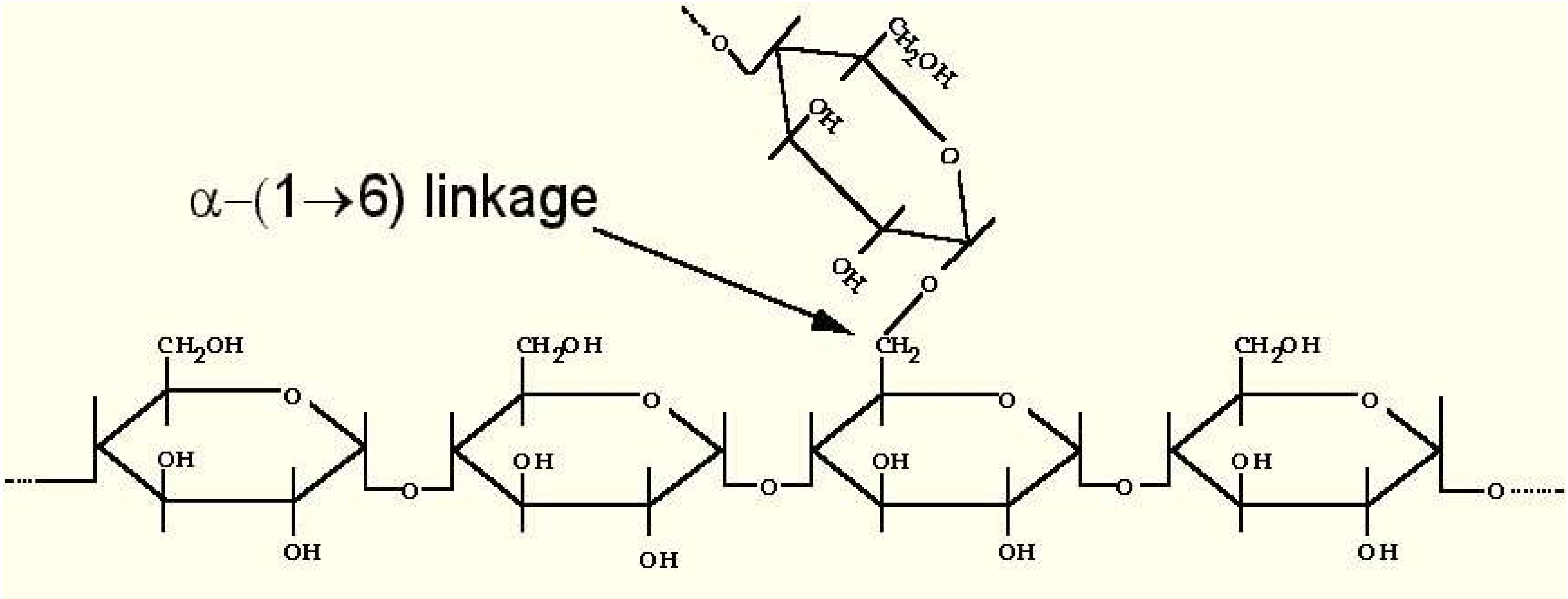


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Figure 3 : Amylopectin molecule

Amylopectin has been found to form the basis of the structure of starch granules. This is because the short branched (1-4) chains are able to form helical structures which crystallise.

<u>Semicrystalline structure</u>

It is now accepted that amylopectin crystallises according to a cluster model. (Peat et al., *J.Chem Soc, 1952, 4546*). This model is shown in Figure 4. Amylose fits into this structure in ways which are still not clearly understood. One amylopectin molecule spans several clusters and the branches can be labelled A, B or C. The A chains are the outer chains linked to an inner B chain. The B chains are linked to other B chains or the C chain. This is identified as the only chain having a free reducing end. There is only one C chain per amylopectin molecule.

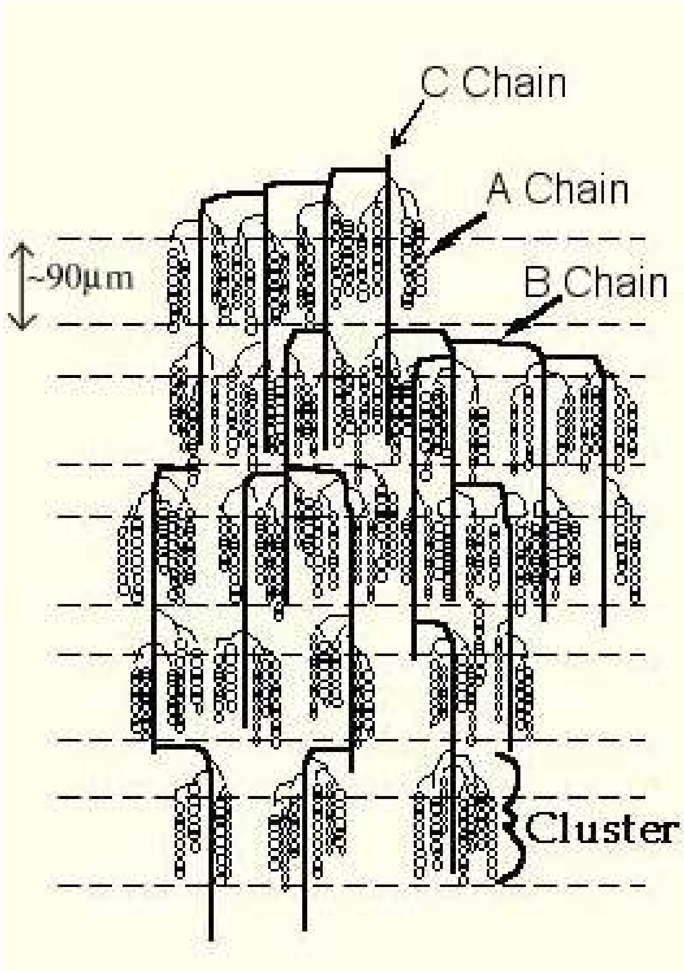

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Figure 4 : The cluster structure formed by amylopectin

With this A, B and C chain structure there are crystalline and amorphous domains. It is the extended B chains that provide the rigidity to the granule structure by bridging the amorphous regions.

Crystal Structure

There are two naturally-occuring crystal structures of amylopectin, A and B-type. It is found that almost all cereal crops are A-type whilst tubers are usually B-type. There is also a C-type, which is intermediate to the A and B-types. Pea starch has C-type crystallinity.

Growth Rings

When hydrated starch granules are viewed between by a light microscope, it is possible to see a ring structure. When starch granules are partially digested with amylase enzymes these rings become more visible (Figure 5). These rings are called "growth rings", as they form during the laying down of amylose and amylopectin (it is thought that these rings form during the diurnal cycle but this is still being investigated). The part of each ring which is less susceptible to enzyme attack is termed the semicrystalline growth ring, with the other part being predominantly amorphous. The precise arrangement of molecules within these two regions is poorly understood.

When starch is viewed under crossed polars a "maltese cross" is observed. This is present due to the packing structure within the growth rings. Figure 5 shows both the maltese cross and growth rings.

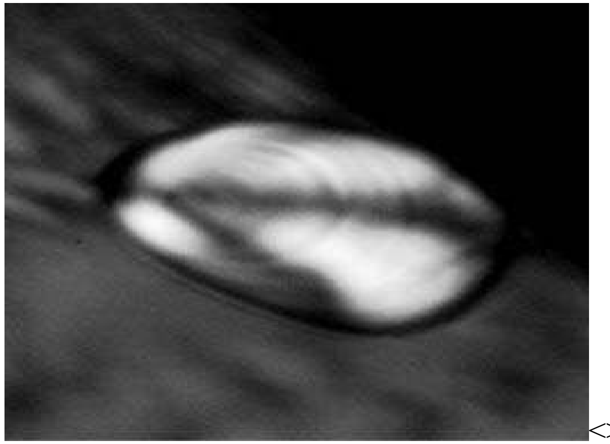

Figure 5 : A Potato starch granule showing growth rings and maltese cross

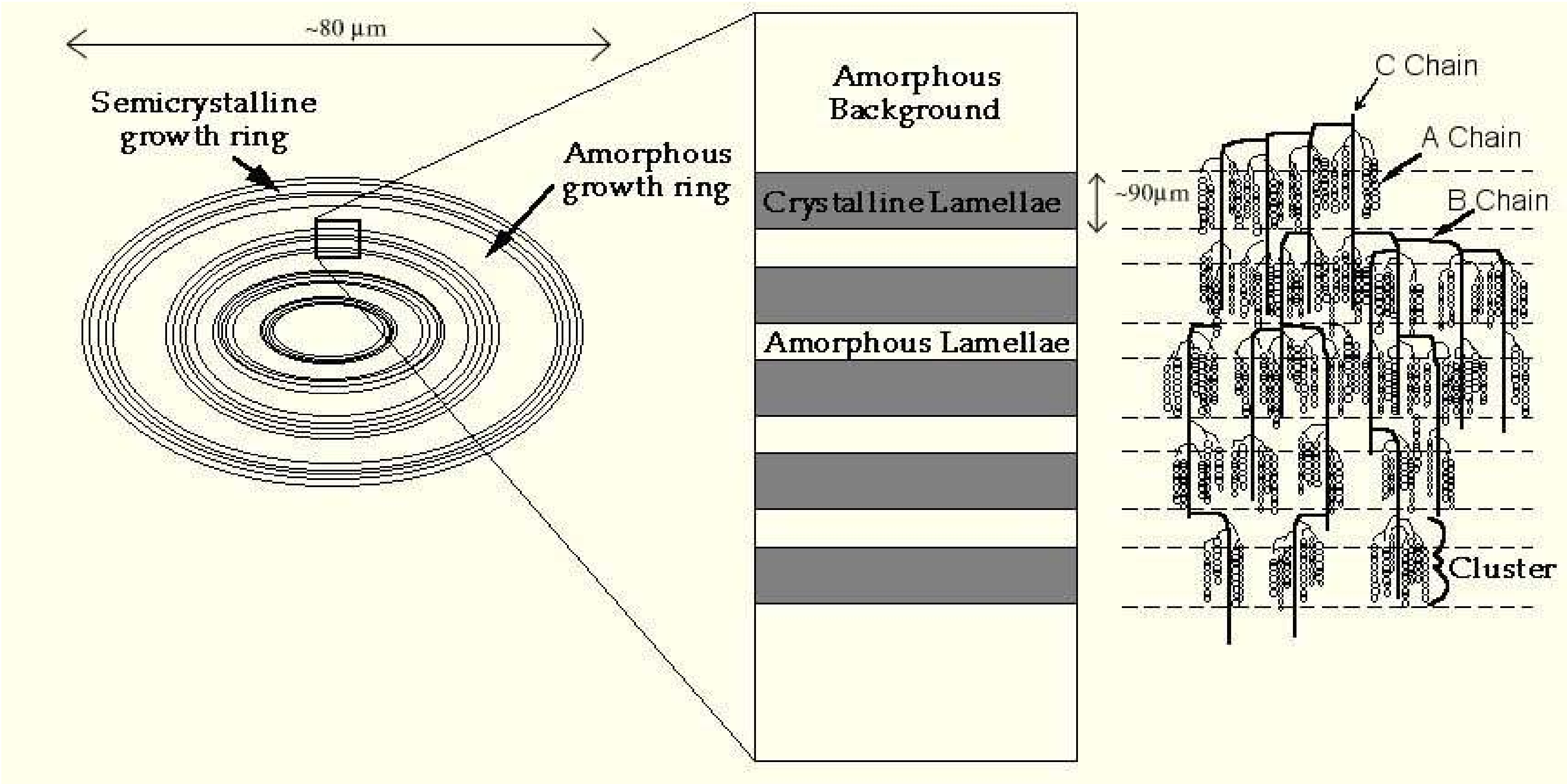

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Figure 6 : The complete make-up of a starch granule

Growth rings can be seen by Environmental Scanning Electron Microscopy (ESEM) as seen below.

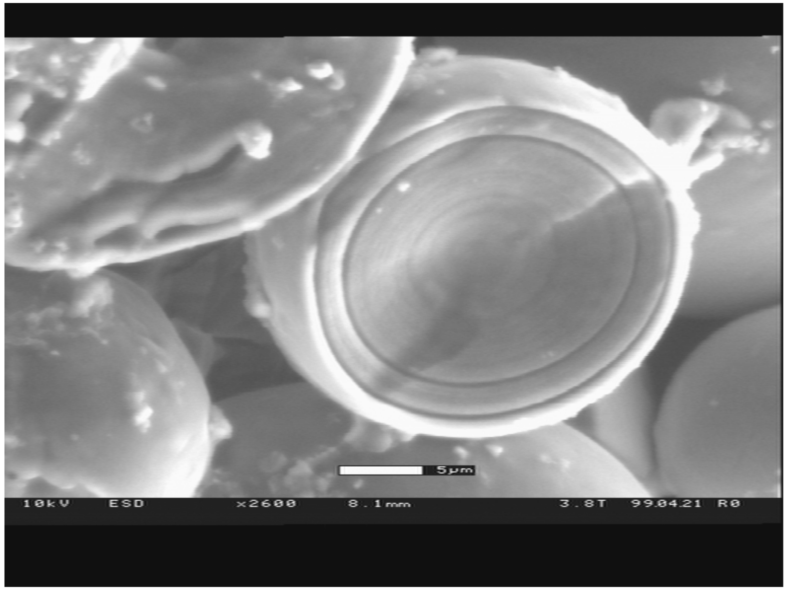

Figure 7 : Growth rings seen by ESEM (scale bar = 5um)

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