

# Advanced Biofuels

## Lignocellulosic Bioethanol

**Keywords** Bioenergy, biofuel, sustainable, renewable, biomass, yield, waste, bioethanol, lignocellulose, lignin, microbes, yeast, enzyme, fermentation, gribbles, varieties, pentose, hexose.

## Background

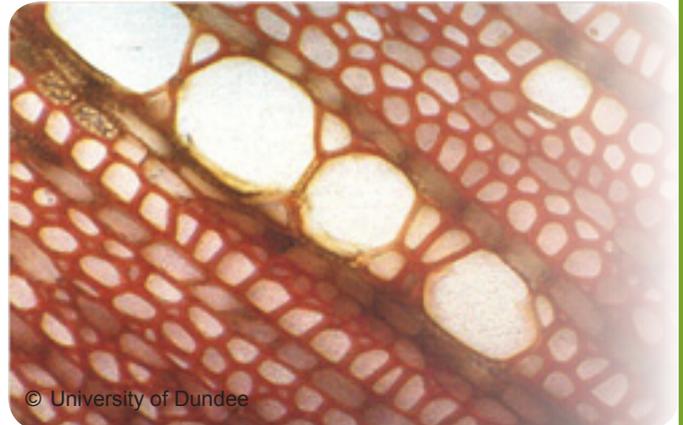
**Bioethanol** is produced by fermentation of sugars by yeast. Currently sugar beet and sugar cane are the main sources of sugar for bioethanol. In the future the biomass locked up in plant cell walls (**lignocellulose**) may be released for fermentation and production of bioethanol. This would enable bioethanol to be produced from wood, straw and waste materials.

Research to achieve this is going on in many areas including

- **Improving perennial biomass crops**
- **Manipulating lignin to optimise sugar release**
- **Improving release of sugars from plant cell walls**
- **Discovering new enzymes for sugar release**
- **Developing yeast strains to ferment sugars**
- **Bacterial fermentation of sugars to butanol**

We can use **enzymes** to break down plant biomass to release sugars for fermentation. In plants the sugars are locked into the cell walls as long chain polymers in ways we currently do not fully understand, preventing effective digestion by enzymes. If we can understand better how the plant sugars are arranged in the cell walls, we can select plants and match them with the most appropriate enzymes for more effective biofuel production.

Improving the properties of lignin in barley straw will make it easier to produce biofuel (or bioenergy) from this material without detrimental effects on the yield or quality of the crop. Lignin is a strengthening and waterproofing polymer that encrusts the sugar-based polymers in plant cell walls, making them hard to access for biofuel production. Lignin and its by-products are also toxic to microorganisms used in fermentation. Feedstocks rich in lignocellulose require treatment with acids, alkalis or steam explosion methods to hydrolyse hemicellulose and break down lignin, enabling access to the cellulose by enzymes. Steam explosion has significant potential as chemical methods have to be managed with recovery and waste water processes and can inhibit enzymes and fermentation.



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Plant cell wall lignins under the light microscope



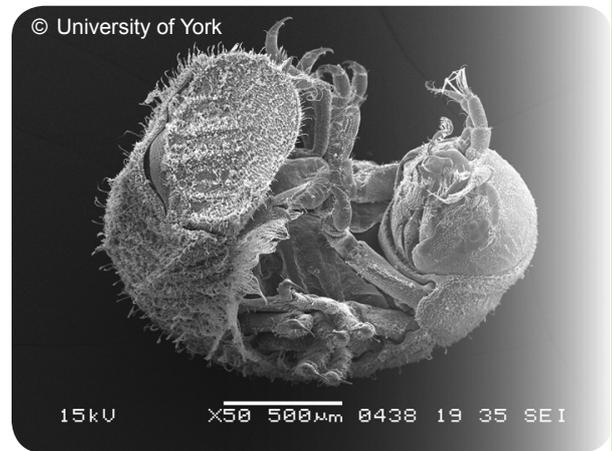
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Willow planting measurements

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Discovering new enzymes in bacteria, fungi and marine wood borers (gribbles) will enable the conversion of non-food plant biomass into biofuels. Wood and straw contain polysaccharides (polymers of sugars) that can be converted into simple sugars suitable for fermentation to produce liquid biofuels. Currently we lack effective enzymes to digest these woody materials. However, marine wood borers are voracious consumers of lignocellulose and have all the enzymes needed for digestion of wood and straw. Scientists have already sequenced the genes that are expressed in the marine wood borer gut and which encode the digestive enzymes. Scientists will study the digestive process in borers as well as a range of microorganisms and investigate the industrial applications of their enzymes for biofuel production.

To harness the potential of lignocellulosic (plant cell wall) materials for sustainable production of bioethanol, we need to optimise energy output without negative environmental, social or economic impacts. We need to optimise the release of sugars from plant cell walls in agricultural and wood-industry wastes to produce a fermentable feedstock that microorganisms can use to produce fuels. Developing robust microbial strains that can use these feedstocks will enable sustainable production of bioethanol.



Marine wood borer (gribble)

