

# TURNING BIOFUELS INTO A TRULY SUSTAINABLE INDUSTRY

## The Microbiogen “Fuel and Food” Biorefinery

Dr Philip Bell

Director of Research

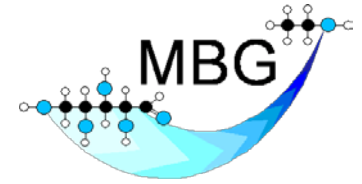
**Microbiogen Pty Ltd**

Ausbiotech conference

Adelaide, Australia

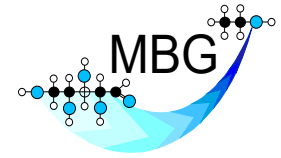
OCTOBER 2011

# Microbiogen Pty Ltd



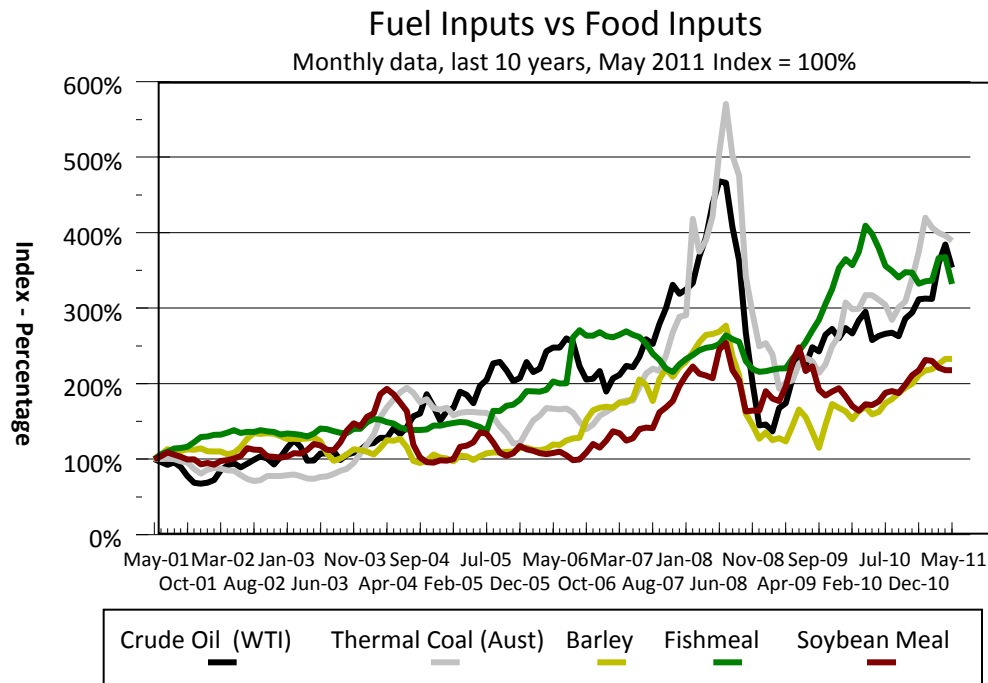
- Australian company founded in 2001
- Strong focus on developing industrial yeast strains
- Principal scientists: >20 years experience in industrial yeast development
- 15 employees
- Have developed unique 2<sup>nd</sup> Gen technology to produce 'Food and Fuel' from waste plant material
- Awarded "The 2011 Frost and Sullivan Global Green Excellence Award for Technology Innovation in Biotechnology"

# Food and Fuel supply are closely interlinked



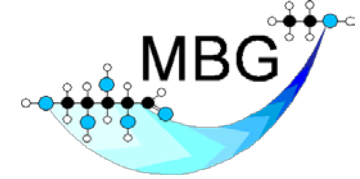
## Industrially produced food is cheap abundant due to non-renewable hydrocarbons

- Hydrocarbon fuels are used to produce critical nitrogen fertilisers
- Hydrocarbon fuels are used for ploughing, planting, harvesting, transportation, refrigeration etc

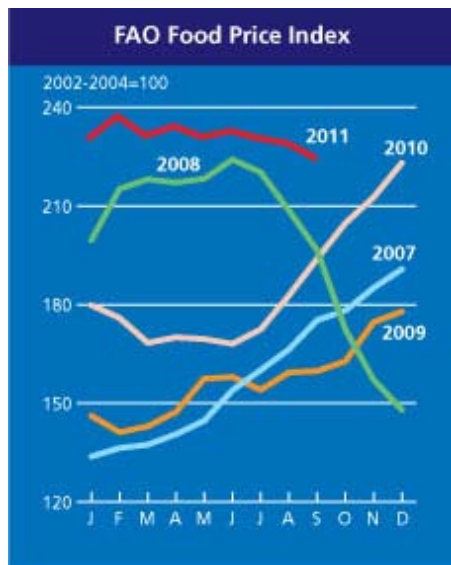


Price of food is tracking the price of fuel

# Food security is an emerging global problem

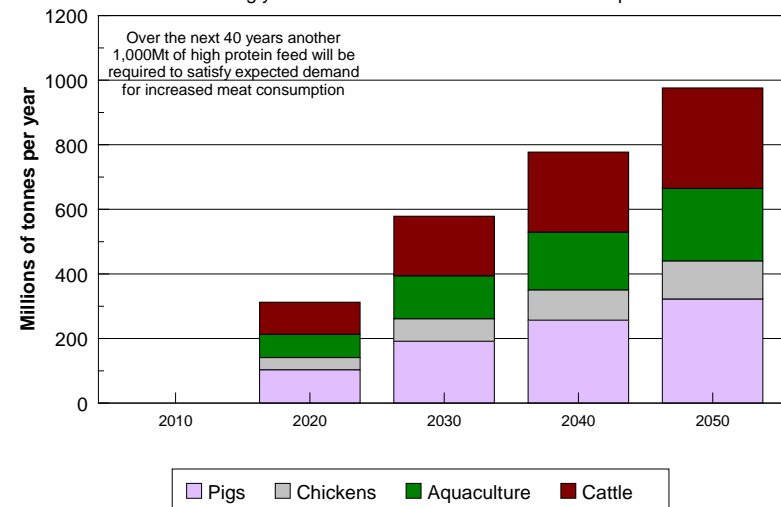


- Increasing world population = More food required (doubling in 40 years)
- Increasing standards of living = More animal protein demand (1B MT feed)
- Climate disruption = Decrease in food supply (Drought, flood, cyclone)
- Increased fuel costs = Increased food price (Fertiliser, transport)
- = Increase in food to fuel biorefineries

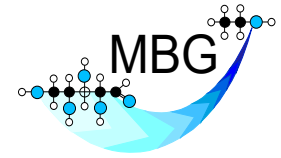


## Estimated increase in protein feed requirements - Next 40 Years

Assuming yeast as a substitute for other sources of protein



# Fuel security is a global problem



## Demand increasing more rapidly than supply

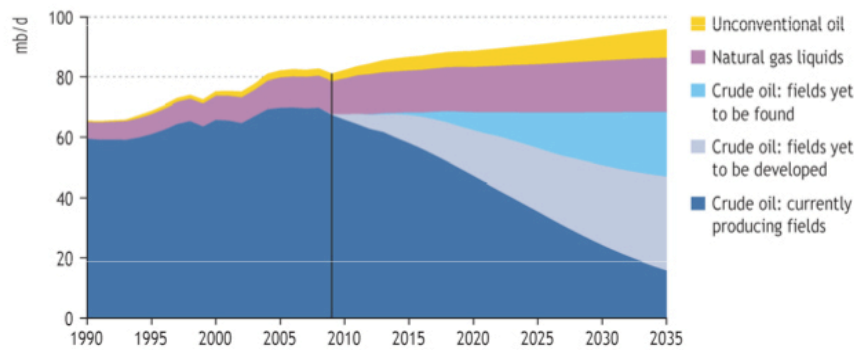
- IEA forecasts a 14% increase in supply of non-renewable liquid fuels by 2035
- DOE forecasts a 38% increase in demand for liquid fuels to 2030 in the US alone
- Factoring in developing countries... = A significant shortfall
- High oil prices despite recession

World oil production by Type  
IEA: World Energy Outlook: 2010

## Oil production becomes less crude

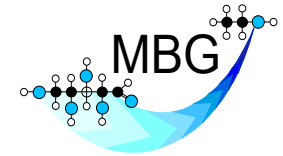
World  
Energy  
Outlook  
2010

World oil production by type in the New Policies Scenario

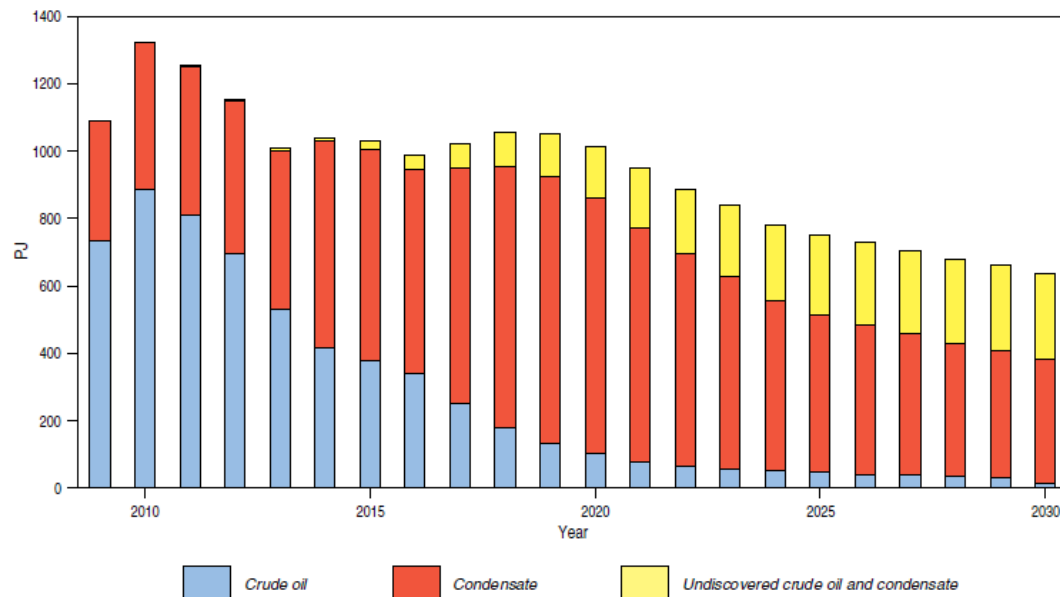


*Global oil production reaches 96 mb/d in 2035 on the back of rising output of natural gas liquids & unconventional oil, as crude oil production plateaus*

# Australia's is vulnerable to oil security shocks



Australian crude oil production peaked in 2001 at 214 million barrels  
Australian crude oil production in 2010 was 112 million barrels  
Production predicted to continue falling



**Figure 3.43** Australian oil production outlook from proven hydrocarbon basins

**Note:** the production forecast is based on data from an industry survey of producing fields and Geoscience Australia's assessment of undiscovered resources in proven basins

**Source:** Geoscience Australia

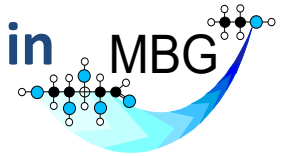
Microbiogen is developing novel yeast strains that will enable production of both food and fuel on a large industrial scale

# Saccharomyces cerevisiae: The industrial workhorse

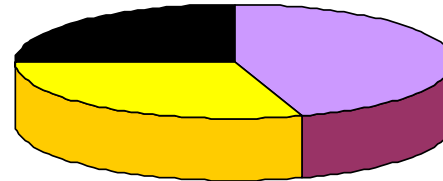
- *Saccharomyces cerevisiae* - an industrial yeast used in production of fuel ethanol, bread, wine, beer, flavors and nutraceuticals.
- Exceeds production of ALL other industrial microbes by two orders of magnitude (Hansen 2004, Verstrepen 2006) and underpins US\$300B in products per year
  - Total yeast market worth US\$5B/year by 2015 (BCC Research)
  - US animal feed yeast market is US\$100M/year and growing at 5-10% pa. (Frost & Sullivan 2007).
  - First Generation Corn Ethanol yeast market US\$ 90M/year and growing



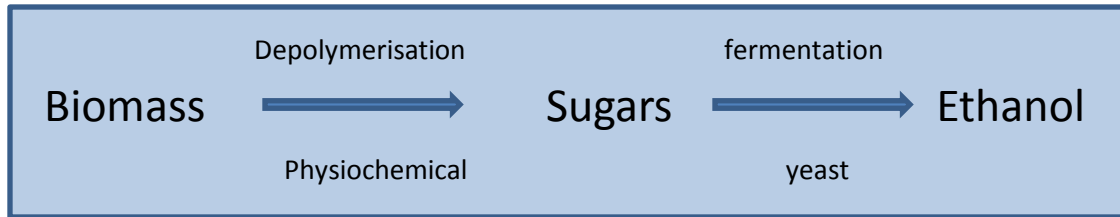
# *Saccharomyces* yeast are not currently suitable for use in Second Generation (2<sup>nd</sup> Gen) facilities



Non-food biomass



- Cellulose 45% (100% glucose polymer)
- Hemicellulose 30% (primarily xylose polymer)
- Lignin 25%

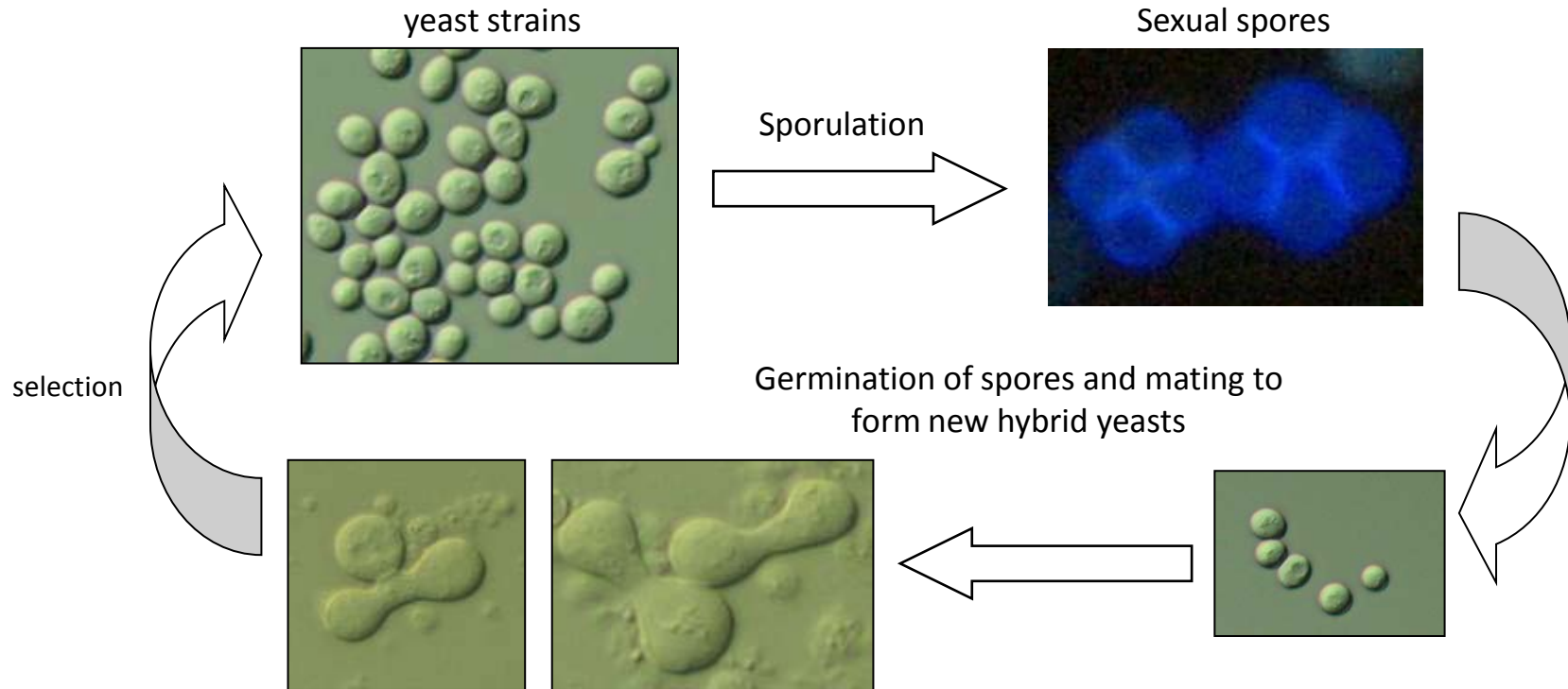
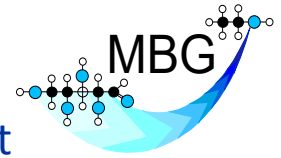


Critically for 2<sup>nd</sup> Gen bio-refineries, biomass contains abundant xylose and *Saccharomyces* is considered a non-xylose utilising yeast



# Our core technology

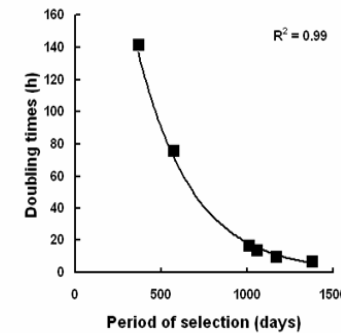
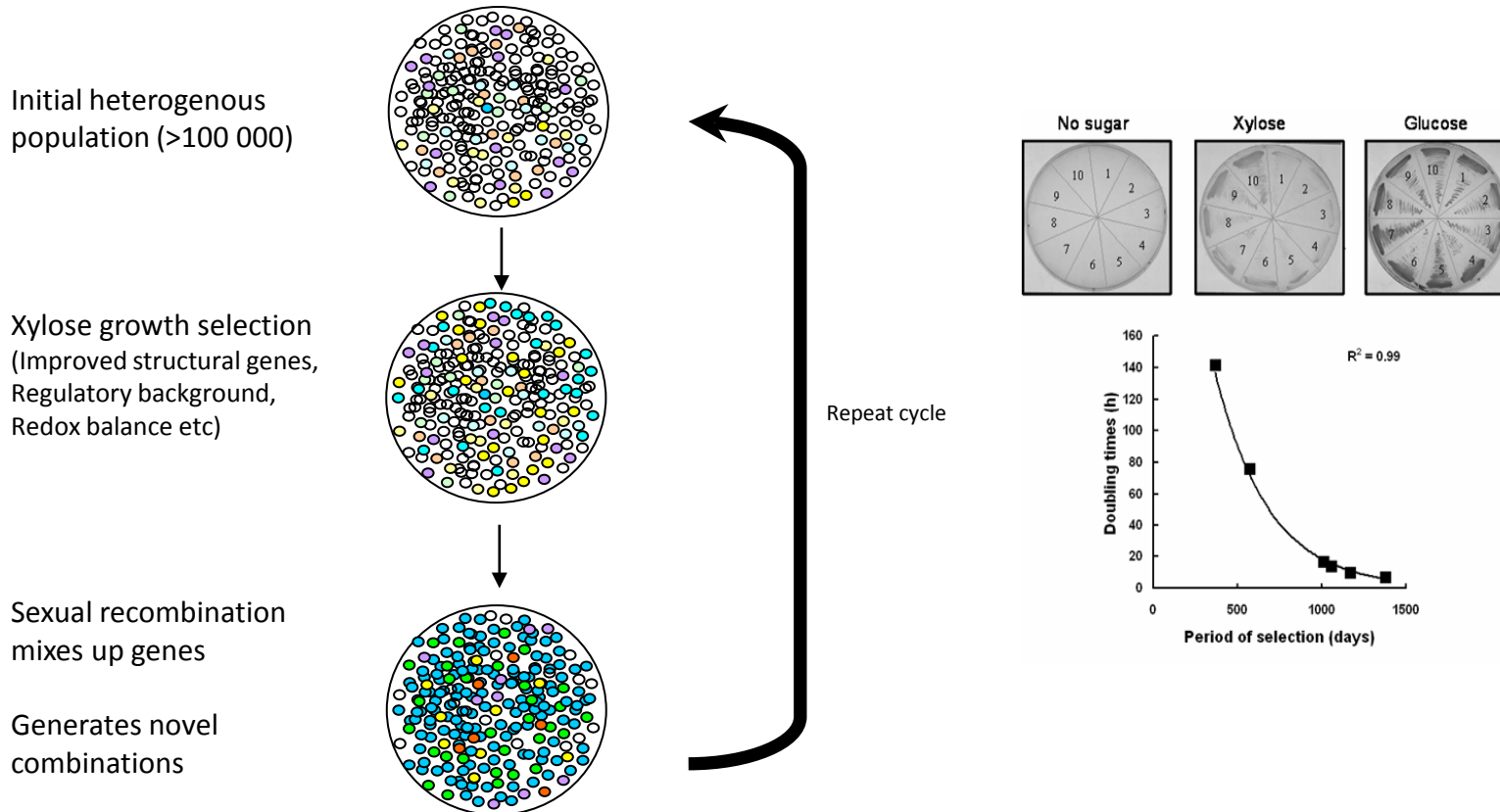
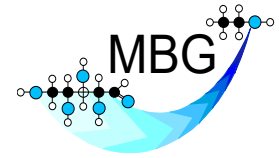
Use breeding and evolution to develop improved industrial yeast



Technology is based on over 20 years of research into methods to breed and evolve yeast to have improved industrial characteristics

We are applying our technology to develop special *Saccharomyces* yeast strains for use in 2<sup>nd</sup> Gen biofuel production

# Example: introduction of unique ability to use xylose into *Saccharomyces* yeast via evolution

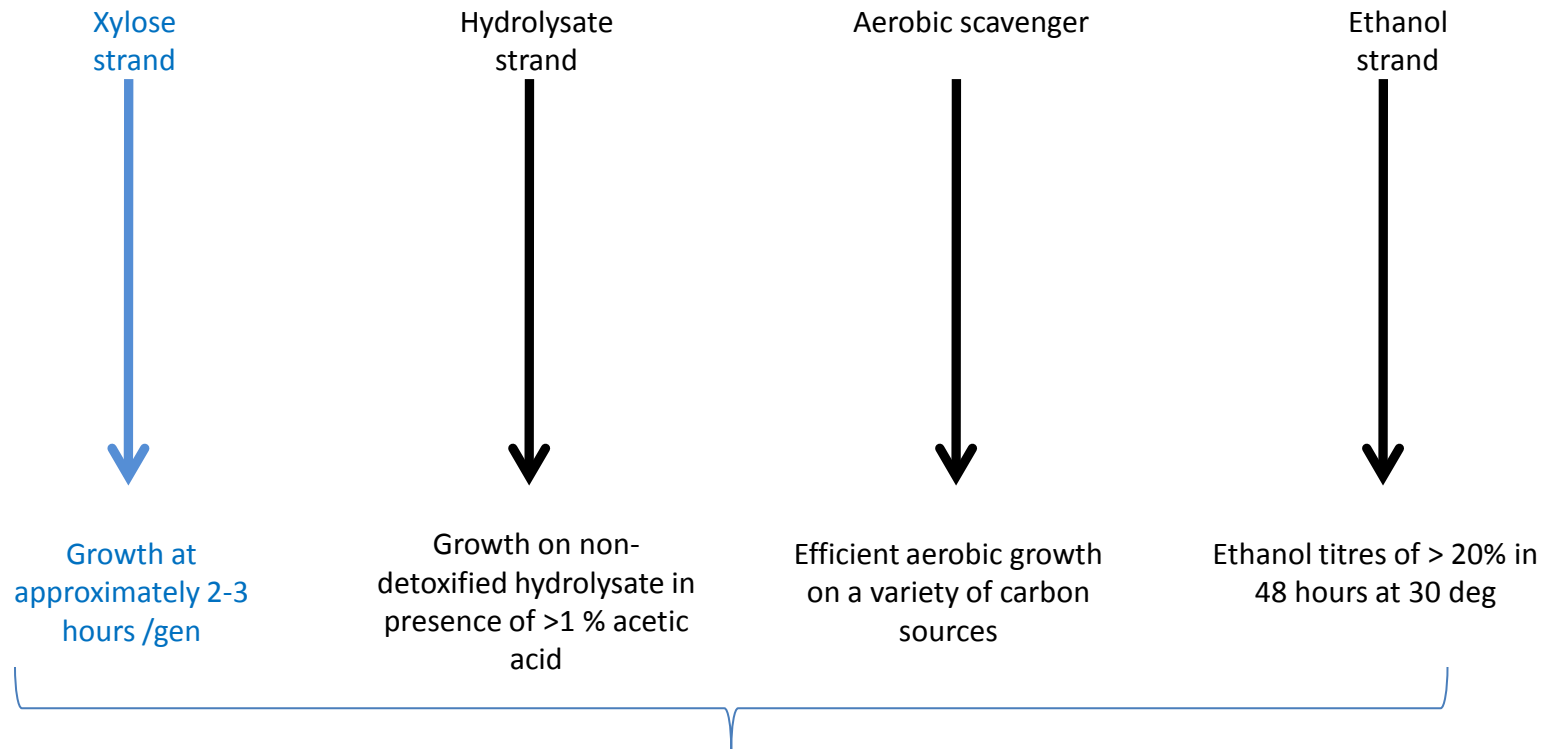


We are applying  
classical evolutionary  
principles to develop  
different phenotypes

Source: Microbiogen

After ~3650 days of continuous natural selection our **patented** *Saccharomyces cerevisiae* can now efficiently use xylose as a sole carbon source

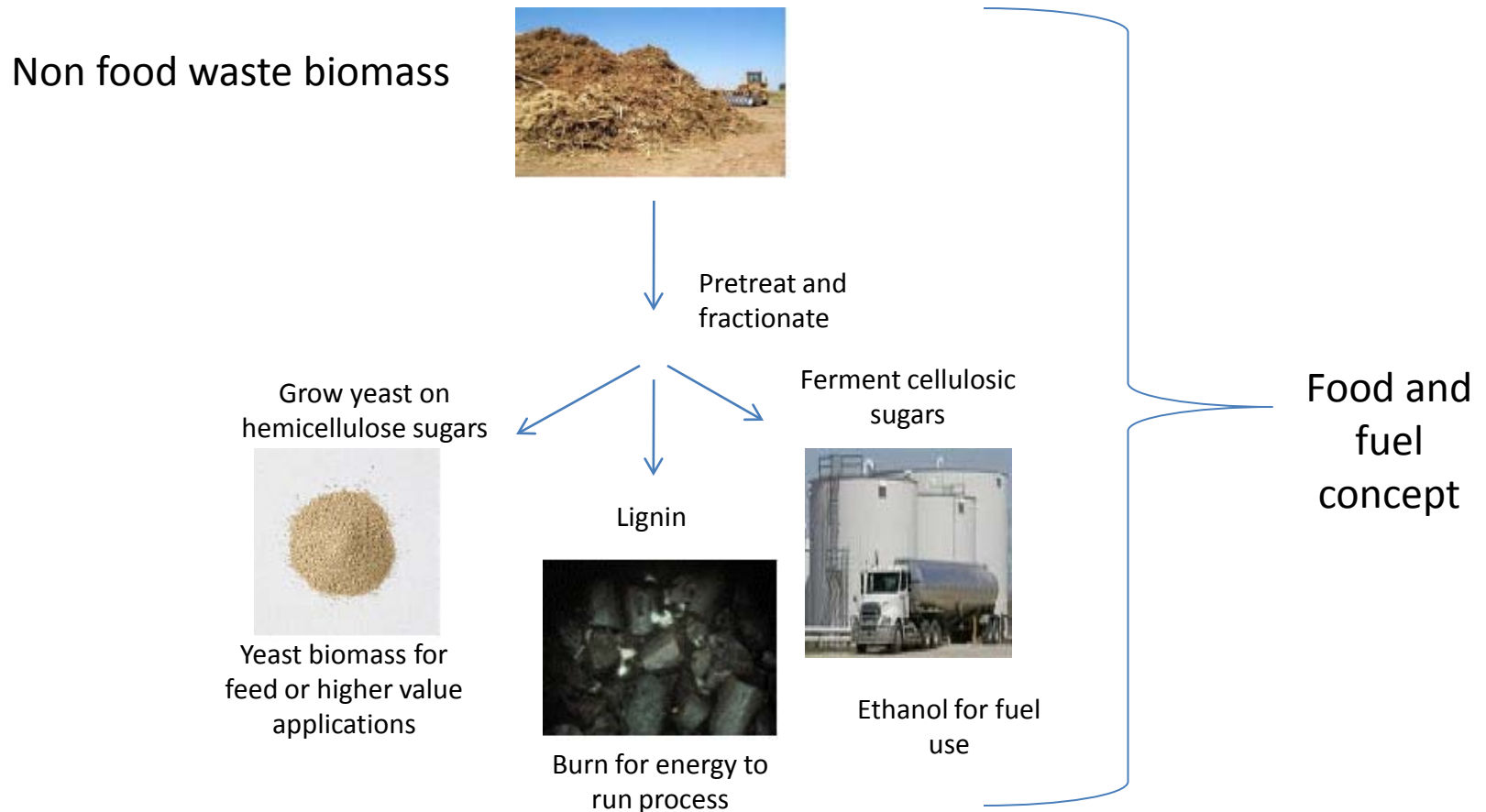
Xylose utilisation is only one of the unique features required to operate under 2<sup>nd</sup> Generation conditions



2<sup>nd</sup> Generation Yeast strains

Use as base strains for “Drop in fuels” (Butanol, isoprenoids)  
Use in Microbiogen’s 2<sup>nd</sup> Gen food and fuel bio-refinery

# Microbiogen's food and fuel cellulosic bio-refinery



We are currently demonstrating our process in bagasse hydrolysates at pilot scale

Current techno-economic analysis underway using NREL/DOE models

# Fuel AND Food: Potential To Improve Land Productivity

## Current Ethanol Facility



Converting all the sugar and molasses into ethanol – per hectare



Ethanol



5,550 Kg

## “2nd Generation biorefinery”

Sugar, molasses per hectare, AND



Per hectare dry bagasse, trash and tops

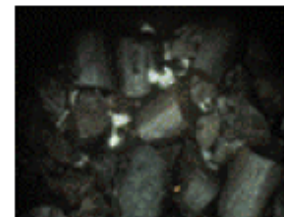
Pre-treat and fractionate waste biomass

Grow yeast on hemicellulosic sugars



Yeast (protein) for feed  
2,106 Kg  
~1,000 Kg protein

Lignin

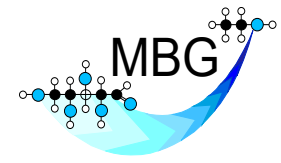


6 GJ per tonne of waste biomass

Ferment cellulose and molasses



Ethanol  
8,960 Kg



# Can 2<sup>nd</sup> Gen ethanol production replace petroleum in Australia?

Australia consumed 20 BL of Automotive petroleum in 2003-2004 (Australian Petroleum Statistics, Dept of Industry Tourism and Recources)

Australia consumes 0.35 Million tonnes soybean as feed additive and imports 0.30 Million tonnes of this (12 th Australian Soybean conference)

The world produced 258 Million tonnes of Soybean in 2010 (2011 edition of Soy Stats® )

Microbiogen’s Sugarcane Food and Fuel biorefinery produces 8 960 kg (11 365 L) ethanol and 2 100 kg of yeast biomass per hectare

	Australian Petroleum Usage	Australian Soybean Imports	World Soybean production	Ethanol	Yeast	Total land use	Number of 200 ML Plants
E10	20 BL	0.3 MT	258 MT	2 BL	0.37 MT	42 km x 42 km	10
E85	20 BL	0.3 MT	258 MT	17 BL	3.15 MT	122 km x 122 km	85

## Current Commercial activities

- Anticipating full scale industrial trials of one of our yeast before year end
- High antioxidant/nutraceutical yeast
  - Licensing negotiations underway
  - Production feasibility study
- 2<sup>nd</sup> Gen partnerships with >15 international companies
- Commercialisation funding being sought for several opportunities

## Acknowledgments

Thanks to colleagues at Microbiogen:

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- NSW DSRD BioBusiness
- Federal Government DRET Gen 2 grant recently awarded to assist with development of technology to commercial demonstration scale

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