

# C5.6 Technologies



# C5•6 Technologies

## Enzymatic Production of New Feedstocks for Biofuels

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**C5.6 improves the conversion efficiency of agricultural feedstocks in bioprocessing**

- **Spun out from Lucigen Corporation**
  - All technology and molecules transferred under a no-charge license arrangement



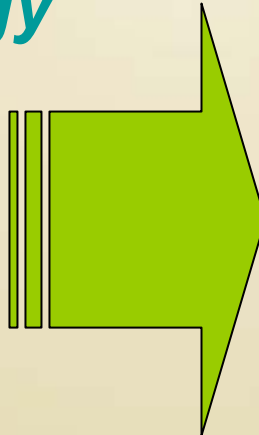
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# C5-6's Technology Application

Lucigen's Unique Cloning Tools  
Single Cell Genomics

*Platform Technology*

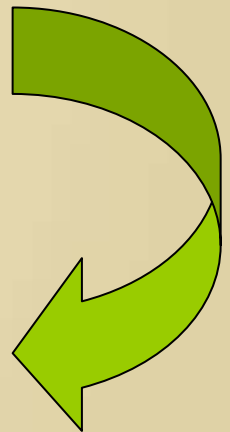
*Rare Microbes*



High Value  
Enzymes



*Biofuels*



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# Biofuels Overview

	Current	Future
Plant	Dry mill Wet mill	Biorefinery
Raw Material	Corn	Cellulosics
Feedstock	Starch	Cellulose Xylan
Product	Ethanol	Ethanol, Butanol, Others



# Biorefineries Are Coming!

**DOE goal - 25 billion gallons ethanol by 2025**

- Half from corn-based plants
- Half from cellulose-based biorefineries



# Biorefineries – Why Not Now?

## What remains to be done?

- **Source of Cellulose**
  - Crop or residue?
    - Harvesting
    - Storage
- **Processing**
  - Pretreatment
  - Clean-up?
  - Hydrolysis
  - Fermentation



# C5-6's View

	Current	MIDTERM	Future
Plant	Dry mill Wet mill	Dry mill	Biorefinery
Raw Material	Corn	Grains, Soy, Ag Waste	Cellulosics
Feedstock	Starch	Hexose Sugars	Cellulose Xylan
Product	Ethanol	Ethanol	Ethanol, Butanol, Others

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# Benefits for Biofuels

**Lucigen has the ability to find and produce new enzymes with targeted attributes**

- **Developing enzymes to fit the process rather than a process to fit the enzyme**
- **Bioethanol process = 80°C, pH 5-6; requiring thermostable enzymes with specific characteristics**



# C5-6's Technology Advantage

## Unique Enzyme Products

- High thermal stability
- High activity
- Multi-functional activities
- Works in current plant process



# Biofuels Market Overview

## Exciting market dynamics

- Fits today's cars and today's liquid fuel system
- Already part of the global fuel market

## Strong national rationale

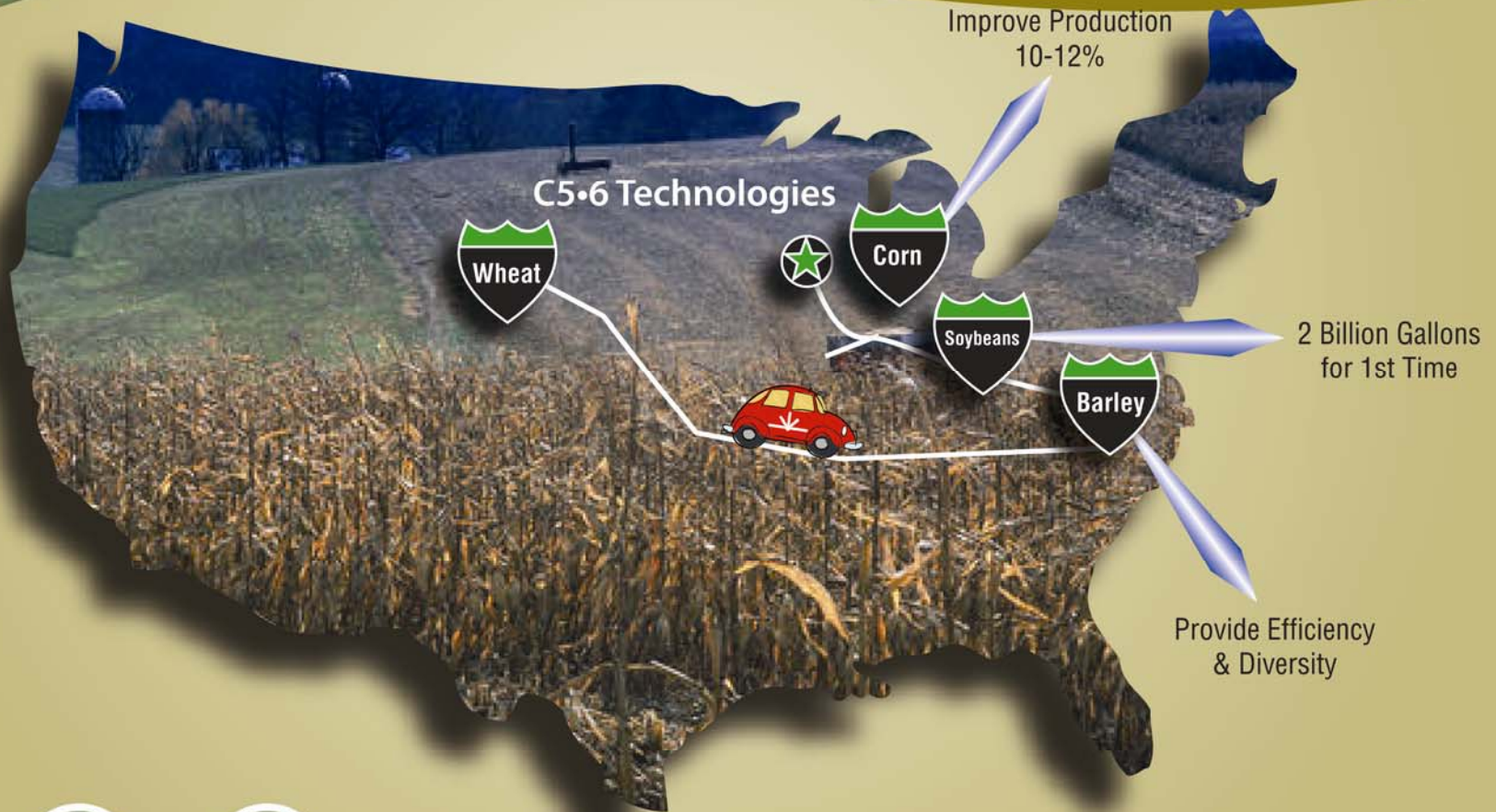
- Improved fuel and national security
- Positive impact on debt and balance of payments
- Benefits to agriculture and family farms

## Strong consumer rationale

- Cheaper fuel
- Cleaner environment



# C5-6 Technology Roadmap



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# Corn Composition

- **72% Starch**
- **13% Fiber**
- **1/3 cellulose**
- **2/3 hemicellulose**
- **9.5% Protein**
- **4.3% Fat**



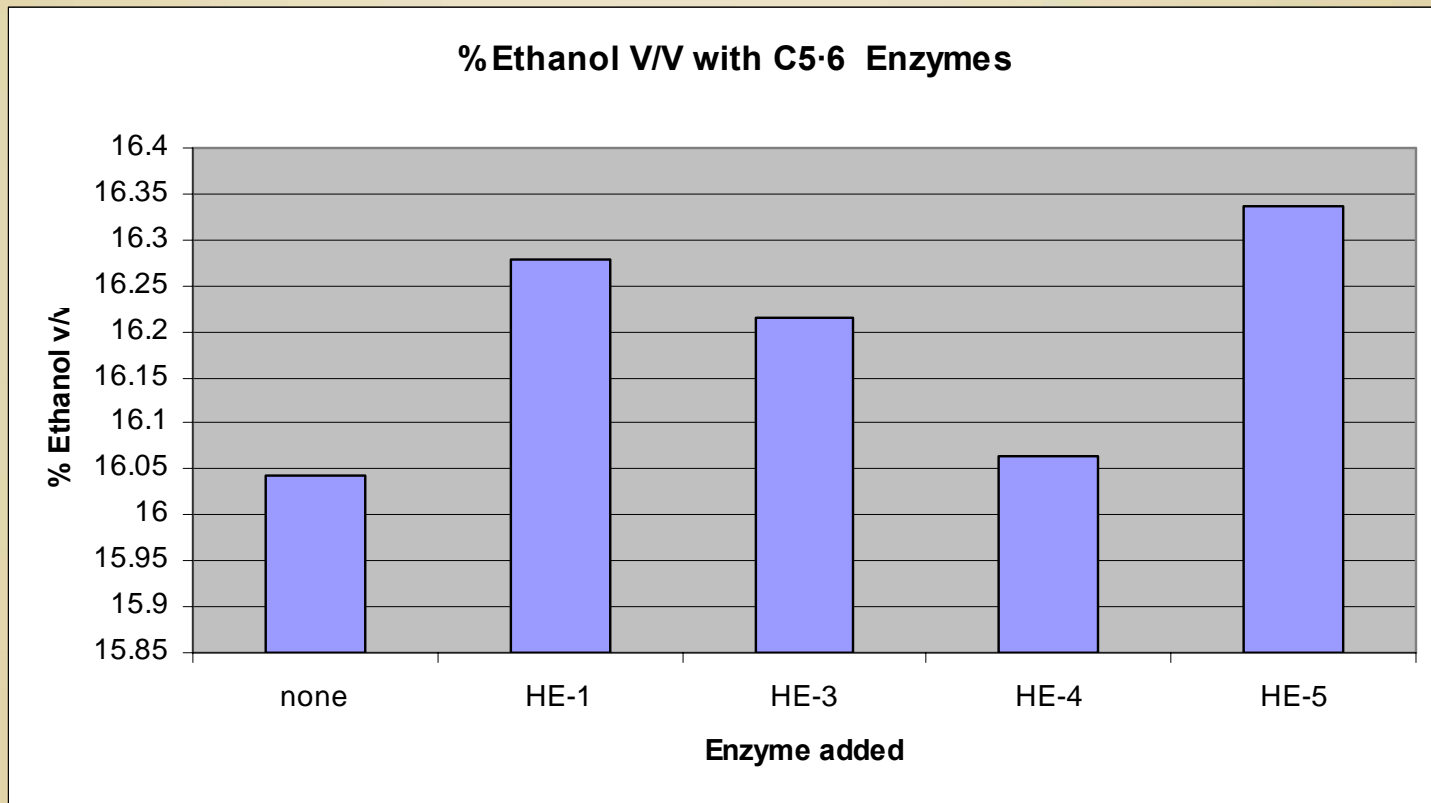
# C5-6 Technology Roadmap: Corn

**15% of carbohydrate in current process not converted to alcohol**

- Cornbuster™ 1 — 2-3% of starch remains bound to cellulose
- Cornbuster™ 2 — 11-13% of corn is cellulose and hemicellulose



# Results With Cornbuster™ 1



# Corn Ethanol Value Proposition

## C5-6 enzymes deliver a strong value proposition for dry-mill producers

- +2% efficiency target = \$2M additional production (*50 million gallon typical plant/\$2 gallon ethanol*)

OR

- \$1M in corn and energy savings if plant is at capacity (*corn @ \$2 bushel*)



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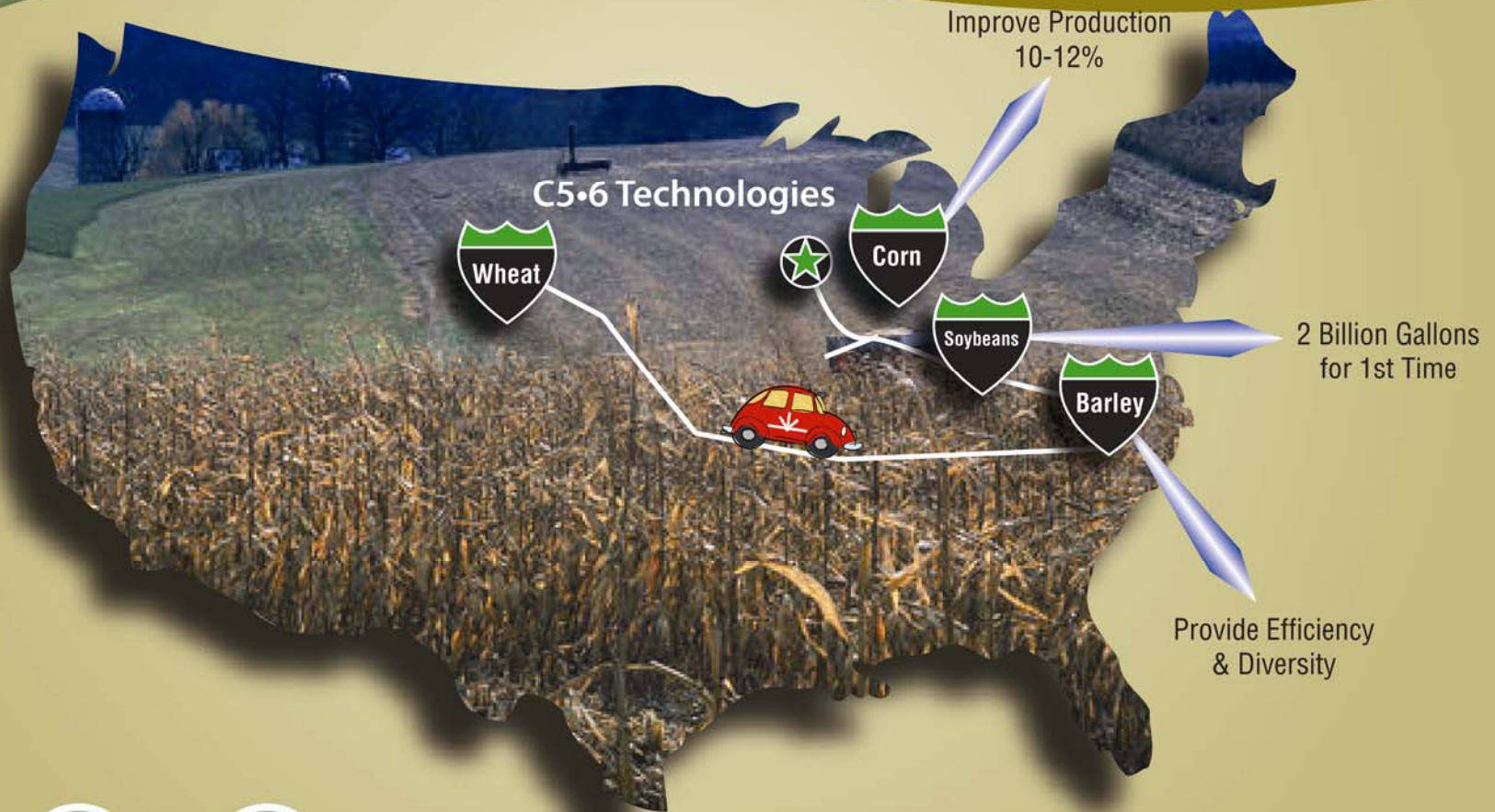
# Converting the Cellulose

## Novel thermostable cellulase isolated and characterized

- Active as soluble protein
- Contains both *endo*-glucanase and *exo*-glucanase activities
- Patent filed, lab evaluation underway



# C5-6 Technology Roadmap



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# C5-6 Technology Roadmap: Soy

## C5-6's Goal: Utilize soy in current dry mill corn plants

- 2+ billion gallons of ethanol possible from current soy meal production
- Soy market dynamics extremely favorable



# Why Soy Carbohydrates?

Soy contains a mixture of sugars and non-starch polysaccharides (NSP) but no starch or xylan!

	<i>Starch</i>	<i>Xylan</i>	<i>Cellulose</i>	<i>SOY</i>
<i>Avail.</i>	+++	+/-	+/-	+++
<i>Conver.</i>	Easy	Easy	Difficult	Easy/?
<i>Products</i>	C6	C5	C6	C6
<i>Ferment.</i>	+++	Poor	+/-	+++



# C5-6's Route to Soy Ethanol

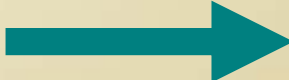
**C5-6's Plan: Develop thermostable hydrolases to convert soy meal carbohydrates to ethanol**

- *alpha*-galactosidases to convert soluble sugars
- Galactanases and mannanases to convert NSPs



# Soy Ethanol Value Proposition

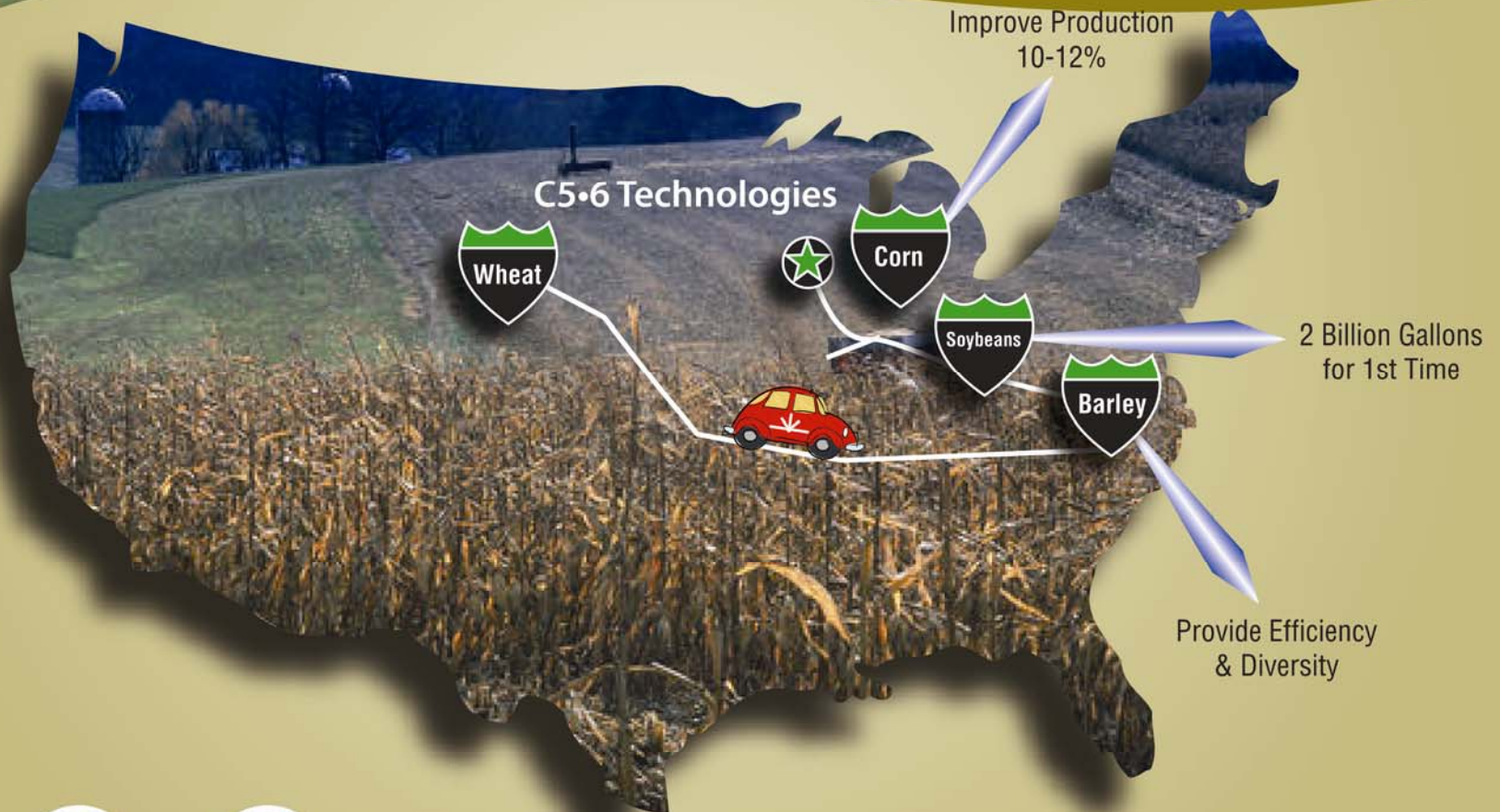
C5-6's ability to convert soy delivers high value to producers and millers

	<i>Current/ Pound</i>	<i>Current/ Bushel</i>	<i>C5-6/ Pound</i>	<i>C5-6/ Bushel</i>
<i>Oil</i>	\$0.23	\$2.40	\$0.23	\$2.40
<i>Carbs</i>	\$0.0	\$0.0	\$0.12	\$2.40
<i>Protein</i>	\$0.09	\$3.75	\$0.09	\$3.75
<i>Total</i>		\$6.15		\$7.55

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# C5-6 Technology Roadmap



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# C5-6 Technology Roadmap: Alternative Grains

**C5-6's Goal: Improve barley and wheat performance in current dry mill corn plants**

- Wheat in Canada and Europe
- Barley in Eastern U.S.

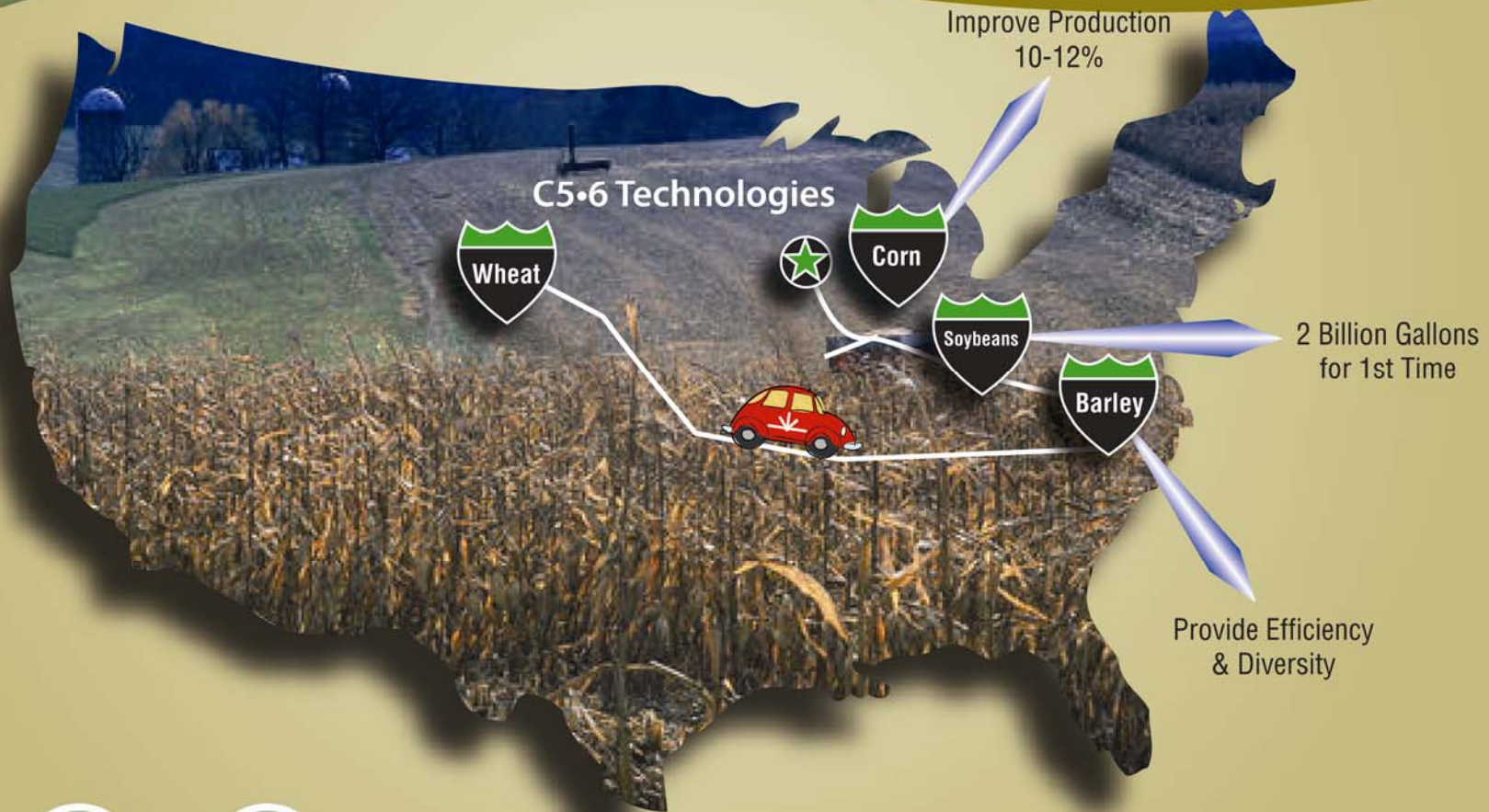


# Improving Ethanol Production from Grains

- Production limited by viscosity of grain mashes
- Problem caused by *beta*-glucans in grain
- Thermostable *beta*-glucanases identified and being evaluated



# C5-6 Technology Roadmap



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Thank You!  
Questions?

