# INDUSTRY SHARES TECHNOLOGY NEEDS with FEDERAL LABORATORIES

JUNE 11, 2013

# AGENDA

- INTRODUCTION RIC TROTTA
- OVERVIEW OF ETN JOE FOX
- DOW GRETCHEN BAIER
- WEYERHAUSER MILES DRAKE/LINDA BELTZ
- ASHLAND JOE FOX
- MONSANTO DAVE RUSSELL
- GOODYEAR DEREK SHUTTLEWORTH
- WRAP-UP RIC TROTTA

# An Overview of the Industrial Research Institute's External Technology Network (ETN)

**Joe Fox**
**Director, Emerging & External Technologies**
**Ashland Performance Materials**

FLC / ETN Webinar
June 11, 2013

ASHLAND®

# The Industrial Research Institute (IRI)

- IRI is celebrating its 75th anniversary in 2013.

- > 200 members
  - Private sector companies
  - Federally-funded laboratories

- IRI's Mission is to enhance the effectiveness of technological innovation by networking the world's best practitioners and thought leaders to seek, share, learn and create.

- Eight Networks:
  - Health, Safety and Environment
  - R& D Support Services
  - Finance, Strategy & Portfolio Analysis
  - New Business Development
  - Human Resources
  - Innovation Leaders
  - IS / IT
  - External Technology

# External Technology Network (ETN)

- Focus is on sharing of best practices related to identification and acquisition of external technology.

- The openness and willingness to share is very refreshing!

# ETN Members

- Largest network in IRI
  - Number of members: 150

- Professionals involved:
  - Directors of Corporate Partnerships
  - Managers of Technology Transfer
  - External Research Directors
  - Technology Scouts
  - Open Innovation Leaders

# ETN Member Companies

- Industrial members
  - Chemicals, materials, consumer products…..
- Federal laboratories

**Member companies represented**

Acorn Technologies
Agilent Technologies
Air Liquide
Air Products
Alpha
American Science & Engineering
Amway
Archer Daniels Midland
Arkema
Armstrong
Ashland
Babcock & Wilcox
BD
Boeing
Boston Scientific
BP
Ceramatec
Chevron
Coca-Cola
Colgate-Palmolive
ConocoPhillips
Corning
DuPont
Eastman Chemical
ExxonMobil
GE
Georgia Pacific
GM
Goodyear
Hershey
Honeywell
HRL Laboratories
IBM
Invetech
KAO
Kellogg
Kimberly-Clark
Kraft
Lawrence Berkeley National Laboratory
Lord Corporation
Los Alamos National Laboratory
MeadWestvaco
Milliken
Motorola
National Science Foundation
Oak Ridge National Laboratory
Pacific Northwest National Laboral
Parsons
Pfizer
Philip Morris International
PPG
Praxair
Procter & Gamble
Rhodia
Roche Diagnostics
S.C. Johnson & Son
Sabic Americas
Sandia National Laboratory
Sasol North America
Sealed Air
Shell Chemicals
Sherwin-Williams
Solvay
Sunoco
Teledyne
Touchstone Research Laboratory

# Examples of Discussion Topics at ETN Meetings

- Interactions with:
  - Universities
  - Federal laboratories
  - Small companies
- Budgeting for external technology
- External technology needs lists
- Using Open Innovation intermediaries effectively
- Organizational structures

# A Typical ETN Meeting

- 20 - 40 representatives
- 1.5 or 2-day meetings
- Opening Roundtable:
  - Sharing of issues and hot topics
- Presentations / panel discussions by member companies:
  - *Examples:*
  - "Selection Criteria for University & National Lab Partners"
    - L Beltz (Weyerhaeuser), R Guschl (DuPont)
    - J Wenstrand (Agilent), T Boccanfuso (UIDP)
- Presentations by external parties:
  - *Example:*
  - Karina Edmonds, Technology Transfer Coordinator, US DOE
- Group dinner and gift exchange

# Benefits of Being a Member of ETN

- Excellent source of best practices
  - Especially for people new to an external technology role
- Excellent networking opportunities
  - Collaborative relationships

# For More Information…..

- Current ETN co-chairs:

Tom Mildenhall
Kimberly Clark
tmildnhl@kcc.com
770-587-8561

Linda Beltz
Weyerhaeuser
Linda.Beltz@weyerhaeuser.com
253-924-6638

Mike Cameron
Sherwin Williams
jmcameron@sherwin.com
216-515-4686

- Former co-chair:

Joe Fox
Ashland
jfox@ashland.com
614-790-3686

WORLDWIDE PARTNER

# Research Areas of Interest

Gretchen Baier, P.E., Ph.D.

June 11, 2013

baierg@dow.com

# The Dow Chemical Company

- FOUNDED BY HERBERT H. DOW
- HEADQUARTERS IN MICHIGAN
- LARGEST U.S. CHEMICAL COMPANY
- 52,000 EMPLOYEES WORLDWIDE
- MORE THAN 5,000 PRODUCTS
- 197 SITES IN 36 COUNTRIES
- CUSTOMERS IN >160 COUNTRIES
- SALES OF US$57 BILLION IN 2012

# Dow's Operating Segments

## Advanced Materials, $11.8B*

- Dow Electronic Materials
  - Semiconductor Tech
  - Interconnect Tech
  - Display Technologies
  - Growth Technologies
- Functional Materials
  - Dow Wolff Cellulosics
  - Dow Home & Personal Care
  - Dow Microbial Control
  - Dow Performance Additives
- *JV: Dow Corning Corporation*
- Dow Building & Construction
  - Dow Building Solutions
  - Dow Construction Chemicals
  - Dow Solar Solutions
- Dow Coating Materials
- Dow Water & Process Solutions
- Performance Monomers
- *JV: Dow Corning Corporation*

## Agricultural Sciences, $5.7B

- Dow AgroSciences
  - Agricultural Chemicals
  - Seeds, Traits & Oils

## Performance Materials, $14.6B*

- Amines
- Chlorinated Organics
  - SAFECHEM
- Dow Automotive Systems
- Dow Formulated Systems
- Dow Oil & Gas
- Dow Plastics Additives
- Epoxy
- Oxygenated Solvents
- Polyglycols, Surfactants & Fluids
- Polyurethanes
- *JV: BASF Dow HPPO B.V.*
- *JV: Saudi Acrylic Monomers Company LLC (SAMCO)*
- *JV: The SCG-DOW Group*

## Performance Plastics, $16.2B*

- Dow Performance Packaging
- Dow Elastomers
- Dow Electrical & Telecom
- Dow Hygiene & Medical
- *JV: EQUATE Petrochemical Company*
- *JV: Equipolymers*
- *JV: The Kuwait Olefins Company K.S.C.*
- *JV: The SCG-DOW Group*
- *JV: Univation Technologies, LLC*

## Feedstocks & Energy, $11.3B*

- Chlor-Alkali/Chlor-Vinyl
- Energy
- Ethylene Oxide/Ethylene Glycol
- Hydrocarbons
- *JV: EQUATE Petrochemical Company*
- *JV: MEGlobal*
- *JV: Compañia Mega. S.A.*
- *JV: The SCG-DOW Group*
- *JV: The Kuwait Olefins Company K.S.C*

**2011 Revenue**

WORLDWIDE PARTNER

http://www.dow.com/investors/dow-at-a-glance/index.htm

# Research & Development

| Product Research | Process Research | Application Development |
|---|---|---|
| Invent new molecules and materials | Invent new processes and catalyst technologies<br><br>Process Scale up | Understand customers' needs in current and emerging markets.<br><br>Develop new applications & markets for Dow products.<br><br>Drive customer intimacy |

**$1.7 B annual budget**

**5500 researchers, world-wide, mostly Ph.D.s**

DOW
WORLDWIDE PARTNER

# Dow and Federal Labs

- Many Long-Standing Relationships & Success Stories
  - Mostly User Agreements
    - Proprietary and non-proprietary
  - WFO, CRADA, grants, MSOF, Hubs, EFRCs…..
- Across many agencies
  - DOE, DOD, DOC, DOI, USDA…..
- Very much looking forward to more *collaborative* opportunities!

# Summary

## Strategic Areas

- Agricultural
- Functional Foods
- Ruminant Nutrition
- Electronics & Communications
- Packaging & Converting
- Alternative Energy & Feedstocks
- Energy Storage
- Energy Production & Efficiency
- Home & Personal Care
- Construction
- Paints & Coatings
- Transportation
- Water

## Long Term Technologies

- Solar
- Direct activation of alkanes
- Efficient catalysis
- High strength to weight ratio low cost materials and processes
- Non-halogen flame retardants
- Isocyanate free foams and adhesives
- Non-epiclhorohydrin routes to epoxy
- Other
  - Advanced low energy separations
  - Recovery of low waste heat

# Strategic Opportunities

## Agriculture

- Novel crop protection chemicals
- Elite plant genetics
- Biotechnology traits
- Enabling technologies

## Functional foods

- Healthy oils
- Quality traits

## Ruminant nutrition

## Electronics & communications

- Photoresists
- Interconnects
- Circuit boards
- Displays
- Lighting

## Packaging & Converting

- Packaging solutions
- Photovoltaic films
- Post-harvest freshness

# Strategic Areas (con't)

## Alternative energy and feedstocks

- Renewables and sustainable resources
- Wind energy

## Energy storage

- Batteries
- Heat transfer fluids
- Electrical and telecommunications

## Energy production and efficiency

- Insulation
- Photovoltaics
- Separation
- Carbon dioxide capture

# Strategic Opportunities (con't)

## Home & personal care

- o Cleaning
- o Biodegradable surfactants
- o Paper and publishing

## Construction

- o Green building materials
- o Smart windows
- o Adhesives
- o Construction chemicals

## Paints/coatings

- o Low VOC
- o Smart coatings

## Transportation

- o Lightweight materials and composites
- o Diesel particulate filters
- o Energy absorbing foams
- o Glass bonding

## Water

- o Purification by desalination
- o Filtration
- o Contaminant removal

# LONG TERM TECHNOLOGY AREAS

# Solar

- Low cost "nano-inverters" that could control maximum power point tracking and produce AC PV power for a 10-20W PV module using exclusively highly robust components (i.e., film capacitors instead of electrolytics) with a 30+ year life
- High power inverters with long lifetimes and reliability (>30 years)
- Earth abundant flexible PV cells with high efficiency (>20%) and very low cost (<0.10 / Wp)
- Any living organism that converts sunlight and CO2 into a useable feedstock (ethanol, n-alkanes, etc.) with a solar efficiency of 8% or greater. For example, 8% efficient EtOH would represent ~25,000 gal EtOH/acre·year
- Low cost (< $5/m2) robust film or coating to up- or down-convert light with high efficiency

# Solar (con't)

- Any way to break out of the Schockley limit for a single-junction PV cell
- Low cost polymers that are stable to sunlight, rain, heat (to 85C) for >30 years with a CLTE ≤ 10 ppm per degree C
- Low cost ultra-reliable thin-film PV cell (i.e., CIGS) interconnect technology that is stable for long times (>30 years) without any increase in contact resistance, cost <$0.03 / W
- Barrier films with high optical transparency and good barrier to H20 and O2 (WVTR $<10^{-4}$ g/m$^2$/day at 85C/85%RH)
- Any solar cell with >40% efficiency and < $1 / Wp
- <u>Low cost</u> technology to transfer epitaxially-grown GaAs thin films from a GaAs wafer, which is then reused many times (epitaxial lift-off without acres of HF)
- Low cost methods to efficiently cool PV modules

# Direct Activation of Alkanes to Products

- High carbon efficiency >90%
- Conversion >75% per pass
- This could include methane, ethane, propane, etc without having to put in the capital for crackers, purification, and subsequent reaction.

# Efficient Catalysis for Aryl C-C Bond Formation (cross-coupling)

- High Efficiency ligands for Pd catalyzed Aryl-Aryl coupling
- 100 – 1000x current efficiency (1-5 mol %)
- "Leave in" catalyst
- No Pd Aryl-Aryl coupling, e.g. oxidative cross-coupling

# Low Pressure Polyolefin Catalyst Capable of Incorporating Polar Monomers with Ethylene

- Key monomers to be incorporated: vinyl chloride and acrylate esters
- Order of magnitude reduction in pressure (from 40,000 psig)

# High Strength to Weight Ratio, Low Cost Materials and Processes

- Composite Materials compatible with epoxy / urethane thermosets
- Compatible with existing parts fabrication (RIM)
- Low cost, high modulus, high strength fibers

# Non-Halogen Flame Retardant Materials without Trade-off in Performance

- Intumescent materials
- Suppresses flame propagation in gas phase and solid state
- Focus on B,P,N and S heteroatoms
- Safe to environment and to human health
- Target 2x cost performance improvement over existing systems

# Isocyanate-Free Foams and Adhesives

- Benign to end users
- Compatible with di-functional polyols
- Similar mechanical properties to cured isocyanates

# Non-Epichlorohydrin Route to Liquid Epoxy Resins

- Controllable curing temperature (from 10°C to 200°C)
- Comparable strength, Tg and modulus to existing liquid epoxy resins
- Viscosity < 5000 mPa.s
- Cash cost competitive to conventional liquid epoxy resin routes
  - 35% Lower capital than existing processes

# General Areas

- Advanced low energy separations techniques
- Economical recovery of low waste heat
- Nitrogen fixation
- Oxygen transport at low temperature
- Hydrogen transport membranes capable of operating at high fluxes and high temperatures

# THANK YOU!

# WEYERHAEUSER

## A Unique International Forest Products Company


**Miles Drake**

*Chief Technology Officer and SVP Research*

**Linda Beltz**

*Director, Technology Partnerships*

# SUSTAINABLE SOLUTIONS AND PRODUCTS

**OUR VISION** → **SUPERIOR SUSTAINABLE SOLUTIONS FOR THE WORLD**

- **Timberlands** – Sustainable, scale production of timber & biomass
- **Wood Products** – Products for green building and energy efficiency
- **WRECO** – Regional builders providing products to meet the emerging trends in home building
- **Cellulose Fibers** – Sustainable products and materials serving global markets
- **Weyerhaeuser Solutions** – Bringing sustainable solutions to clients
- **Technology Services & Products** – Technology-based services & licenses
- **Catchlight Energy** – JV for liquid transportation fuels from forest feedstocks

Weyerhaeuser + Chevron = Catchlight Energy™ A Chevron | Weyerhaeuser Joint Venture

# OPPORTUNITIES – SEE OUR WEBSITE

## WEYERHAEUSER IS INTERESTED IN
## TECHNOLOGY COLLABORATION OPPORTUNITIES

### TIMBERLANDS

Forest safety

Forest & biomass management
- Precision forestry applications
- Fertilizer technologies
- Silviculture
- Remote sensing
- Breeding, evaluation & selection
- Biomass harvesting, production & logistics systems
- Biological process modeling
- Biometrics
- Impact of wildfire

Plant propagation
- Somatic embryogenesis
- Cryopreservation
- Bioreactors and culture control
- Automation and scale plant propagation
- Manufactured seed
- Forest and other biomass species germplasm
- Seedling stocktypes & nursery practices
- Forest and nursery pathology

Environmental sustainability & certification
- Watershed management
- Biodiversity
- Slope stability assessment
- Soil carbon & compaction
- Carbon dioxide soil flux sensing
- Life cycle analysis
- Carbon sequestration
- Hydrology

### WOOD PRODUCTS

Building technologies
- Improve structural connections & optimize structural integrity
- Reduce the energy consumptions of the residential home utilizing wood product solutions
- Green/benign chemicals for wood adhesives
- Methods to detect wood imperfections using optics, audio, x-ray or other methods at high rates of detection
- Fire retardant
- Insect resistant

Wood composites
- Structural
- Dimensional stability
- Emissions resistant
- Formaldehyde free

Engineered wood solutions

Adhesives development

Wood-chemical interactions

Hydration of harvested/dried/processed plant tissue

Design & use of wood framing in construction

Advancements in lumber & venner break-down, drying and grading

Non-destructive evaluation of structural wood components

Processes to improve wood performance in structural applications

### CELLULOSE FIBERS

Absorbent applications

Modifications of cellulose

Cellulose derivatives

High tech cellulose fibers

Nanocellulose

Lignin-based materials

Cementatious compounds

Composites applications
- Fiber reinforced
- Absorbent

Textile applications

Plastics from cellulose

Manufacturing effectiveness

Food packaging applications
- Liquid packaging board
- Coffee/noodle cups

http://www.weyerhaeuser.com/Company/Innovation/Collaboration

# DRIVERS FOR TECHNICAL INNOVATION

- **Supply chain cost reduction**
  - Seed to timber sustainable efficient precision landscape forestry
  - Pulp and paper processing
  - Lumber and engineered wood manufacturing technology
- **Some Market Drivers**
  - Affordable green building
  - Global demand for hygiene natural textiles
  - Secure, sustainable fuels for power and transport
  - Carbon and eco footprint reduction
  - Clean water

# WOOD PROCESSING

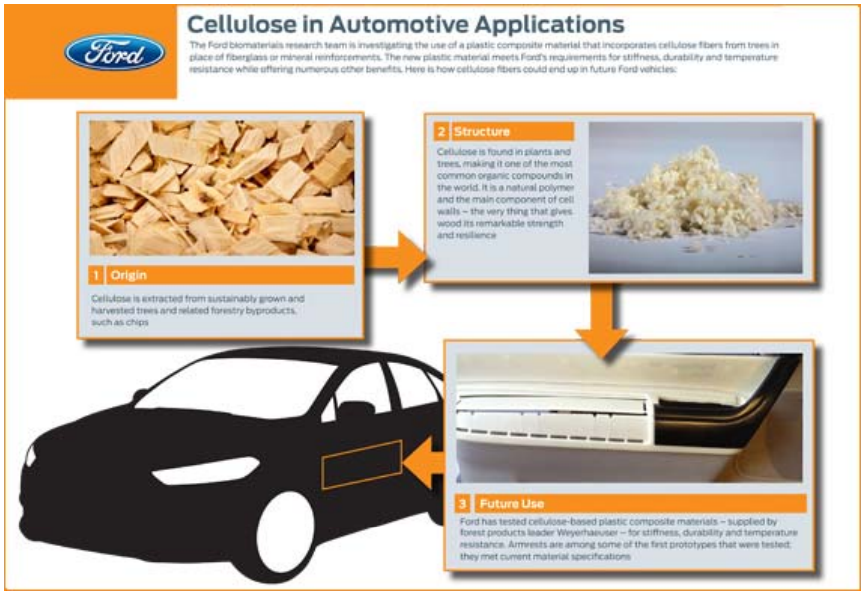
- **Low cost, high volume enhancements to wood based structural materials**
  - Improved performance against: fire, water, bugs , energy, ease of use
  - Cost reduction of wood adhesives for composite structures
- **High rate, industrially rugged non destructive evaluation of wood as trees, logs, lumber and chips.**
  - Strength, modulus, moisture
  - Internal structure and defects

# FORESTRY

- **Safe, low cost inventory of forest at landscape scale**
  - Timber volume, quality, location
  - Health of forests and stress
  - Local growth rate
- **Low cost seedlings in rugged conditions**
- **Measurement of carbon storage and fluxes in forest environments at scale**
  - Soil carbon, $CO_2$ flux

# CELLULOSE FIBERS

- **Modeling and characterization of natural material composites**
- **Modeling of multiphase slurries under high shear for mechanical effects**



# FOLLOW-UP SESSION

- **June 25, 1-3 pm EDT**
- **Sign up by June 21 with Michelle Chambers (mchambers@totaltechnology.net)**
- **Please specify your interest area**

# External Technology Needs List for Ashland Performance Materials

**Joe Fox**
**Director of Emerging & External Technologies**
**Ashland Performance Materials**

ETN / FLC Webinar
June 11, 2013

jfox@ashland.com
614-790-3686

ASHLAND®

# An Overview of Ashland Inc.

- A global, diversified specialty chemical company with $8B in sales
  - *No longer Ashland Oil!*
- Strengthened by the acquisition of Hercules in 2008 and International Specialty Products (ISP) in 2011

Consumer Markets

***Formulated Motor Oils***

Water Technologies

***Water Treatment Chemicals***

Specialty Ingredients

***Functional Additives***

Performance Materials

***Adhesives & Resins for Composites***

I represent Performance Materials
HQ = Dublin, OH

# Ashland Performance Materials (APM)

- **Primary market focus**
  - Transportation
  - Building & Construction
  - Packaging & Converting

**Resins for Composites**

- **Business-to-Business focus**

**High Performance Adhesives**

- **Major product lines**
  - Resins for composites
  - High performance adhesives
    - Structural adhesives
    - Pressure-sensitive adhesives
    - Flexible packaging adhesives

- **Products are based on thermoset resin chemistry**
  - Unsaturated polyesters, vinyl esters
  - Urethanes
  - Acrylics
  - Hybrids

# Needs to Be Discussed Today

| | | |
|---|---|---|
| 1. | Bio-based Chemical Building Blocks for Thermoset Resins | Composites & Adhesives |
| 2. | Thermoset Resins with Improved Fire Resistance | Composites |
| 3. | Thermoset Resins with Improved Weatherability | Composites |
| 4. | Composite Materials for Green Buildings | Composites |
| 5. | Recycling Technology for Thermoset Resins & Composites | Composites & Adhesives |
| 6. | Low Migration Coatings & Adhesives for Food Packaging | Adhesives |

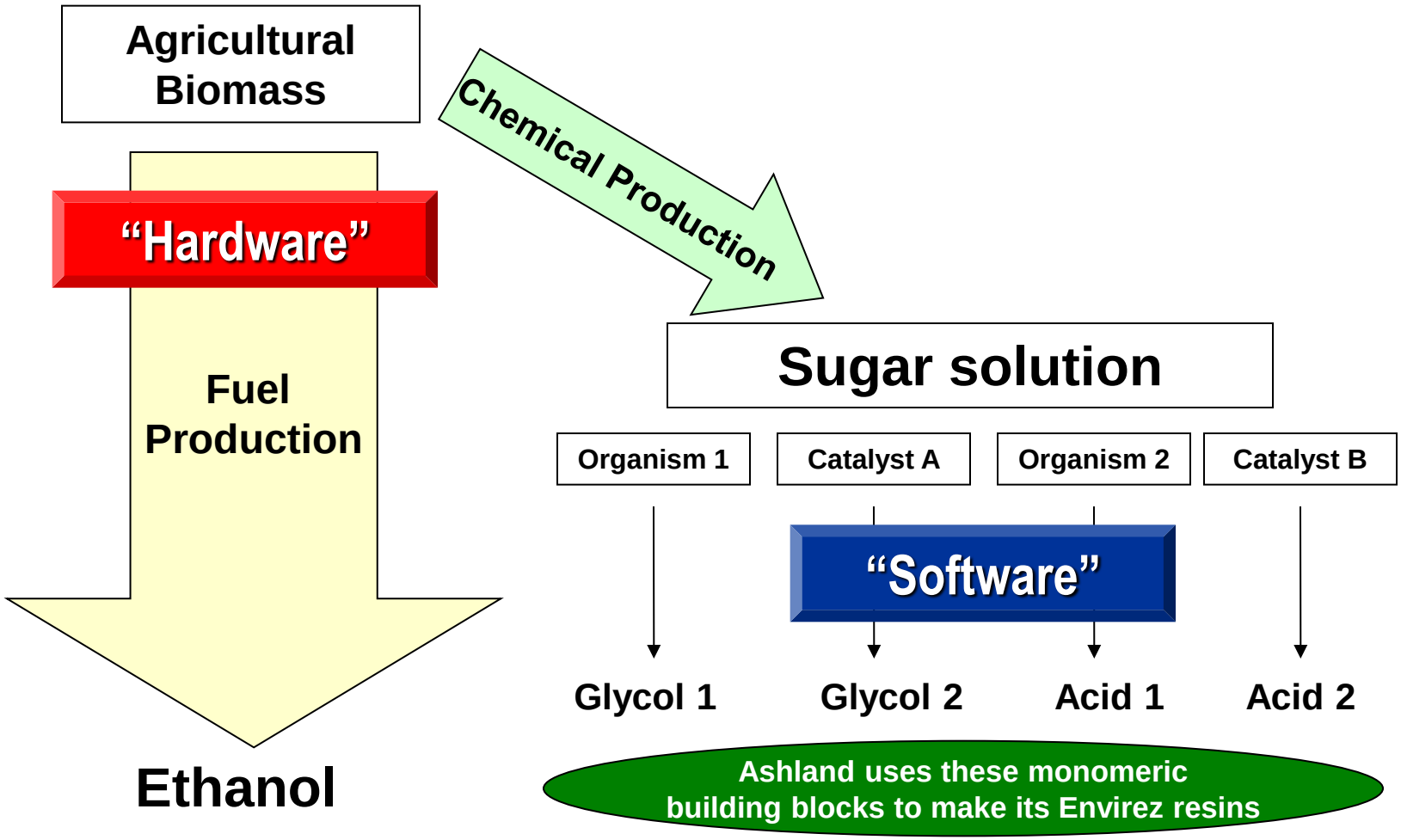
# Bio-Based Chemical Building Blocks for Thermoset Resins

- Motivation:
  - Lower cost, greater price stability, greater accessibility relative to petroleum-based raw materials
  - Pull from our customers for green, sustainable products

ENVIREZ®

- The Need:
  - Cost-effective sources of sugar for chemical production from biomass
  - Highly selective organisms or catalysts for the production of chemical building blocks

# Vision for Chemical Production at an Ethanol Biorefinery




- Ashland does not intend to build or operate a biorefinery, but we represent a strong downstream channel-to-market partner for bio-based chemicals.
- We look for partners that have the necessary "hardware" and/or "software".

# Chemical Production from a Biorefinery

- Specific chemicals Performance Materials is interested in:
  - Glycols:
    - Ethylene glycol (EG), Propylene glycol (PG)
  - Unsaturated di-acids
    - Fumaric acid, Itaconic acid
  - Acrylates
    - Butyl acrylate, 2-Ethylhexylacrylate
  - Aromatics
    - Isophthalic acid, Terephthalic acid
    - Replacements for Bis Phenol A

- Economics:
  - Bio-based chemicals must be cost competitive with their petroleum-based equivalents

- Technology gap:
  - Enzymes /organisms for selective conversion of biomass to these chemicals
    - Ashland does not have expertise in this area

# Thermoset Resins with Improved Fire Resistance

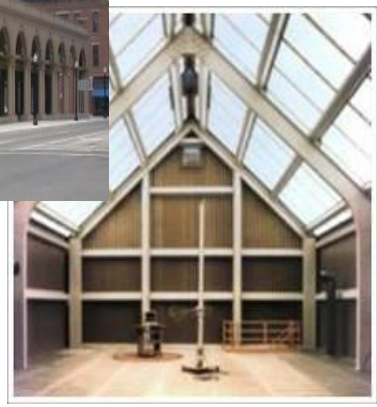
- Motivation:
  - Expand the use of thermoset composites in the transportation and building and construction industries

- The Need:
  - Thermosetting resins with:
    - Low flame spread
    - Low smoke generation
    - Low smoke toxicity
    - Processability suitable for composite fabrication
      - Infusion, pultrusion
    - Mechanical properties comparable to fiber-reinforced unsaturated polyester and vinyl ester composites

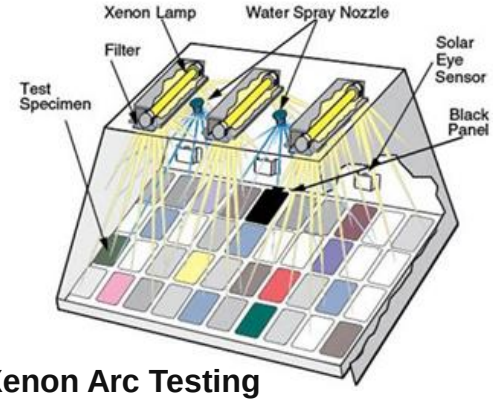
# Thermoset Resins with Improved Fire Resistance

- Resin Requirements:
  - Meet the requirements for mass transit, architectural and international maritime applications
  - Relevant tests include E84, E119, NFPA 285 and IMO specifications
- Types of Technology of Interest:
  - Unsaturated polyester, vinyl ester and phenolic resins with inherently better fire resistance
  - Additives that can be incorporated into liquid resin systems without large increases in viscosity
  - Halogen-free systems
- Types of Technology Not of Interest:
  - Thermoplastic resins
  - Post-cure solutions
    - eg., intumescent coatings

# Thermoset Resins with Improved Weatherability



- Motivation:
  - Expand the ability of thermoset composites to be used in outdoor applications
- The Need:
  - Resin systems with:
    - Greater resistance to uv
      - Non-yellowing, non-fading
      - Improved QUV, xenon arc performance
    - Greater resistance to moisture
      - Improved freeze thaw behavior
    - Stable interface with fibers and aggregate
- Additional Details:
  - Not interested in coatings that are applied post-cure




**Xenon Arc Testing**

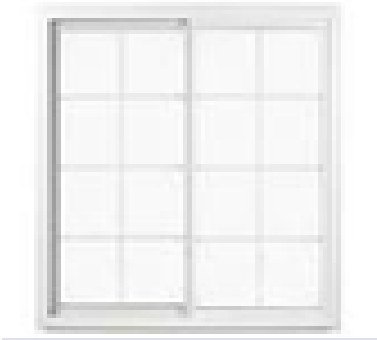
# Composite Materials for Green Buildings

- Motivation:
  - Take advantage of the benefits of composites to increase their utilization in the building & construction industry, especially in green buildings
    - Energy-efficient / insulating
    - Durable
    - Easy to install
    - Light weight
    - Corrosion-resistant
    - Attractive aesthetics

- The Need:
  - Prototypes for applications where composites can replace or enhance traditional materials of construction (concrete, steel, aluminum, wood….)

# Composite Materials for Green Buildings

- Types of Materials / Prototypes of Interest:
  - Hybrid materials
    - Wood + composites
    - Concrete + composites
    - Foam + composites
  - Composites with extremely high R values (low U values)
  - Low density composites
  - Composites with unique aesthetics



- Joining technology for dissimilar materials

# Recycling Technology for Thermoset Composites

- Motivation:
  - Provide resin and composite users who are concerned about the total life cycle of their products with viable options for recycling of thermosetting resins and thermoset composites.

The Waste Hierarchy

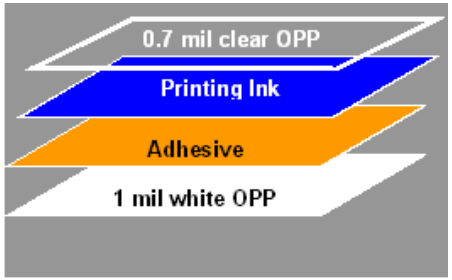
- The Need:
  - Economically-attractive technologies for the recycling and/or re-use of thermoset composites or thermoset resins

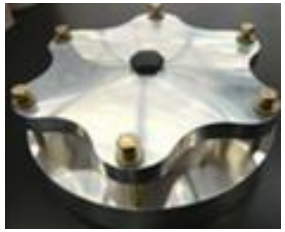
- Technologies of Interest:
  - Reversible thermosetting resins
  - Efficient dissolution / digestion processes
  - Novel or improved shredding / post-shredding technology

# Low Migration Adhesives & Coatings for Food Packaging

- Motivation:
  - More and more products are using flexible packaging
  - The expectations of brand owners for safe packaging materials are constantly increasing

- The Need:
  - Laminating adhesives and coatings (primers, overprint varnishes) comprised of thermosetting resins with a low propensity to migrate through the packaging films into the food.
    - Low residual monomer content
    - Fast curing laminating adhesives
    - Photoinitiator-free, solvent-free
  - Migration modeling software
  - High throughput, ultra low detection analytical methods for migration testing



# Follow-up Session with Ashland (Joe Fox)

- Thursday, June 27th  1:00 to 3:00 pm EDT

- To register for the session and to schedule a time slot, contact  Michelle Chambers by Thursday, June 20th.

  mchambers@totaltechnologyinc.net

- Indicate to Michelle
  - The technology need(s) you would like to discuss
  - How much time you think we will need to an initial discussion

# Monsanto Serves Farmers Around the World

## Working With Growers Large and Small, Row Crops and Vegetables

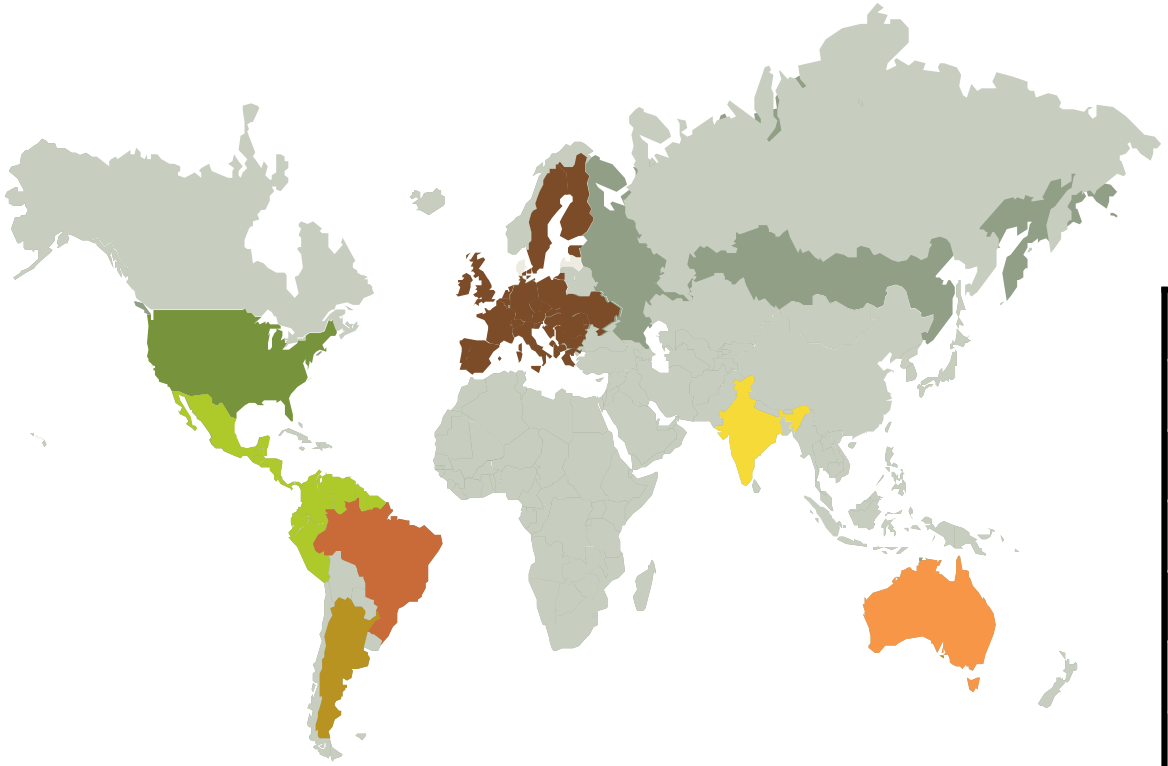
# Monsanto Technology Needs

June 11, 2013

David Russell, PhD
Director of Technology Prospecting

# Who We Are

## A Global Company: Diverse in People, Products, Geographies



***Primary Market Geographies***

- **United States**
- **Latin America North**
- **Brazil**
- **Argentina**
- **EU 27**
- **India**
- **Australia**

| | |
|---|---|
| Headquarters: | **St. Louis, MO** |
| Total employees: | **~21,000** |
| Global locations: | **>500** |
| Net Sales (FY12) | **$13.5 billion** |

**Corn** **Soybeans** **Cotton**

**Vegetables** **Roundup®**
**agricultural herbicides**

# Our Products and Innovation

## Providing Tools to Help Produce More, Conserve More, Improve Lives

### SEEDS & GENOMICS

- **Row Crops:** Corn, Soybeans, Cotton and Canola
- **Vegetables:** Open Field and Protected Culture
- **Major Brands:** DEKALB®, Asgrow®, Deltapine, Seminis® and De Ruiter®

### AG PRODUCTIVITY

- **Roundup® agricultural herbicides & Selective Chemistries**
- **Roundup Ready PLUS™ Platform**
- **Acceleron® Seed Treatment Products**
- **Lawn and Garden**

### TECHNOLOGY/R&D

- **Breeding**
- **Biotechnology**
- **Agronomic Solutions**
- **Industry-leading pipeline**

### OTHER PLATFORMS

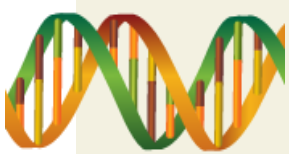
- **Crops:** Wheat, Sugarcane
- **Precision Agriculture**

# A Systems of Solutions for Sustainable Agriculture

**BREEDING**

Highest yielding genetics for target environment

**BIOTECHNOLOGY**



Complementary agronomic and yield-enhancing traits

**BIOLOGICALS**

Derived from natural materials to support plant health and pest protection

**CHEMISTRY**

Protecting the crop from pests, weeds and diseases

**AGRONOMICS**

Optimizing farm management practices

# Partner with Monsanto

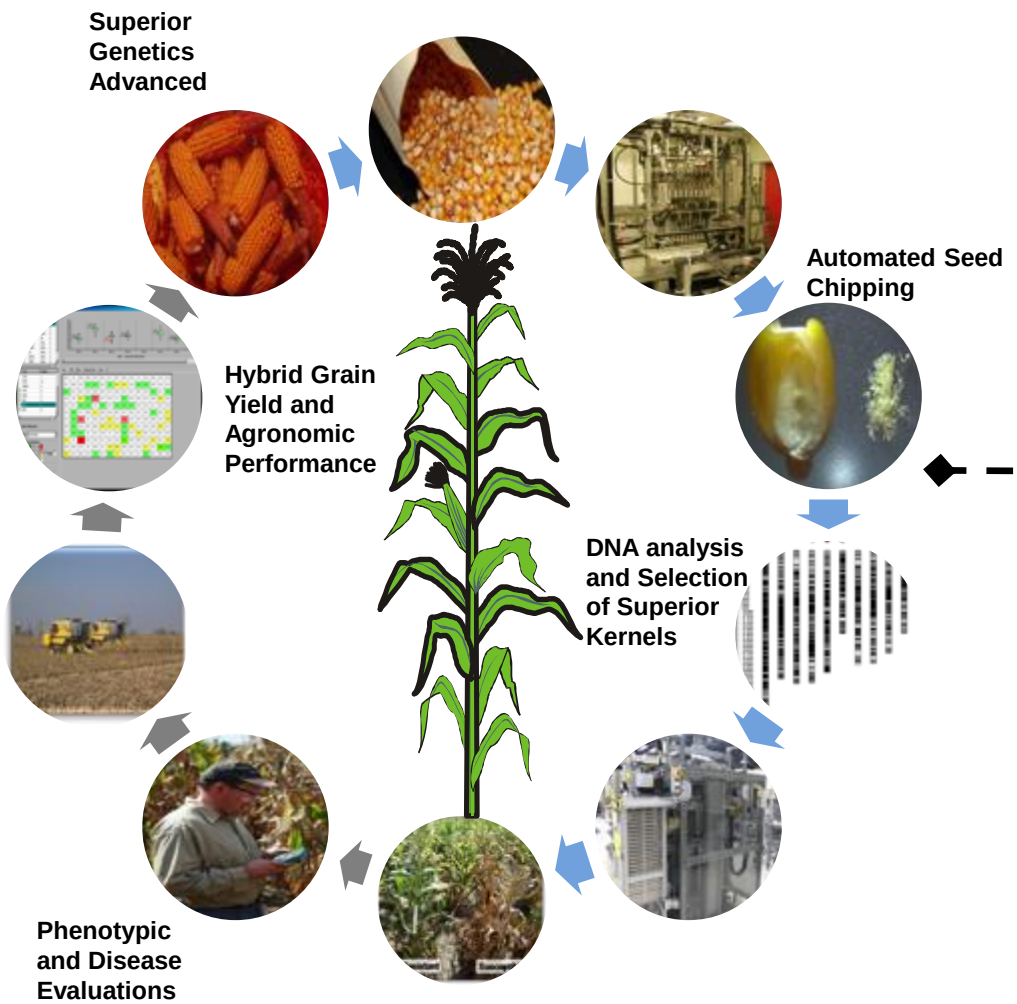
**We are seeking a wide variety of technologies. We can work together to have real and positive impact addressing the issues facing world agriculture**

| | |
|---|---|
| **Plant Biotechnology**<br>Novel traits & genetic methods for improved plant performance | **Plant Breeding**<br>Genotyping technologies, linking genotype to phenotype |
| **Protein and Nucleic Acid Technologies**<br>Methods for rapid and sensitive detection in lab & field. Technologies to manipulate nucleic acids & proteins. | **Precision Agriculture**<br>Advanced on-farm agronomic practices to improve yield and farming efficiency |
| **Computational Biology , Informatics, and Analytics**<br>*In-silico* approaches and predictive modeling. Leveraging Structured and Unstructured data to gain actionable insights into research & development data | **Imaging and Sensing**<br>Ranging from analysis of cells to whole field remote and in-field analysis to evaluate soil, hydrology and crop health to manage agricultural systems |
| **Automation**<br>technologies in lab, greenhouse, or field to improve efficiency and accuracy | **Ag Chemistry, Formulation & Biologics**<br>Seed or foliar treatments for plant health and protection |
| **Big Data Solutions**<br>Integrate genotypic, phenotypic, and other data on heterogeneous platforms enable analytics & insight generation | **Machine 2 Machine (M2M) Communications**<br>Capture and share data from diverse environmental and soil sensors, and communicate with various farm equipment, sensors and control systems |
| **Data Mobility & Rural Wireless Connectivity**<br>Wireless connection of people, equipment, and sensors to each other and wider data networks | **High Performance Computing**<br>Batch & Interactive computing to support massive data-intensive algorithms for sequencing, genomics, imaging |

*Feel free to contact David Russell to discuss your ideas. david.r.russell@monsanto.com*

# Breeding Technology Toolkit Enhances Next Level of Yield Gains

## SELECTION IN THE LAB COMPLEMENTS SELECTION IN THE FIELD

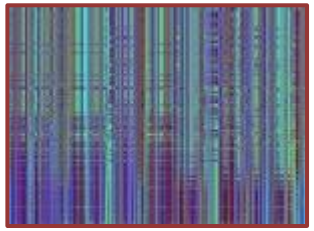



## DEPLOYING THE TECHNOLOGY TOOLKIT

### ❶ Analyze – Global Database of 10 Years of Mapping

- **High-resolution trait knowledge enhances phenotypic selection**
  - Over 40 million marker-trait associations
  - Derived from over 630,000 hybrids from more than 3,400 breeding pedigrees

### ❷ Select – High-Density SNPs and Seed Chipping



- **DNA selection identifies superior seeds based on genotype**
  - 100s of millions marker data points every year
  - 10s of millions of samples every year
  - Whole genome SNP knowledge
  - 75,000 SNP assays

### ❸ Introgress – Accelerate Breeding with DH

- **Doubled haploid (DH) inbreds enhance rate of genetic gain**
  - 2nd generation of DH-derived Commercial Products
  - All global breeding programs
  - Over 500,000 doubled haploid inbreds produced every year

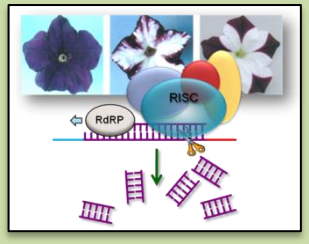
# Enabling Technology Platforms Drive the Biotech Pipeline

Gene Discovery → Transfor-mation → Gene Optimization → Trait Development → Trait Integration → Breeding → Stewardship

**Herbicide Tolerance** | **Insect Protection** | **Quality** | **Yield & Stress**

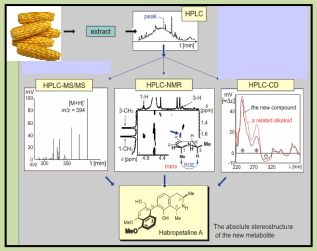
## Enabling Technologies

### RNAi Technology



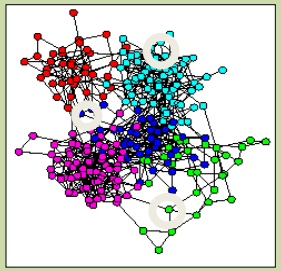

### Greenhouse Automation

### Metabolomics




### Automated Screening

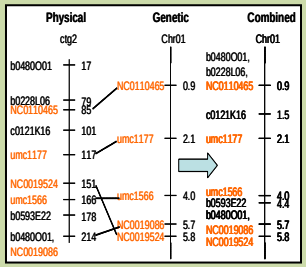
### Bioinformatics & Systems Biology



### Molecular Testing in Genotyping

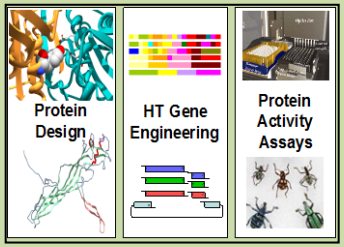
### Transformation Automation

### Genomics

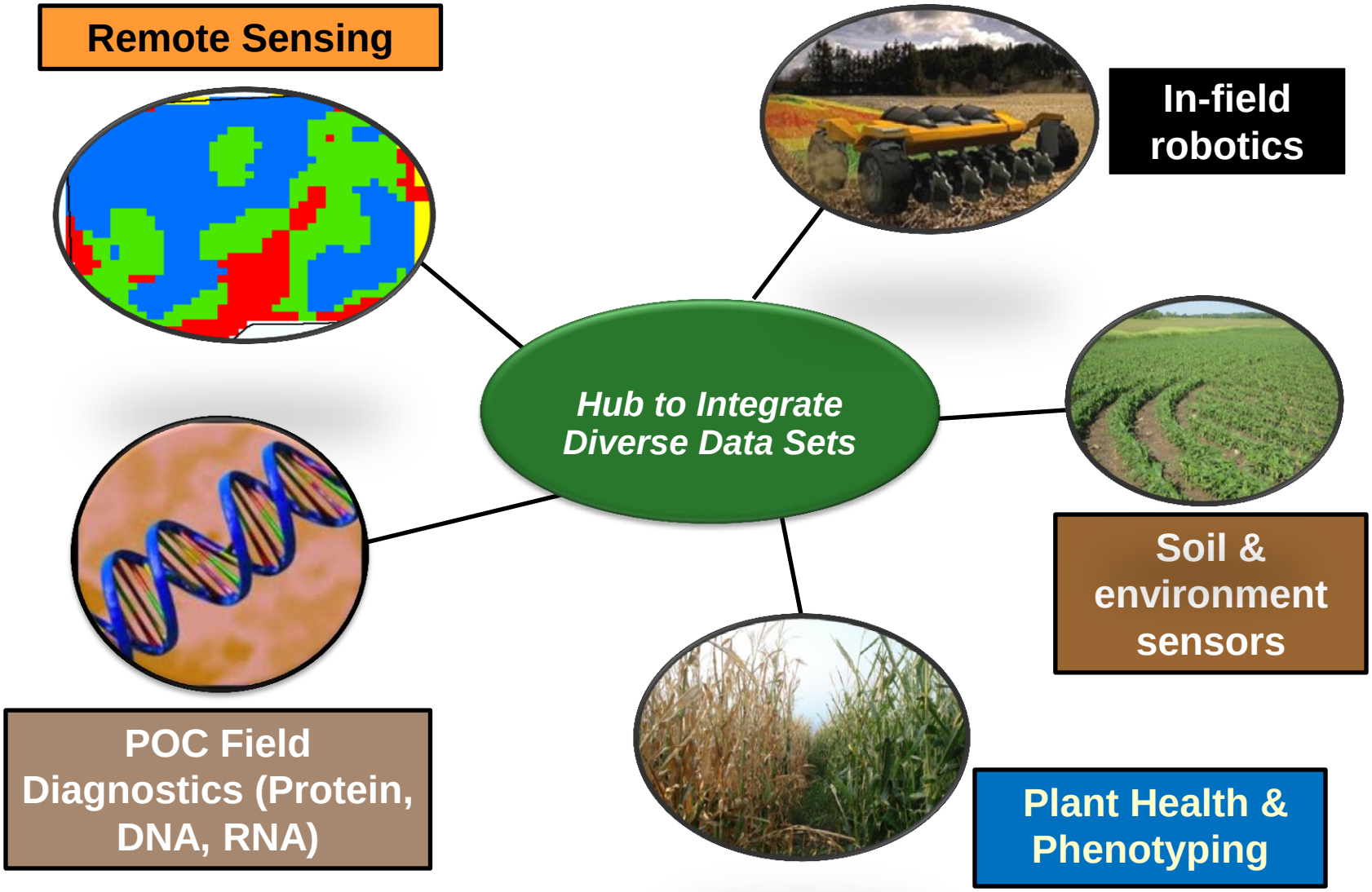



### Protein Science

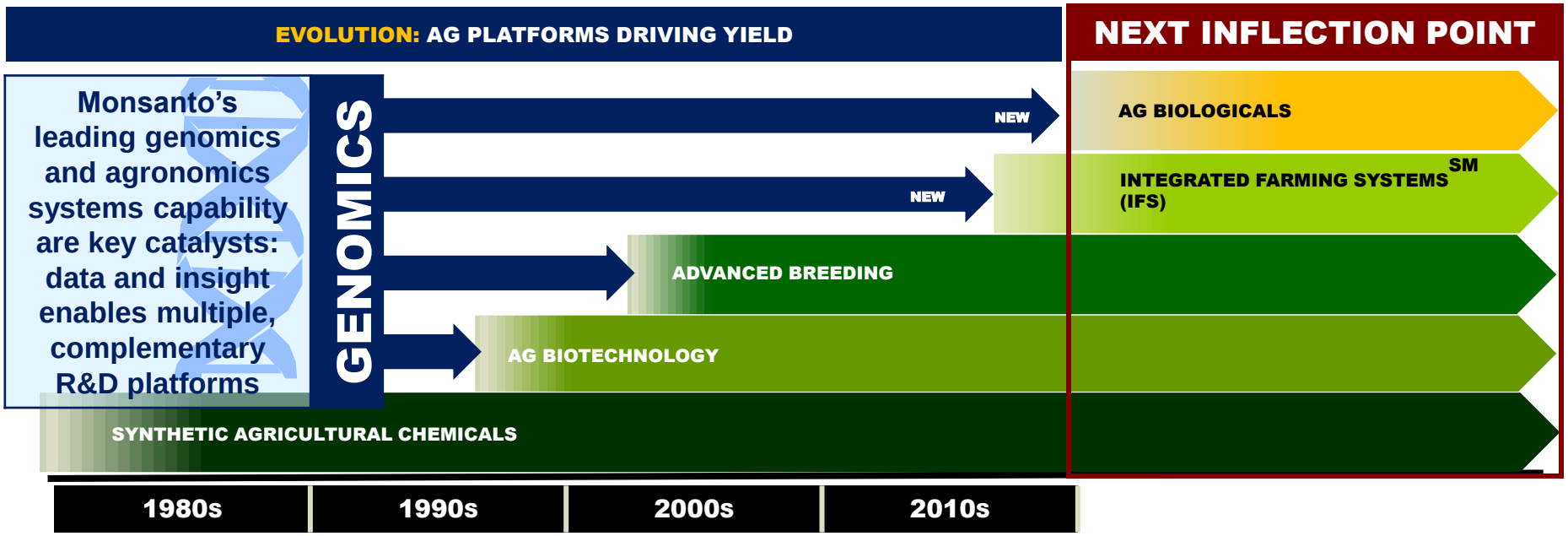
### Protein Optimization



# Many tools are needed to gather data and make decisions in the field



# Two New Platforms Are The Next Step In Evolution Of Technologies For Solving Farmers' Challenges



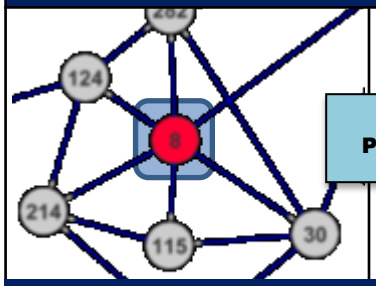

**BRINGING GENOMICS TO THE FIELD WITH INTEGRATED FARMING SYSTEMS SM AND AGRICULTURAL BIOLOGICALS**

# A New Class Of Agricultural Biologicals With The Potential to Deliver Effective Plant and Beneficial Species Protection

## MONSANTO's AG BIOLOGICALS PLATFORM
## FOCUS AREAS

- BioDirect™ TECHNOLOGY
  - TOPICALLY-APPLIED PRODUCTS
    - WEED MANAGEMENT
    - INSECT MANAGEMENT
    - VIRUS CONTROL
    - BEE HEALTH
- MICROBIALS TECHNOLOGY
  - SEED TREATMENTS
    - INSECT MANAGEMENT
    - VIRUS CONTROL

| GENOMICS-ENABLED DESIGN | SPECIFIC, EFFECTIVE CONTROL USING TOPICAL SPRAYS OR SEED TREATMENTS |
|---|---|

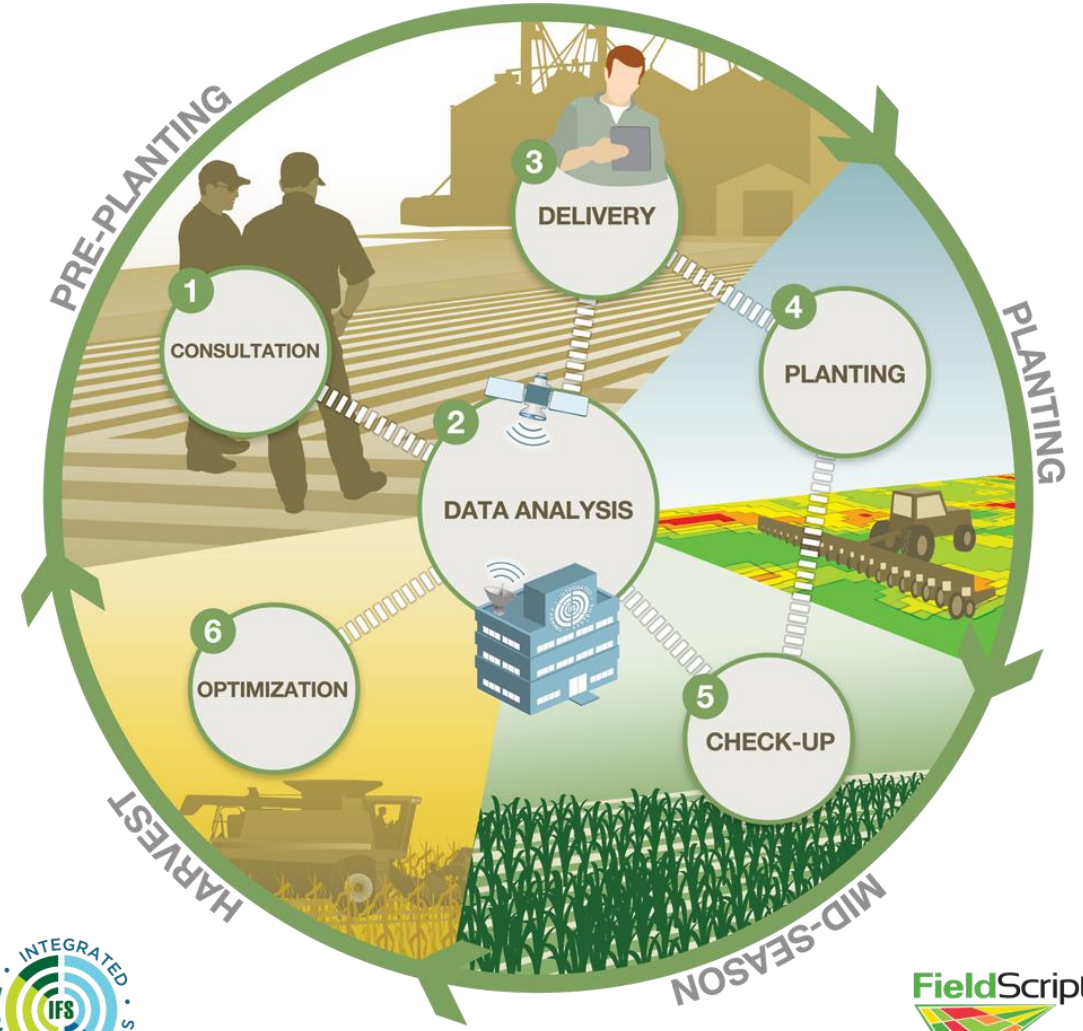



PRODUCT DEVELOPMENT

Precision in design and targeting of products would lead to effective, specific control of a pest (plant, insect or virus).

# Integrated Farming Solutions FieldScripts℠

## Will Combine Grower Knowledge With Massive Data




Getting more productivity from every seed requires an integrated approach. Integrated Farming Systems℠ is designed to **maximize the potential of every seed in every acre of a farmer's unique field conditions**.

# Follow-up Session with Monsanto (Dave Russell & Prospecting Team)

Wednesday June 26, 2:00 to 4:00 pm EDT

To register for the session and schedule a time slot, contact Michelle Chambers by Thursday June 20.
mchambers@totaltechnologyinc.net

# Forward-Looking Statements

*Certain statements contained in this presentation are "forward-looking statements," such as statements concerning the company's anticipated financial results, current and future product performance, regulatory approvals, business and financial plans and other non-historical facts. These statements are based on current expectations and currently available information. However, since these statements are based on factors that involve risks and uncertainties, the company's actual performance and results may differ materially from those described or implied by such forward-looking statements. Factors that could cause or contribute to such differences include, among others: continued competition in seeds, traits and agricultural chemicals; the company's exposure to various contingencies, including those related to intellectual property protection, regulatory compliance and the speed with which approvals are received, and public acceptance of biotechnology products; the success of the company's research and development activities; the outcomes of major lawsuits and the previously announced SEC investigation; the previously reported material weakness in our internal controls over financial reporting; developments related to foreign currencies and economies; successful operation of recent acquisitions; fluctuations in commodity prices; compliance with regulations affecting our manufacturing; the accuracy of the company's estimates related to distribution inventory levels; the company's ability to fund its short-term financing needs and to obtain payment for the products that it sells; the effect of weather conditions, natural disasters and accidents on the agriculture business or the company's facilities; and other risks and factors detailed in the company's most recent periodic report to the SEC. Undue reliance should not be placed on these forward-looking statements, which are current only as of the date of this presentation. The company disclaims any current intention or obligation to update any forward-looking statements or any of the factors that may affect actual results.*

***Individual results may vary**, and performance may vary from location to location and from year to year. This result may not be an indicator of results you may obtain as local growing, soil and weather conditions may vary. Growers should evaluate data from multiple locations and years whenever possible.*

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# The Goodyear Tire & Rubber Company

## Technology Challenges

## Federal Labs Consortium Webinar

*Derek Shuttleworth PhD*
*External Science & Technology Program Manager*
*dshuttleworth@goodyear.com*
*Tel: 330.796.3021*

*June 2013*

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# About Goodyear

- ***One of the world's most recognized brands***
- ***Manufacture and market tires for most types of vehicles***
- The world's largest operator of commercial truck service & tire retreading centers
- Operate more than 1,800 tire and auto service center outlets
- ***Manufacture products in more than 53 facilities in 22 countries***
  - Global and North American Tire HQ in Akron, Ohio
- ***More than 73,000 associates around the world***
  - 27,000 in the US (16,000 jobs are manufacturing related)

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# Diverse Product Offering

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# Consumer Tire Attributes

Quiet

Safety

Treadwear

Fuel Economy

Wet & Dry
Traction

Cost/Value
Proposition

Snow & Ice
Traction

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# Technology Direction for Tires

Light Weight Low RR Tire
- Manufacturing processes to enable thinner gauges at high yield
- Advanced materials
- Energy efficiency

Tire Noise, Vibration and Handling
- Improve noise/vibration characteristics
- Maintain noise/vibration characteristics over tire life
- Tire uniformity (manufactured at high yield)

Intelligent Tire
- Intelligence, Sensors, Telematics, Condition monitoring

Longevity
- Traction: dry, ice, snow, wet-handling, wet-braking, aquaplaning
- Worn tire performance, ROF
- Environmental burden: re-use and recycling

Flexibility
- Meet proliferation of vehicles
- Flexible manufacturing w/o complexity
- Predictive model performance of tire/vehicle as a system

Energy-Efficient Manufacturing
- New manufacturing processes
- Process modeling

**"Green" will be permanent global theme for Tire Industry**

# Domains of Change: Future Tire Technology & Business

- Nanotechnology
- Sensors – intelligent systems
- Smart materials
- Natural materials (Green)
- Manufacturing flexibility
- Exponential Growth in IT

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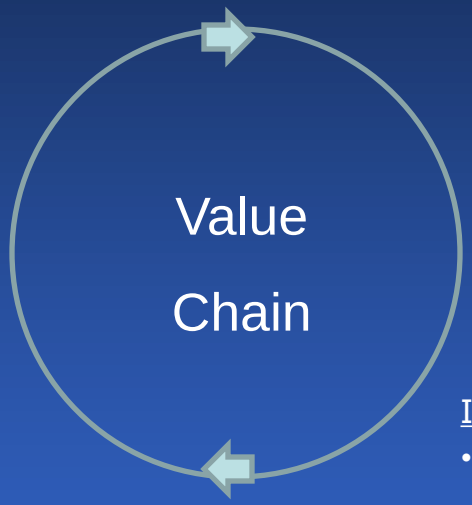
# Enterprise Challenges

Tire Manufacturing
- Core Process
- **Plant operations -** energy efficiency
- Manufacturing **complexity** (SKU proliferation)
- **Manufacturing Modeling**

Procure Raw Materials Globally
- **Forecast**
- **Future Materials**

Product Offering
- Product Performance
- Product System
- **Service**

Tire Sales Forecasting
- Access to dealer's recent tire sales data?
  - Tires sold through 3rd party dealers
- **Forecast consumer and commercial tire sales**
  - By tire type/size and zip code?
- **Commercial tires forecast**
  - Owner-operators
  - Fleets
- Climate effects?




Distribution/Delivery
- **Logistics** (national & international)
- Channel
- Brand
- **Customer Experience**

Finance
- Business Model
- Networking

Informatics
- **Value from big data**
  - Internally
  - Externally
- Telematics
- **Fleet services**
- **Consumer services**

**Integration across functions and borders**

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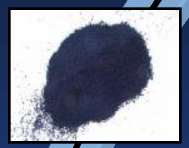
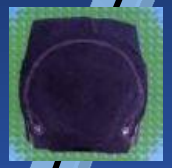
# MegaTrend #7: Unlikely to experience game-changers….evolutionary, not revolutionary

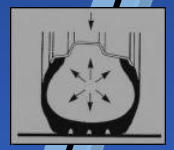
1904
Carbon black discovered as rubber reinforcement

1903
Bias-ply tires





1846
Tomas Hancock produces the first solid rubber tire



1845
Robert Thomson invents the pneumatic tire

1839
Charles Goodyear discovers vulcanization

1913
Radial ply tire patented by Christian Hamilton

1926
Drop-center, one piece rim adopted as standard equipment for automobiles

1937
First low profile tire

1947
Tubeless tires

1948
The steel belted tire

1966
First low profile for high performance tires

1979
Mini-spare

1986
Goodyear introduces the first HP All season tire

1992
Goodyear introduces the Run-on-Flat

2007
Run-on-Flat Standard Equipment at BMW

**Evolutionary Pace of Technology Change Makes Investment Returns More Predictable**

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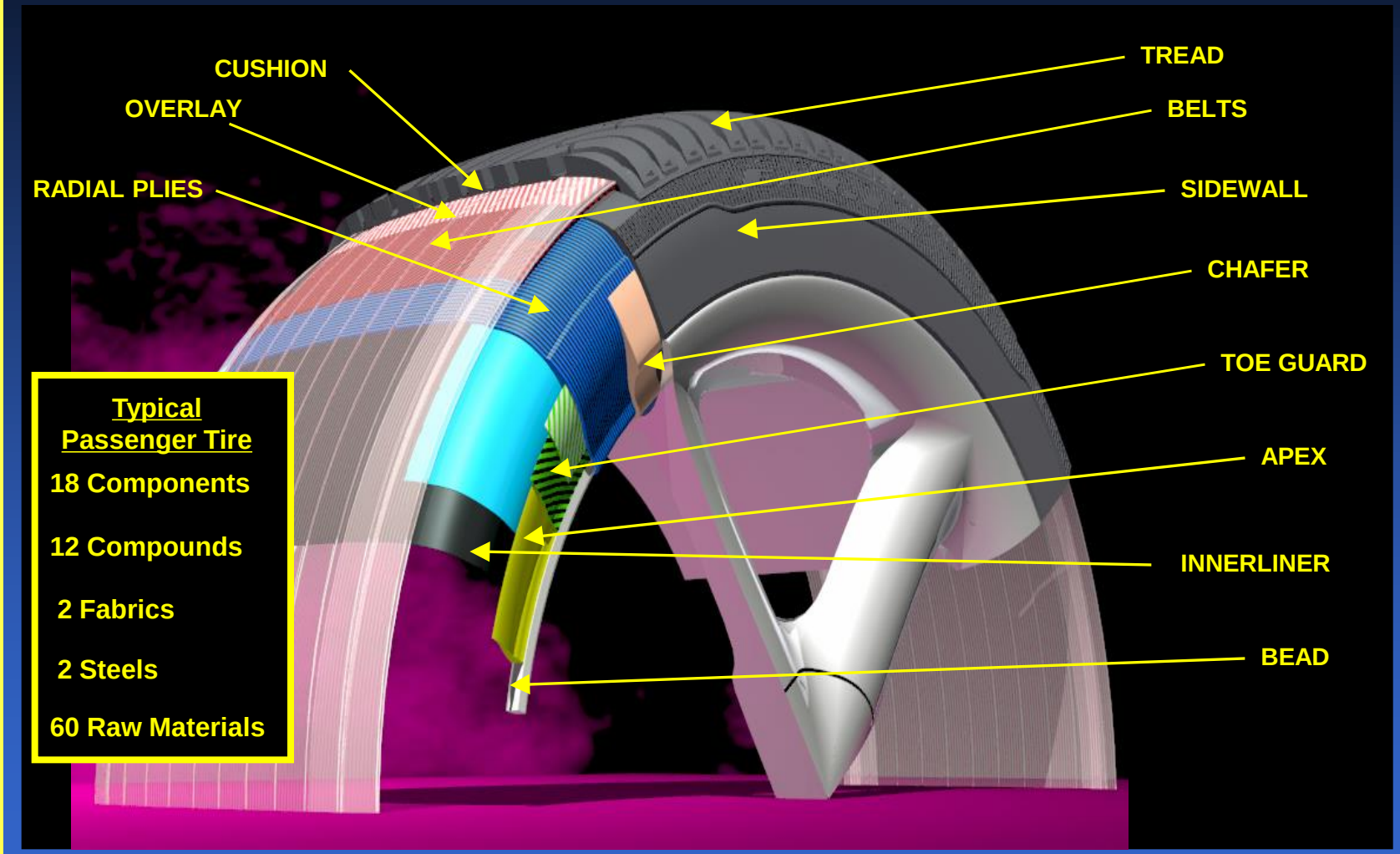
# Tire is a Complex, Highly Engineered, Reinforced Rubber Composite




**Typical Passenger Tire**

18 Components

12 Compounds

2 Fabrics

2 Steels

60 Raw Materials

**~ 45 Million Cycles During an 60,000 Miles Tire Life**

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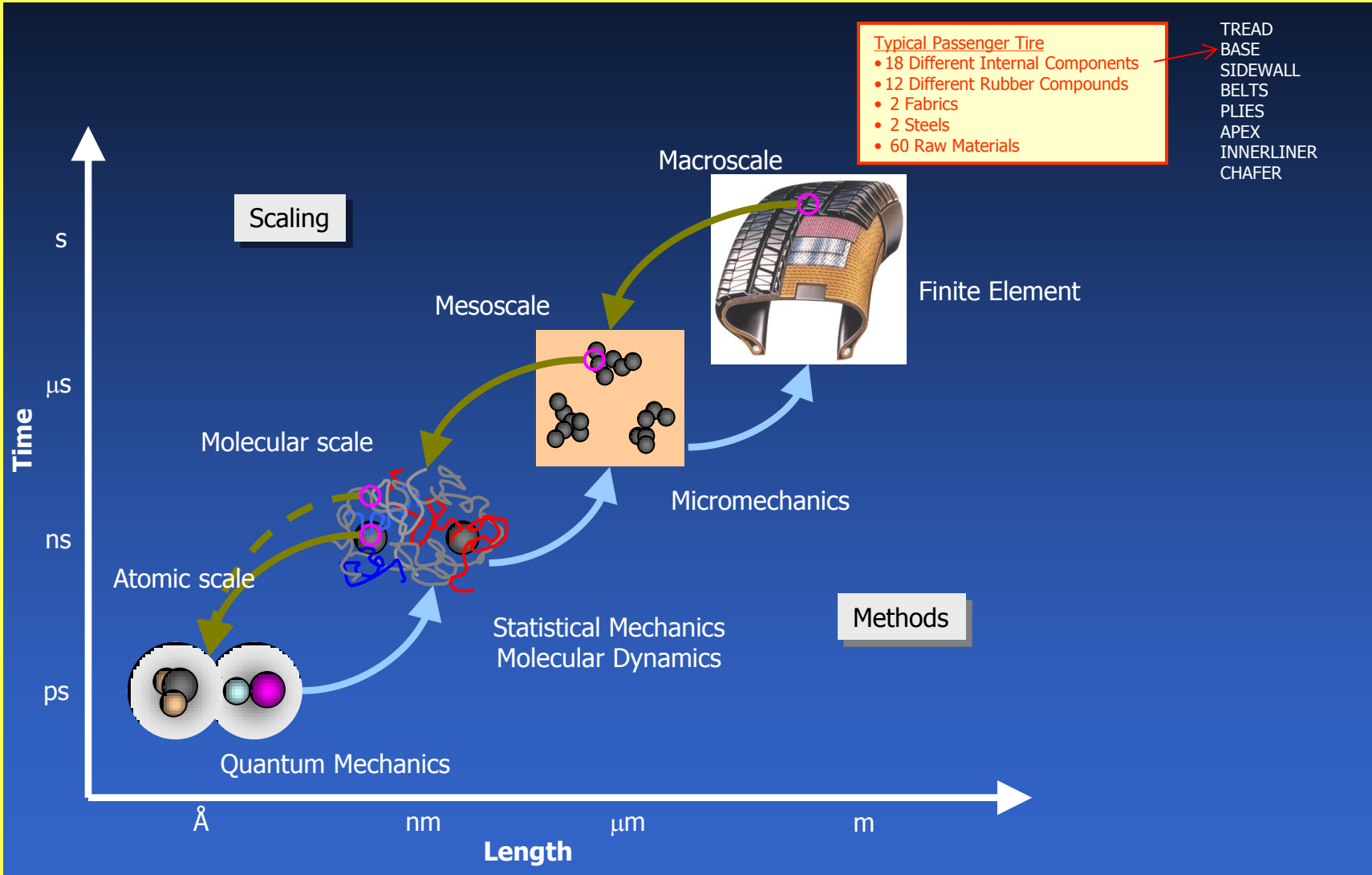
# Tire as a Complex Multi-Scale Rubber Composite




**Interfaces within interfaces within interfaces….**

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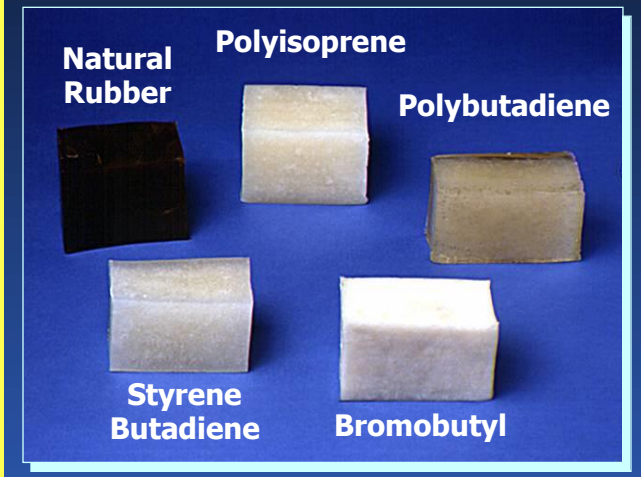
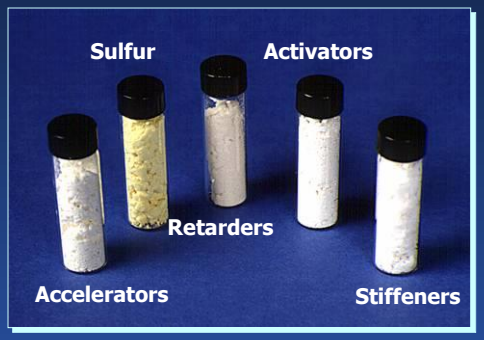
# Raw Materials




Polymers

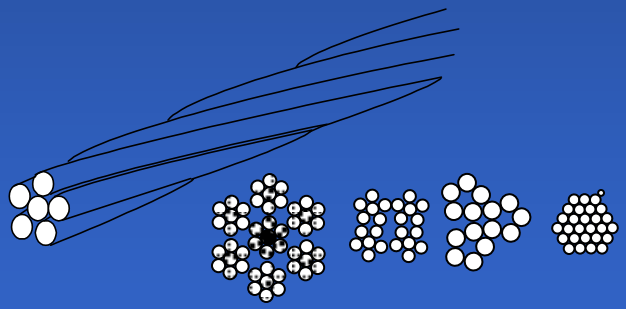
Fillers




Curatives

Processing Aids

Fabric Cords



Steel Cords

Reinforcements

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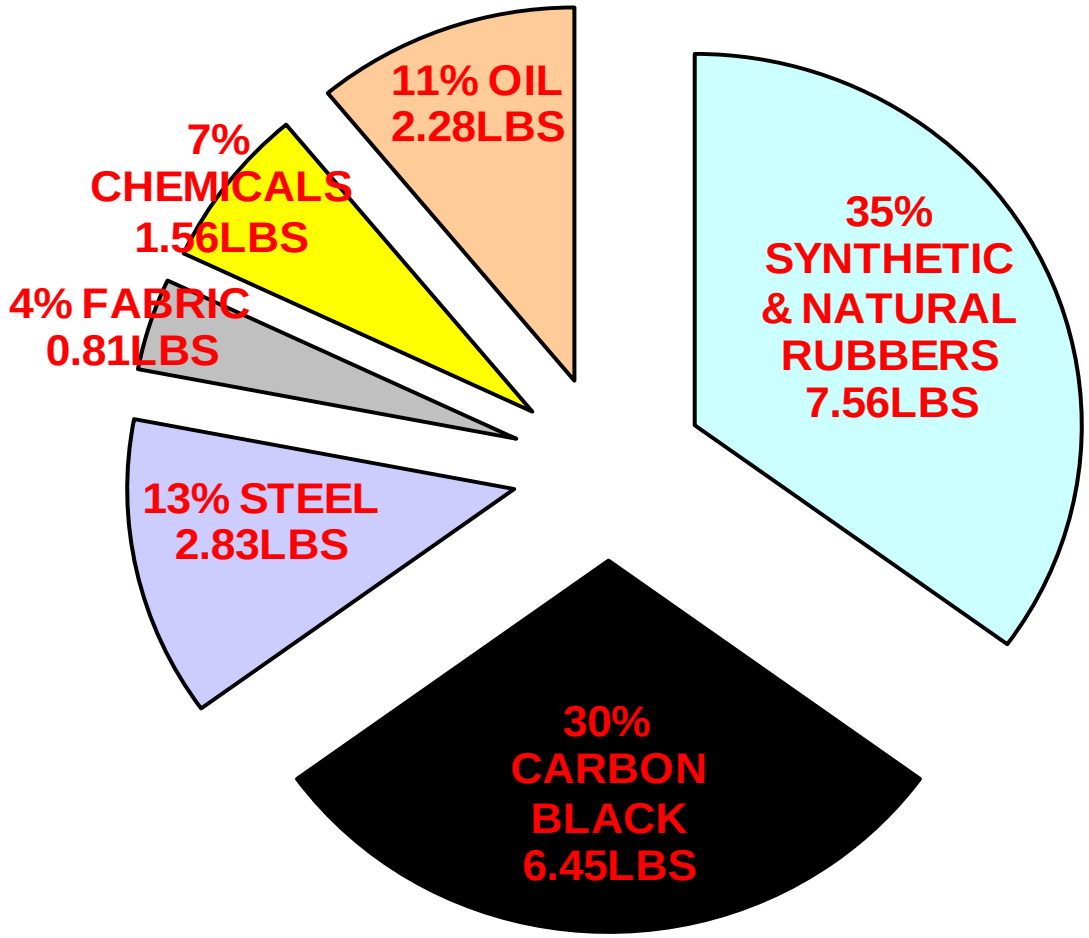
# Composition - Materials




**Over 70% petroleum derived**

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# Rubber Compounds

- **Multi-scale particle-reinforced rubber composite**
- **Potent combination of many reactive chemistries:**
  - Unsaturated, dynamic polymer chains, well above $T_g$ at service temperature
  - Amines, thiazoles, thiurams
  - Sulfur (ides)
  - Oxygen (ides)
- Physical and chemical structure is unclear
- **Constantly evolve during manufacturing and in service:**
  - Physical chemistry processes ongoing (diffusion, kinetics, phase structure ..)
  - Cross-linking reaction never stops
  - Thermal and oxidative degradation
  - Mechanochemical reactions
  - Physical structure changed by deformation and deformation-history
- **Complex rheology:** Non-Newtonian, extremely high viscosity, highly-elastic fluid
  - Generates its own temperature during processing
- **Complex mechanical behavior after curing:** Strong Non-Linear Viscoelastic behavior
  - Generates its own temperature in service

**Rubber Compound Formulation is the result of many decades of evolution**

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# Technology Challenges of Tire Materials

1. **New technology (novel polymers, novel fillers, novel polymer-filler interface)** to break traditional property/performance trade-off (rolling resistance, treadwear and traction)
2. **Novel reinforcement fillers with tailored morphology or surface chemistry** for mechanical, electrical and thermal property enhancement
3. **Nano-fillers** for more efficient reinforcement
4. **Alternative sources of natural rubber:** novel materials exhibiting natural rubber properties
5. ***Responsive materials:*** *temperature, water, mechanical*
6. **Non-petroleum** based (bio-based) monomers for sustainability
7. **Thermoplastic materials** for longevity and value
8. ***Tire Liner****: materials with superior oxygen barrier properties*
9. ***Novel cross-linking chemistries:*** *reversible cross-linking for reusable rubber*
10. **New Tire Cord materials:** light weight with high stiffness; new non-formaldehyde / resorcinol adhesives for rubber cord
11. ***Adhesives for Cured Tires:*** *adhering articles or devices post manufacture to the interior or exterior of a tire present unique challenges for longevity and dynamic loading*

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# Interfacial Science for Better Rubber Composites

- **Context:** Rubber matrix with silica and carbon black particles. Multi-disciplinary approach – chemistry AND physics/engineering
- **Gaps:**
- **Characterization of the dispersion and shape/size of particles within the matrix:** 3-D particle size distribution as well as their special distribution in a statistically-meaningful volume of composite.
- **Characterization of the interphase between particles and rubber matrix:** size of the interphase around particles and viscoelastic properties (both hysteresis and modulus) of the interphase. Volume-fraction of interphase and particles within the composite.
- **Quantification of elastomer chain mobility at interface with filler particles**
- **Quantification of the surface region of a rubber composite** (mechanical properties (hysteresis and modulus vs depth from the surface). Frictional deformation in the presence of air induced changes in the physical characteristics of the surface region (softening due to mechanical and chemical changes)
- **Interfacial technology for tire tread surface temperature in the contact patch during braking/accelerating**
- **Tribology of the tire-road interface as a system**
- Mechanism of dry and lubricated friction between rubber and "road"
- Predictive relationships between the structure of the vulcanized rubber composite and its physical response (global hysteresis, modulus, strength, friction)

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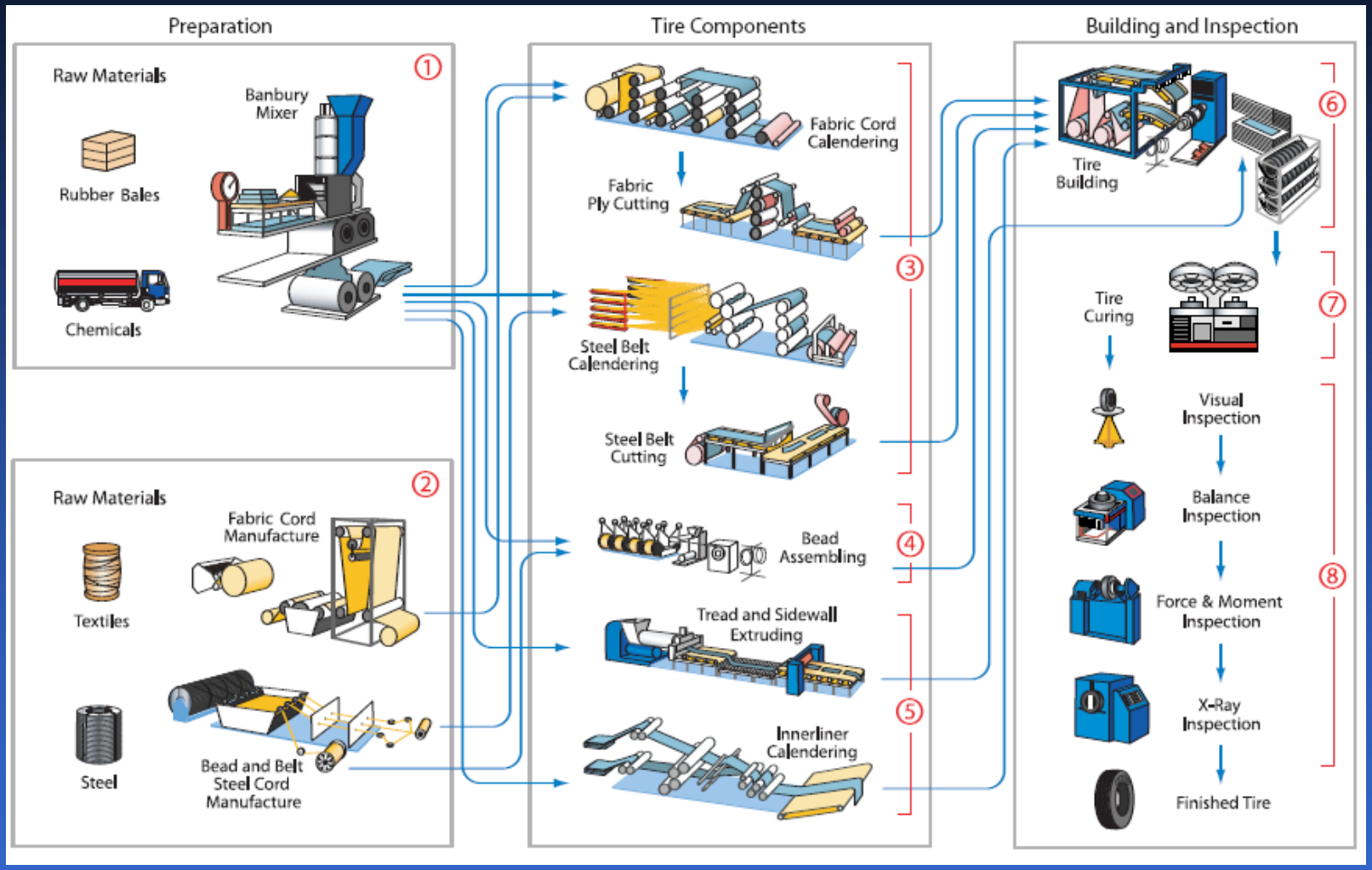
# Traditional Tire Manufacturing




**Component Prep meant for continuous operation for mass production of only a few types of tires but future business targets small volume, high-value added tires: proliferation of complicated SKU's**

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# Technology Challenges for Tire Manufacturing

- **Sensing techniques** to accurately determine the on-line Chemical Composition of a rubber composite in a factory environment, including minor components (e.g. vulcanizing chemicals - sulfur, sulfenemides), state of cross-linking and density. The composite is moving at 100 ft/minute (e.g. an extruded tread).
- **Processability of unvulcanized rubber composites** (mixability, extrudability, viscoelasticity); Structure-processability-relationships. Chemical effects, desired particle size distribution
- **Tire curing process optimization –** energy efficiency
- **Reduce number of mixing stages** for fuel-efficient treads
- **SKU proliferation –** complexity
- **Tire Manufacturing and tire materials processing modeling/simulation**
- ***New approach to tire manufacturing?***

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# Business Model Innovation

- Identify opportunities for future **growth** in **tires and adjacencies**
- **White-space opportunities**
  - Future Tire Designs: Non-pneumatic tires; AMT solutions
  - Intelligent Tire

    Tire traction, temperature and strain sensors

    Stretchable Electronics

    Active devices: stiffness, traction & handling control, noise cancellation

    Self- diagnostic/self-healing
- **Service Transformation:**
  - Technological developments enabling to add innovative services
  - Stability of revenues – services vs products
  - Lock in customers/lock out competitors
  - Increased level of differentiation
  - Customers demand it

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# Creating a New Environment of Innovation

- Goodyear challenges are drawn from business needs, product needs and manufacturing needs
- Heavily dependent on materials science and based on fundamental understanding of physics, chemistry and mechanics
- Opportunities also in the areas of composite science, electronics, Big Data and more…

***Decades of Innovation brought us here,***

***Open Innovation will take us there!***

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# FOLLOW-UP SESSIONS

- DOW 6/18 1:00 – 3:00 EDT GRETCHEN BAIER
- WEYERHAUSER 6/25 1:00 – 3:00 EDT M.DRAKE/L. BELTZ
- ASHLAND 6/27 1:00 – 3:00 EDT JOE FOX
- MONSANTO 6/26 2:00 – 4:00 EDT DAVE RUSSELL
- GOODYEAR 6/19 1:00 –3:00 EDT DEREK SHUTTLEWORTH
- To reserve a time slot please contact Michelle Chambers
  - mchambers@totaltechnologyinc.net
  - Please indicate the technology needs you would like to discuss and the amount of time needed for an initial discussion

# WRAP-UP

- Send any additional questions regarding the presentations to Michelle Chambers
- Please answer the survey
- To reserve a timeslot for the June 18 or 19 sessions send your request to Michelle by June 14
- To reserve a timeslot for any of the June 25-27 sessions send your request to Michelle by June 20
- Thank you for participating