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Transforming Lignin into Biocompatible Aliphatic Acids via Oxidative Dearomatization using a Polyoxometalate Catalyst

Background/Objective

- Lignin valorization is hindered by the difficulty of breaking stable aromatic rings into useful aliphatic products.
- Use a polyoxometalate catalyst for oxidative dearomatization of lignin into biocompatible organic acids.

Approach

- Employed a cholinium phosphotungstate catalyst in an aqueous system.
- Optimized reaction conditions (temperature, pressure, time) to maximize the yields of biocompatible organic acids (C1-C3 aliphatic acids).

Results

- Achieved >400 mg and upto 1200 mg of aliphatic acids directly from biorefinery lignin streams and untreated biomass, respectively.
- The resulting acid stream supported 95% growth of engineered microbial strains compared to pure glucose controls.

Significance/Impacts

- Supports the BER mission by developing chemical pathways to convert complex biomass into upgradable intermediates.
- Advances JBEI goals by enabling a robust bioeconomy where lignin waste is transformed into bioproducts.

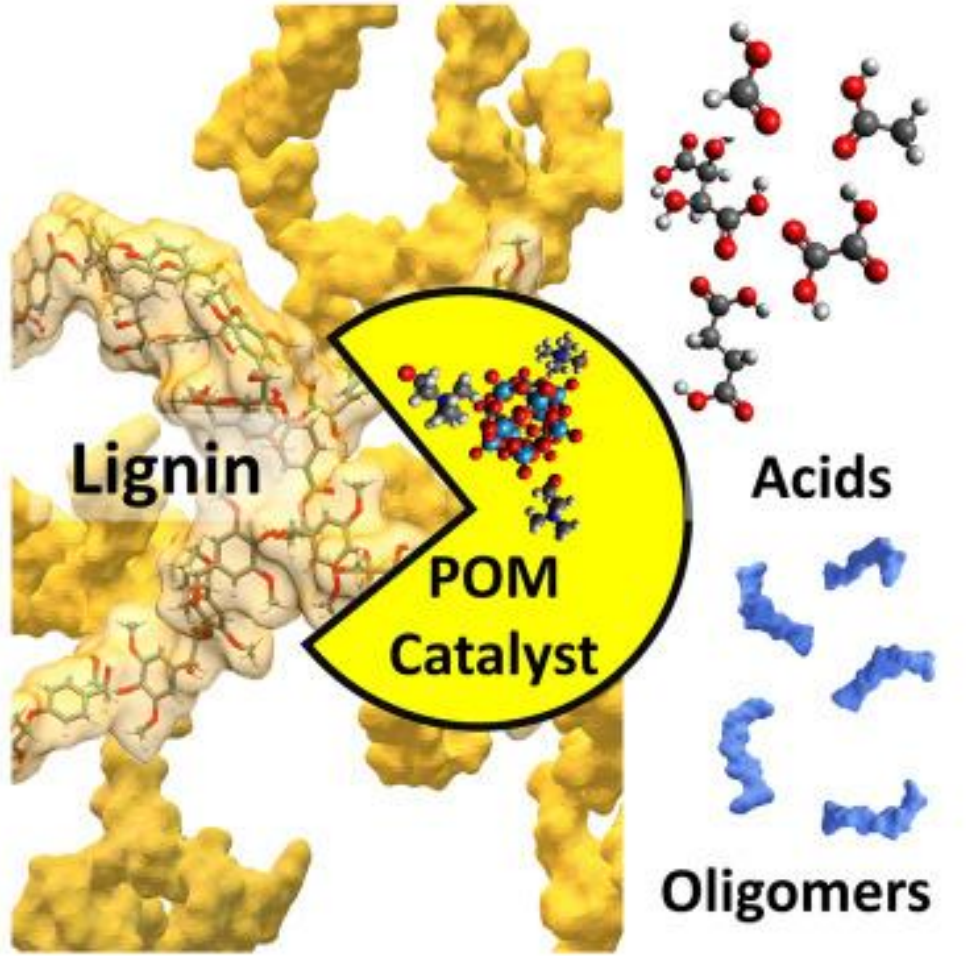

Figure caption: Illustration to show breakdown of polymeric lignin into water soluble and biocompatible organic acids over a polyoxometalate (POM) catalyst.

Wendt, O., et al. Cell Reports Sustainability. 10.1016/j.crsus.2026.100638 (JBEI #1301)

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Aqueous Ionic Liquid–Mediated Depolymerization of Textile Waste

Background/Objective

- Textile waste is an abundant and underutilized chemical feedstock; however, no satisfactory scalable chemical recycling solution currently exists.
- Ionic liquid systems offer promising chemistries for depolymerizing blended textile waste.

Approach

- Applied aqueous ionic liquid systems to isolate and depolymerize cellulosic and synthetic fibers.
- Evaluated solvent systems and processing variables to assess process variability and enable efficient selective depolymerization in blended textiles.

Results

- Demonstrates a facile chemical recycling method for complex textile waste blends.
- Enables high conversion of PET while preserving cotton of the polycotton textiles.

Significance/Impacts

- Aligns with DOE BER goals by repurposing waste carbon streams into valuable bioproducts.
- Promotes JBEI's vision of the bioeconomy by valorizing mixed waste streams generated by the global textile industry.

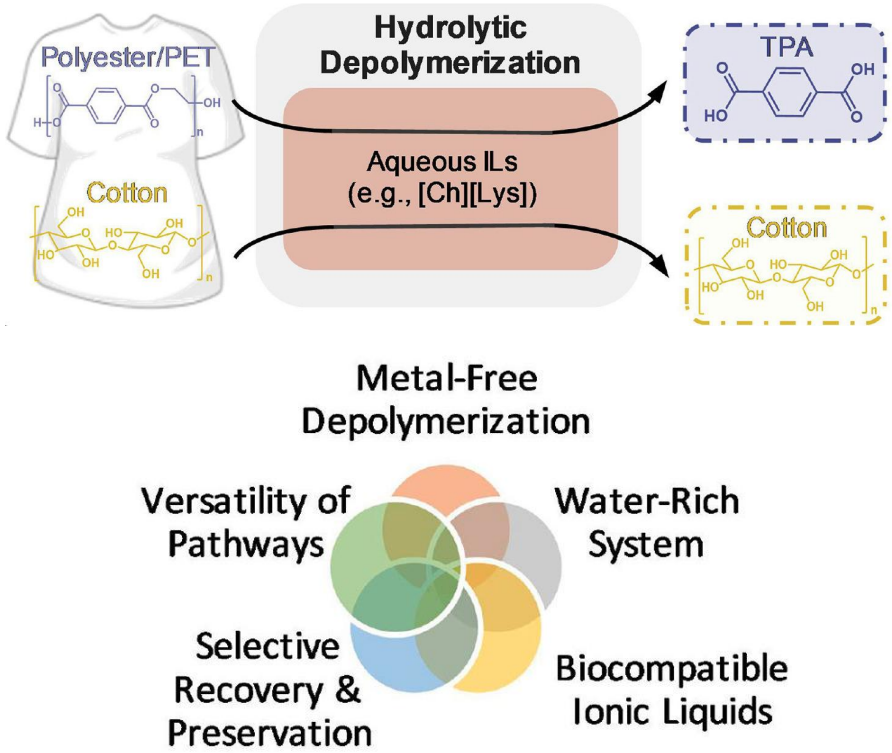

Figure caption: Schematic of aqueous ionic liquid systems for the isolation and/or depolymerization of blended textiles (top) and its key features (bottom).

Chen, Xueli et.al. Journal of Ionic Liquids. 10.1016/j.jil.2026.100199 (JBEI #1302)

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Evaluating Isoprenol Production using the IPP-bypass Pathway in the Oleaginous yeast Rhodosporidium toruloides

Background/Objective

- Isoprenol is a promising biofuel precursor but its production in oleaginous yeasts is unexplored.
- *R. toruloides* is an attractive host due to its lipid accumulation and production success in hydrolysates.

Approach

- Introduced the IPP-bypass pathway into *R. toruloides* to generate isoprenol.
- Used proteomics to evaluate pathway performance, identify bottlenecks, and guide further engineering efforts.

Results

- Expands *R. toruloides* as a platform for the production of terpene-based biofuels by demonstrating production in sorghum hydrolysates.
- Identifies specific metabolic targets for further yield optimization in non-conventional yeasts.

Significance/Impacts

- Functional expression of the IPP-bypass pathway resulted in measurable isoprenol titers.
- Multi-omics profiling identified engineering targets to improve flux toward the isoprenoid pathway.

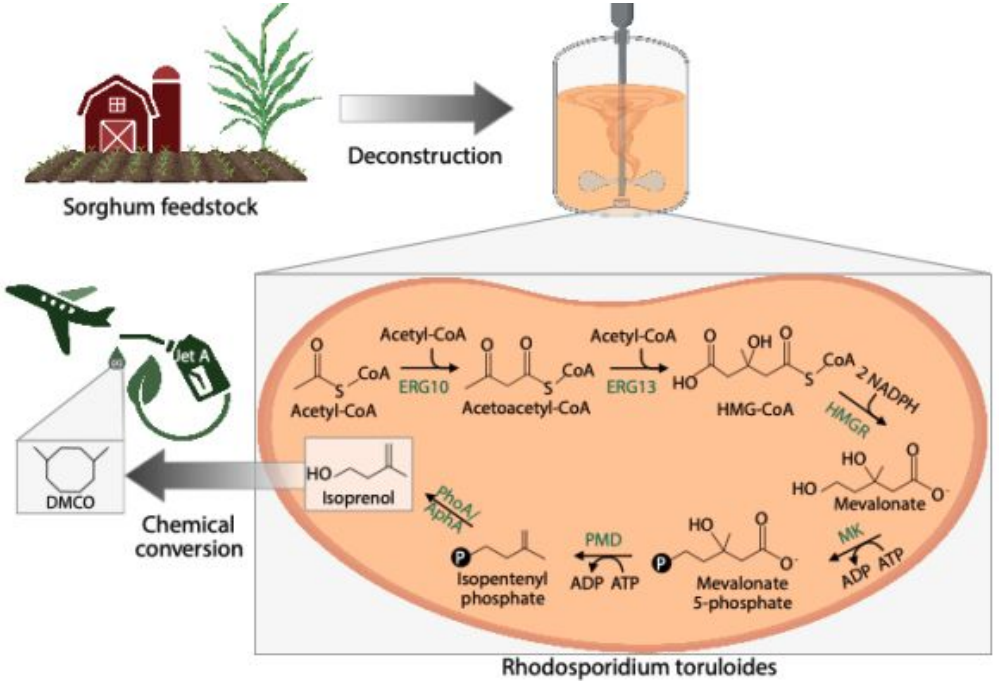

Figure Caption: Overview of isoprenol production from a plant-based feedstock for DMCO conversion using the IPP-bypass pathway in *R. toruloides*. Figure created using BioRender.

Garcia, V., et.al. Biotechnology for Biofuels and Bioproducts. 10.1186/s13068-026-02750-w (JBEI #1303)

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Multi-layered Metabolic Remodeling of *Pseudomonas putida* for Efficient Conversion of Lignocellulosic Sugars to the Precursors of Advanced Aviation Fuel

Background/Objective

- 1,4-Dimethylcyclooctane (DMCO) is a Synthetic aviation fuel (SAF) and its biosynthetic precursors can be synthetized from lignocellulosic sugars.
- *P. putida* is a robust chassis for SAF precursors due to its metabolic versatility.

Approach

- Applied multi-layered metabolic engineering including pathway insertion and cofactor balancing to produce isoprenyl acetate in *P. putida*.
- Tested strains on mixed lignocellulosic sugar streams under realistic biorefinery conditions.

Results

- Enables biological production of isoprenyl acetate (IPA) from renewable feedstocks.
- Demonstrates a synergistic approach to enhance IPA production and carbon utilization in engineered *P. putida* strains.

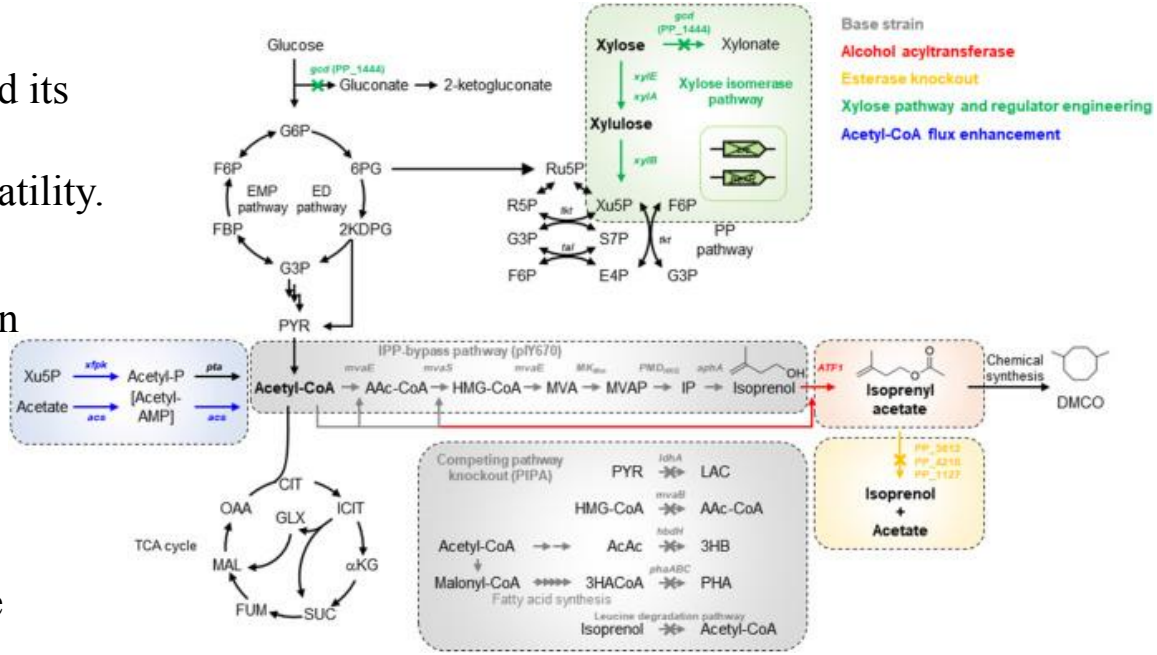

Figure caption: Overall scheme of strategies employed to modify *P. putida* metabolism for the production of isoprenyl acetate (IPA) from glucose and xylose.

Significance/Impacts

- Engineered *P. putida* strains achieved significantly improved yields of isoprenyl acetate, precursor of DMCO, from glucose and xylose.
- Multi-layered remodeling systematically contributed reduction of product degradation and improved the IPA production titer.

Kang, C., et.al. Metabolic Engineering Communications. 10.1016/j.mec.2026.e00274 (JBEI #1304)

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Quantitative Dissection of Agrobacterium Virulence to Generate a Synthetic Ti Plasmid

Background/Objective

- Agrobacterium is the primary plant engineering tool, but its Ti plasmid is poorly characterized.
- A synthetic Ti plasmid could enable more precise and efficient transformation for bioenergy crops.

Approach

- Quantitatively dissected virulence genes using systematic genetic and functional genomic methods.
- Designed and assembled a minimal synthetic Ti plasmid based on essential determinants.

Results

- Provides a preliminary defined and modular tool for more precise genetic engineering of bioenergy crops.
- Serves as a starting point for rationally engineered Agrobacterium to improve bioenergy crop transformation.

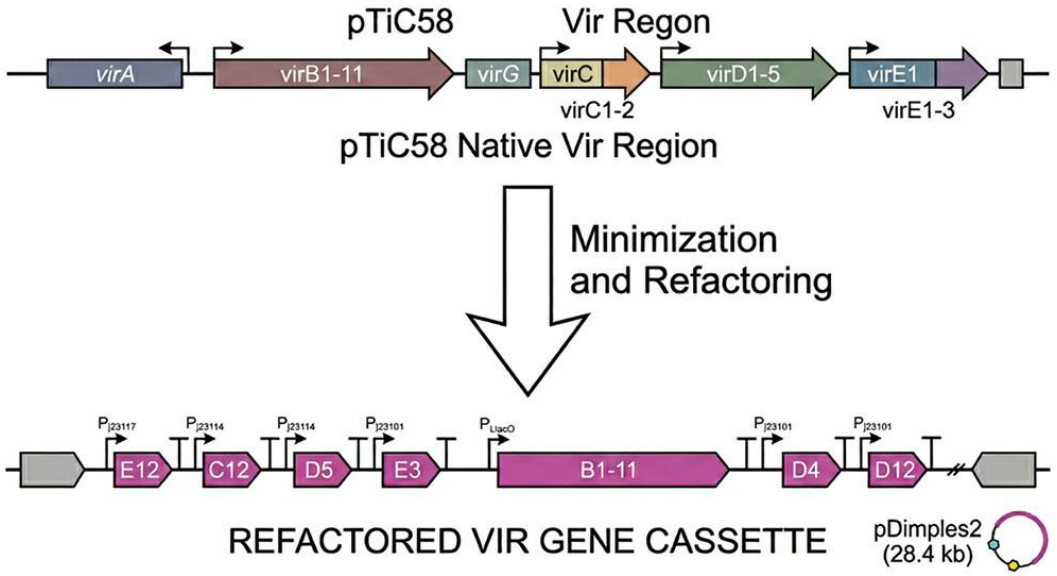

Figure caption: Rational minimization and refactoring of the Agrobacterium pTi plasmid.

Significance/Impacts

- Generated a comprehensive virulence map identifying essential and dispensable Ti components.
- Demonstrates the feasibility of synthetic pTi plasmids.

Thompson, M., et.al. ACS Synthetic Biology. 10.1021/acssynbio.6c00064 (JBEI #1305)

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Liquid Biofuels for Transportation: Lessons of the Last Two Decades for the Next Two

Background/Objective

- Biofuel mandates drove a ~5x global increase in crop-based ethanol and biodiesel, but environmental and economic impacts remain uncertain.
- Synthesizes lessons from the past 25 years to inform better biofuel policy for future.

Approach

- Reviews lifecycle assessments, economic modeling, and policy analysis across first- and advanced-generation biofuel pathways.
- Evaluates how feedstock, production practices, and policy design affect sustainability outcomes.

Results

- Biofuels are most effective for hard-to-electrify sectors (aviation, ocean freight) given advances in batteries and green hydrogen.
- Targeted policies (e.g., CA's Low Carbon Fuel Standard, ecosystem service incentives) outperform broad mandates.

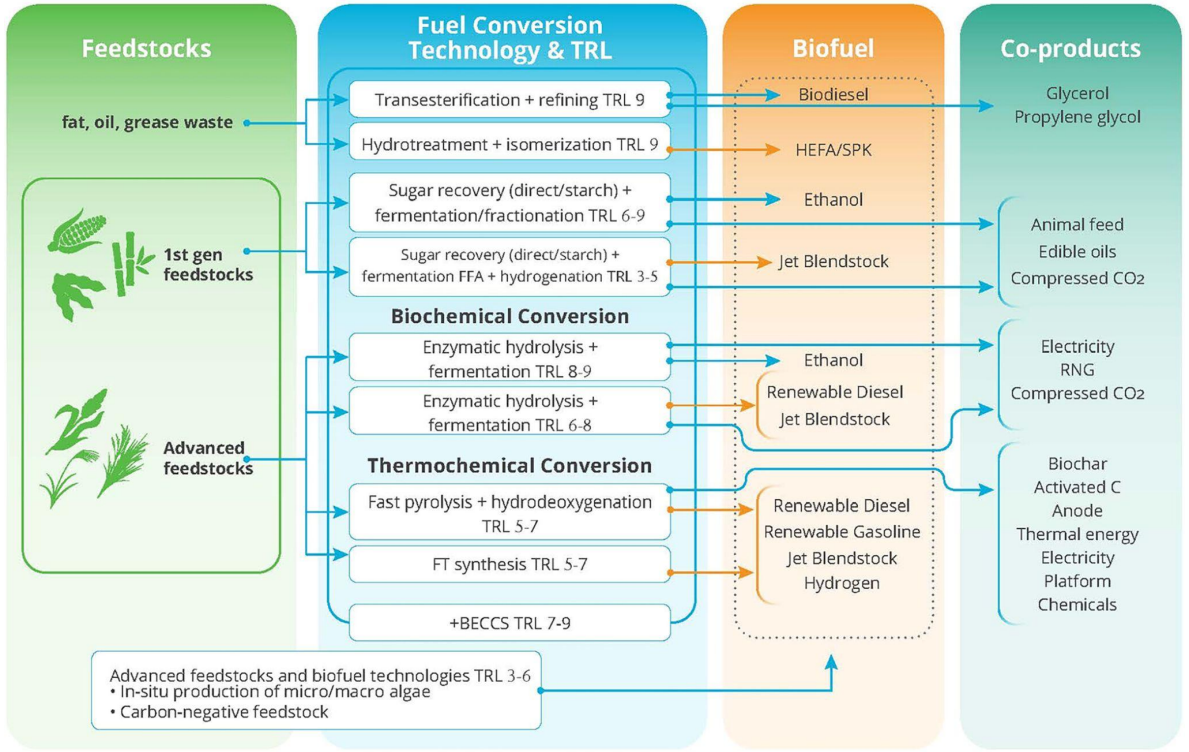

Figure caption: This diagram illustrates various biofuel conversion pathways from feedstocks to fuels and coproducts, categorizing them by technical maturity (TRL) while distinguishing between drop-in (orange) and blendable (blue) fuels.

Significance/Impacts

- Provides a roadmap to shift investment from food crops to waste biomass and energy crops, reducing the food-fuel trade-off.
- Better-targeted policies could unlock technological breakthroughs and make advanced biofuels commercially viable at scale.

Rajagopal, D., et.al. Environmental Science & Technology. 10.1021/acs.est.5c16314 (JBEI #1306)

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Higher Wood Density Lowers Feedstock Cost and Has Minimal Impact on Biomass Conversion to Biofuels

Background/Objective

- Woody feedstocks can supply 200M tons/year, but wood density as a yield trait is largely overlooked.
- Determine if higher wood density reduces biofuel production costs without hurting yield or conversion.

Approach

- Measured density, growth, and composition across 1,089 *P. trichocarpa* trees with techno-economic modeling.
- Tested high- vs. low-density wood in two pretreatment-to-fuel pipelines (SAA→ethanol; ionic liquid→bisabolene).

Results

- Higher density (0.3→0.5 g/cm³) cut total feedstock costs ~20% and transport costs up to 34%.
- Density showed no meaningful effect on biomass composition or biofuel yields.

Significance/Impacts

- Density is heritable and independent of growth — making it a clean, simultaneous breeding target.
- A biological densification strategy that improves supply chain economics with no conversion trade-offs.

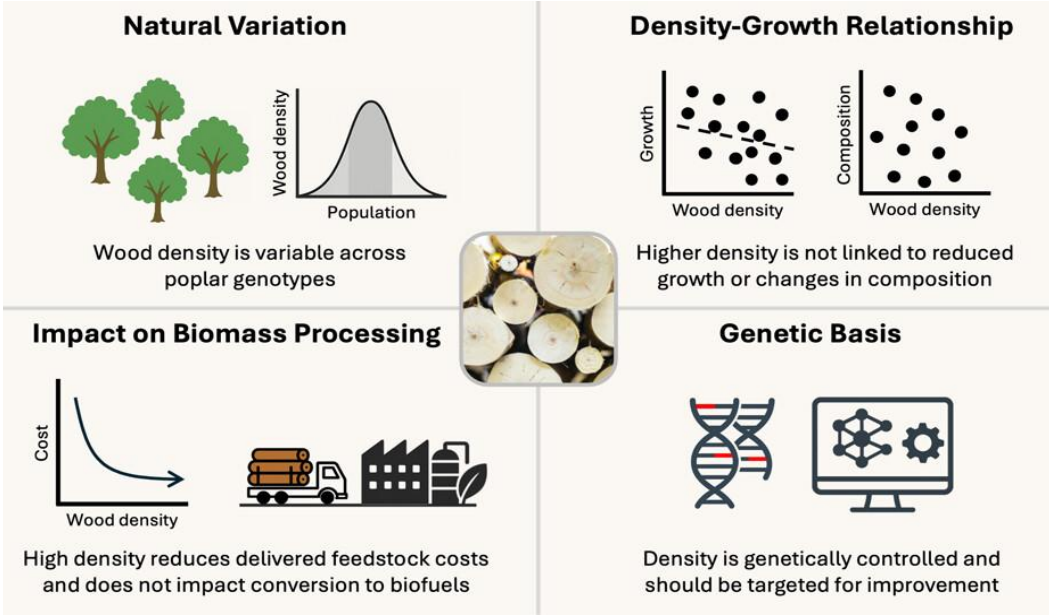

Figure caption: A multidisciplinary study on the potential benefits of breeding and converting poplar variants with high wood density

Ployet, R., et.al. ACS Sustainable Chemistry & Engineering. 10.1021/acssuschemeng.5c10590 (JBEI #1307)