

Fungal Genomics Program

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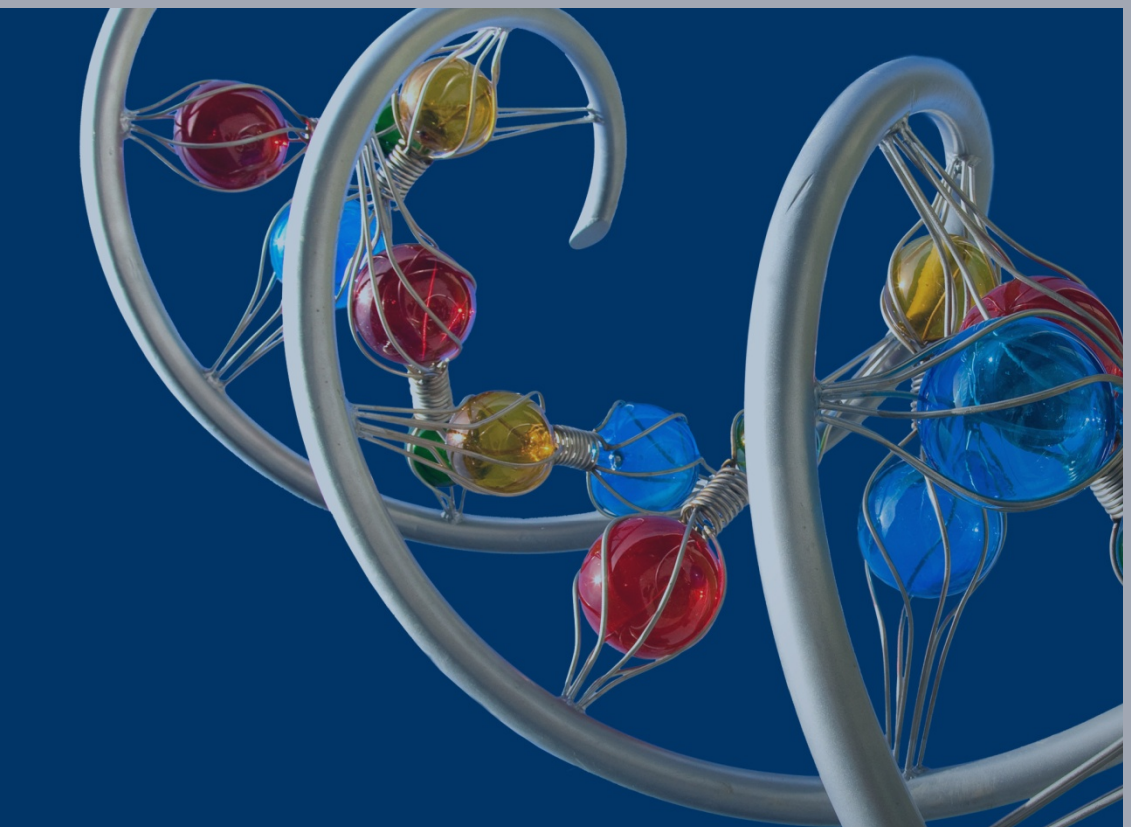
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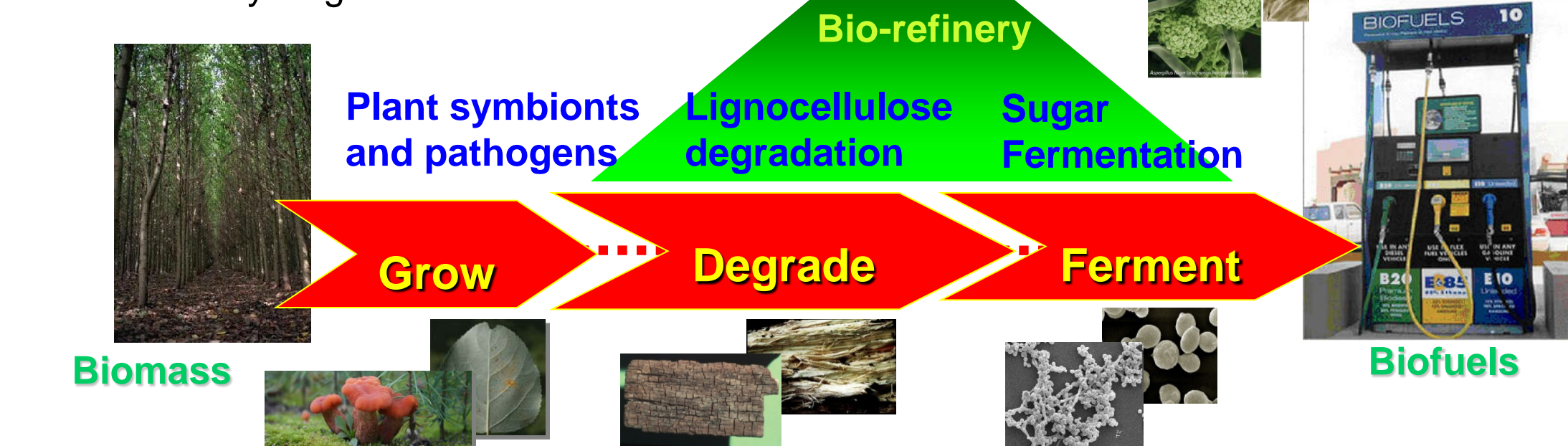
ABSTRACT

Doubling the number of sequenced and annotated genomes every year, the JGI Fungal Program (jgi.doe.gov/fungi) is moving towards the new large scale initiatives aligned with the 2010 Grand Challenges for Biological and Environmental Research: a long term vision. One of the initiatives, the *1000 Fungal Genomes* project, is aimed to explore fungal diversity across the Fungal Tree of Life in order to provide references for research on plant-microbe interactions and environmental metagenomics. Another initiative, the *Genomic Encyclopedia of Fungi*, is focused on diversity among DOE relevant fungi in the areas of plant health and biorefinery parts lists, which will help us to explore the interactions of bioenergy crop species with symbionts and pathogens as well as to catalog industrially relevant genes, pathways, and hosts for biotechnology applications. In addition to broad exploration of fungal diversity, we will also focus on the functional analysis of several *fungal systems* of varying complexity: new model organisms, symbiotic systems such as lichens, and metagenomes of complex communities

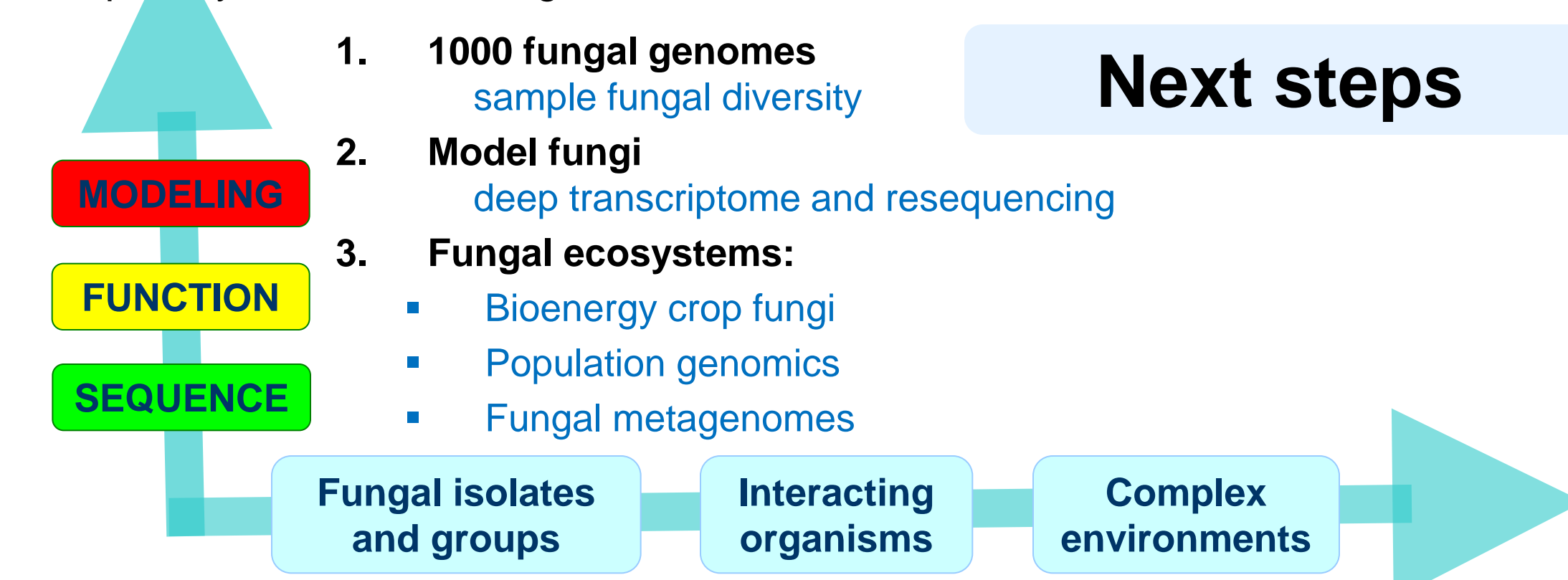


Mission and Strategy

Encoded in the genomes of the organisms of the **kingdom Fungi** are biological processes with high relevance to the DOE missions in bioenergy production, biogeochemistry, and carbon cycling.

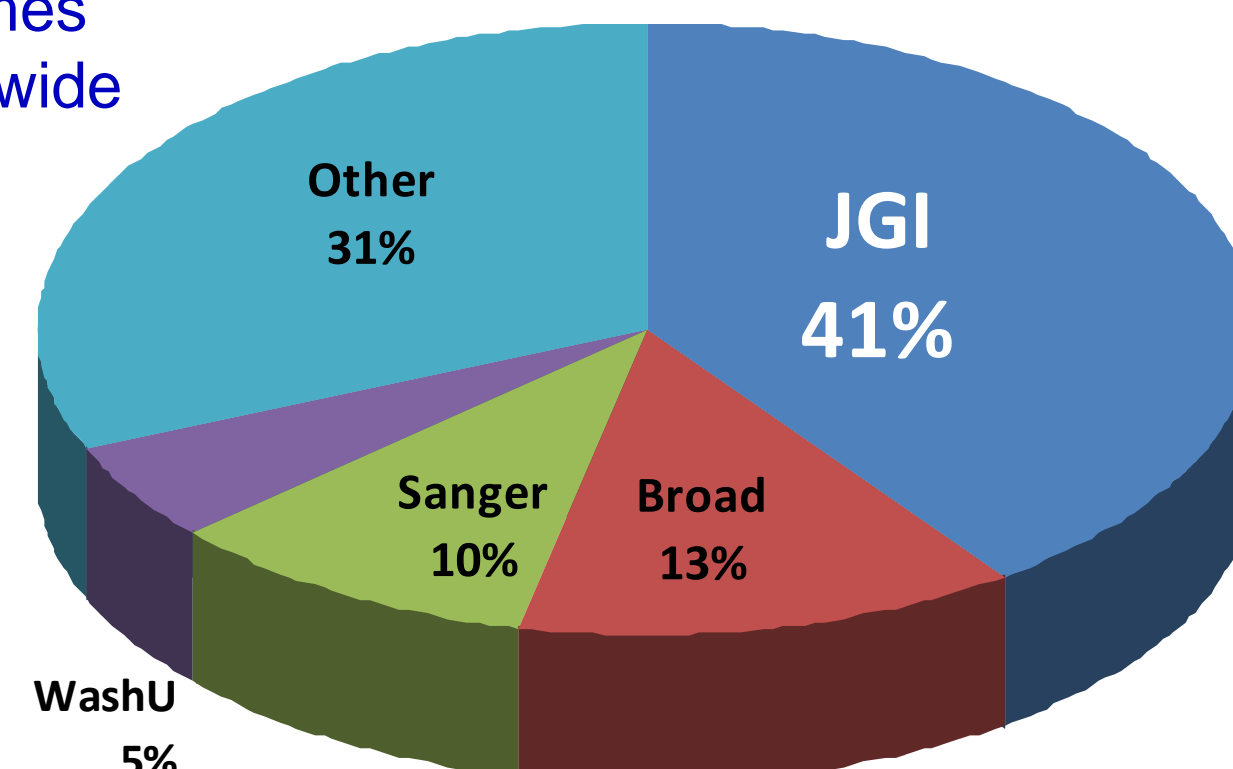


The **JGI Fungal Genomics Program** aims to scale up sequencing and analysis of fungal genomes to explore the diversity of fungi important for energy and the environment, and to promote functional studies on a system level. Combining new sequencing technologies and comparative genomics tools, JGI is now leading the world in fungal genome sequencing and analysis. Over 120 sequenced fungal genomes with analytical tools are available via MycoCosm (www.jgi.doe.gov/fungi), a web-portal for fungal biologists. Our model of interacting with user communities, unique among other sequencing centers, helps organize these communities, improves genome annotation and analysis work, and facilitates new larger-scale genomic projects. This resulted in 20 high-profile papers published in 2011 alone and contributing to the Genomics Encyclopedia of Fungi, which targets fungi related to plant health (symbionts, pathogens, and biocontrol agents) and biorefinery processes (cellulose degradation, sugar fermentation, industrial hosts). Our next grand challenges include larger scale exploration of fungal diversity (1000 fungal genomes), developing molecular tools for DOE-relevant model organisms, and analysis of complex systems and metagenomes.



Lead the World in Fungal Genomics

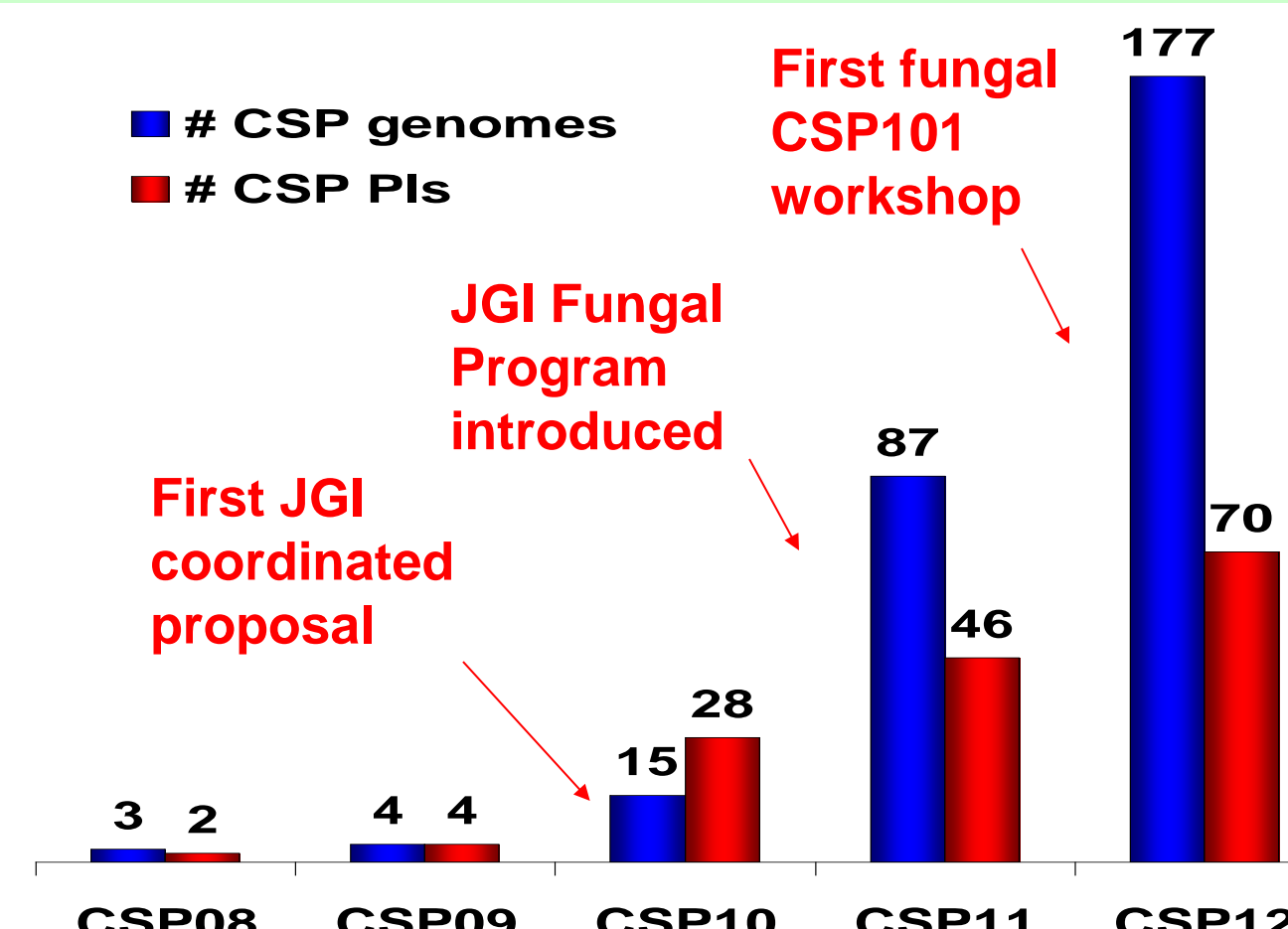
758 fungal genomes sequenced worldwide (GOLD:Oct 2011)



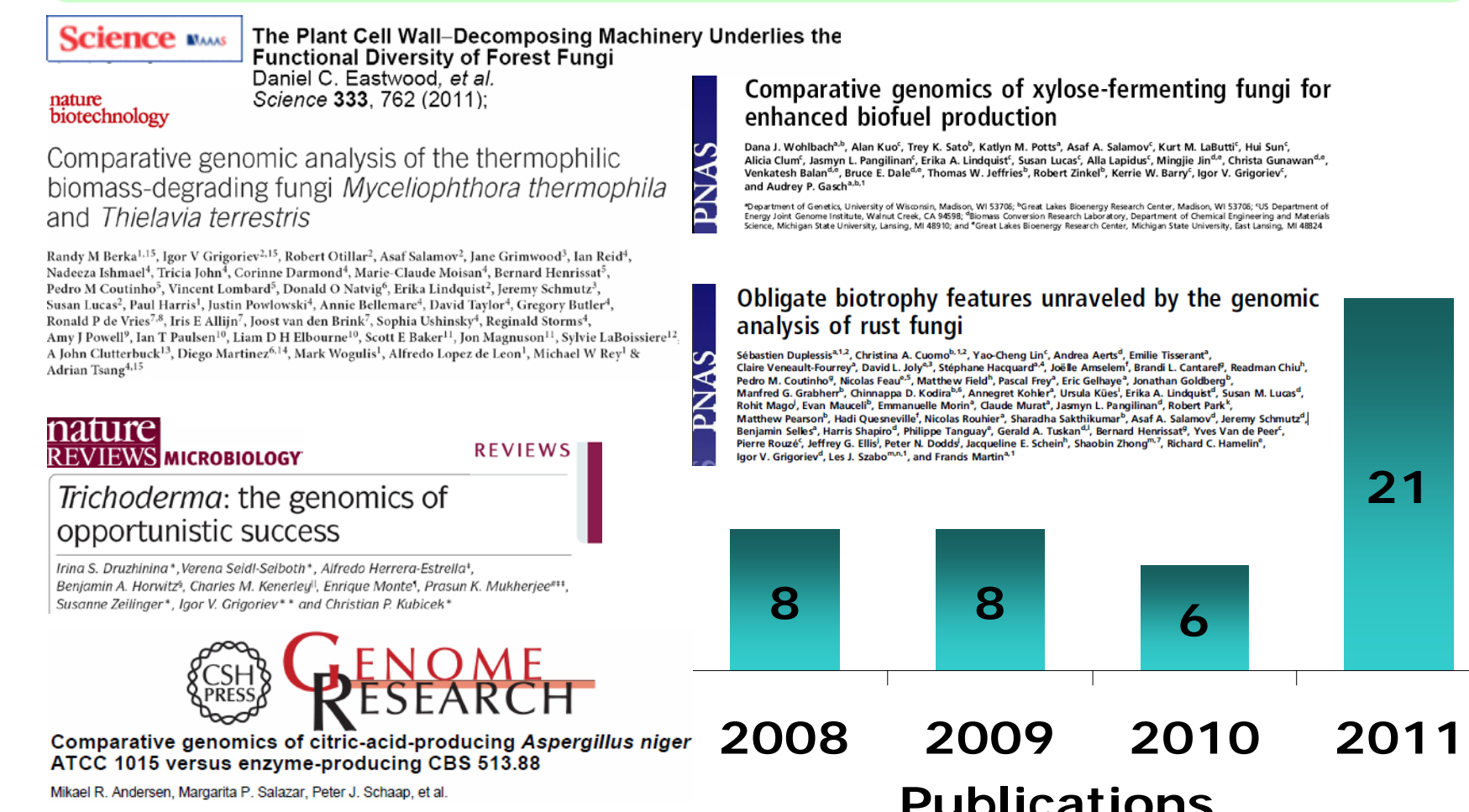
For the second year in a row, we have doubled the number of sequenced and annotated fungal genomes

Accomplishments

Organized User Communities



Published High-profile Science

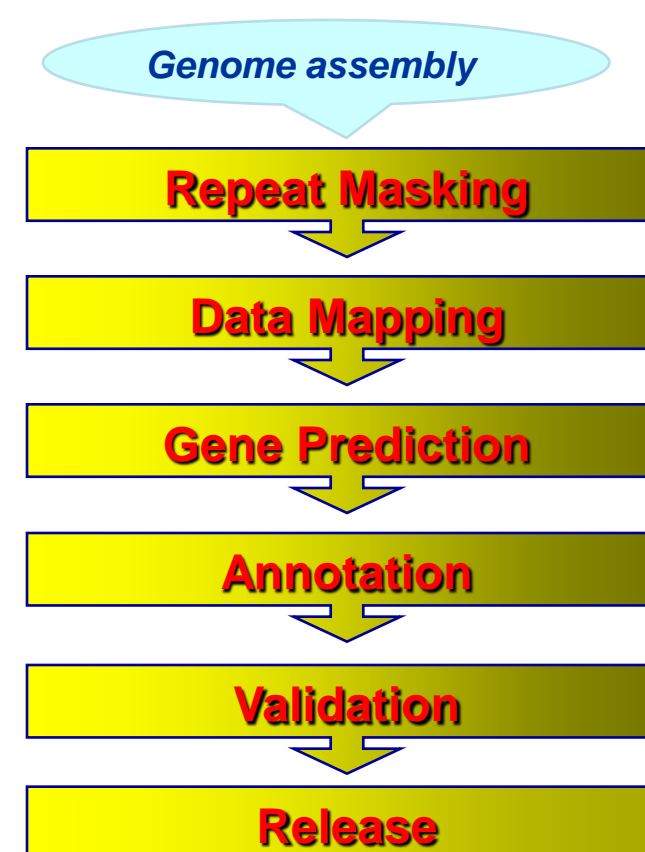


Tools

The Annotation Pipeline

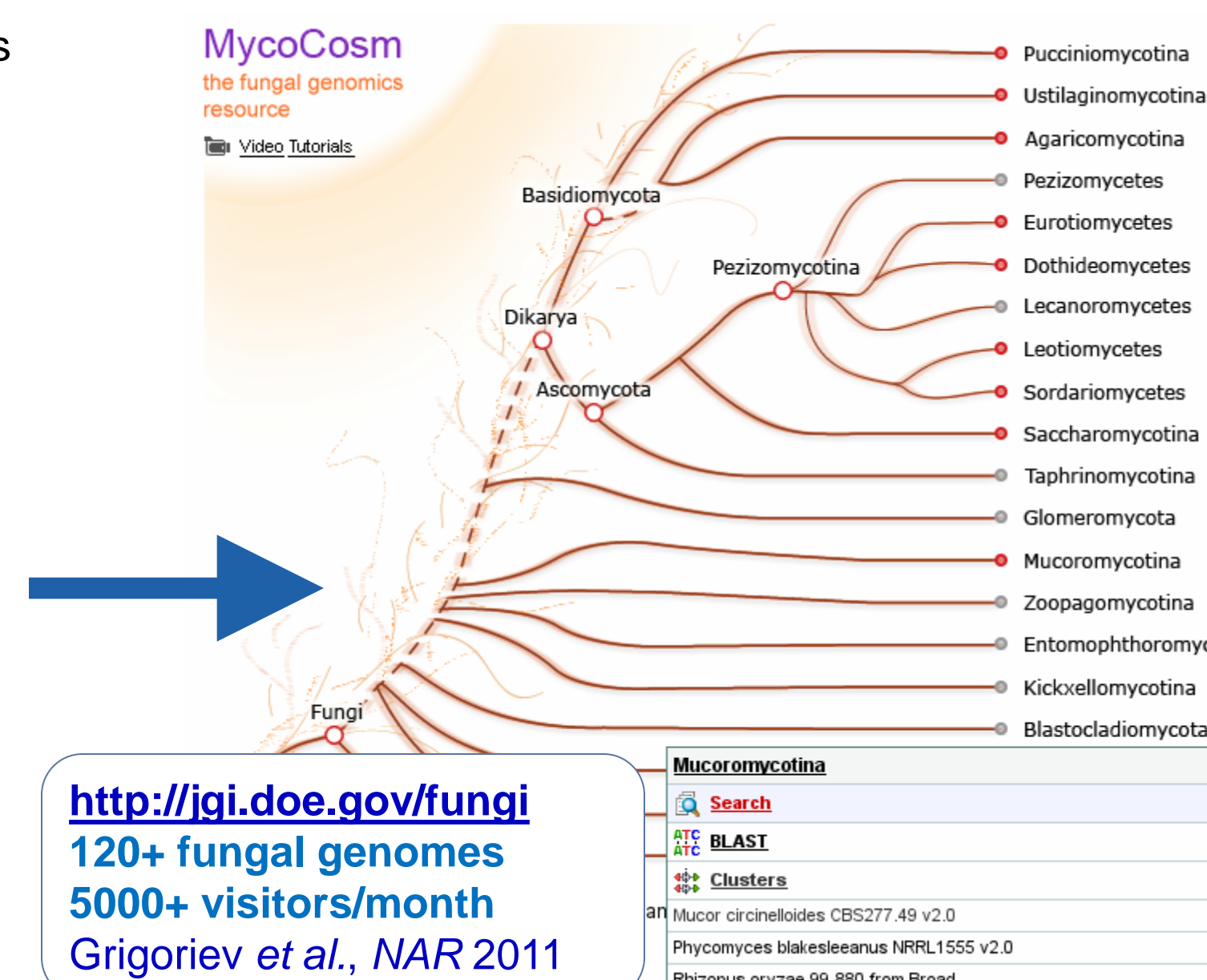
Automated **Annotation Pipeline** tuned for high-throughput annotation of fungal genomes runs on compute clusters at NERSC and is equipped with graphical monitoring tools. **MycoCosm** provides interactive web-based tools for functional and comparative genomics. **Quality assurance** is implemented at every stage of the annotation process: built-in pipeline controls, benchmarked tools, two-tier pre-release data/portal QC, user feedback, and community annotation.

Pipelines Comparison	MAKER	JGI pipeline	JGI R&D
# of predicted gene models	9,940	12,290	12,802
with Swissprot hits	6,521	7,356	7,900
with PFAM domains	5,365	6,010	6,353
with EST support	9,252	10,796	11,105
# of unique PFAM domains	2,207	2,245	2,322
EST coverage per gene	93.0%	93.3%	93.3%
# EST-supported splice sites	99,627	102,200	104,246



Pipeline benchmarks, development, and release to production

MycoCosm: 100+ fungal genomes



<http://jgi.doe.gov/fungi>
120+ fungal genomes
5000+ visitors/month
Grigoriev et al., NAR 2011

Community Outreach

Jamborees to analyze genomes

- Dothideomycetes, Walnut Creek, CA Mar 15, 2011
- Basidiomycota, Walnut Creek, CA Mar 21, 2011
- Symbiosis, INRA-Nancy, France Sep 28-29, 2011

MycoCosm Tutorials to introduce the program and tools

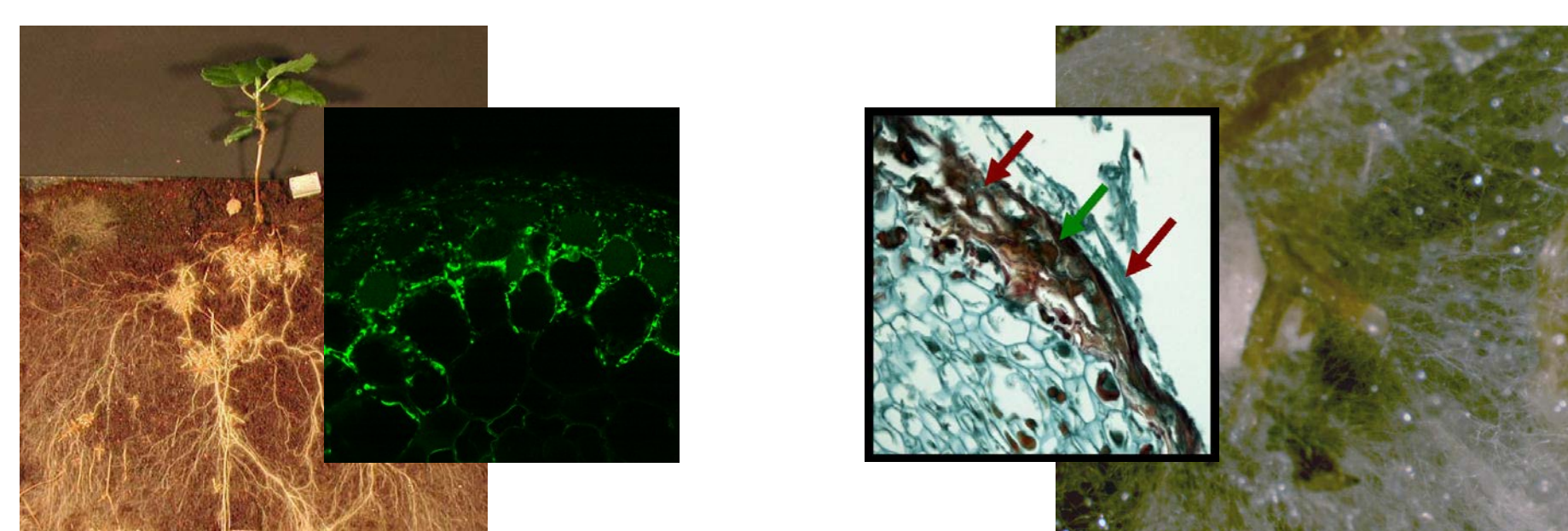
- MGM (3x@JGI)
- MycoCosm Online video tutorial
- Satellite Meetings

Close interactions with users to develop strategy and coordination

- FGC-Asilomar and ECFG Meetings
- JGI User Meetings
- MSA Meetings

Science: Genomic Encyclopedia of Fungi

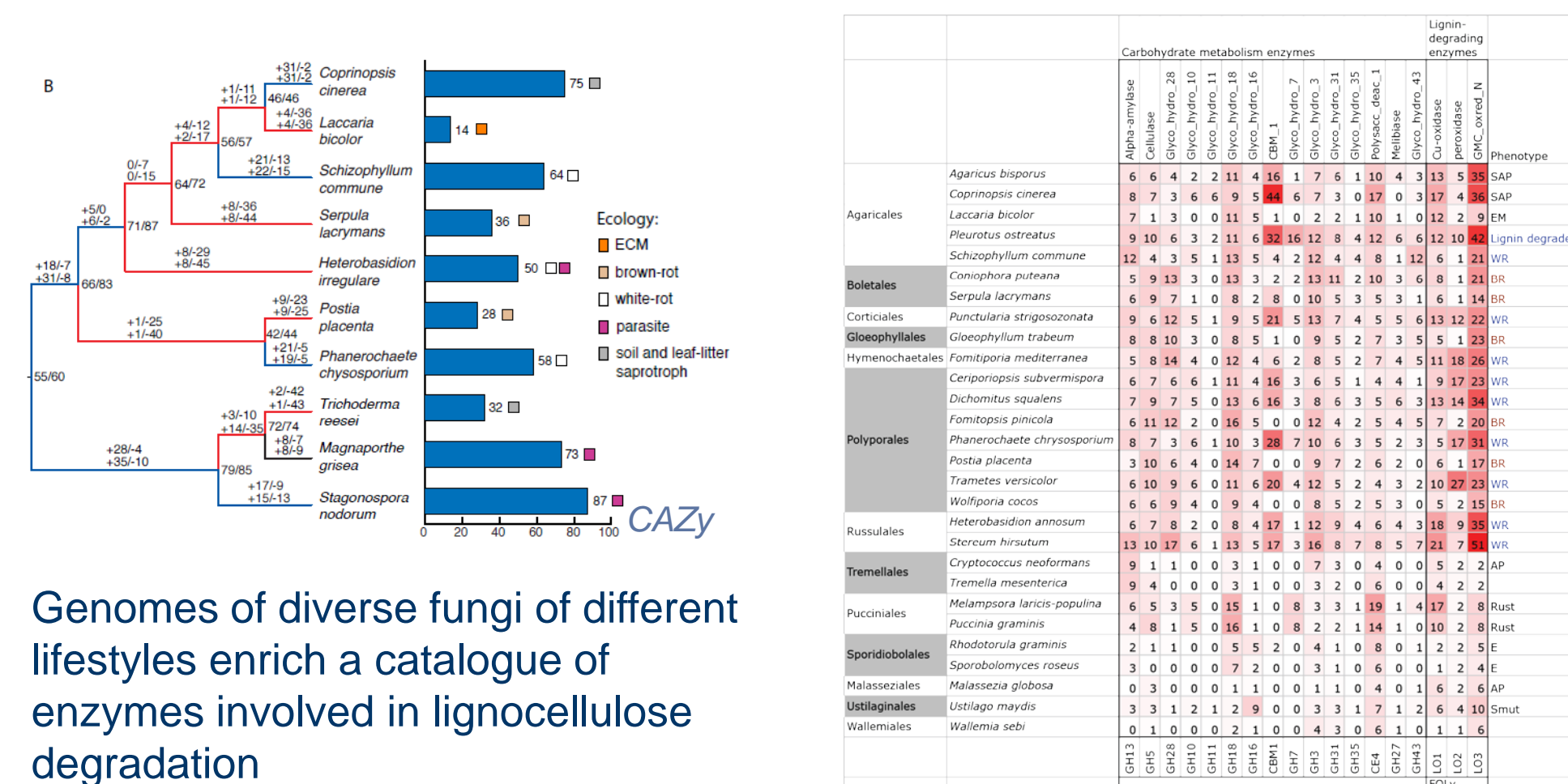
Plant Health: Symbionts



Laccaria bicolor (ECM)
Small secreted proteins are expanded in poplar symbiont and overexpressed in ECM tissue.
Martin et al., Nature 2008

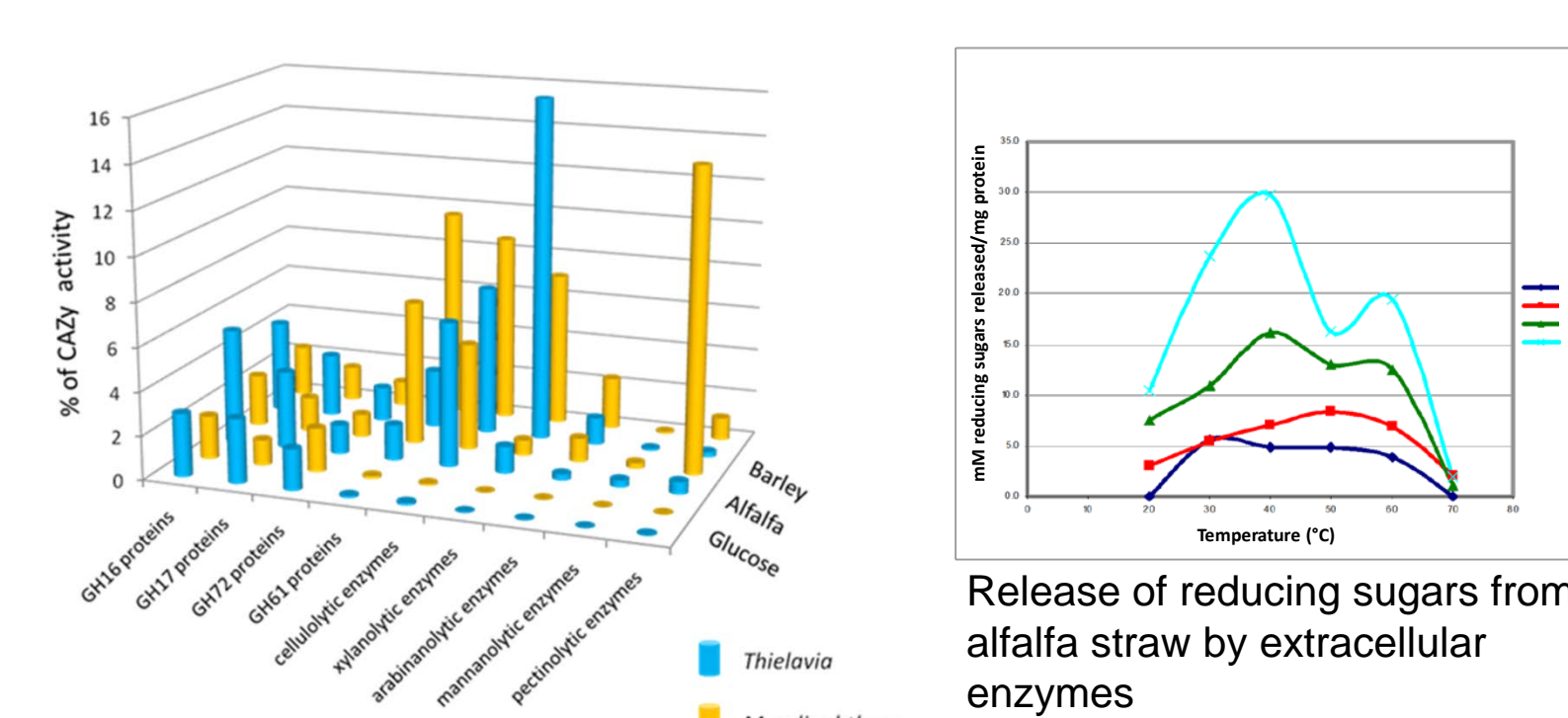
Serpula lacrymans (brown rot)
Convergent evolution of brown rot and ECM fungi from white rot ancestor.
Eastwood et al., Science 2011

Biorefinery: Lignocellulose Degradation



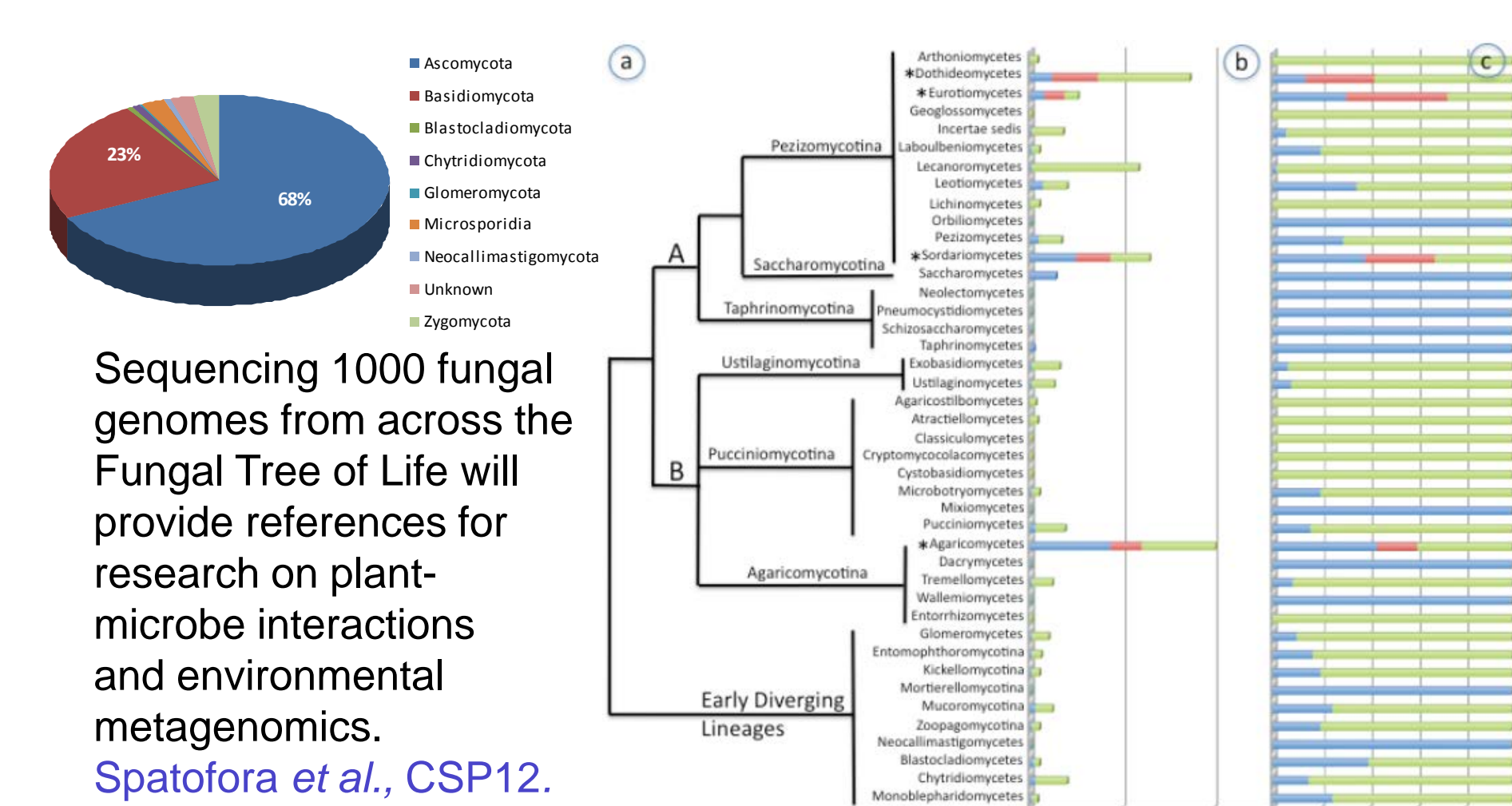
Genomes of diverse fungi of different lifestyles enrich a catalogue of enzymes involved in lignocellulose degradation
Riley et al., in prep.

Biorefinery: Thermophiles



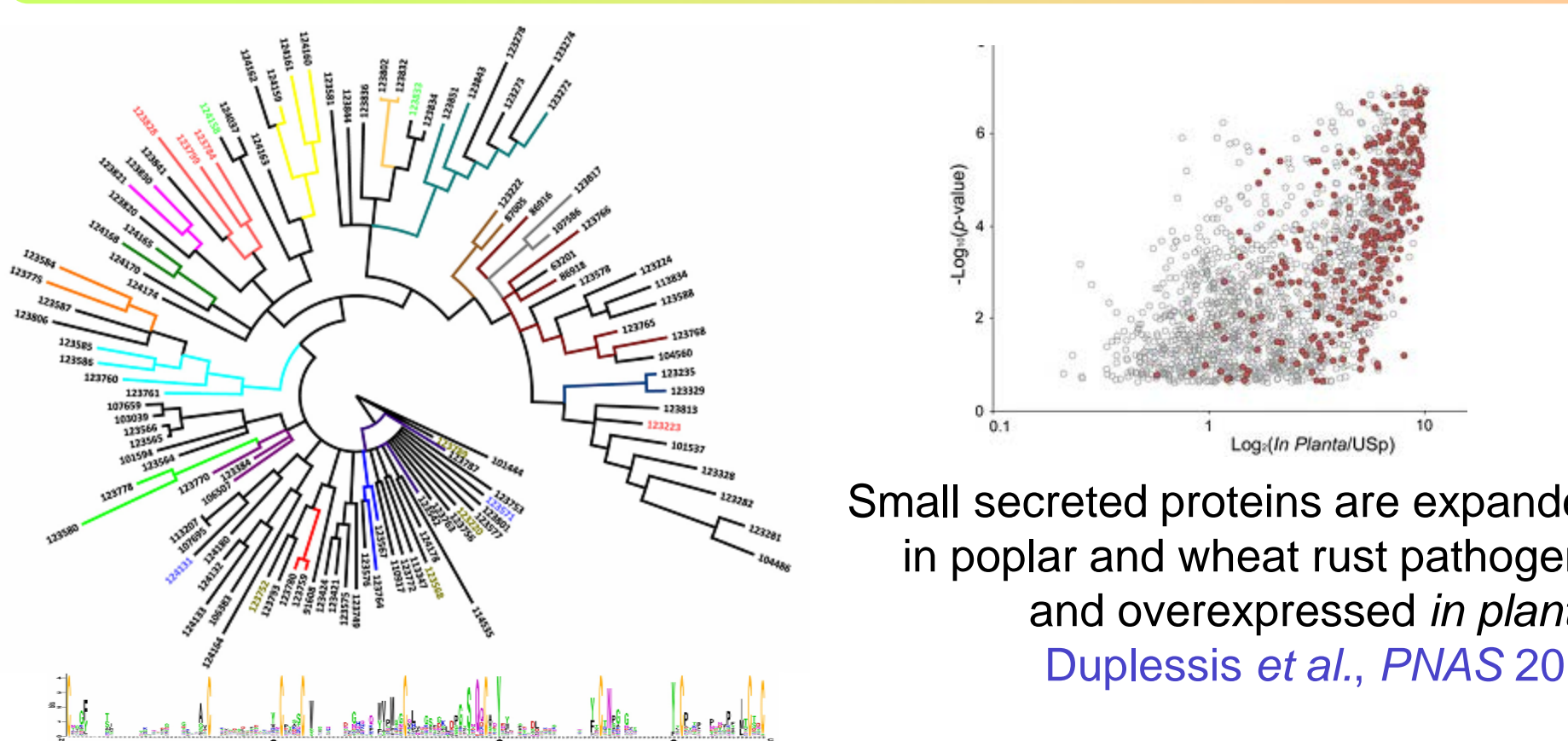
Thermophilic biomass-degrading fungi *M.thermophila* and *Thielavia terrestris*, the first with completely finished genomes, are new candidates for cell factories with secreted thermostable enzymes.
Berka et al., Nat Biotech 2011.

Diversity: 1000 Fungal Genomes



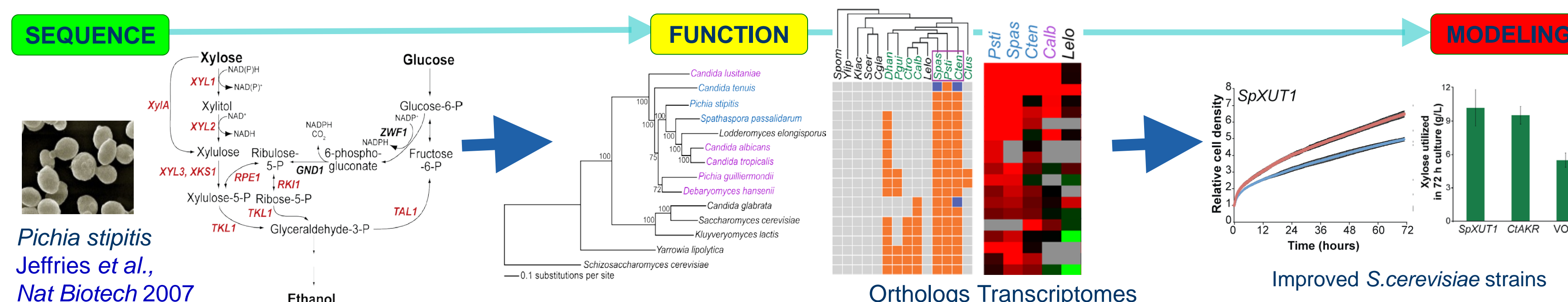
Sequencing 1000 fungal genomes from across the Fungal Tree of Life will provide references for research on plant-microbe interactions and environmental metagenomics.
Spatofora et al., CSP12.

Plant Health: Pathogens



Small secreted proteins are expanded in poplar and wheat rust pathogens and overexpressed in plants.
Duplessis et al., PNAS 2011

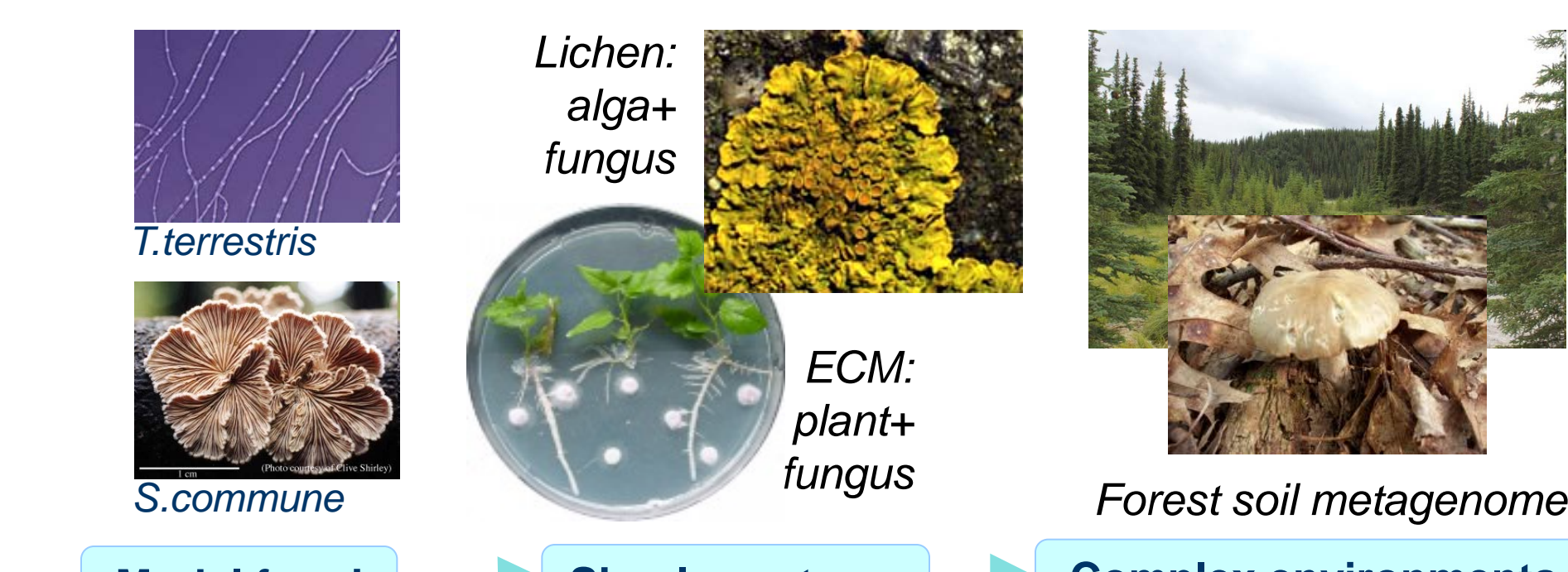
Biorefinery: Engineering Improved Xylose Fermentation



Pichia stipitis
Jeffries et al., Nat Biotech 2007

Comparative genomics and transcriptomics of *xylose fermenters* and *xylose growers* revealed candidate genes for *S.cerevisiae* strain improvement.
Wohlbach, et al. PNAS 2011

Fungal Systems & Metagenomes



Model fungi -> Simple systems -> Complex environments

Understanding fungal systems requires developing molecular and analytical tools for model organisms, simple systems and complex environments