

BASF – a chemical company mastering the challenges of biologicals

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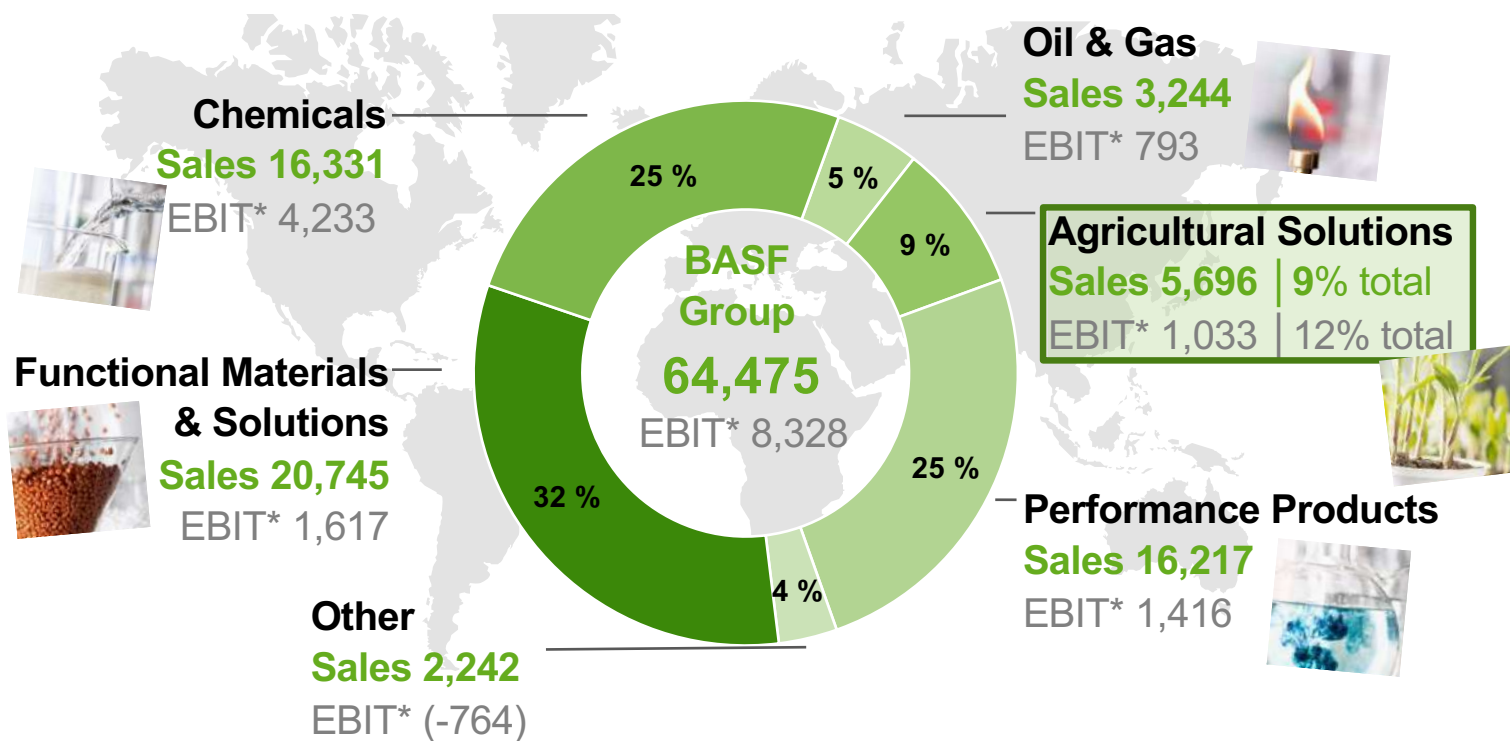
White Biotechnology Research – Lab Team Leader Microbiology

 **BASF**
We create chemistry

BASF Group - 115,500 employees create chemistry for a sustainable future

Sales and EBIT by segment 2017

€ million

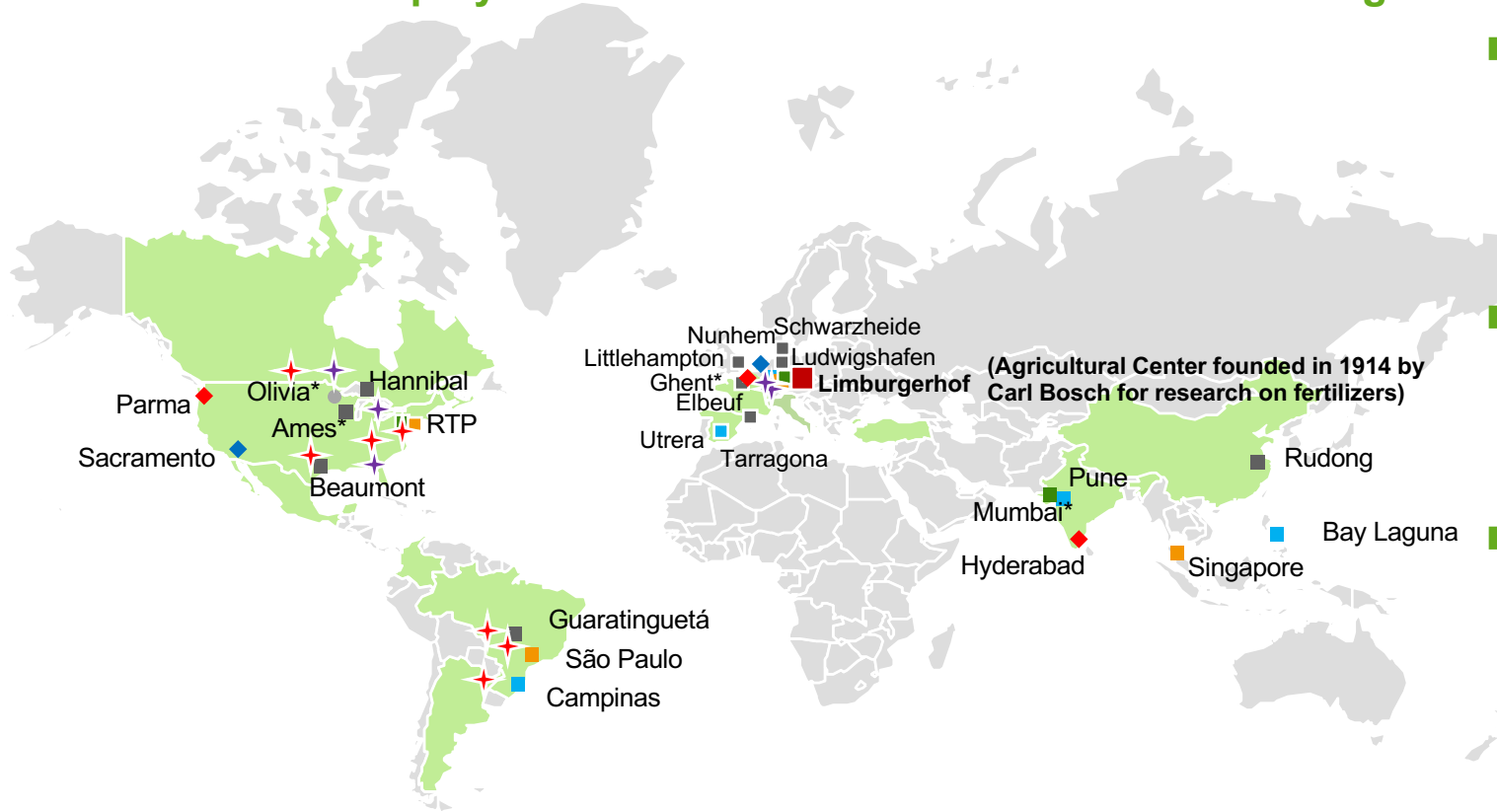


- In 6 research divisions 10,000 employees are running ~3,000 projects worldwide
- Expenditures for R&D: €1,888 million, world leader in chemical industry (23% of EBIT)

* Before special items

BASF Agricultural Solutions

More than 12000 employees create solutions for sustainable farming



Current BASF sites

- Global HQ
- Regional HQ
- Production centers
- Research centers
- Global agro research stations

Transferring sites

- ★ Glufosinate production sites
- ★ Major seed production sites
- ◆ R&D sites vegetable seeds
- ◆ Main operation centers vegetable seeds

■ Countries with major seeds business

- Agricultural Solutions is one of the world's leading research-based companies in crop protection
- €507 million invested in R&D in 2017 (27% of the company's research investment)
- Continued investments in innovation to expand portfolio in and beyond crop protection, such as biological solutions and digital tools and devices



Why Biologicals?

Biologicals offer new tools for the grower

Growers need new solutions

- Political pressure to reduce chemical input
- Consumer demand for lower residues
- Diseases and pests developing resistance
- Yield increase



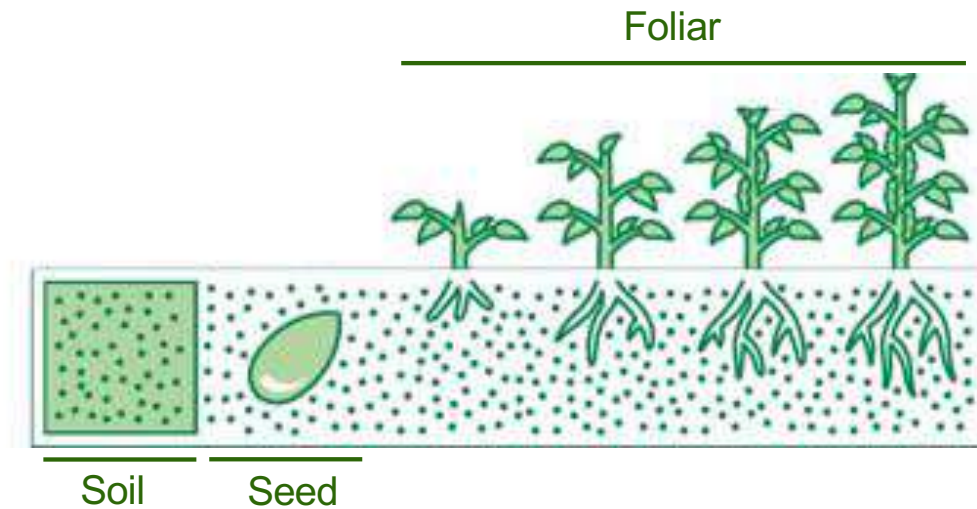
Biologicals can provide solutions

- Different modes of action versus chemistries
- No chemistry-like residues
- Low likelihood of resistance
- Yield effects beyond disease & pest control



Biologicals in Agricultural Solutions

Important technology for crop protection that complements chemistry-based solutions over the full cropping cycle



Products for soil, seed and foliar application to meet today's and tomorrow's agricultural challenges

Challenges

Many challenges to be mastered when working with biologicals ...

Application
Colonization
Regulatory profile
Sales
Complex interactions
Stability
Results green house vs field
Competitive production costs
Missing positive effects
Mode of action
Performance profile
Downstream processing
Contaminations
Market fit
Formulation
Variability of performance
Shelf life
Fermentation
Candidate selection

Selected biologicals of our growing portfolio for foliar or seed application

A natural complement to chemistry

Bradyrhizobium japonicum
Inoculant, Biofertilizer
(Vault[®], Nodulator[®], HiStick[®])

- Nitrogen-fixing rhizobia stimulate root nodulation improving nutrient uptake
- More consistent overall performance, reducing uncertainty

Steinernema spec.
Bioinsecticide
(Nemasys[®])

- Entomopathogenic nematode
- Excellent compatibility and performance with chemistry as part of an IPM program

Bacillus amyloliquefaciens
Biofungicide
Serifel[®] Integral[®]

Bacillus subtilis
Biofungicide
(Velondis[®])

- Mode of action via biofilm formation, secondary metabolites, stimulation of plant's natural defenses...
- Usable in combination with chemical treatments

Beauveria bassiana PPRI5339
Bioinsecticide
(Velifer[®])

- Fungal spores applied to insect attach to cuticle and initiate infection
- Low likelihood of resistance due to complex interaction with host

Product profile: Serifel®

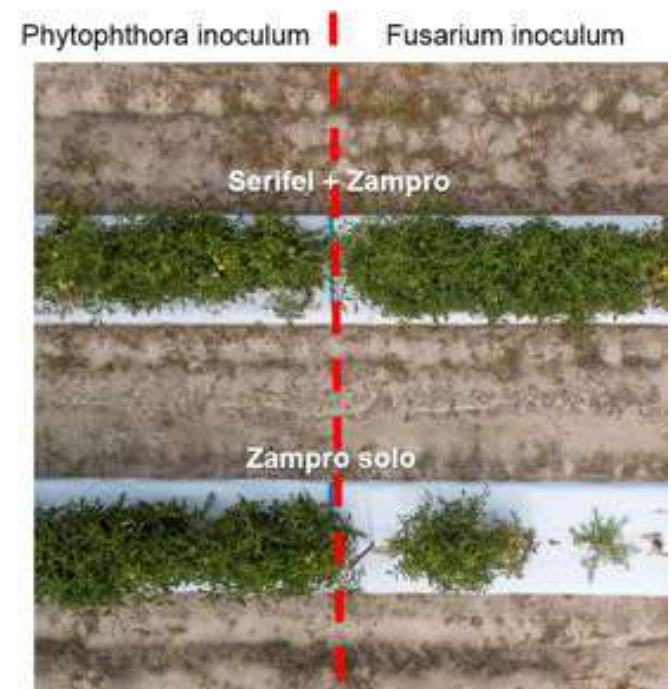
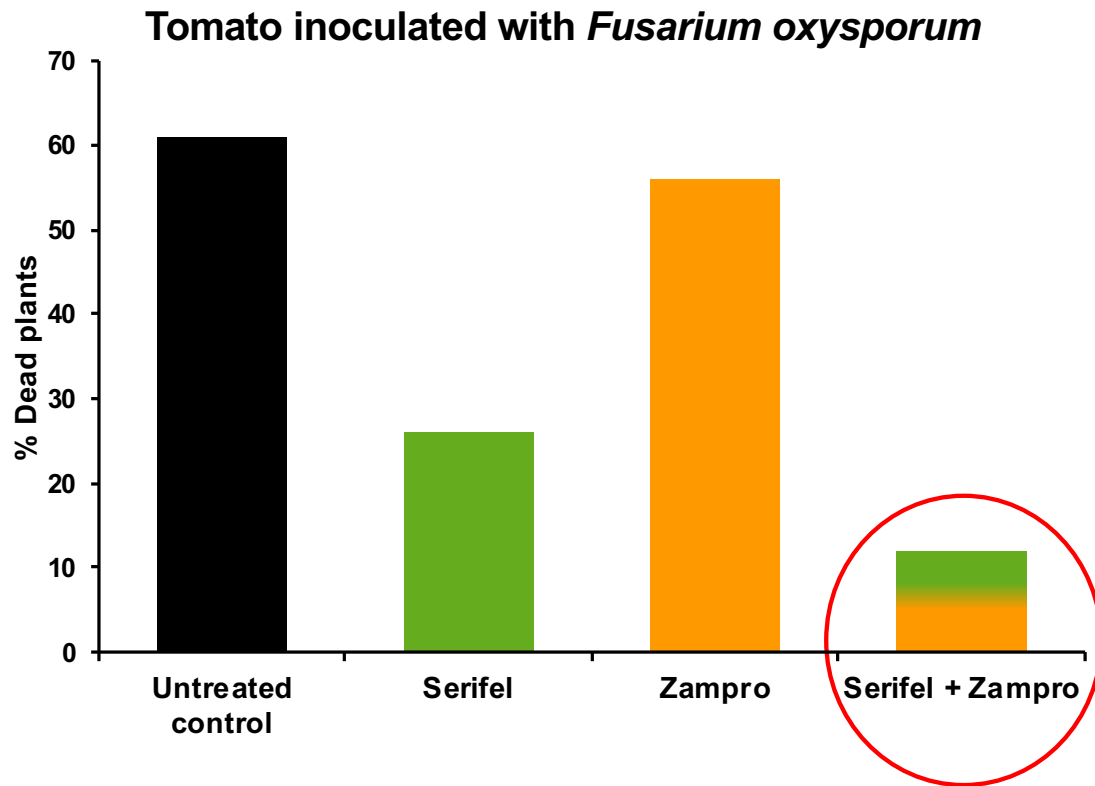
BASF's first proprietary biological fungicide based on *Bacillus amyloliquefaciens* strain MBI600

Active ingredient	<i>Bacillus amyloliquefaciens</i> strain MBI 600
Formulation	Min. 5.5×10^{10} CFU/g WP formulation
Key markets	Specialty crops including leafy vegetables, fruiting vegetables, potatoes, grapes, strawberries; tobacco, hops
Disease targets	Foliar and soil diseases including <i>Fusarium</i> species, <i>Alternaria solani</i> , <i>Botrytis cinerea</i> , <i>Rhizoctonia solani</i> , powdery mildew, sour rot
Modes of action	<ul style="list-style-type: none">■ Physical exclusion of disease pathogens via biofilm formation■ Production of fungicidal metabolites■ Competition for resources
Unique value proposition	<p>Pure spore formulation works more efficiently than the competition:</p> <ul style="list-style-type: none">■ More rainfast■ Productive over a wider range of temperatures■ Lower application rate <p>➤ Serifel® creates a synergistic effect when used with chemistry-based solutions</p>



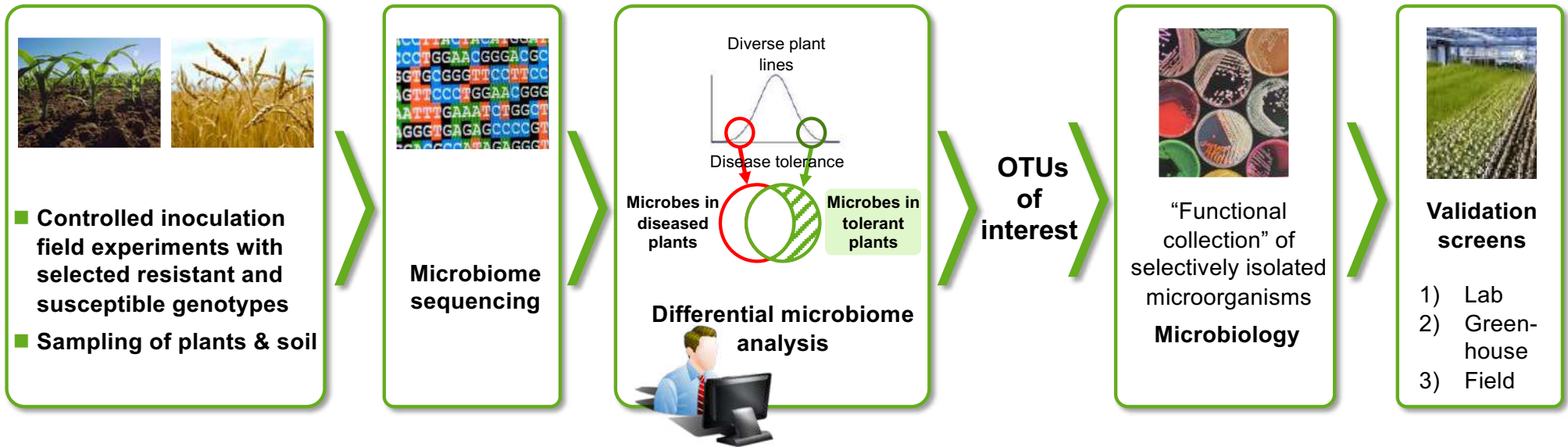
Spotlight: Serifel® - Broadening disease spectrum

Complementary tank mixes broaden the disease control spectrum



Insight into one of our discovery strategies for biocontrol biologicals

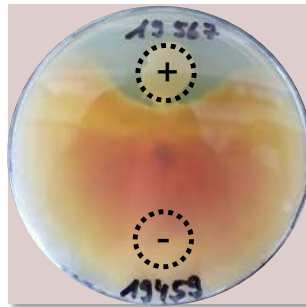
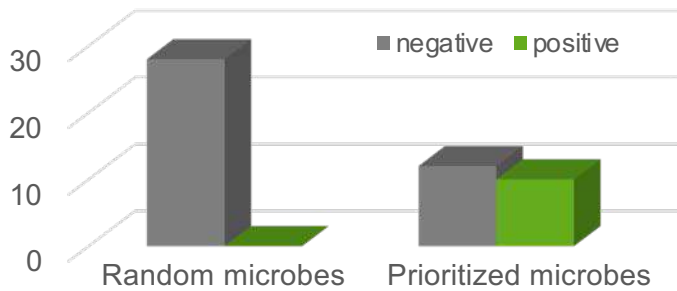
Computational discovery strategy – a differentiating approach to detect novel biologicals



First validation of the approach via functional assays

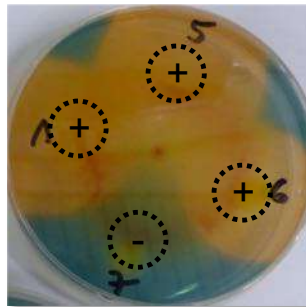
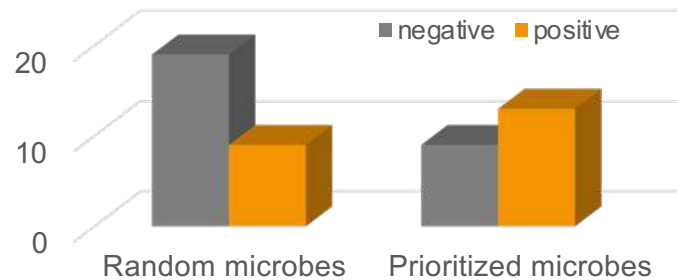
Prioritized microbes more likely to be active than random ones

Pathogen confrontation assay



➤ Functional assays are only a first evidence showing the benefit of the computational approach to identify microbes for biocontrol

Siderophore assay



➤ Upcoming greenhouse and field trials will investigate their biocontrol potential *in planta*

White biotechnology

Expertise in microbiology, fermentation and downstream processing is essential for production of biologicals

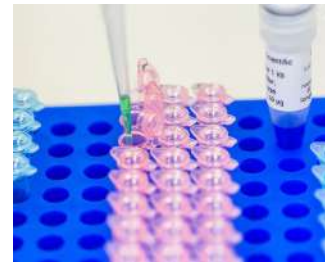
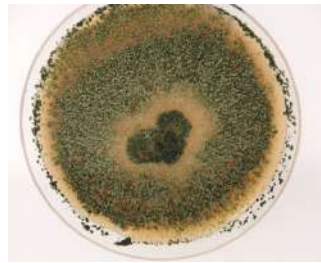
Pilot plant

- Upscaling: Shake flask → 5m³ bioreactor
- Supply of small amounts of new product candidates for initial application tests
- Development of new bioprocesses
- Optimization of fermentation and purification processes
- Process transfer to production plants



Key takeaways

- BASF is investing heavily in crop protection research with a growing portfolio of biological products
- Benefit of our computational discovery pipeline shown in functional assays, but *in planta* potential still needs to be investigated
- Biologicals are challenging from R&D and market perspective
- New product launches will strengthen BASF's position to tackle these challenges



Thank you!

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