Competence regulation in Gram-positive bacteria

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Background

Transformation is one type of horizontal gene transfer that involves the uptake of extracellular DNA by the development of a specific physiological state called genetic competence. The machinery for DNA-uptake is similar among bacteria but the competence regulatory circuits are species-specific. Here, we review the current knowledge regarding competence regulation among Gram positive bacteria.

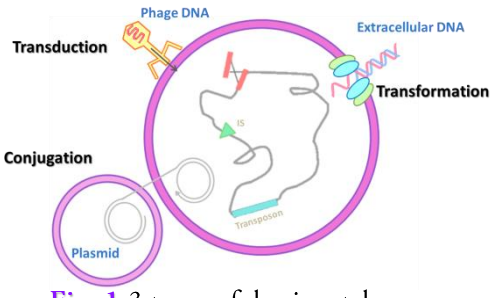

Fig. 1 3 types of horizontal gene transfer

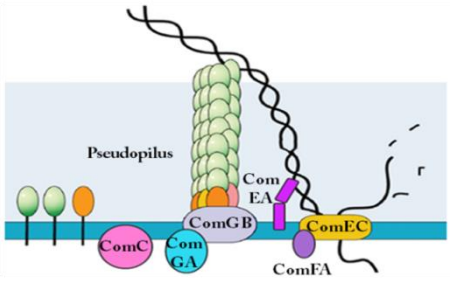

Fig. 2 DNA-uptake machinery (Modified from (1))

Competence regulation

Among Gram-positive bacteria, there are two different and evolutionary distinct central competence regulators: the alternative sigma factor ComX (also known as σ^H) and the transcription factor ComK. σ^H has two recognized functions, it regulates competence or sporulation development, while ComK role is to activate competence.

Species	Competence	Sporulation	σ^H	ComK
B. subtilis	✓	✓	✓	✓
L. monocytogenes	?	×	✓	✓
S. aureus	✓	×	✓	✓
S. pneumoniae	✓	×	✓	×

Table 1 Competence regulators in Gram-positive bacteria

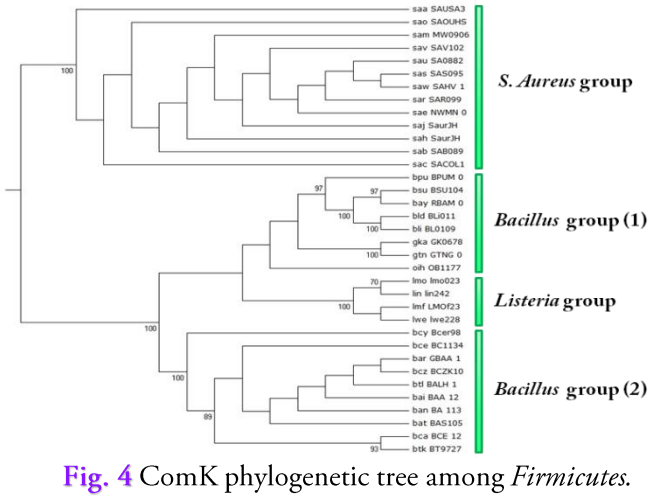

Fig. 4 ComK phylogenetic tree among *Firmicutes.*

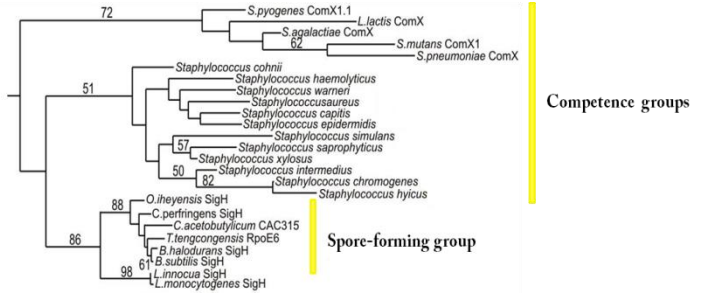

Fig. 3 σ^H phylogenetic tree among *Firmicutes.*

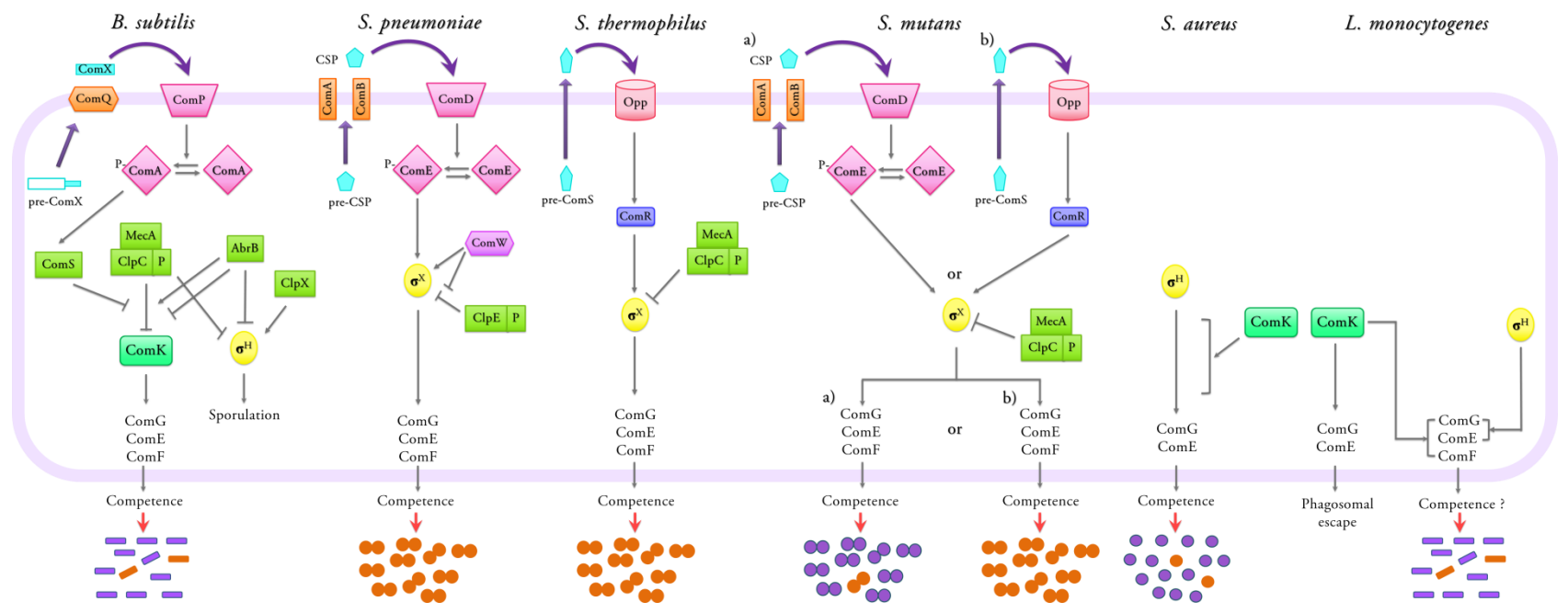

Fig. 5 Regulation pathways involving ComK and SigH in Gram-positive bacteria.

The networks that regulate competence development are complex; they involve the two reported competence regulators (when present).

- *B. subtilis,* has an interconnected regulatory network for the development of competence and sporulation. σ^H activates sporulation and ComK induces competence in only a fraction of the population (2).
- *Streptococci,* this genera lacks ComK and is non-spore forming. σ^H is the main competence regulator. However, there are differences in the regulatory flows that govern the activity of σ^H between species. Two different regulatory cascades, that induce competence in all the population, have been described in *S. pneumoniae* and *S. thermophilus. S. mutans* has a bimodal behavior; it uses both cascades and a fraction or all the population can achieve competence (2).
- *S. aureus:* σ^H controls competence development in a few cells of the population. ComK can enhance the σ^H directed transcription of *comG* and *comE* operons (3, 4).
- *L. monocytogenes:* it is unknown if it can develop competence, but the transcription of competence operons depends on both regulators. Only a percentage of the cells can express the competence genes (Medrano Romero et al., in preparation).

Conclusion

The development of competence is regulated by species specific pathways. The competence regulators and the networks that control them have evolved differently among Gram-positive bacteria.

References

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