Review

Development and regulation of single- and multi-species *Candida albicans* biofilms

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Nature Reviews Microbiology **16**, 19–31 (2018)
doi:10.1038/nrmicro.2017.107
Download Citation

Biofilms Microbial communities
Fungal immune evasion Fungal infection
Fungal pathogenesis Fungal physiology

Published online: 03 October 2017

Abstract

Candida albicans is among the most prevalent fungal species of the human microbiota and asymptomatically colonizes healthy individuals. However, it is also an opportunistic pathogen that can cause severe, and often fatal, bloodstream infections. The medical impact of *C. albicans* typically depends on its ability to form biofilms, which are closely packed communities of cells that attach to surfaces, such as tissues and implanted medical devices. In this Review, we provide an overview of the processes involved in the formation of *C. albicans* biofilms and discuss the core transcriptional network that regulates biofilm development. We also consider some of the advantages that biofilms provide to

C. albicans in comparison with planktonic growth and explore polymicrobial biofilms that are formed by *C. albicans* and certain bacterial species.

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Acknowledgements

The authors thank Sheena Singh-Babak for comments on the manuscript. Research in the authors' laboratories related to this work is supported by NIH grants R41AI112038 (to C.J.N.) and R01AI083311 (to A.D.J.), and by a Pew Biomedical Scholar Award (to C.J.N.) from the Pew Charitable Trusts. The funders had no role in planning and writing the Review or in the decision to submit the work for publication.

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Competing interests

C.J.N. and A.D.J. are cofounders of BioSynesis, Inc., a company developing inhibitors and diagnostics of *Candida albicans* biofilm formation, and M.L. is a consultant of BioSynesis, Inc. M.G. does not declare competing interests.

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Supplementary information

Word documents

1. Supplementary information S1 (box)
   The host immune response to *C. albicans*

Glossary

Yeast-form cells

Spherical fungal cells that form daughter cells, which bud off from the parent cell.

Pseudohyphal cells

Ovoid chains of fungal cells that contain constrictions (rather than septa) at the cell junctions.

Hyphal cells

Elongated, cylindrical fungal cells that contain complete septa at the cell junctions.

Extracellular matrix

A protective physical barrier that surrounds cells in a biofilm and is composed of proteins, carbohydrates, lipids and nucleic acids.

Persister cells

Non-dividing fungal cells with decreased metabolic activity that are resistant to antimicrobial agents.

White–opaque switching

The ability for *Candida albicans* cells to switch between the 'white' and 'opaque' phenotypic cell types. The switch occurs epigenetically; that is, without a change in the primary DNA sequence of the genome.

Horizontal gene transfer

The process through which genetic material is transferred between microorganisms through mechanisms such as transformation, conjugation and transduction. This process is distinct from vertical gene transfer, in which genetic material is transferred from mother cells to daughter cells.

Quorum sensing

A method of communication that allows microorganisms to sense cell density and microbial community composition and respond as a group. The process involves the production and detection of soluble quorum sensing molecules.

Glycosylphosphatidylinositol (GPI) anchors

Post-translational modifications of proteins in which a glycolipid is covalently attached and anchors the protein in the plasma membrane.

Flow cell

A light microscopy method for observing biofilm formation *in vitro* under laminar flow conditions.

Glucoamylase

An enzyme that catalyses the hydrolysis of glucosidic linkages in starch, which releases glucose.

Glucan synthase

A glucosyltransferase enzyme that catalyses the synthesis of glucans, which are critical polysaccharide components of the fungal cell wall and the extracellular matrix.

Chromatin-modifying complex

A protein complex that alters the chromatin structure.

Complement system

A group of proteins that, when activated, mediate the innate immune response and inflammatory response to a pathogen.

Mucin

A glycosylated protein that is the major component of mucus.

Ergosterol

A sterol component of the fungal cell membrane necessary for membrane fluidity.

Bacteriocin

A pore-forming peptide produced by some bacterial and archaeal species that is toxic to other microorganisms.

Nature Reviews Microbiology ISSN 1740-1534 (online)