Fungal Genetics and Biology 89 (2016) 1–2

Contents lists available at ScienceDirect

Fungal Genetics and Biology

journal homepage: www.elsevier.com/locate/yfgbi

Editorial

The art of design

Synthetic biology is one of the most important technologies of the 21st century. If one asks twenty synthetic biologists, what synthetic biology is, one would get twenty different answers (Arkin et al., 2009). Why such variations? Well, when completely new approaches are taken, often practices are not clearly defined yet. The process of image formation is still on-going; the protagonists are right in the midst; the final picture is yet enigmatic.

The most common definition of synthetic biology refers to both (i) the design and construction of new biological parts, devices, and systems and (ii) the re-design of existing natural biological systems for useful purposes (www.SyntheticBiology.org). According to George Church, one of the pioneers in synthetic biology, "a living organism, after all, is a ready-made, prefabricated production system that, like a computer, is governed by a program, its genome. Synthetic biology and synthetic genomics, the large-scale remaking of a genome, are attempts to capitalize on the facts that biological systems are programmable manufacturer systems, and by making small changes in their genetic software a bioengineer can effect big changes in their output." (Church and Regis, 2012).

Bioengineers designing and redesigning fungal organisms underscore and extend this definition by adding fungal-specific examples. One particular focus lies on discovering and unlocking the biosynthetic treasure chest of filamentous fungi which hides a tremendous reservoir of cryptic natural products such as non-ribosomal peptides, polyketides, terpenoids, and alkaloids. Engineering native and artificial hosts for a controlled/increased production of these natural secondary metabolites, designing new unnatural small molecules and proteins as well as whole genome editing to change metabolic flux is trend-setting. If penicillin was the antibacterial breakthrough of the 20th century, one of these engineered organisms may be producing the breakthrough of the 21st.

Not only scientists, but also artists think about possibilities to re-engineer fungi for a plethora of purposes. We are very proud to feature one of the pieces from the project "Designing for the Sixth Extinction" by artist, designer, and writer Alexandra Daisy Ginsberg on the cover of this special issue. Her *Self-Inflating Antipathogenic Membrane Pump* relates to a fungal-inspired synthetic biological device designed to treat the devastating plant disease Sudden Oak Death that is caused by the oomycete *Phytophthora ramorum*. Her invention is distributed via spores to establish filamentous networks within oak trees where it detects infection and produces an antipathogenic serum that is pumped into the infection site. Post-injection, the pump deflates, decouples, and spores are released. The device operates using a 6-base DNA code that produces synthetic materials, to prevent ingestion by natural organisms (Fig. 1). With this fictitious patent, Daisy hits the nail on the Janus-faced head: Fungi can be friends or foes; how we decode and reprogram them to suit global needs, is limited simply by our intelligence, ingenuity, and imagination. What

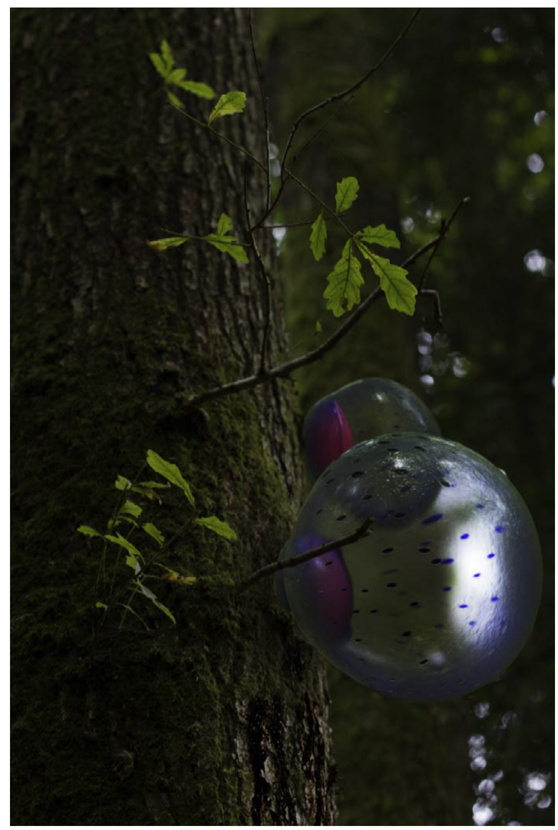

Fig. 1. Self-Inflating Antipathogenic Membrane Pump. "The single-use device is distributed via spores to establish filamentous networks within oak trees. A proprietary biochemical sensor activates the dormant network on detection of infection. A two-part diaphragm pump self-assembles with an inner and outer chamber. The self-inflating outer chamber surface is distributed with non-return valves to permit the ingress of air. The inner chamber produces an antipathogenic serum. At full inflation, the membrane pump pushes serum into the infection site. Post-injection, the pump deflates, decouples, and spores are released. The device operates using a 6-base DNA code that produces synthetic materials, to prevent ingestion by natural organisms. Biological waste is managed by the proprietary *Autonomous Seed Disperser*." Courtesy of Alexandra Daisy Ginsberg from the 2013 project "Designing for the Sixth Extinction". For more information go to www.daisyginsberg.com.

http://dx.doi.org/10.1016/j.fgb.2016.02.006

seems like today's science fiction, could become tomorrow's reality.

Welcome to the **Special Issue on the Synthetic Biology Era of Yeast and Filamentous Fungi**! This issue celebrates milestones in fungal synthetic biology of the last years and features the latest breakthroughs in unicellular and multicellular fungi. Our intention has been to compile manuscripts from both areas, yeasts and filamentous fungi, to facilitate the communication between the two scientific communities and foster synergistic efforts. This issue showcases what has become possible in terms of fungal gene and genome editing (Alexander et al., 2016; Schuster et al., 2016), how bioinformatic and genetic tools help to predict, discover (Brown and Proctor, 2016; Li et al., 2016; van der Lee and Medema, 2016) and encrypt natural products (Sun et al., 2016). Furthermore, it covers genetic engineering approaches that decipher metabolic pathways to induce and overproduce the metabolite of choice (Polli et al., 2016; Wang et al., 2016; Wanka et al., 2016) but also new-to-nature compounds (Boecker et al., 2016). Additional contributions illustrate how conventional and non-conventional yeasts are being used for re-designing nature for small molecule production and protein engineering (Bond et al., 2016; Wagner and Alper, 2016; Wiltschi, 2016; Wriessnegger et al., 2016). We invite the interested reader to dig through the issue, to become inspired and hopefully join the scientific community, to expand the dialogue for more interdisciplinary projects and discussions among biologists, chemists, engineers, bioinformaticians, artists, and designers, and to explore the possibilities of this mind-blowing field. The future is promising!

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