Bag-Bug: Adaptive Horizontal Transfers

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Abstract

Integrating biological data and phenomenon in the creative process, and proposing a transversal reflection considering the subthemes for ISEA 2017, "Bag-Bug: Adaptive Horizontal Transfer" is an invitation to reflect on the intersections between biocreation and heritage from a cross-scale perspective. Beyond media, does bioart have the capacity to preserve heritage? The ongoing project is a tribute to the Brazilian artist Helio Oiticica's work "B50 Bólide Saco 2 'Olfático' (1967; plastic and coffee)", consisting of a series of apparatus exploring genetic information horizontal transfers due to the eventual molecular scale superficial contaminations/transferences. Customized sleeping bags – plastic, coffee beans and electronics (sensor module, microcontroller and displays) – and the whole body of someone from the audience gets involved in a cross-scale conversation that can potentially consists in a "Horizontal Gene Transfer Session (HGTS)".

Keywords

Horizontal Gene Transfer (HGT), Bioart, Biocreation and Heritage, Metagenomics, Helio Oiticica, B50 Bólide Saco 2 Olfático.

Figure 1 A close-up view of the coffee berry borer. (Image source: http://newscenter.lbl.gov/2015/07/14/microbes-coffee-pest/)

Introduction

Horizontal gene transfer (HGT) involves the nonsexual transmission of genetic material across species boundaries. Although often detected in prokaryotes, examples of HGT involving animals have become commonly detected. In 2012, Ricardo Acuña from Cenicafé - Centro Nacional de Investigaciones de Café, in Manizales, Colombia, studied a case of adaptive horizontal transfer of a bacterial gene to an invasive insect pest of coffee by analyzing the genes that are switched on the little bug's guts – the coffee berry borer (figure 1). One of them – HhMAN1 – creates a protein called mannanase that breaks down galactomannan, one of the major carbohydrates in coffee beans. The bugs in question aren't meant to have mannanases.

Beyond the natural occurrence of gene transfers, through bioengineering techniques scientists are able to simply insert genes from one microorganism into another. A team of scientists from the University of Austin, as an example, developed a portable caffeine degradation operon by refactoring the alkylxanthine degradation (Alx) gene cluster from Pseu domonas putida CBB5 to function in Escherichia coli (Quandt et al, 2013).

Bacteria and humans have been swapping DNA for millennia. Studies suggest that gene transfer events can and do occur in human tissues, sometimes with devastating consequences. The human body external and internal surfaces can be seen as constantly open doors for molecular transit – and sometimes this 'transit' implies the interchange and recombination of genetic information between species.

Most of microbiome studies have been focused on the health implications of gut microbiome. As a recent phenomenon, a crescent number of labs and companies are running research experiments interested in the microorganisms that populate our glands, hair follicles and epidermis. As an example, as reported by Julia

Scott for the New York Times (Scott, 2014), L'Oréal' has patented several bacterial treatments for dry and sensitive skin. According to Doctors Elizabeth Grice and Julia Segre, in a paper published in 2011 at Nature Microbiology, viral communities, as an example, have the potential to modulate states of cutaneous health and disease. Dr Grice collaborated in an effort to establish a resource for the cutaneous research community to guide experimental design in characterizing skin microbiota, presented in a paper in January 2016 (Meisel et al, 2016).

Bug! How dangerous an Olfactive Sleeping Bag can be?

Integrating biological data phenomenon in the creative process, and proposing a transversal reflection considering the sub-themes for ISEA 2017, "Bag-Bug: Adaptive Horizontal Transfer" is an invitation to reflect on the intersections between biocreation and heritage from a cross-scale perspective. Beyond media, does bioart have the capacity to preserve heritage? Additionally, ISEA 2017 can be taken as a call to connect our reflection as artists and its hosting region n Colombia. Accepting the challenge, the work here presented explores metaphorically potential microbiome genetic information horizontal transfers in the specific region in Colombia known as the Coffee Cultural Landscape, declared as a world heritage site by UNESCO

Considering the importance of the sub-theme Bio creation and data, in the Project that is a tribute to the Brazilian artist Helio Oiticica's work "B50 Bólide Saco 2 'Olfático' (1967; plastic, and coffee)" (figure 2), the artist is working in the design of a series of apparatus exploring genetic information horizontal transfers considering eventual microbial and molecular scale superficial contaminations/transferences. Plastic, coffee beans and electronics (sensors, microcontroller and displays) and the body gets involved in a cross-scale conversation thought the approximately 2 million holes and surrounding microscopic scale neighborhoods of our epidermis. Considering the fruition of the artwork, the intention is to have 2 'bagbugs' set up in an open space – that could be a collective exhibition space, where several apparatuses – the 'BagBugs'' – will be setup on the ground allowing the audience to lay down on it. The dimension of the 'BagBugs' is 2,0 meter x 1,2 meters x 5 to 10 centimeter high.

Figure 2 Hélio Oiticica, B50 Bólide Saco 2 'Olfático' (1967; plastic, coffee). (Image source: http://espacohumus.com/helio-oiticica/

The term 'bólide' is used in astronomy to refer to an extremely bright meteor that explodes in the atmosphere. Accoring to the TATE Modern (2016) web archive, Hélio Oiticica "[…] discussed the title of the Bólide series in 1979, stating that it was inspired by Brazilian director Humberto Mauro's 1933 film Ganga Bruta (Brutal Gang)".

According to Angela Varela in her master thesis about Helio Oiticica's Bólides, there is not a fixed definition for a Bólide – it has as many definitions as its realizations (Varela, 2009). According to the researcher, if it is considered as an ongoing process more than an object, a Bólide offers open possibilities for a creative behavior. According to Hélio Oiticica (Oiticica, 2017) the B50 proposes the discovery and experience of the smell. Our proposition critically extrapolates the intention of the B50, considering an arts and science approach, and invites to a whole body experience since the audience gets immersed in a cloud of invisible particles-microbiome that can be perceived and recognized through the sense of smell and that can be distributed along the body surface – like a coffee microscopic snowstorm.

Adaptive Transfer: Cross-scale heritage

According to Cordero and Hogeweg, horizontal gene transfer is one of the most dominant forces molding prokaryotic gene repertoires that can be as small as ≈200 genes in intracellular organisms or as large as ≈9,000 genes in large, free-living bacteria. As the researchers defend, long-distance horizontal gene transfer (dHGT) can have a cumulative impact, increasing nonlinearly in large genomes (figure 3). Caffeine imparts a bitter

taste that inhibits insect feeding and can also intoxicates insects by inhibiting specific cellular activities.

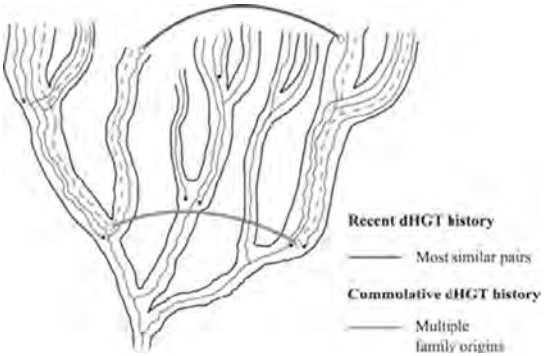

Figure 3 Illustration of the ancestral and recent dHGT events. (Image source http://www.pnas.org/content/106/51/21748.long)

Caffeine toxicity is also related to its negative effects on DNA repair and recombination. Because of its demonstrated negative effects on insects caffeine is considered a natural pest repellent. According to Ceja-Navarro (Ceja-Navarro et al, 2015), while over 850 insect species can feed on other parts of the coffee plant, and a few of them occasionally on the coffee seed. As reported by the researchers, "[…] only Hypothenemus hampei (Ferrari) (Coleoptera; Curculionidae: Scolytinae) has developed the ability to feed and complete its life cycle solely on the economically important caffeine-rich coffee bean" (Ceja-Navarro et al, 2015). The coffee berry borer Hypothenemus hampei is now present in most coffee-producing nations (figure 4) and the cryptic life cycle inside the berry makes insect control extremely difficult.

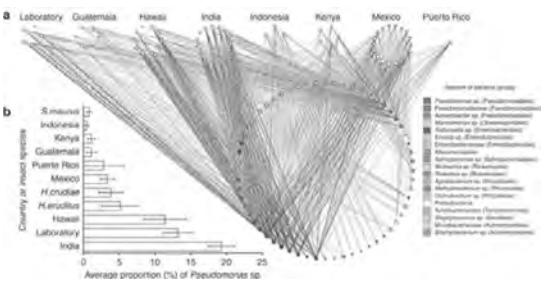

Figure 4 The core gut microbiome of Hypothenemus hampei specimens collected from multiple coffee-producing countries. (Image source http://www.nature.com/articles/ncomms8618)

The hypotheses present by some scientists is that HGT between the bug and a specific kind of bacterial is the responsible for the bug ability in digesting caffeine, that, before this transfer, was toxic for the animal. According to Ceja-Navarro (Ceja-Navarro et al, 2015), caffeine degradation in Hypothenemus hampei,is primarily mediated by the activity of its gut microbiota. He and his lab team present an interesting study of the microbiome of Hypothenemus hampei and its role in the detoxification of caffeine in the insect, documenting the discovery of a microbiota component to the transformation of caffeine and subsistence of Hypothenemus hampei on coffee beans.

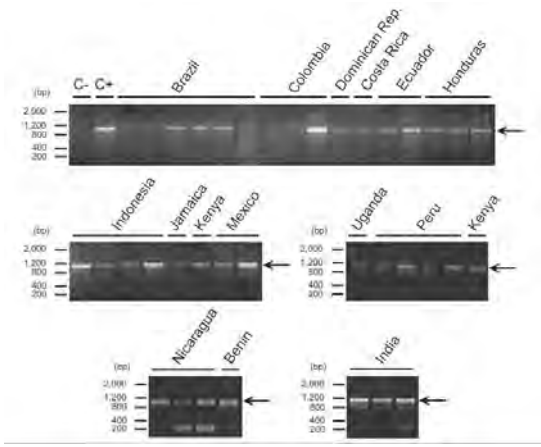

Figure 5 Detection of HhMAN1 in genomic DNA from a geographically broad range of Hypothenemus hampei accessions. (Image source http://www.pnas.org/content/109/11/4197.full.pdf)

It is important to remember that it was in the paper published in 2011 in the Proceeding of the National Academy of Sciences of the United States of America (Acuña et al, 2011) that the study was the gene HhMAN1 from the coffee berry borer beetle was identified showing clear evidence of HGT from bacteria since HhMAN1 (Figure 5) encodes a mannanase, representing a class of glycosyl hydrolases that has not previously been reported in insects.

Bag-Bug: HGT-Bólide

The human body external and internal surfaces can be seen as constantly open doors for molecular transit – and sometimes this 'transit' implies the interchange and recombination of genetic information between

species. According to a study on microbial horizontal gene transfer in humans, HGT candidates in a human microbe may originally come from either external microorganisms or from other microbes within the human body (Li Liu et al, 2012). The research show that horizontal gene transfer occurs between human microbes from different sites of human body. In the panel presented bellow (Figure 6), the microbial communities C2, C3, C6 and C9 contain high fractions of gastrointestinal microbes, but also many microbes from the skin and urogenital system. Oral microbes are mainly distributed on communities C1, C2 and C5, and frequently transfer and receive genes among themselves and to and from gastrointestinal and urogenital microbes. Skin microbes were mainly found in communities C10 and C12, and interact with gastrointestinal, oral and urogenital microbes.

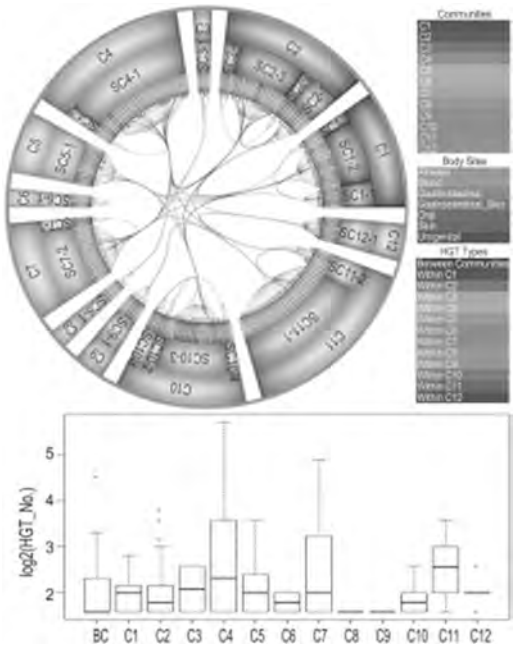

Figure 6:Horizontal gene transfer network of the human microbiome. The panel shows the hierarchical structure of the HGT network composed of 165 reference genomes. The 12 parts represent microbial communities with their respective subcommunities.(Image source:http://www.sciencedirect.com/science/article/pii/S0888754312001577)

Figure 7 Bag-Bug: Adaptive Horizontal Transfer (Digital COllage by the author)

Considered as a contribution to the reflections on biocreation and heritage for ISEA 2017, "Bag-Bug: Adaptive Horizontal Transfer", consists in a series of sleeping bags filled with Colombian coffee beans from the region known as the Coffee Cultural Landscape. Considering that the superficial molecular transfer is a fact, the audience will be invited for a 'contamination session' or, better to say, a "Horizontal gene transfer Session (HGTS)" where the whole body surface – external and internal (mouth, ears, eyes, nose) will be exposed or suitable for microbial and molecular scale interchanges.

Despite the evident metaphorical character of the work, HGT from coffee beans and powder microbiota can potentially happen since some of these microorganisms can be integrated in the population that inhabit different parts of the human body, including the skin, mouth, and intestinal tract. Considering that coffee is one of the human foods and beverages that are made from mixed microbial fermentation, Pectolytic enzymes from Erwinia dissolvens and Bacillus sp., and yeasts in the genera Saccharomyces and Endomycopsis are involved in the process as are lactic acid bacteria (Lactobacillus, Leuconostoc, and Streptococcus) (Hock, 2001). A considerable microbial population is persistent in the commercialized coffee beans and powder. This population can nowadays be documented thanks to the use of next generation sequencing (NGS) such as metagenomics, phylobiomics, and metatranscriptomics (Tamang et al, 2016).

In "Bag-Bug: Adaptive Horizontal Transfer", the electronic part of the apparatuses will be constantly collecting data from the air near the apparatuses surface that is in contact with the human body using a DSM501A (Dust sensor module) for Arduino (Figure 7). This

way, the microbial-particles' cloud can be digitalized and visualized as numerical information, feeding the imaginary of the audience with 'quantitative information related to the possible actual 'microbial and molecular scale transfers'. Both actually and metaphorically, the microbial population that is integrated with the coffee beans that has inhabited the Colombian landscapes for millennia, carrying an environmental biological heritage, will be in a cross-scale transit – potentially changing the audience microbiome configurations and possibly producing recombinant genetic scenarios that will be shared and spread all around the world.

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Clarissa Ribeiro, Ph.D., is an Architect, Media Artist and Researcher. She is currently an Associate Professor and coordinator of the CrossLab research group and the LIP (Lab for Innovation and Prototyping) at the Department of Architecture, University of Fortaleza in Brazil, supervising final year students and researchers and teaching ground courses and core studios in experimental design strategies involving robotics and parametricism. From 2014 to 2015 she was an Associate Professor at Roy Ascott Studio's B.A. in Technoetic Arts in Shanghai, and from 2013 to 2014 she was living in Los Angeles, California, as a Postdoctoral Research Scholar in Arts at James Gimzewski lab, UCLA, connected to the Art| Sci Center and Lab. Her artistic practice is viscerally linked to her research interests that for the last 20 years have been focused on investigating and understanding the influences, connections and cross contaminations between the sciences of complexity and artistic expressions and poetics involving media arts and sciences.