The International Journal of Biochemistry & Cell Biology 56 (2014) 20–29

Contents lists available at ScienceDirect

The International Journal of Biochemistry & Cell Biology

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

Growing for different ends☆

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ARTICLE INFO

Article history:
Received 3 June 2014
Received in revised form
24 September 2014
Accepted 25 September 2014
Available online 5 October 2014

Keywords:
Semi Living
In vitro meat
In vitro leather
Tissue engineered art
Tissue engineered design

ABSTRACT

Tissue engineering and regenerative biology are usually discussed in relation to biomedical research and applications. However, hand in hand with developments of this field in the biomedical context, other approaches and uses for non-medical ends have been explored. There is a growing interest in exploring spin off tissue engineering and regenerative biology technologies in areas such as consumer products, art and design. This paper outlines developments regarding in vitro meat and leather, actuators and bio-mechanic interfaces, speculative design and contemporary artistic practices.

The authors draw on their extensive experience of using tissue engineering for non-medical ends to speculate about what lead to these applications and their possible future development and uses. Avoiding utopian and dystopian postures and using the notion of the contestable, this paper also mentions some philosophical and ethical consideration stemming from the use of non-medical approaches to tissue constructs.

This article is part of a directed issue entitled: Regenerative Medicine: the challenge of translation.

1. Introduction

Tissue engineering and regenerative biology are usually discussed in relation to biomedical research and applications. However, alongside, some of the developments of this field are pursued outside to the biomedical context in areas such as consumer products, art and design (Reviewed in Tandon et al., 2014; Myers, 2012; Aldersey-Williams et al., 2008). This paper outlines developments regarding in vitro meat (food) and leather (fashion), actuators and bio machine interfaces, and provides an index of tissue engineered works in the growing areas of speculative design and contemporary artistic practices.

Within the fields of design and engineering there is a growing interest in using biological processes and materials as a new manufacturing paradigm. This new paradigm goes beyond biomimicry, it represents a shift from the logic of building to that of growing. With the increased knowledge of biological processes and modes of manipulation of living systems and matter, the notion of highly controlled and engineered growth of biological products is ever so seductive. This new paradigm covers all aspects of the life sciences and all scales of biological complexity; with the bulk of attention given to the engineering of bacteria under the guise of synthetic biology (Reviewed in Ginsberg et al., 2013). In addition the use of algae, fungi and plant material in less traditional ways is more established, probably due to the fact that these materials are considered less problematic from an ethical perspective and require quite different technical considerations (Reviewed in Myers, 2012; Aldersey-Williams et al., 2008). In the context of this article, we focus on the reappropriation of regenerative medicine technologies and hence concentrate mainly on the use of mammalian tissue and cells.

There are numerous reasons for the use of tissue engineering and regenerative biology beyond the medical applications. We would like to indulge in speculating as to the main motivations for the use of this particular knowledge and know how:

- The collaborative and trans-disciplinary nature of tissue engineering: the field develops through mutual efforts and interests of disciplines such as biology, medicine, engineering, chemistry, material engineering and more. Therefore, by its nature this field is open for diverse frames of thoughts, methodologies and applications.
- The field of tissue engineering and regenerative medicine has developed rapidly since the early nineties and led to the development of sophisticated and expensive tools and technologies. Due to economic interests (among others) there is a need to capitalise on these investments by diversifying the use of these tools to a wider range of end products that go beyond the original intent for which they were developed.

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http://dx.doi.org/10.1016/j.biocel.2014.09.025
1357-2725/

- The realisation that tissue engineered constructs that are not intended to be (re)introduced in vivo, and can operate solely within in vitro environments reduces some of the complexities and problems involved with clinical and transplant research, making way for a new venue of research; tissue constructs that act as "tools" or grown for specific ends within an artificial, technological environment.
- The abundance of tissue and its unique properties can lead to many unexpected outcomes. Also, concepts such as scaffolding, fluid dynamics, self-healing and generative materials, are prevalent in architecture, design and engineering.
- Cheap tools and DIY approaches to tissue engineering become more available and are explored by hobbyists for different ends. For Example; the DIY Bioprinter that was developed last year by members of the biohacker movement in the Bay Area in California USA as an inexpensive device to print cells (Leber, 2013).
- The rhetoric concerns sustainable modes of production and the promise of biological materials as efficient adaptations to problems of scarcity, makes tissue engineering a seductive material of fabrication.
- The Authors' work as The Tissue Culture & Art Project which led to the establishment of SymbioticA – The Centre of Excellence in Biological Arts, School of Anatomy, Physiology and Human Biology at The University of Western Australia may have played a pivotal role in the introduction of these technologies to artists and designers (Myers, 2012; Anotnelli, 2011; Stocker and Schopf, 2007). This will be discussed further in the article.

Tissue – as a medium of manipulation – will always carry ethical and philosophical implications that bring into question deeper notions regarding life and bodies, and therefore every discussion about its use beyond the strictly medical is publically debated and culturally scrutinised. Tissue derived from complex organisms for purposes beyond the strictly biomedical raises numerous ontological, bioethical and biopolitical concerns ranging from the use of animals (whether human or/and non-human); the sacristy of life; the values in terms of agency and currency of different lives and/or gradients of life and more. We will touch on some of these issues in the concluding section.

2. Historical reflections

2.1. "Earmouse"

Tissue engineering in many respects, co-evolved with the field of biofabrication (Mironov et al., 2009), both relying on the concept and actuality of the Bioreactor technology. The history and the name Bioreactor own roots are in agriculture and food production via fermentation which has been practiced for thousands of years.

The development in tissue engineering came from the collaborative work of a surgeon, Dr Joseph P. Vacanti, and a material scientist, Dr Robert Langer, in the early 1990s. They developed a system that used specially designed degradable polymers that act as a scaffold for the developing tissue. Their research stemmed and aimed for biomedical purposes; although as will be illustrated, this was never a clear cut. One of the earliest "poster boys" for tissue engineering was the nude mouse with the human ear grown on its back (nicknamed "earmouse"), developed by Professor Vacanti and colleagues in the mid-nineties (Cao et al., 1997). However, once the image of the *earmouse* entered the public realm, it had a larger effect beyond the biomedical and became one of the symbols, in the public imagination, of the best and worst in biotechnology.

The *earmouse* had also impressed upon the art world. It may be that the *earmouse* was a visceral realisation of the plasticity of the body and possibility of tissue to be used as something that may be shaped and altered in many "sculptural" forms which exceed the strictly biomedical realm. The image was inspirational to many artists (Piccinini et al., 1997; Rockman, 2000; Cadet, 2004; Stelarc, 2008; Strebe, 2014) including the authors of this paper (Catts et al., 2003) and was instrumental to our ongoing investigation into the use of tissue technologies as a medium for artistic expression.

The survey presented in this article is not chronological, and not complete; rather it takes its starting point from the use of tissue engineered constructs for utilitarian uses such as consumer goods, to more symbolic and aesthetic examples of the use of tissue technologies for non-medical purposes. Furthermore, the scope of this paper will focus on the developments of tissue engineered consumer goods and will give some introductory notes and detailed index of the contemporary artistic work done with tissue engineering. Every project presented in the index deserves a full article outlining the technical, theoretical, conceptual and aesthetic aspects the project/developer presents, but this is outside to the scope of this paper. The authors hope that the limited information provided in this article will act as a guide for further research in this bourgeoning field. However, as will be illustrated, the history of the use of tissue engineering techniques for non-medical applications was influenced by artistic work throughout the years, and some of the most recent projects speculate about future utilitarian uses of tissue engineering, within a cultural and consumer context.

2.2. Semi-Living art & SymbioticA

To start with the survey we would like to introduce another concept developed by the authors that will reappear through the article; a term used to define in vitro/tissue engineered constructs which are not intended to be implanted in a body – but rather exist and function as independent technological entities. While publishing our hypothesis for using tissue engineering for the creation of entities in the environment (Catts and Zurr, 2002) we referred to these tissue constructs as *The Semi-Living* – as these are living fragments of complex bodies which are dependent on non-living artificial support mechanism for their function and survival.

The Semi-Living are a new class of objects/beings constructed of living and non-living materials; cells and/or tissues from a complex organism grown over/into synthetic scaffolds and kept alive with an artificial support. They are both similar and different from other human artefacts (homo-sapiens' extended phenotype) such as constructed objects and selectively bred domestic plants and animals (both pets and husbandry). These entities consist of living biological systems that are artificially designed and need human and/or technological intervention in their construction, growth and maintenance (Catts and Zurr, 2013, 2010, 1998).

Experiments with Semi-Living tissue constructs were and are conducted globally, though the focus for artistic explorations with regenerative biology stemmed from the work of the authors through their Tissue Culture & Art Project, initiated in 1996 as an open ended research project, exploring the use of tissue technologies as a medium for artistic expression, and later through the establishment in 2000 of the SymbioticA Laboratory. SymbioticA is the first research laboratory of its kind, enabling artists and researchers to engage in wet biology practices in a biomedical science department. SymbioticA is unique as it enables a creative biological research by non-biologists who are embedded within a scientific faculty at the University of Western Australia. SymbioticA encourages better understanding and articulation of cultural ideas around scientific knowledge and informed critique of the ethical and cultural issues of life manipulation. The Centre offers a new means of artistic inquiry where artists actively use the tools and technologies of science, not just to comment about them but also to explore their possibilities.