Skin does not necessarily form a distinct border between the inside and the outside of an entity, even of something that is already known and concrete. *sk-interfaces* – to use the neologism coined by Jens Hauser for the exhibition at FACT – lack concreteness, as skin is a medium that is continuously growing. When artists deal with tissue culture and various kinds of skin, they use the potentials of the medium in a very material way, similar to the way in which a landscape architect makes use of the growing potential of plants within specific limits. Tissue can shift the borders of organisms and species and, when used as a material in art, it can question the limits of what was once thought to be known. This essay will, therefore, emphasize the tension between the physicality of 'skin' as a medium and the disformation of *what* actually grows.

Endogenous Design of Biofacts:
Tissues and Networks in Bio Art and Life Science

Nicole C. Karafyllis

ENDOGENOUS DESIGN AND THE MEDIALITY OF SKIN

Here, skin is not considered a mere surface nor a physical container but instead as a hybrid of constantly rearranging natural and social orders. As this hybridity can be triggered by the endogenous design of living things normally employed in the biosciences, its products are called *biofacts*.[1] Fused from the Greek 'bios' for life and the Latin 'artifact', this neologism is itself a hybrid. The word *biofact* still carries the connotation of technical interference with life to arrive at ends envisaged by a human designer, even if the act of interference leaves behind no traces. Biofacts can grow inside the lab or outside, challenging the very border of the laboratory. These living sculptures seem to overcome the design stage during growth. However, they still hint at what they once were and at what they are supposed to become in the future. The modality of biofacts is a general 'inbetweenness'. They materialize in the space 'in between' what is necessary for life and what is possible. Working with tissues requires laboratory skills to cultivate, inhibit and stimulate living media. For that reason artists cannot use cells or tissues as they would use 'dead' materials because they need the medium's specific, endogenous capacities for design. Biofacts exist as the intermediaries of functions which were initially modelled by others but which in the end they have to create themselves.

At present, we are experiencing a general tendency towards rematerialization in new media art, which is taking place in light of an ongoing biologization of the soul, the innermost part of living beings which is assigned no specific location. The internal was always the concealed which had to be exposed before it could be studied. In contrast, the external was the visible casing upon which internal happenings left their mark. Skin as the physical border was and is, therefore, always also a medium of representation of the external past and the internally changeable. It presents the subjectively experienced, scarred and acute and yet, as a tissue capable of regeneration, belongs to the interior of the subjective body (German: *Leib*; French: *le corps propre*). As signifier and signified it provides physiognomical images on the medial border between the interior and the exterior of individual humans as well as other creatures. Even when it is operatively tightened ('lifted'), browned by the sun or tattooed, it says something about the individual and the person's subjective depth of character: the desire to re-fashion and rejuvenate the self. In the face of the other the skin still cannot be objectified.

Tissue can cross the boundary between art and science, as well as between public and private. The term 'tissue culture' even suggests this crossing of nature and culture, the existence of tissue in biology laboratories and the possibility of shaping it in the life world (*Lebenswelt*). Tissues are cultivated and modelled and in the process continue to grow on their own. The following example is almost paradigmatic for endogenous design in so-called 'Bio Art': in her *hymNext Designer Hymen Project*, artist Julia Reodica takes the experimental activities of the laboratory into the private sphere of the home, growing

1 Nicole C. Karafyllis (ed.), *Biofakte. Versuch über den Menschen zwischen Artefakt und Lebewesen* (Paderborn: Mentis, 2003) and 'Biofakte – Grundlagen, Probleme, Perspektiven', *Deliberation Knowledge Ethics/ Erwägen Wissen Ethik* 17.4 (2006), 547–58.

artificial hymens *in vitro* which people can potentially then transplant onto themselves. When we explore the 'othering' of the laboratory in this, at least three viewpoints emerge: free space (into which the growing objects will be 'released'), the life world (in which subjects deal concretely with these new types of 'growths') and society, which of course consists of more than just laboratory assistants and scientific experts dealing with breeding and biotechnical cultivation. When artists use laboratory techniques and imagery, they problematize not only the borders between *in vivo* and *in vitro* but above all the third conceptual method of biological sciences as well: *in situ*. 'In situ' refers to the location where something 'naturally' happens.

The provocative questions posed by the *hymNext Designer Hymen Project* are manifold: Why does the hymen have to grow inside the body? Why does the act of defloration have to take place in the female body, and why only once? And why does the costly restoration of the hymen before marriage, which takes place dozens of times each day as a result of societal pressures, have to take place within the exclusionary domains of experts, that is, in laboratories and clinics? The recovery of the awareness of one's own virginity, of the new ground, the *tabula rasa*, is an element in overcoming elitist laboratory borders. These metaphors suggest that a person can repeatedly begin again and grow in their own life and have a personal history of beginning which is not stipulated by a third party. That means that there are no alternative experts for one's own 'life' and the 'lives' of others any more than there is an alternative owner. One of the discursive symbols that refer to foreign possession, the hymen is a membrane that belongs neither to the internal nor to the external regions of the female body and its biological function remains unclear. It is a skin *under* the body skin, yet nevertheless a delicate skin growing *on* the surface-tissue of the vaginal channel. Even after being stretched or torn, small pieces of the membrane remain on the vaginal surface. However, in the body of an adult woman the hymen no longer grows. Rather, its material limits represent a functional shift in 'being a woman' against the background of ownership. Reodica describes her project as follows:

> *The hymNext Designer Hymen Project* is an installation that comments on modern sexuality, confronts the traditional roles of the female body, and presents a collection of synthesized hymens. The unisex hymens are sculpted with living materials and the artist's own body tissue into a variety of designs for application on the human body.[2]

The *hymNext Designer Hymen Project*[3] initially appears to consist merely of the *in vitro* breeding of hymens, which are grown from a mixture of fibroblasts from a man's foreskin (no more definite origin is given), smooth muscle cells from a rat aorta and the artist's own vaginal tissue cells. At first, the unisex hymen hybrids develop as a result of the use of biochemical stimulants. They grow on Petri dishes in artificial metal forms (reminiscent of the biscuit cutters used for baking Christmas biscuits) and on artificial matrices of bovine collagens. With the aid of a ceremony box, in which the 'finished' hymens are stored, the deflowering ceremony can be repeatedly performed as a ritual event. This means that a person can be deflowered and can deflower others – irrespective of gender – many times over. Alongside the gender aspect of this installation, which points to internal growth as the pure and virginal in women which someone (a man) could culturally appropriate, Reodica's designer hymens reflect a certain personalization through the use of one's own body tissue. They belong to the individual because a person can 'make'

2 Cf. http://www.vivolabs.org (accessed 7 December 2007).

3 Reodica's installation-happening was first shown on 8 April 2005 at *Living Sculptures*, Contemporary Arts Center, New York.

Julia Reodica, *The hymNext Designer Hymen Project*, 8 April 2005. Metal forms for the cultivation of artificial hymens and cell seeding on Day 1. Artist's body tissue, rat aortic smooth muscle cells, bovine cellular matrix, cell media. Courtesy of the artist

the hymen, and in using it can establish a boundary which one breaks through or allows to be broken through – or perhaps does not. People can mix their own tissue with that of other people or even with that of animals. Rat cells and human cells and bovine growing matrixes generate a flimsy, transparent membrane on a Petri dish which can be symbolically transplanted wherever one wishes. Men, too, here have the opportunity to ritually perform their deflowering. The living laboratory ('vivolab') is conceived of as the site of individual education, in which people continually externalize and internalize themselves, and not as a hidden stronghold of expert culture behind institutional walls.

Purification is a theme of this installation in a variety of ways. First, ritual innocence is stressed critically as a biographical purity that will be lost. Secondly, Reodica plays with the concept of sterile culture and of contamination in the laboratory, which must be prevented in order to ensure the growth of the hymen.[4] Thirdly, a sociological interpretation of Reodica's project of replacement hymens can be made in the context of Bruno Latour's notion of purification. Because the modern era especially defines itself, according to Latour, by so-called purification processes, in which the notion of hybridity is *not* condoned but which instead promote segregation, hybrids are driven underground and are a burden to institutions.[5] Purification is a process of denaturalization, which in turn promotes the homogenization of human, animal and vegetable entities (and the all-inclusive organism metaphor is an element in this homogenization). This suggests that people should be purified, healed and freed from that which leads to social inequality on the basis of a natural occurrence, for example, when people of particular ethnicities, whose noses or ears have grown 'differently', want to be surgically adapted to conform to a certain notion of 'human'. On the other hand, this process is at the same time a renaturalization of the body insofar as it is desirable that the technology that played a role in designing the body, and the fact that the homogenized nose is not a natural development, should remain imperceptible. 'Sameness' should appear 'natural'.[6] Endogenous design, which transforms skin into a medium for artistic creation, leads to the fusion of denaturalization and renaturalization because that which has been artificially normalized still grows as the body matures.

BIOFACTS INSIDE AND OUTSIDE THE LABORATORY

In the life sciences, trans-species production of biofacts and their implantation in other contexts is quite common. For example, 'purified' viruses are used as vectors in order to smuggle genetic information from an organism into a host and integrate it into the host's genome. Such a course of action is called a 'controlled infection'. The exogenous DNA thereby becomes endogenous, and the host's own cells grow in accordance with the once-foreign information, assuming that the infection has been placed properly, that is, integrated in a specific locus on the host's DNA. A recurring problem is that the gene-expression of the foreign DNA is only sustained in the short term rather than the long term by its 'own' DNA; nature often re-corrects the designer's corrections. Controlled infection takes place not only through the instrumental use of widely varying species components (viruses, bacteria, yeasts, plants, animals and humans), all of which must be bred and cultivated in the laboratory, but it also functions – more or less – across classes. Naturally occurring infections are consequently exploited for technical purposes. Thus, for example, tobacco mosaic viruses are used for the controlled infection of cultivated plants and influenza

4 Email communication from Julia Reodica with the author on 19 April 2006.

5 Cf. Bruno Latour, *We Have Never Been Modern* (Cambridge, MA/London: Harvard University Press, 1993).

6 See Peter Wehling, 'Social Inequalities beyond the Modern Nature–Society Divide? The Cases of Cosmetic Surgery and Predictive Genetic Testing', *Science, Technology & Innovation Studies* 1.1 (2005), 3–15.

viruses for the controlled infection of people, for example within the framework of an experimental gene therapy for lung diseases.

A growth type that is technologically modified in the laboratory and then released into society as if naturally occurring (e.g. transgenic plants) was first defined in 2001 as a *biofact*, initially within the framework of scientific theory and natural philosophy,[7] and without any reference to 'Bio Art'. This coining of a new term came about because of unremitting public resistance to agro-genetic engineering, which since the 1980s had been producing optimized plants in laboratories which, once released into the public sphere, no longer bear the marks of gene-technological manipulation. It is not merely the question of risk but precisely the invisibility and untraceability of genetically modified plants that stimulated political debate. Clearly, the differentiation between nature and technology is significant for praxis in the life world. Because the argument about the terms 'nature' and 'technology' was (and still is) carried out to some degree on ideological grounds, a newer term became necessary to account for the condition of 'inbetweenness'. At the same time, at the turn of the twenty-first century many were attempting to efface the terminological clarity of terms for mixtures such as chimera, bastard, hybrid and cyborg – which in the scientific community still exclusively referred either to animals (chimeras), plants (bastard, hybrid) or humans (cyborg) – for epistemological reasons. With biofacts, the borders between plants, animals and humans are terminologically removed because they have also been methodologically removed in the laboratory. Accordingly, the life sciences laboratory does not consist merely of the experiment room, with the character of a workshop, in which nature is analysed and reproduced, but rather of a variety of cultivation and reproduction rooms, from incubators to hothouses and media rooms in which growing things are stabilized and new growths are produced. Working with substances capable of growth is always provisional and remains dependent on the body and moist media (blood, plasma, gelatine, buffer solutions). Growth and its corresponding media belong to the typical 'malleability'[8] of living things scrutinized in the life sciences.

The term 'biofact' is supposed to occupy the terminological no-man's-land between concepts of nature and technology. The term refers to products that are necessarily at once finished *and* unfinished. This also includes the possibility of manipulated self-reproduction, currently in experimental stages within the laboratory, for example with the aid of purified endogenous retroviruses such as HIV, to which germ line cells may fall prey (or with which they may be artificially infected). Biofacts are natural-artificial hybrids which enter the world as the result of a deliberate procedure but which can, nevertheless, grow. However, while biofacts may grow, they no longer grow independently. Growth is taken here to be the epitome of the alliance between nature and life, which is why such living products always appear to be natural. In contrast to bionics, the interest in biofacts, with respect to the technical possibilities of design, is not in the final form *after* it has grown but rather in the possibility of this growth *before* it has taken place. Therefore the border layer, the skin, in biofacts is from the very beginning not only a medium but also a biotechnical means for a targeted growth. In biofacts, the prosthesis, which is always considered external, from the very beginning grows internally as well. In the words of Jean Baudrillard,

> if the prosthesis is commonly an artifact that supplements a failing organ, or the instrumental extension of a body, then the DNA molecule, which contains all information relative to a body, is the prosthesis par excellence, the one that will allow for the indefinite extension of this body by the body itself – this body itself being nothing but an indefinite series of prostheses.[9]

Baudrillard's statement, however, does not encompass the subjective perception of the independent body situated within the wealth and limitations of personal experiences which are shared with others. Purified DNA is not information and it is not a body; rather it can, when situated correctly, become *informatio* in the true, that is phenomenal, sense of the word.

The various techniques of *endogenous design* are included in these conflict-laden perspectives. This collective term suggests such diverse approaches as regenerative medicine, nanotechnology, gene therapy and biostimulation. In this essay, I am going to concentrate on the models relevant for biomedicine. Biomedical models are based on the dialectic of oppositional concepts – on the one hand, inner and outer and, on the other, growth and movement. They cannot manage without a notion of complete, healthy and functional ideotypic *bodies*, in the broadest sense; however, they attempt to regulate their growth process to the point of functionality within society from the inside out and thereby to mask the fact that growth is an element of their structure. Both denaturalizations and renaturalizations are part of this process. Observed from outside, the bodies appear to develop naturally and thus to *be* 'natural'. Growth as a process suggests an inherent dynamic, although directed growth ensures from the beginning that technical control and the feedback loops of society and the body of the future are taken into consideration *a priori*. This trick, applied across the fields of science, of allowing living material to grow as natural material, although it is considered technology and is cultivated for specific purposes, can be summarized with the keyword *biofacticity*. Biofacticity is found at various levels of 'life' and connects genetic engineering with social engineering, that is, the biological modelling of bodies with the technical modelling of society. Its most important characteristic is the levelling out of the difference between model and reality. The most important meta-subject in this area at present is the 'human' brain, although in neuroscience this always means a particular model human: rational, functional, young and male.[10] But since this perfect brain must also first be created and grow, the pre- and post-reproductive work and thus also partner choice and pregnancy (elements conceived as female) have recently received a great deal of attention in the neurosciences. 'Neurological' requires 'biological' (including blood and hormones) in order to come into existence, despite computer modelling of the brain as a network.

TRANSPLANTS: THE INTERNAL IS TEMPORARILY EXTERNAL

Techniques for opening the body and the soul, which turn the natural inside-out, have been communicated via images since the Early Modern era, like those physiognomical patterns for interpreting surface structures. Since then, people have wanted to peer beneath the skin and thus into the internal workings of natural things, though originally they could not examine their own. In the twentieth century, the physiological sketches, woodcuts and copperplate engravings were supplemented by x-rays and ultrasound scans, among other technologies, which allowed people to see their own hearts, tumours and embryos. Nature beneath the skin is visible today via technology and thus made accessible in the external sphere. The objectification

7 Cf. Nicole C. Karafyllis, *Biologisch, Natürlich, Nachhaltig. Philosophische Aspekte des Naturzugangs im 21. Jahrhundert* (Tübingen/Basel: A. Francke, 2001), 189ff.

8 Karin Knorr-Cetina, *Epistemic Cultures* (Cambridge, MA/London: Harvard University Press, 1999), 26.

9 Jean Baudrillard, *Simulacra and Simulation* [1981] (Ann Arbor, MI: University of Michigan Press, 1995), 98.

10 Nicole C. Karafyllis and Gotlind Ulshöfer (eds), *Sexualized Brains. Scientific Modeling of Emotional Intelligence from a Cultural Perspective* (Cambridge, MA: MIT Press, 2008 in press).

of the body's interior has meanwhile reached the personal sphere, but it always operates with normalizations of organs and dispositions that bear the epistemic trace of objective history and thus the history of others and the external. Interiors that can be seen and be recognized as one's own must have once been the other, exterior. The body is the most important mediating concept between inner and outer, and where it no longer exists or does not yet exist, natural and cultural reflection on its relation to the world is difficult. It is remarkable that literature in the philosophy, history and sociology of science – critical of the idea of scientific progress – has focused primarily on supposedly natural bodies or corpuscles (cells) and their technical analogies with machines. Within the framework of cybernetics and with regard to the control and regulation of living beings, organic and machine metaphors have become obligatory.[11] However, the use of machine metaphors to describe the body dates back earlier than the Early Modern era, and can be found in Aristotle and his theory of the *organon*, which can be translated as 'tool'. A perspective that is often forgotten in all this, however, is that of the *vegetal*, which has always accompanied the machine discourse.[12] This refers to both the pre- and post-bodily defining characteristics of humans. These include the substantial capacity of instinct and of assimilation, which show themselves in the creation and passing away of 'life' and which have their indefinable interior in the modern psyche. The Freudian *Trieb* (literally 'shoot' but often translated as 'drive') grows 'there' independently, without knowing its particular place, its beginning or its purpose.

In *De anima (On the soul)* Aristotle describes the soul of plants (*anima vegetativa*) as the lowest and essential stage of an ontology of life which can strive beyond the animal stage – the physical stage and the stage of perception – to the stage that is actually human: reason. With the introduction of the modern term 'mind', the soul is finally cleansed of vegetable drive metaphors and denaturalized. Simultaneously, however, it is also biologized, since through 'life', plants, animals and humans are connected as a special nature. Across cultures, life begins with plants, and as a result of this metaphysical view of life every living thing is at the start vegetal. For Aristotle, due to their lack of perception, plants were not considered *living beings* (Greek *zoa*) but rather *living things* (Greek *zonta*) (*De anima* II 2.413b) which conceptually united *nature* (Greek *physis*) with the growth and passing of life in particular *forms* (Greek *morphe*). Since then the autonomous and transgressive vegetal has been the epitome of nature, opposed to technology and instrumental agency. Aristotle's conception of nature and technology is still central for the modern Western world, and the idea of a vegetal beginning is even older than Aristotle's philosophy. In Homer's *Odyssey*, Odysseus digs for the hidden roots of an all-powerful plant, for its *physis*, in order to protect himself against being transformed into a pig by Circe.

At first glance, Aristotle's theory that whatever grows 'from itself' is natural and that whatever is set in motion 'from outside' is technological appears to be suitable for the everyday world without qualification. His technomorphic model of the body as a house and its regulated functions as the household (Greek *oikos*) is similarly convincing. A body is run according to material and formal aspects, similar to the activity of a technician, who for Aristotle is simultaneously both an architect and a craftsman, that is, he plans and builds an object for a particular purpose. In his *Physica (Physics)*, however, Aristotle replaces the concept of growing-from-itself with that of self-motion, which had a momentous impact on the West. Precisely because the *Physica* has historically been one of the most

11 Cf. most recently Barbara Orland (ed.), *Artifizielle Körper – lebendige Technik. Technische Modellierungen des Körpers in historischer Perspektive* (Zurich: Chronos, 2005).

12 This is thoroughly explained in Nicole C. Karafyllis, *Die Phänomenologie des Wachstums. Zur Philosophie des produktiven Lebens zwischen Natur und Technik* (Bielefeld: transcript, 2008 forthcoming).

widely received and critically examined books in the Aristotelian canon, this conception of a self-organization of the natural qua controlled movement has persisted over the centuries. However, in Aristotle's biological writings (especially *De anima, De generatione animalium* and *Historia animalium*), and there primarily with regard to the consideration of embryology, the technician is not an architect of the living but rather a gardener and cook: through planting and incubation, with the help of a mixed substance containing the soul, he develops the form of something which must first become a body.[13] 'Inner' and 'outer', with strict boundaries, do not yet exist, but there are indeed inherently dynamic media such as blood, flesh and soul which one has to know how to mix in the right way at a particular natural location. This mixture yields a milieu from which something emerges. In the hierarchy of nature in the ancient world, this mixture creates the plant soul, which in animal and human bodies is still located in the stomach. There the plant soul is responsible for nutrition, growth and reproduction. In medical history, the tissue of the liver, the uterus and the skin fall under its influence, since these tissues could renew themselves for the entire life of the being.

It is precisely this vegetal capacity that is now required in the laboratory for the production of bodies, and that brings together epistemic approaches to a functional design of the living. Techniques for seeding and transplantation as well as procreation are included here, techniques which always relate to a preconceived notion of completed growth. The typology of biofactual phenomena therefore also includes areas beyond biology, such as imitation, automation, simulation and fusion, which initially determine particular forms in nature and make them imaginable. The design of biofacts is not really endogenous since the origin, when technologically modelled, is no longer hidden in an imaginary interior.

Art that appropriates tissue engineering as a means for its creative purposes explicitly plays with this dialectical potential. Thus, Oron Catts and Ionat Zurr from the Tissue Culture & Art Project, in *Disembodied Cuisine*,[14] speak explicitly of 'seeding' their cells in (or on) their biodegradable polymer-framed sculptures:

> This is an exciting moment – that's the seeding. It's like being a farmer seeding his field. Farming is also a human construct – it is only a difference in complexity, we are creating something that could not exist in nature. These parts of animals were living happily as part of a muscle of a frog. We are now providing a new body for those cells to grow into.[15]

What is categorically new here, then, is the notion that the internal is not merely the opposite of the external, but rather a preliminary stage of an interiority that must still be achieved, that is to be made visible and that can be influenced. 'Nature', then, is no longer the other of 'technology' but its earlier *and* later stage, when reading 'technology' from a historical-biographical perspective, as Gilbert Simondon, for example, suggested.[16] The achievement of an 'artificial naturalness' is, on the other hand, the result of an abstract, prototypical modelling of natural design potentials (of a 'natural artificiality'), for example genes or totipotent cells. Thus, the interior of the individual's own body is less the focus of the concept of biofact than the individual(ity) of the interior. For while the interior of an individual is accorded concrete form through graphic representation, a biofact, as a kind of dialectical negation of visualization, provides no real image for recognizing the living but rather malleable material with its own inherent dynamic and open form.

13 One of the places in which the technician of the living acts as a cook is *De generatione animalium* II 6.743a 26ff.

14 *Disembodied Cuisine* was produced in conjunction with the *L'Art Biotech* exhibition in Nantes as a performative installation whose theme was 'meat production without victimization'. The Tissue Culture & Art Project cultivated tissue to create a pseudo-positivistic junk-food alternative to massive factory farming. Edible 'semi-living sculptures' were cultivated from isolated muscle cells from frogs on biodegradable polymer scaffolds in bio-reactors. See Oron Catts, Ionat Zurr and Guy Ben-Ary, 'Que/qui sont les êtres semi-vivants créés par TC&A?', in Jens Hauser (ed.), *L'Art Biotech* (Nantes/Trézélan: Le Lieu Unique/Editions Filigranes, 2003), 20–32.

15 Quoted from *Pictures at an Exhibition: Disembodied Cuisine by the Tissue Culture & Art Project*, a video by Jens Hauser (Paris, 2004).

16 Gilbert Simondon, *Du mode d'existence des objets techniques* (Paris: Aubier, 1958).

The amorphous nature of becoming shifts into technical focus as homogenate or matrix, like a brown layer of humus, without itself being able to provide an image of growth still under way. Mediating models and their images, like that of the network, are thus necessary for the design process. In the language of endogenous design, 'technology' starts conceptually with 'interior' and allows something to grow, through which the term nature appears to become obsolete owing to a quasi-natural design. As a result of developments in tissue engineering and stem cell research, 'semi-living' models of something that does not yet have a body but could have one and, if the occasion arises, should have one, are increasingly at issue. This is also a central idea in art concerned with biotechnologies, such as the diform organic doll-size garments of *Victimless Leather*[17] by the Tissue Culture & Art Project, or Orlan's *Harlequin Coat*,[18] a prototype of a biotechnological coat containing skin cells of various origins bred *in vitro*.

Skin, membranes and tissue become substances with which something can be designed. Skin is no longer the medium and border of bodies and individuals but rather an imagistic vehicle for designers that should grow either internally or externally – although it is unclear how such spatially assigned borders become plausible. Tissue can be implanted, replanted or bedded out, respectively, depending on the purpose it is intended to fulfil. It should, therefore, be open and yet not transgressive and still locate its border of interiority. How this process of appropriation, which is not a classic integration process, can take place and by whom it will be carried out remains questionable in view of the biotechnical and IT possibilities. Precisely because with biofacts the trace of technical production is lost through growth, doubt is sewn outside the laboratory about just what it is that has grown. In any case this process must be recognized by a self in order to belong to it bodily – and that also means biographically – and it is precisely here that problems arise through the objectifications of third parties. Plants and tissues, in the literal sense of 'network', constitute cross-disciplinary metaphors for such processes, which upset the classic subject–object dichotomy.

Why is the phenomenon of growth of such central importance? In scientific theory growth is almost exclusively modelled as movement ('interaction', 'self-organization') and quantity, while the general public is still familiar with growth as potential regeneration and quality. Between these two conceptual poles so-called blind spots emerge in relation to technologies of the natural, and their mediality. These blind spots will become clear in the example of the concept of a *network*, which terminologically belongs to the metaphorical field of tissue. The metaphor of the textile network as unfinished tissue has always gone hand-in-hand conceptually with the anatomy of adult bodies and functional organs.[19]

Tissue and Networks

Only following the modelling of neural networks by brain researchers, who on the one hand speak of the brain's plasticity (i.e. of its principle of openness to the world) and on the other hand of its endogenous design (i.e. of the principle that it can be technologized), have the humanities in the twenty-first century come to understand that even the spirit requires fluid media and – in the words of William James – is not purified 'mind stuff'[20] but rather a part of the subjectively experienced body. These media have their own historicity of having been grown and are physically existent. In contrast to construction, design can only become effective technical activity when the starting material, as well as the end product, are understood as merely temporary. In anticipation of a technological term

17 http://www.tca.uwa.edu.au/vl/vl.html (accessed 3 November 2007).

18 In BEAP, *Stillness* (Biennale of Electronic Arts Perth, 2007), 44.

19 Thus, for example, the textile metaphor 'needlework' used by Nehemiah Grew, a plant anatomist, at the end of the seventeenth century, and the naturalist Charles Bonnet in the early eighteenth century, who imagined body tissue as weaved by looms. Cf. Nehemiah Grew, *The Anatomy of Plants* (London: The Royal Society, 1682); Charles Bonnet, *Philosophische Prinzipien* [1754], ed. and trans. Tobias Cheung, *Charles Bonnets Systemtheorie und Philosophie organisierter Körper* (Frankfurt am Main: Harri Deutsch, 2005).

20 William James, 'What is an Emotion?', *Mind* 9 (1884), 188–205.

oriented upon design and modelling, the neo-Kantian Ernst Cassirer spoke as early as 1930 of the 'plasticity' of formed nature as its 'inner flexibility', the reforming of which is the task of culture.[21] The project to apparently overcome bloody and muddy nature marches straight through the life sciences, which are, primarily, technological sciences including mathematics and computer science. In the Early Modern era the boundary of growth, which was understood as the border layer *upon* which growth was perceived, was reconceived as an abstract, moveable point in a Cartesian coordinate system. Growing entities became – by means of the mathematical ability to represent something using points – 'pointilistic things' with apparently fixed bodily boundaries at particular points in time. Foucault's *The Order of Things* and Latour's *Parliament of Things* could, in an approach to growth in the modern era critical of ideology, be expanded to include a *pointilism of things*.[22]

This becomes particularly clear in the network modelling of growth, which is fundamental, for example, for protein modelling in proteomics. The proteome, as an accumulation of molecules containing protein which derive from a specific genome, provides the three-dimensional type case for the body in biomedicine that, nevertheless, like the genome, remains interactive and continually reorganizes itself. Network modelling achieves the epistemological step from DNA as a text structure for the genome[23] to the proteome as a three-dimensional body structure of a synthetic conception of 'life'. With the aid of this model, it becomes possible to visualize what can become of genetic structure. Here we come across a second blind spot in biofacticity, because 'becoming' is understood in this modelling as exclusively functional: only a protein that makes it possible to conceive of a function for the entire organism can be calculated in the model. The term 'ability' also remains an open question in the modelling of something that 'can become' something. Do abilities grow, so to speak, naturally and are they thus, on the basis of their capacity, endogenous or can abilities be supplied from outside, technologically? To answer this question, a more detailed examination of current network modelling is necessary. In bioscientific attempts to discover the endogenous potential of living beings, genetics provides a heuristic for establishing structures that are capable in the broadest sense, and that can become specific capacities with the aid of technology. For this, they must be controllable in the laboratory. Since the recent successful total sequencing of the genome of the thale cress (Arabidopsis *thaliana*), yeast (Saccharomyces *spec.*), the roundworm (Caenorhabditis *elegans*), the fruit fly (Drosophila *melanogaster*) and, as of 2001, human beings (Homo *sapiens*), proteomics has focused on the systematic examination of a gene's products (proteins). Practitioners view proteomics as functional genome research in which primarily bioinformaticians collect so-called expression data and create interactive networks (protein–protein interaction networks) on the basis of *random scale-free network* modelling.[24] 'Interaction' is one of the important keywords in the creation of a network, because the proteome functions in the discovered structures of the genome are what is sought. The model term that mediates between the genome and the proteome is the *interactome*, and it models growth, along bioinformatic lines, as the movement of data. With such methods it becomes clear that speaking of *converging technologies* from biotechnology, information technology and nanotechnology is to some extent justified. For this reason biofacts can also not be assigned strictly to the field of biotechnology; rather, they first pass through certain typologies of technical formation which lie beyond biology. In the process, the types of biofactual effects discovered (imitation, automation, simulation and fusion) are put to use in the production of a functional interaction

21 Ernst Cassirer, 'Form und Technik' [1930], in Ernst Cassirer (ed.), *Symbol, Technik, Sprache* (Hamburg: Meiner, 2nd edn 1995), 39–91, here p. 60.

22 Michel Foucault, *The Order of Things. An Archaeology of the Human Sciences* [1966] (New York: Pantheon Books, 1970); Bruno Latour, *Das Parlament der Dinge* (Frankfurt am Main: Suhrkamp, 2001) (German translation of Bruno Latour, *Politiques de la nature. Comment faire entrer les sciences en démocratie* [Paris: La Découverte, 1999]).

23 Lily E. Kay, *Who Wrote The Book Of Life?* (Stanford, CA: Stanford University Press, 2000).

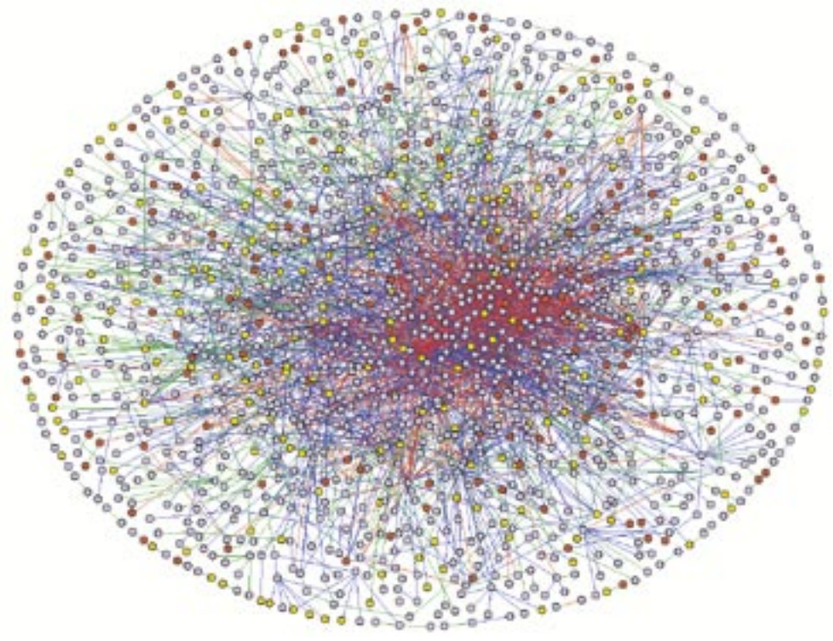
24 Cf. Evelyn Fox Keller, 'Revisiting "Scale-free" Networks', *BioEssays* 27 (2005), 1060–68.

network, as can be seen in the statement below from proteome researchers Ulrich Stelzl and Erich Wanker:

> The goal of functional genome research is to enter all possible interactions which could take place in a cell – called an 'interactome' – on a map and with this masterplan of the cell to explain the function of uncharacteristic human proteins. With the yeast-two-hybrid procedure protein networks for the roundworm and the fruit fly were initially constructed. Since that time, with robot-supported yeast-two-hybrid projects, we have also managed to construct the first comprehensive protein network for the human organism […] The network maps are a valuable source of information for further studies. They are the reason that a so-called wiring diagram for our body can now be constructed.[25]

The corresponding network map of an interactome is shown below.

Stelzl and Wanker refer to the pioneer of random scale-free networks, Albert-László Barabási, who along with his colleagues first published the idea that there are scale-free and thus 'teleologically' open networks which follow a power law distribution.[26] He developed his conceptual model based on the distribution of hyperlinks (understood as connections of so-called 'hubs') in the world wide web. What was initially a loose comparison between body and network has since become a basis for the rapidly increasing popularity of the model. The random scale-free network model emerged at the same time as the publication of volumes of data about the human genome without knowledge of the genome's function in or regulation of the whole. Shortly after the publication of the work of Barabási



The network of a human interactome. It represents 3186 protein–protein interactions based on 1705 proteins. Proteins are shown as coloured circles (orange: illness proteins; yellow: unknown proteins; grey: known proteins), and interactions between proteins are shown as lines. Red lines depict interactions with a high level of confidence, which means that there is a good deal of experimental and theoretical evidence to suggest that the interactions fulfil a biological function. Blue or green lines represent interactions with middle or low levels of confidence.
Courtesy of Professor Ulrich Stelzl of the Max Delbrück Centrum in Berlin.

25 Ulrich Stelzl and Erich Wanker, 'Proteinwechselwirkungsnetzwerke: Aufklärung der Funktion von Proteinen', *Biologie in unserer Zeit* 36.1 (2006), 12–13.

26 Reka Albert, Hawoong Jeong and Albert-László Barabási, 'Diameter of the World Wide Web', *Nature* 401 (1999), 130–31.

and his colleagues, cancer researchers Bert Vogelstein, David Lane and Arnold J. Levine described the modelling of tumour supressor gene p53 as follows:

> One way to understand the p53 network is to compare it to the Internet. The cell, like the Internet, appears to be a 'scale-free network': a small subset of proteins are highly connected (linked) and control the activity of a large number of other proteins, whereas most proteins interact with only a few others. The proteins in this network serve as the 'nodes', and the most highly connected nodes are 'hubs'.[27]

The cells were thus visually determined as scale-free networks and yet mathematically interpretable as open. The network does not have, for example, a given architecture, but is understood by means of the power law distribution as generative, that is, as self-generating. Thus, 'life' can be modelled as an interaction network of cells. In order to problematize the obvious assumption that in this modelling we are dealing with nature and its own apparent growth potential, which is now allegedly known, the following points should be borne in mind:

- Scale-free networks work with stochastic models, that is, with *probabilities* from which *potentials* are derived. With reference to the important differentiation between possibility and potential, in networks it is a question of a *representation of possibility* which is nevertheless weighed. In the process of weighing, a confidence value and thus also a potential for an endogenous ability become initially understandable and move into the sphere of biomedical control. The internal is shifted to the external because it can only be represented as an external. Hence, the idea of interiority of self-starting is lost.
- The question of how a hub 'approaches' another, that is, how an interaction is initiated, remains open. The growth problematic remains hidden behind this ability to create relations: simultaneously to be oneself while also being able to become another.
- Body and network topologies use different referential presuppositions: the comprehensive border (as skin or membrane) with body topologies, the structuring nodes ('hubs') with networks. The constitution of the border itself cannot be modelled and thus the step from network to body remains a blind spot which still symbolically assures the vegetal ability to take root and assimilate as a distinct residue of nature.
- The matching with *wet ware*, that is, with the biological system for monitoring the function, remains necessary. The so-called yeast-two-hybrid experiments perform this function.

Yeast serves as the simplest model organism for eukaryotic cells and thus for human cells as well. With respect to the yeast-two-hybrid technology as the final link in the chain of modelling, the following points, mentioned by Stelzl and Wanker in an aside, are important here: with the help of this technology, it 'is then possible, by means of *growth tests on specific nutrient media*, to prove the interactions of proteins and make them real'.[28] Only growth generates the evidence that there is life. Indeed it is through this growth that what 'comes out' of a gene is exactly the functionality that was expected of it in the network model.

The blind spot of this modelling is the apparently technical appropriation of the self-beginning potential. Biotechnologies make available, through the concepts of *genes* and the *totipotence* of cells (typical of all plant cells and a few animal and human cells, such as stem cells), materialized beginnings, including productive potentials

27 Bert Vogelstein, David Lane and Arnold J. Levine, 'Surfing the p53 Network', *Nature* 408 (2000), 307–10, cited in Keller, 'Revisiting "Scale-free" Networks', 1060.

28 Cf. Stelzl and Wanker, 'Proteinwechselwirkungsnetzwerke', 12, my emphasis.

which, however, must be excorporated to be appropriated. In endogenous design the models of molecular biology and genetics and the cultivation techniques of tissues are paradigmatic in the formulation of hypotheses. The appropriation of cells and tissues takes place between donors and recipients of transplants through the mediation of third parties, the scientists who have a good command of the methods of excorporation and incorporation, as well as interim storage, breeding and controlled growth. The most important method is *planting as explantation*, transplantation and implantation, which in previous medical terminology was called 'implant healing'. A potential growth introduced into a body can lead to endogenous processes there – where the endogeneity then refers to the receiving space. Endogenous design, today, does not merely serve the purposes of classical healing but the precautionary improvement and future enhancement of patients as well. The acquisition of functions and their maintenance are the normative suppositions of endogenous design, and they are already inscribed in the network model of the functioning of the as-yet bodiless. The modelling of living beings is not possible without growth and nutrient media, if their construed realities are to become real. And in order for something living to become patently evident, experience in the life world with living beings is necessary so that it can be 'recognized' as such.

HYBRIDITY REVISITED

It is important to point out the scientific, theoretical and anthropological content of these border layers which in design no longer serve as a border and thus defy familiar classifications. With regard to the concept of humans as hybrid beings, humans since antiquity have been defined as an anthropological mixture of nature and *techne*. They are part of the natural order of things, its forms and materialities; however, as a result of human cultural achievements, they represent the other of this order as well. Bruno Latour has pointed out that attempts at purification through separating nature and culture in the modern world are destined to fail. This is not least because the phenomenon of growth is no longer the exclusive preserve of nature since, with the aid of biotechnology, we can make things grow as we want them to. Nonetheless, there remains a last, invisible potential in nature, in which lies the justification that we *can* do that. Human beings are necessarily then not the 'absolute other' of nature, as references to interface technologies for purely informative purposes suggest. So, *sk-interfaces* retain their own productive force and mediality which first of all must be *there* before they can be used for modelling. It is not produced or built; it is first of all perceived.

Hybridity describes a twin structure with an inherent ambivalence which is typical for human life. It is formed of the dichotomies of nature and technology, growth and action, subject and object, inner and outer as well as knowledge and experience. Interpretive conflicts arise chiefly when these anthropological hybrid constellations have to be brought into agreement with biotechnological models of 'life'. In order to achieve a complete harmonization, the phenomenon of growth must be disregarded. Through this suppression and the idea of a living product which is already finished from the very beginning, the bioscientific model becomes an apparent reality. Such efforts towards an anthropological mixture of at least two ways of being nevertheless require, among other things, empirically established, socially negotiable points of orientation for that which can be reasonably understood today by 'nature' and 'technology'. We can strengthen the phenomenon of growth, despite biofactual modelling, as movement, quantity and 'creation probability' with the

help of coordinate systems and networks as a qualitative differential marker between nature and technology. For nature is that which can grow in a self-determined location, and it is absolutely necessary for transplantation not only as material but also the medium for taking root in a place. The mediality of tissue growth can indeed be appropriated as a means; but mediality as that which takes on and transforms cannot be synthesized. This *ability to become* remains in the province of nature. This will become forcefully clear with a particular cultural technology that provides for cultures themselves: transplantation. Derived from the Latin *colere*, 'doing agriculture', sowing, precultivation and transplantation were always dependent upon an inherently dynamic moment of taking root. Only where plants could take root and be cultivated could people also settle.

We have already become familiar with the numerous indications of the genuine vegetal capacities of tissues, for example, the terms sowing, transplantation as well as deflowering. Art that deals concretely with biological systems can call attention to the eradication of borders between bodies and tissues and the appropriation of 'internal' media as 'external', designable means. In so doing the phenomenon of growth becomes a performative medium in order to dramatize the crossings of borders between the living spaces of subjects and objects. Through this, the gap between elitist, biomedical-technological scientific experience and the supposed egalitarian everyday experience of 'life' itself can be problematized. Not everyone can gain access to spaces of knowledge in order make meaning for one's own life out of media. Our living rooms are not – yet – laboratories. Through the transgressive characteristics of the vegetal in private 'interiors', Julia Reodica plays repeatedly with the phenomenon of growth as a supposed guarantor of external nature. In the installation project *Chlorophilia*[29] she and Denise King exhibit the *Lawn Chair* in a living room installation.

Reodica calls attention to human hybridity, especially visible in humans' 'love' of plants: our adoration as well as our design of their lives. The art project stresses

Julia Reodica and Denise King, *Lawn Chair*, 10 April 2002 (sitting: Katherina Audley). Wheat grass, fabric, metal, wood. Courtesy of the artists

29 At Exploratorium, Art & Science Museum, 10 April 2002, San Francisco (CA), curated by Philip Ross.

the consciousness of humans being dependent upon reproductive and assimilable means of life in the broadest sense. In this *Lawn Chair* covered with growing grass on a medium suffused with nutritional fluid, external living space is brought inside and is depicted as growing. The covering of the lamp with a vegetal material that shrouds the light also emphasizes the reversal of interiority and exteriority, of natural and social orders. It is not the plants that need light here to grow but human beings who need it to read, that is, for their cultural technology. One sits in a 'growing chair' and in a 'living room' embedded in a natural surface that continually expands its own borders. Reodica and King emphasize the historical settledness of people through the act of planting as well as the potential danger of manipulation, as expressed in the term 'unsettling' in the installation description which is antithetical to settling and early agriculture. The history of constituting objects thus becomes natural and cultural history and vice versa: natural and cultural history appear in the history of objects. As a result, the tension between subject and object, between observer and 'nature', will be dissolved in a practical, day-to-day perspective. Viewers, even when in terms of their own lives they more strongly position themselves as either a natural being or technology user, cannot escape the historicity of their own, diachronous *experience with nature*. This includes a thoroughly normative moment which refers to nature's own time and its reliance on processes which cannot be entirely appropriated through technology.

'Bio Artists' and bioscientists share a core experience: waiting for growth. It takes a relatively long time for cells and tissues to grow sufficiently that they can be used as media and means. The phenomenon of growth, in its slowness, mediates between subject and object because it *makes present* the time both share with one another synchronously. In biotechnical laboratories, scientists employ methods analogous to agrarian practice, though under sterile conditions: seeds are sown, they are injected in nutrient-rich soils to ensure strong growth, scientists produce mixed forms like bastards and chimeras, that is, they fuse and transplant that which possesses the inherent ability to self-start. Particularly in the medical field, in the field of organ and tissue transplantation, it is clear how often root-taking does not occur and that the location experts select for rooting functions only temporarily. Rejections take place only after a certain period of time and demonstrate that a superficial root-taking does not necessarily lead to integration into a space (e.g. a body or a landscape), that is, to rootedness.

The hybridity and the biofacticity of an organism do not therefore mean the same thing. Hybridity is an ontological and anthropological term, while biofacticity is an epistemological term. The terms hybrid and biofact each describe the perspective of a relationship to oneself and to others, both of which remain reflexively related to each other. The biofact provides evidence of a technical intervention in the laboratory as well as of the growth of a body outside the laboratory. However, the intervention belongs to the others, while growth belongs to oneself. Biofacts arise of necessity through foreign designs. In contrast, hybridity suggests self-design without the laboratory perspective, that is, that which a person who exists 'freely' can be. This includes rather than excludes human rootedness.[30] By means of the root as the imaginary beginning of everything, the growing object could remain the same and nevertheless become something else. In the modern concept of the subject, this semantic of rootedness has been retained primarily in psychology with its plant metaphors such as 'drive' (*Trieb*) and 'internal growth', despite all the machine metaphors. Humans can move

30 Simone Weil, *L'Enracinement* (Paris: Gallimard, 1949).

about to different locations and walk through areas, but they remain biographically connected to their own beginning. Age (childhood, youth, adulthood, old age), biography and homeland are corresponding concepts of a historico-genetic self-referentiality which function to foster the subject's identity, especially in the age of mobility. Its vanishing point is a person's own birth as an uncaused beginning of becoming oneself – a long-neglected counterpoint which Hannah Arendt, with the term 'natality', put in opposition to the dominance of mortality in Western philosophy.[31]

However, embryo growth before implantation in a natural (or, perhaps in the future, an artificial) uterus is – because of the preimplantation diagnostic – no longer free from control and regulation with reference to a desirable 'growth' that is supposed to come into the world. What does this biologicalization of the psyche mean for the developing subject? How will our openness to the world change if in the future we view ourselves as explicitly constructed by other people? By 'explicit' I mean that there are specific characteristics, scanned and designed in advance, which ultimately account for a person's birth. The question to be posed – with Jürgen Habermas[32] – to modern philosophy and sociology, therefore, is whether or not autonomy as the freedom to think and act is based upon one's own beginning as an existing growth, which has thus far always been considered secure and has therefore been neglected by philosophy. For is it possibly a part of our genus identity as humans that we cannot 'construct' ourselves through biotechnology? On the other hand, when people breed other people through biotechnology, what then remains characteristic of human-beingness – 'the life' of the 'body' in human form? However, not everything in the laboratory grows according to expectation. The refusal of growth always to take place according to expectation demonstrates that growth is one of the conditions of possibility for organisms and binds the term nature to the term life in the laboratory. Endogenous design is, therefore, a dialectical concept of growth and action within closed spaces which have to open themselves in order to be experienced.

Art has dealt with this problematic,[33] while scientific and technological research has largely ignored it.[34] The latter has focused in the field of biotechnology for the most part on ethical implications which are then examined under the keyword 'bioethics'. That which can be considered '*bio*' is, thereby, by means of an epistemology oriented on classical physics and mechanics, itself theoretically in the grip of dissolution. There is a concentration on particles and their self-organization. Moreover the idea of life is only meaningful in the day-to-day world. The self-design of human-beingness, that which humans as 'humans' can be (their hybridity), collides with the foreign design of living nature-as-such (with biofacticity), understood as that which can be 'made' with nature. In hybrid thinking, nature and technology remain necessary as concepts. This necessity exists also for the conception of biofacts. Biofacts are second-order hybrids because the technical setting cannot necessarily provide contact with 'another' growing self. The established border may in fact be *real* but not *actual* because, in order for it to be actual, it must be possible to experience a border beyond the laboratory.

With biofacts, exclusive *knowledge* of the technical intervention provides access to the visibility of the phenomenon. For all those not in-the-know, this trace is lost. The technologizing of nature began a long time ago; hence, the oft-deployed argument that technicians working on molecules and cells are only carrying on the tradition of agriculture and of grafting varieties of fruit appears at first plausible. What is new, however, is that the trace of construction is lost because it takes place in particular

31 Hannah Arendt, *The Human Condition* (Chicago: University of Chicago Press, 1958).

32 Jürgen Habermas, *Die Zukunft der menschlichen Natur* (Frankfurt am Main: Suhrkamp, 2001).

33 Cf. Jens Hauser (ed.), *L'Art Biotech* (Nantes/Trézélan: Le Lieu Unique/Editions Filigranes, 2003); Eduardo Kac (ed.), *Signs of Life. Bio Art and Beyond* (Cambridge, MA: MIT Press, 2007); Ingeborg Reichle, *Kunst aus dem Labor* (Berlin/Vienna/New York: Springer, 2005).

34 Cf. on endogenous design and nanotechnology, Olaf Arndt, 'BBM. Endogenes Design. Anmerkungen zu einigen Bezügen des Projektes "Nanobots" von BBM', in Elke Bippus and Andrea Sick (eds), *Industrialisierung<> Technologisierung von Kunst und Wissenschaft* (Bielefeld: transcript, 2005), 112–23.

rooms which are not shared with the day-to-day world. While biological growth cannot be replaced, it can be so strongly provoked that only the abstract starting point of root-taking as an automatic element of nature remains. Taking root guarantees the ability to begin. Growth is always *present at hand* in the conception of nature and constitutes *the* medium of life. It becomes a means when it is available, *ready at hand*. Since the formation of agrarian societies, growth has been available as a means within determinate boundaries. Through biotechnical influence, growth becomes chronologically ever earlier a means and spatially ever more central. We are speaking here, too, of a higher level of invasiveness in the body. However, a space is assumed here which still has to be created. For the subject, who undergoes growth as a 'unity of becoming', it remains to ask whether it experiences that growth as a medium of its own life, that is, with its own bodily experience and possibilities to develop itself. Only then will it become an individual. Or perhaps the subject from the very beginning conceives of itself as endogenously designed, as a growing construct that externalizes the goals of third parties. It would then appear as one clone among many, even if it is not cloned in the biotechnological sense. If doubt is created about life-world phenomena through an overdose of scientific information and an enlightened attitude of expectant modern subjects is nourished, what remains instead of a fascination for the endogenous design of growing 'external' objects is the dialectical opposite: the retreat of the subject into the interior as regression and depression.

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Fitter, Better, Stronger, Faster

John A. Hunt

Providing materials that will function as an alternative or adjunct to human skin is one of many significant medical and scientific issues coming to the fore as we progress as a species that lives faster, fuller and longer lives. Average life expectancy increases with each generation and although the numerous potential impacts of this point are much debated, the economic disarray and panic concerning pensions and financial projections seems to point to a future with a significantly increased aged if not retired population. If it only came down to economics this detail could be accepted and accounted for financially; however, as we successfully tackle the major fatal diseases, sustain life after major injury and provide more successful treatments for cancers and genetic disorders, we create a new pressing set of issues. Inherent in the animal in all of us is the drive to live for as long possible in the 'best' possible way. The multifaceted complications of life and living come to the fore in many guises; faced with the dilemma of switching off the life support machine for someone, a family is brutally confronted with the issue of life and what's best. Parents wish to provide the best opportunities for their offspring and as individuals we constantly strive to do our best. Death is not an option and is a very unsatisfactory end point for a species that can achieve anything and everything. A slow painful deterioration towards the inevitable would, if we were presented with choices from a healthy perspective, perhaps nudge most towards a brave-hearted exit, to live life to the full to the last day and then pass quickly. It is conceivable (and it can be modelled) that the medical landscape and life expectancy scenarios may force our species to the point where there will have to be a defined end of the road, wherein the date of death will be on the line below the date of birth, and our maximum shelf life or organic lifetime will be clearly defined. With the current critical breakthroughs in science being centred around biological sciences and medical technology these are exciting times, and our knowledge base grows exponentially, providing direct and indirect benefits to the continuation and creation of life – albeit we should consider the potential end point scenarios and plan for our success. Future successes will raise difficult societal issues that will require resolution, but on a daily basis and within the current generations facing these issues, we strive to provide each individual with the opportunity to live a fulfilled and independent life. The coming together of science, engineering and medicine is history, the potential for future successes is tremendous, and the way in which this potential is realized will need to be addressed by society sooner rather than later.

Medicine is increasingly required to maintain form and function after sustaining life itself during and following disease or trauma. Life can be successfully maintained with increasing efficiency, and individually within our own social scenes, and globally as a species, we should rightly be delighted about this. This does, however, create another set of issues pertaining to a patient's fundamental heartfelt desires to return to the way life was before. Often bandied around with impunity and budgeted for in medical health as *quality of life units*, the scientific potential to improve the quality of life rather than merely to sustain life becomes increasingly an economic issue and clashes with the human being in most. In between the times of sickness or injury, life is taken for granted and the living get on with it. In evolutionary terms, as just one of many life forms we should rightly take life for granted; it would be inefficient not to, and surely we should spend our time and energies on the fundamentals for all species: survival and reproduction. At what point will we transcend our origins? Have we already? Is the species already established on different evolutionary pathways that direct us away from solely furthering the species to the next generation? What cost the price of health when you don't have it? The answer is placed firmly in the hands of the healthy. The stark evidence weighs in favour of us having transcended our organic animal origins. In the future life will be mapped genomically and proteomically,