

## Scientific Contribution

### Engineering flesh: towards an ethics of lived integrity

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**Abstract.** The objective of tissue engineering is to create living body parts that will fully integrate with the recipient's body. With respect to the ethics of tissue engineering, one can roughly distinguish two perspectives. On the one hand, this technology is considered morally good because tissue engineering is 'copying nature'. On the other hand, tissue engineering is considered morally dangerous because it defies nature: bodies constructed in the laboratory are seen as unnatural. In this article, we develop a phenomenological-ethical perspective on bodies and technologies, in which the notion 'lived body' and concrete experiences of health and illness play an important role. From that perspective, we analyse the practice of tissue engineering by focussing on one specific example: the engineering of heart valves. On the basis of this analysis, we propose that the ethics of tissue engineering should be framed not in terms of 'natural' or 'unnatural' but in terms of 'good embodied life' and 'lived integrity'.

**Key words:** biomedical technologies, body ideals, body-technology relations, good life, illness, intertwining, lived body, lived health, phenomenology, tissue engineering

#### Introduction

We are working on human bodies. Thus, when the medical doctor in Switzerland says 'Yes, but those children....', then our PhD students think to themselves 'The heart valves I am making will be implanted in a child later' (...). That is why PhD students working on pressure ulcers are required to visit at least one patient whose body has a large cavity of this nature. 'It smells', the PhD students conclude. 'Yes', I then say. 'This is what you are working on.'

(Senior researcher 3, October 2003,  
translated from Dutch)

There is a heartbeat in the cell laboratory. Bioreactors, incubators and the laboratory setting cause any daily bodily life to seem distant. But the rhythm of the air pump that mimics a body-like flow of medium through the tissue engineered heart valve is familiar, and the researchers joke that perhaps if they stand there long enough their own heartbeats will synchronise with the mechanical beat. The professor agrees. However, for those

equipped with a stethoscope, a valve engineered here will one day soon be audible in the chest of a young child. Will it continue to beat and to adjust to the body, or will it wear out? Will the child live or die? These are questions that tissue engineers ask themselves in the face of a clinical trial. The above quote indicates how the notion of tissue engineering (TE) changes when engineers link their work to *bodies* and especially to *patients being these bodies*. In the work of Merleau-Ponty, the latter distinction is central. Bodies in daily life are not simply collections of nerves, muscles and tissue; rather, people are their bodies and live their bodies as their 'abilities and directedness to the world': this is expressed by the term 'embodiment' (Merleau-Ponty, 2002). In this article, we explore relations between embodiment and laboratory work in TE. In particular, we show how a phenomenological perspective helps to understand how intervening with our material bodies implies affecting our embodiment.

The focus on TE is of interest, as this area is seldom explored in philosophy and ethics.<sup>1</sup> In public accounts of TE, the differences between it and more traditional body-technology relations

like having a prosthetic leg or a mechanical heart valve are often pointed out. In expressions like 'mimicking nature' it is suggested that because TE involves amending fleshy beings through amending flesh, it remains closer to what we understand as our natural bodies than do bionic technologies. Accordingly, TE is often considered to be a morally innocent technology (Kent et al., 2006, p. 14). However, in accusations of playing God or of creating Frankensteins, it is suggested that TE transforms our bodies in a much more radical way than do bionic technologies. This is because rather than simply adding something to our bodies, TE intervenes with our fleshy existence (Thacker, 2002). From this perspective, TE seems to be a dangerous technology. Instead of stressing the differences between bionic technologies and TE, and making either type of technology more innocent or more dangerous, a phenomenological analysis demonstrates that TE is not special, and can be analysed in terms similar to those used in other technologies. We will make clear that it is a pitfall to discuss TE in terms of it being more or less right a priori because of its fleshy nature.

To develop a phenomenological-ethical perspective on TE, we need to understand what TE entails. To that end we studied the relevant literature and performed ethnographic research (Hammersley and Atkinson, 1995) in a broad sense. One of us travelled to Boston, where most TE research originated, and visited the laboratories of leading researchers, who were interviewed. Moreover, since 2003 we have closely followed one specific project, a Dutch-Swiss Heart Valve Project, a collaboration between a Swiss research group based in a hospital and a biomedical technology group located at a Dutch technological university. This project has as its objective the creation of a fully autologous aortic heart valve. This means that patients' cells are used and that ideally the final implants will contain no foreign materials. One of us attended internal meetings, visited the laboratory, had informal contacts with researchers and conducted taped interviews with the investigators involved and with thoracic surgeons. In this article, we will use this ethnographic material to develop a phenomenological-ethical perspective on body-technology relations in TE. Although the focus is on TE, we think that this perspective is fruitful to study other biomedical technologies as well.

First, we develop a normative framework for analysing biomedical technologies and in particular TE. We refer to the insights of Merleau-Ponty, Don Ihde, Francesco Varela and Jean-Luc Nancy to explore the meaning and relevance of the notion

of transparency for embodiment. We then consider two alternative frameworks of 'good embodied life' that might be used to evaluate body technologies: Frederik Svenaeus' analysis of lived health as a balance between transparency of the body and a directedness to the body and Gail Weiss' concept of multiple bodily experiences. We conclude that notions of 'good embodied life' should go beyond mere 'transparency' of the body, for that notion implies that awareness of the physiological body as in illness is evaluated negatively. We will argue for a notion of 'lived integrity' that does justice to experiences of being this hurting or changing body, which are often central during illness. 'Lived integrity' refers to the achievement of living illness, body change and technological additions as oneself. In the light of this perspective, we analyse in what sense biomedical technologies enhance or threaten 'lived integrity'.

Second, we make use of this phenomenological perspective to open up the field of TE to a normative analysis in terms of lived bodies. We first show how ideas about what a normal body is play an important role in the practice of TE. TE is presented as making body parts that are more natural and therefore better than other prostheses. We then analyse how in the practice of TE 'the normal body' is closely linked to the notion of transparency. For this we make use of interviews with surgeons who are able to link problems of prosthetic heart valves in physical bodies to the lived experiences of their patients. The phenomenological perspective as developed in the first paragraphs leads us to argue for a broader concept of 'normal bodies and embodiment' in TE. We suggest that once the simple logic that engineering 'natural body parts' leads automatically to 'good life' has been taken apart, the introduced perspective can be used to study all kinds of tissue engineered body parts as well as different kinds of lived experiences.

In our conclusion, we argue that biomedical technologies like TE may both improve and threaten 'good embodied life' and that these technologies therefore need to be discussed and evaluated in phenomenological terms: namely, embodiment. But let us start with a phenomenological perspective on body-technology relations.

### **Embodiment as transparency**

To build our framework of lived bodies, we start with some important insights of Merleau-Ponty. He showed how we experience our physical bodies

in daily life as ourselves, how we live the world through our bodies and how technologies can be like body parts in body-world experiences.

Merleau-Ponty analysed what he called 'being-in-the-world', and observed that as a human being a person is not 'a consciousness in a body' or 'having a body'; rather, he/she lives his/her body as being-in-the-world. Throughout his work, Merleau-Ponty illustrates that we live our bodies through the world, and we live the world through our bodies. One clear example is body size. Even though a man might be of average height, he could experience his body as huge upon entering a tiny – at least in his bodily experience – campsite toilet. However, just a few moments later he might feel small when looking up into the endless sky. How we live our bodies is thus not in any definite sense determined by our physical make-up. Our physical body is what makes being-in-the-world possible, while we live our bodies as potentialities rather than as collections of tissue (Merleau-Ponty, 2002, p. 126). In daily life we experience our hands not as skin, bones and nerves, but as being able to catch a ball, do the dishes or stroke the dog. In fact, we can do all these things because we are our body.

Being-in-the-world also involves being part of the world without collapsing into it. One of Merleau-Ponty's examples is that of a person's left hand touching his or her own right hand. The toucher is part of the tactile world, but there is a shift between touching and being touched (Merleau-Ponty, 2002, pp. 130–155). Clearly our own bodies are part of the world but are also our centre of experience. It is from this picture that Merleau-Ponty also develops a notion of intersubjectivity: we recognise other bodies as centres of lived experience.

Our physical body is what makes being-in-the-world possible, and technologies may become part of our being-in-the world. However, because we do so habitually we often do not pay explicit attention to how we as bodies interact with technology. Consider a Dutch example: Dutch people learn early in life to ride bicycles. When they cycle to work or to the shops they do so without explicitly being aware of how they are using their body. They can cycle without holding the handlebar and at the same time unbutton their jacket. The bicycle is, as it were, part of their being-in-the-world at that moment. Compare this to the experience of skiing for the first time. Dutch people are then very much aware both of the skis moving in undesired directions and of their body. It hurts to fall, even in snow, and their muscles, not being used to these movements, make their presence clearly felt.

Moreover, one needs to think simultaneously about the position of arms and legs and how to avoid trees. However, after a time the skis become part of the albeit clumsy ability to move on snow. The skis, says Merleau-Ponty, have stopped being objects and have become a potentiality of 'the skier'. Often when people remove their skis they find themselves sinking into about a metre of snow because they had forgotten that they cannot walk on it without skis.

Merleau-Ponty points out that technologies become like body parts and not the other way around (Merleau-Ponty, 2002, pp. 165–169). A foot is not like a ski one can take off: rather, the ski becomes like a foot, part of the skier's way of experiencing and relating to the world. In an era where we can add to and take away parts of the body, one may wonder what to think of this observation. Is the experience of a broken tool different from that of a broken hand or even a malfunctioning internal organ? And if so, how? To deal with this question, we compare Ihde's work on the embodiment of technologies with that of Varelo and Nancy on living through the experience of an organ transplantation.

### **Illness as loss of transparency**

Ihde took up Merleau-Ponty's analysis of embodiment and considered in particular how bodily materiality and technologies interact (Ihde, 1990, 2002). Many of Ihde's examples concern scientific visualisation instruments, and his analysis shows that both the human and the world are transformed by technology-mediated interactions. For example, consider a woman putting her glasses on: her own body, her eyeglasses and her immediate environment alter. Her vision changes from being vague to clear, the glasses become part of what she can do (see) and the world gains in important detail. However, the manner in which technology and the body change depends on to what extent a technology becomes part of the body; in that context, Ihde introduces the concept of transparency. In Ihde's analysis of embodiment of technologies, the 'objectness of a technology' is considered a lack of transparency and therefore a negative feature. If the woman's glasses are dirty she needs to clean them, in which case they are objects to her rather than parts of her embodiment. If the object is transparent to someone, he or she does not notice it and it is simply part of his or her being-in-the-world.<sup>2</sup> Thus, Ihde's description of embodiment assumes that our normal

being-in-the-world implies being directed outward to the world rather than to experiences of our body.

The work of Ihde and Merleau-Ponty raises the question of how to interpret experiences of illness. Merleau-Ponty noted that technologies are like body parts in embodiment relations. However, what about the other way around? Are broken body parts also like broken tools? In Ihde's analysis, transparency is broken if the tool is no longer lived as part of a person's relation to the world. Attention is then shifted to the tool as object and away from the activity in which this person-tool was involved. To some extent, a loss of transparency of our own fleshy body parts is experienced in a similar manner: we turn away from the world and actively relate to the diseased body part. When we are ill, the awareness of pain and the loss of control over body parts and so on are part of this. In illness we are often directed to the body instead of to the world. Following Ihde's ideas, the awareness of the physical body during illness should be considered a loss of transparency. But in what sense should we speak of loss of transparency during illness?

In the work of Varela and Nancy, loss of transparency is an important aspect of being ill. These two philosophers lived through a liver and heart transplantation, respectively, and made a phenomenological analysis of their experience (Nancy, 2002; Varela, 2001). Nancy and Varela describe how their own heart and liver, respectively, become like a stranger when doctors point these organs out as being diseased and in need of attention. The organs are no longer part of the person's directedness to the world, because now the organs are actively related to, perhaps most clearly when they are visualised on computer screens. Nancy remarks that only when his body began to disintegrate did the identification of this heart as 'mine' and of an 'I' with this body arise (Nancy, 2002). In Varela's case, the experience of bodily contingency and fragility is also striking. He describes:

It so happens that the Graft Centre is located not a block away from my apartment in Paris. During the interminable wait, I used to take walks in front of it, and ponder the almost tangible contingency of my life (if I survived) within this arrangement (...). After months I was requested to carry on me at all times a dedicated portable phone, and to never be far from the hospital (...). Weeks without end; every minute the pressure of my portable phone as witness awakening me

to the immense fragility of my life and the tenuousness of my identity in this tangle of deferred causalities.

(Varela, 2001, pp. 266–267)

Both Nancy and Varela describe how their experience of loss of transparency is historically and socially situated. Striking is how awareness of technological development affects Nancy's experience of organ transplants. He characterises the crossing of his personal history and the history of technology as 'I' being caught in the possibilities of technology: 20 years earlier he would not have lived; 20 years later there might be other possibilities. But he lives here and now with this transplanted heart (Nancy, 2002). Varela analyses how he lives the social imagery of the gift that is present in the conceptualisation of 'donating' organs.

In the early temporality of the experience, I said, the social imaginary link is intense and gripping. And the longing to find the source of this *don* of life is clearly present; it feels as ancestral and ancient as the compulsion to bury our dead; it surges forth from roots too old to be conscious.

(Varela, 2001, p. 267)

We learn from the work of Varela and Nancy that, when one is severely ill, loss of transparency involves two connected experiences. First, one experiences the diseased organ both an object and as part of self. It stands out simultaneously both as more separate and as a crucial part of being-in-the-world. In addition, the donor organ is experienced both as 'this organ that I have received' and as part of the person's being-in-the-world. Second, illness implies being confronted with the frailty of one's body and the contingency of one's life, in the light of being an organism and of technological developments.

With Varela and Nancy, we have now shown that a loss of transparency can indeed be considered a part of illness. Their work, however, provides an account of an extraordinary experience of illness: that of an organ transplantation. More ordinary experiences of illness do not seem to involve such an extreme focus on the body or such a feeling of being overwhelmed by contingency. When we have a minor headache there is some loss of transparency, though we can still also be world-centred, albeit in a slightly less focussed way. Moreover, even when we do not feel ill we are confronted with our physiological bodies throughout the day: for example, when we need to go to the toilet. Full transparency of the physiological



body thus does not seem necessary for ‘good embodied life’. This raises two questions: ‘What is the role of transparency in lived health?’ and more generally, ‘To what extent does a tool-like approach to the body capture possible ‘good’ embodied experiences?’

In the next two sections, we show how alternative answers by Svenaeus and Weiss to these questions lead to different notions of ‘good embodied life’.

### **Illness as an alienated way of being-in-the-world**

In his analysis of lived health and illness, Svenaeus addresses the balance between being-my-body and awareness of the physiological body as having a life of its own. Like Ihde, Svenaeus builds on Heidegger’s work on the broken tool. It is when the tool breaks down that it becomes an object of attention. While Ihde uses the notion of transparency to differentiate between body-technology relations, Svenaeus relates a loss of transparency to a loss of meaning. According to Svenaeus, it is this loss of meaning that makes a loss of transparency a negative experience.

Svenaeus builds his account of health on how tools form patterns of meaning in our lives. The tool is not a mere thing, but an ‘in order to’. Consider Heidegger’s famous example of a hammer. Only by using it (e.g. to build a roof on our house) do we learn what it is ([Heidegger, 1927] in (Svenaeus, 2000, p. 127)). By merely looking at its shape, colour and so on we do not learn what makes it a tool. Thus, we encounter the world not as a collection of mere things but as a collection of tools: an intersubjective and lived meaning structure (Svenaeus, 2000, p. 126). Svenaeus points out that the lived body can be understood as a tool or part of this meaning structure. Here he also refers to Merleau-Ponty, who said ‘the body understands and inhabits the world’ (Svenaeus, 2000, p. 127). According to Svenaeus, the world is homelike insofar as it is understandable and composed of human actions.

Svenaeus builds on Heidegger’s analysis of the world as pervaded by ‘homelessness’. We experience a sense of homelessness insofar as we have no full knowledge or control of the world. It is experienced both as being ‘my world’ and as ‘other’ in the sense of being beyond my control (Svenaeus, 2000, p. 125). Svenaeus places the social situatedness of embodiment in this context: meaning structures are socially situated and in this sense are part of the otherness of the world (Svenaeus,

2001, p. 94). According to Svenaeus, bodily illness is a specific experience of otherness: namely, the otherness of this body. In other words, it involves experiencing biological processes that are beyond our control but that are also part of being-a-body. Therefore, we touch here on what Varela and Nancy describe as living the disintegration of their bodies: the strangeness of the diseased organs, which, nevertheless, are a part of themselves.

In Svenaeus’ work, the breaking down of the body is an example of what may constitute illness. He gives a wide range of examples, such as having a cold and having a stroke. In illness, the body and the world are experienced as alienated, and we cannot live our usual manner of being-in-the-world. Though in health we are also aware of our bodies as organisms, for we have to eat, urinate, sweat and so on, in illness this conscious presence becomes stronger. An example is an elderly man who is incontinent and can no longer trust his body to warn him that he needs to urinate. Hence, he has to pay particular heed to it. In this regard, two central themes arise in Svenaeus’ analysis: illness as a disturbance of our usual balanced way of both attending to and living our bodies directed towards the world, and as the resulting experience of alienation of our bodies and worlds. In illness, our usual balance is disturbed and we have to make a greater effort: for example, a woman may have a terrible cold and be unable to read comfortably in bed as she normally likes to do. Her morning coffee makes her nauseous, and the normally welcome voices of her children drive her back to bed. Today she cannot live her usual self and relate to the world and to others in her customary way.<sup>3</sup> In health, we are, as it were, at home in our world, whereas in illness the otherness – that which is out of control – of world and body confronts us. Our ordinary understanding of the world and our ordinary activities break down. Svenaeus compares it to keeping one’s balance while cycling. Balancing is normally an active process but it takes place automatically; in illness, the balancing does not function as usual. Illness disturbs important aspects of our being-in-the-world, which go beyond the mere physical aspects: a person does not just have a headache, he is also an inattentive friend today, because he needs to be alone with his headache. Note that there is not necessarily one balance: chronic disease does not have to mean chronic illness in one’s activities. Svenaeus suggests that illness may also lead to new understandings of our worldliness.

Problems with our physiological body are not the only factors that can lead to sickness. The

breakdown of technologies or other meaningful structures in life may also constitute illness. Svenaeus illustrates that a difference between tools and body parts should be drawn phenomenologically, rather than with reference to the body as an organic whole (Svenaeus, 2001, p. 98). Body parts differ from tools in general, for they are more central to a person's being-in-the-world. The broken hammer may be annoying but it is quite different from a broken hand that pervades someone's being-in-the-world. However, in Svenaeus' work, transparency is not merely an aspect of living one's body or of body-technology relations. He gives the loss of a loved one as an example of what may lead to illness in the sense of a breakdown of our meaning structures. The experience of illness as the loss of our homelike being-in-the-world can, according to Svenaeus, also be related to a loss of important tools. For example, the loss of a hearing-aid, glasses or a wheelchair that is not easily replaced can also make the experience of being-in-the-world unhomelike. Similarly, the loss of an appendix does not have to mean living through illness. Svenaeus points out that what constitutes illness depends upon how important a tool, whether technological or body part, is for a person's homelike being-in-the-world. In other words, embodied technologies that are a central part of one's being-in-the-world could be understood as phenomenological body parts.

We wish to add that the experience of health, illness or disability does not just depend upon one's body in a phenomenological sense but also upon the world one lives in. The physical arrangement of one's world influences a person's being-in-the-world. Consider someone who is well accustomed to using a wheelchair. This person has embodied the wheelchair and moves around with an ease similar to that with which we use our legs. However, when moving outside of spaces such as hospitals the wheelchair user will be continually confronted with a world built for upright people. As Kay Toombs explains in her analysis of the experience of multiple sclerosis, embodying a wheelchair in an upright world implies needing assistance: for example, when using phone booths. She also found that toilets on airplanes were too small and she needed to leave the toilet door open (Toombs, 2001, pp. 253–255). An everyday Dutch example of the experience of elderly bodies and how our immediate furniture affects our being-in-the-world is the proposal to distribute more benches throughout neighbourhoods. For many elderly walkers, the distance between benches is currently too great. The placement of extra

benches would transform these people into able walkers. This observation reminds us that to improve the experience of bodies as 'I can', one can also address the environment as well as change the body.

According to Svenaeus, the objective of health care should be to restore the patient's homelike being-in-the-world. And with his notion of balancing, Svenaeus' analysis captures our embodiment well: in daily life we live our bodies directed to the world but we also attend to our bodies. Nevertheless, Svenaeus' account raises a question, as he presumes that encountering one's body as a biological process is alienating. But is this necessarily so? What about the enjoyment of sexual experiences, lactation, pregnancy and even urinating? In this light, we therefore look below at the work of Weiss for an alternative concept of 'good embodied life', which takes such experiences specifically into account.

### **Multiplicity and change as lived bodily integrity**

In the work of Weiss, embodiment is characterised by intercorporeality, a notion that is in striking contrast to the dualism of Svenaeus' mineness/otherness of the world and body. Weiss works within a tradition of feminist philosophers, especially Iris Young, who have stressed that we experience our bodies as invested with meaning, images and ideals. In the work of Merleau-Ponty, we do find a description of being situated in historical contexts, but this is not worked out in terms of embodiment. In reaction to Merleau-Ponty, Young gives examples of female embodiment: namely, how girls learn to move in a gender-specific manner by throwing, walking and sitting as girls. Young females thus learn a feminine embodiment style. Building also on Young and Merleau-Ponty, Weiss' book *Body Images: Embodiment as Intercorporeality* shows how we live through body images that are infused with those of race, gender and technology (Weiss, 1999). The notion of intercorporeality is introduced by Weiss to stress that embodiment is mediated by other bodies – human and nonhuman – and thus is not a private issue; being-in-the-world is being part of situated material, social, political and ethical worlds.<sup>4</sup>

Both Young and Weiss point out that we also live our bodies in relation to body ideals that we learn or develop throughout life. They show that seemingly neutral analyses of embodiment often idealise the body as 'I can', directed outwards to the world. For example, central in Merleau-Ponty's

earlier work is how we live our body as our capabilities. According to Young and to Weiss, this is only one way to live bodies, and it is idealised over other ways. This focus on 'I can' is also present in the work of Svenaeus, who calls illness an 'obstruction to health and its transparency', explaining that 'everything that goes on without us paying explicit attention to it when we are healthy – walking, thinking, talking – now offers resistance' (Svenaeus, 2001, pp. 89–90).<sup>5</sup> Young gives a much richer picture of living a female body: having fun dressing up; the messiness of pregnancy, where body boundaries are changing all the time; and living one's breasts in a society with specific breast ideals. Central to all these experiences is the awareness of being-a-body, and sometimes enjoying this as well. It is an awareness that cannot be reduced to 'I can', or to tool-like relations. Moreover, Young points out the way these cultural ideas may influence embodiment negatively. She notes that in the dominant conception of health a change in bodily condition is considered a disruption or malfunction. Thus, something is the matter when bodily transparency breaks down. Weiss agrees with Young's critique on this ideal of bodily health. Moreover, she states that it is possible to live bodily changes as an experience of integrity. In other words, awareness of bodily change is not necessarily alienating.

Weiss stresses that we may experience 'multiplicity of body experiences' as changes in our embodiment, thus bringing them together in a sense of integrity. We all have continuously changing embodiments, simply because our being-in-the-world fluctuates all the time. In the morning we cycle easily to work, feeling strong and fit. In the afternoon we are sometimes so tired that the trip home seems endless. Or the wind is blowing us almost off our bicycles, and we feel weakened. A denial of multiplicity and change is a danger to bodily integrity, for these changes happen anyway. One example Weiss gives is that there is a tendency to deny that pregnant existence may also be sexual existence, and in that matter to deny women the possibility to live their sexual and pregnant existence in a sense of integrity. Her notion of multiplicity also makes it easier to discuss new medical technologies affecting embodiment without seeing this as a necessary threat to other bodily experiences. For example, she does not agree with feminist critique that ultrasound necessarily intervenes negatively with pregnant embodiment (Weiss, 1999, pp. 124–125). Instead, it adds a dimension to the multiplicity of pregnant embodiment as long as other experiences are not denied.

Weiss' description of living with multiplicity is not dissimilar to Svenaeus' concept of balancing. Both describe active processes in which a person's constantly fluctuating being-in-the-world is lived with a sense of being his or her body and living in his or her world (integrity or homelikeness). However, though Svenaeus' description is not static, it very much emphasises familiarity and rhythm, and it links the breakdown of these to illness. In Weiss' analysis, continual change receives much more attention, and she studies bodily focussed ways of being-in-the-world. Weiss shows that we need multiplicity in our body images to live in a non-pathological way what she calls the turbulence of our bodily existence or our bodily fluidity. The ideal of health, which emphasises transparency, involves only one dimension of lived bodies and is thus a danger to health in terms of integrity. Does this mean that Svenaeus' account has fallen prone to this ideal? We would say yes and no.

With 'yes', there is the suggestion that more than customary attention to our body as an organism with a life of its own is necessarily alienating. One central aspect here is the idea that things need to be in one's control. But sometimes the experience of being bedridden with a high fever can be comforting rather than alienating. The letting go of daily worries and the more or less forced relaxation might be a relief. Even a feverish body might be experienced as one's own. Perhaps for those who mainly live as 'I think' or 'I can', the experience might be alienating. Whereas those accustomed to live 'I breath, hurt, run, stumble, urinate, give birth, and are dependent upon technologies like hearing aids, glasses, wheelchairs, noisy heart valves or stomas, may live their physical bodies as self rather than other. Societal norms play an important role here as well; if bodily noises and smells, or tools such as hearing aids, are a reason for shame, these may be alienating if indeed experienced as otherness rather than mineness, whereas in other situations this need not be the case.<sup>6</sup>

With 'no', while we can argue that Svenaeus does stress the importance of bodily stability, we can also argue that this is an artefact of the specific examples in his work. We therefore suggest that Weiss and Svenaeus analyse different experiences of different bodies. Because Svenaeus analyses living, stable bodies, whereas Weiss analyses examples like pregnant experiences, they are bound to come up with different phenomenologies. Of course, one may critique the choice of analysed experiences. Moreover, situated experience also

means that even someone with an experience of bodily change and body images infused with fluidity can be confronted with the need to learn to live this specific body in a meaningful manner. Each new disease may constitute specific experiences and challenges. And perhaps the experience of existential anxiety points to limits in the experience of integrity. It can be confronting to realise that being flesh and blood means being finite and frail. Finally, note that there is a risk of idealising fluidity as well: though learning to live with bodily malfunction is sometimes a solution, it should not be idealised as the solution. However, Weiss' account is not particularly susceptible to this, for she pays considerable attention to how body technologies are a part of our being-in-the-world.

Let us now answer the question as to what is a good objective for health care in terms of 'good embodied life'. Clearly, transparency is a worthwhile objective, as being meaningfully active in the world is an important aspect of life. Alienation is something to avoid or to overcome. Here the accounts of Weiss and Svenaeus suggest different approaches. According to Svenaeus, experiencing one's body as an organism is uncanny and is an experience of being out of control. Svenaeus also holds that as one lives through the body's processes one feels necessarily alienated. In this line of thought, seeking transparency – a new balance – is the only way to overcome alienation and therefore illness. We agree with Weiss that alienation is not necessary when we strive for lived integrity instead of lived health. This means that we should not strive for wholeness and closure, but seek lived expansiveness, fluidity and multiplicity: namely, learn to accept being this body in all its conflicting ways of existence.

It becomes clear from our analysis that lived integrity is an important additional ethical concept to evaluate new biomedical technologies and health care practices. 'Lived integrity' can, for example, coincide with improving bodily capabilities, as the use of technology is not alienating when there is the possibility to experience multiplicity. This means that 'lived integrity' does not replace objectives like diminished pain or improved hearing, but asks for doing it in such a way that this can be lived as a transition rather than a restoration to a normal state. In other words, in health care, illness should not simply be something to overcome but also be treated as a meaningful part of life. The importance of 'lived integrity' as an objective is that contingency and vulnerability become less overwhelming and uncanny.

Now that we have developed our phenomenological-ethical perspective, we will apply it to the practice of TE as we studied it and to the prevailing goal of TE to bring about 'ideal bodies' by 'mimicking nature'. How does this ideal relate to the notion of 'lived integrity'?

### 'Mimicking nature' versus 'unnatural prostheses'?

In its practice, TE is sometimes presented as to 'help bodies heal themselves' (Williams, 2003). By emphasising how in autologous TE the patient's own cells are used, ethical questions and concerns about this relatively new practice are evaded (Faulkner et al., 2006). Human organs do not grow by themselves in petridishes: they need to be engineered and designed. Unique to TE is the making of fleshy body parts by using cells to engineer living materials. The studied heart valve project is an example of autologous TE, in which the researchers assume that a patient's cells will be used to engineer the tissue in the laboratory, which will be transported back to the patient's body. TE walks a fine line with regard to what people perceive as natural and what they do not, and researchers fear being accused of engineering a Frankenstein or of playing God (Patrick et al., 1998, p. 331). Even for tissue engineers themselves it is controversial and frightening to speak about the design of living body parts; hence, tissue engineers tend to present TE in terms of mimicking nature or of helping the body to heal itself.

Consider the reaction of one engineer whom we asked about the design of human body parts:

I'm frequently asked by the press and the media, 'Don't you think you're playing God? How do you dare?' Yet I have absolutely no sense of doing that. Because what we do is this: we use autologous cells, we don't change them. There is no genetic impact, because we use them like in an ex-vivo wound healing. We take something that is there as a capacity and help it happen outside of the body.

(Senior researcher 1, October 2004)

The tissue engineer in question seems to claim that TE is not about 'changing bodies' and is therefore all right in a normative sense. With the notion of mimicking nature, he stresses that he adheres to the norms of nature. 'There is no genetic impact' means that no interventions are carried out that are essential in a normative sense. Thus, while the technology presents an engineering approach to



bodies, in his eyes TE does not raise the ethical questions one might have about genetic engineering. Another engineer explained that the ideal was not to make natural tissue, but 'native tissue' (senior researcher 3, informal talk, NL, October 2006). This formulation suggests that the engineered tissue was in some sense already part of the body. In Dutch, 'native' is translated as 'lichaamseigen', which loosely means 'the body's own'. This comes closest to what the researcher means: to engineer tissue that the body takes up as if it were tissue generated by the body itself.

In line with the presentation of TE as 'mimicking nature', the need for TE valves is claimed by pointing out that problems with existing heart valve prostheses arise in the interaction between the body and an implanted prosthetic 'unnatural' or 'dead' valve. In one PhD thesis, in a section titled *The ideal heart valve substitute*, the need for the tissue engineering of heart valves is, for instance, identified by referring to the drawbacks of the state-of-the-art valves that are used yearly in 60,000 valve replacements in the United States (Hoerstrup, 2005). Consider how the author discusses problems with mechanical heart valves in terms of foreign materials:

The major drawback of mechanical valves relates to the fact that these prostheses represent foreign materials, associated with the risk of infections and thromboembolic complications. To prevent thromboembolism, a life-long anticoagulation therapy is required (e.g. warfarin), showing a substantial risk of haemorrhagic or thromboembolic incidences (...). Apart from this, additional problems may occur, e.g., in young fertile females because of embryo toxicity of warafin and related substances.

(Hoerstrup, 2005, pp. 2–3)

In plain English, we may say that mechanical valves offer a lifetime solution, but with the drawback of an ongoing need for anticoagulation, which is necessary to prevent the blood from clotting on the artificial material. However, this clotting sometimes happens anyway. Anticoagulation itself entails a risk of bleeding complications that can be minor as well as fatal.

In the forementioned thesis, problems associated with biological valves – either donor valves or those made from bovine (cow) pericardium or pig valves – are summarised in terms of their low durability:

The majority of biological valve prostheses are either glutaraldehyde fixed xenografts (derived from animals) or cryopreserved homografts (derived

from human donors) (...). [These valves] do not require anticoagulation medication, however, they represent non-viable prostheses suffering from structural dysfunction due to progressive tissue deterioration (...). The majority of biological valves, therefore, necessitates re-replacement within 10–15 years, and because of higher immunological competence their durability is even less in younger individuals.

(Hoerstrup, 2005, p. 3)

These valves are always processed and contain no living tissue: therefore, they wear out and have a durability of about 12 years. In young patients the time is less, due to calcification. This is a major issue because heart valve operations are major surgical interventions that require open heart surgery with the use of a heart-lung machine. Patients require intensive care treatment and need considerable time to recover. Moreover, each operation carries with it a risk of complications.

Each one of which has a small but measurable risk. And you know, we have had patients who have not survived these conduit changes and things. So if you would have a better way of approaching this then clearly there would be a number of patients, a large number of patients who would benefit.

(Cardiothoracic surgeon 3, Boston, June 2006)

This is an issue especially for small children, as neither mechanical nor biological valves grow.

There are still patients who we are operating on three or four times between the time they are infants and the time they grow to adults. There clearly is a need, and we don't have anything on the horizon or currently available that would meet that need to avoid these children having these repeated operations.

(Cardiothoracic surgeon 3, Boston, June 2006)

For tissue engineers, the problems associated with state-of-the-art substitutes are straightforward.

All clinically available valve prostheses basically represent non-viable structures and lack the ability to grow, to repair or to remodel. This imposes severe problems specifically on paediatric patients.

(Hoerstrup, 2005, p. 3)

Tissue engineers consider the non-viability of the state-of-the-art prostheses a central issue, and

natural valves seem to be a solution. In that respect, a paper of Harken, in which a list is presented as the ‘Ten commandments’ of an ideal heart valve, is often referred to.

The essential characteristics of ideal heart valve substitutes have been described already in the 1950 by Dwight E. Harken, a pioneer in heart valve surgery, and summarised as the so-called “Ten Commandments” (Harken 1989). These include durability, absence of thrombogenicity, resistance to infections, lack of antigenicity, and the potential of growth. In principle, he stated the fundamental properties of natural, living, autologous tissues. Unfortunately, these requirements are still not met by today’s heart valve prostheses.

(Hoerstrup, 2005, p. 3)

On the basis of problems with current heart valves, the author of the previously mentioned thesis thus argues that the natural valve is a logical objective or ideal implant.

These examples show that in the reasoning of tissue engineers unnatural valves become associated with problems, while natural valves are idealised. Clearly, when engineers speak of natural valves they do not mean that any natural valve will do as an ideal example, nor do they refer to the patients’ original malfunctional valves. ‘Natural’ is thus an abstract ideal that means at least ‘living’ and that ‘patient’s own cells are used’ and are ‘functioning, growing and self-repairing’. But what kind of embodiment does this ideal imply? And how does this compare to living with a biological or mechanical prosthesis?

### **Tissue engineering: transparency as objective**

In terms of the phenomenological perspective on the body that we introduced, the TE practice develops an ideal of a heart valve that implies a desired transparency. Thoracic surgeons in particular express this ideal by explaining what the problems with biological and mechanical valves may mean in daily life. One surgeon, for instance, points to the importance of a certain lifestyle when evaluating the value of a specific kind of valve.

Are there special patient groups for whom you prefer specific types of heart valves? For example, for women who want to become pregnant?

Yes, for women who want to become pregnant. Or people who want to do sports. Well, if people do not fear a second operation, then as far as I am

concerned they may receive a bioprosthesis. I am very liberal about that. If I myself needed a prosthesis I would always choose a biological prosthesis.

So that you do not have to worry about injuring yourself?

Yes, exactly. For example, I am a fanatic horse-rider. That means that I definitely could not use any blood thinners, because if I tumbled... It is not bad if you bump into something once a while. But if you really fell off the horse three or four times a year, then you’d die.

(Cardiothoracic surgeon 1, NL May 2006, translated from Dutch)

The surgeon emphasises that biological valves are preferable if you want to move around freely. It is for this reason that doctors say a person’s lifestyle matters in the choice of a particular type of heart valve substitute. As well as the fact that anticoagulation implies being careful, it also means taking pills and having your blood checked weekly (Cardiothoracic surgeons 1 and 2, NL May 2006). It is probable that patients with a mechanical heart valve do not so much relate to this valve – it is lived as transparent – but to medication: taking the right pills, having blood checks and being cautious. Mechanical valves draw attention to the body as being frail and in need of ongoing surveillance.

The surgeons also make clear that noisy mechanical heart valves may attract attention to themselves, and the patient as well as other people may hear the valve opening and closing. It might even be possible to know, for example, whether the person is agitated. It is an intercorporeal experience, and how people will live with noisy heart valves depends upon how they, together with others, relate to the noise.

Some people are bothered by that [sound of mechanical heart valves]. It is good to mention it. There are people who know they really can’t stand the ticking of clocks: that noise can be really annoying. I believe 20–30% hear their mechanical valves, and that 4–5% find it really disturbing.

(Cardiothoracic surgeon 2, NL May 2006, translated from Dutch)

The complaints, varied from difficulties with falling asleep (12, 8.5%) to irritation (9, 6.4%) and nervousness or fear (5, 3.5%). One patient needed

medication to facilitate sleep. Another patient said he had to stop playing poker, because a faster ticking of his valve would reveal his state of mind. Some patients said they felt frightened by the confrontation with their own heart beating, while only 1 patient said he felt reassured by the valve sound.

(Laurens et al., 1992, p. 59)

There are even cases where the patient requested explantation.

(Takkenberg, 2002)

For many patients, the noise recedes into the background, becoming, as it were, transparent; others, however, may be afraid of hearing something going wrong or may even be comforted by the sounds. But there are many more situations to take into account: for example, a partner who cannot sleep and keeps on listening to make sure the person with the heart valve is fine. And what about encountering new people who are not aware of what a heart valve sounds like? A tissue engineered valve is expected to be transparent also in the sense that it is quiet. Moreover, as the different embodiments of noisy valves indicate, different people will live similar technologies differently. Transparency is not just an aspect of the technology but is something that patients achieve as they become used to and accept living with the noise.

Living with biological valves is quite different. Though biological valves give some freedom for short periods, the imminence of a new operation is for adults and especially children never far away. In some sense, people with a mechanical valve live with minor breaks in transparency all the time, at least if they go without complications. People with a biological valve may live a relative transparency for years, but are then confronted with surgery that will have a major impact. But remember the surgeon who said 'If people do not fear a second operation, they may have a biological valve'. If patients tend to worry, transparency can be disrupted earlier.

When tissue engineers speak of the natural valve as ideal, they suggest that 'natural body parts' imply transparency. For all valve types discussed, the drawbacks were a matter of breaks in transparency, albeit in different ways. Thus, translated in terms of embodiment, the ideal valve is one that it is expected to be fully transparent: it is unnoticeable, draws no attention to itself, either in the form of medication, noise or complication, and in general gives no reason to worry. However, the

link between transparency and 'natural' in the practice of TE is problematic in three ways.

First, it unjustly implies that unnatural biological or mechanical valves are inevitably inferior solutions. The objective of transparency does not necessarily call for tissue engineered valves, as non-living materials can also be lived as transparent. Nor will TE be improving embodiment – in terms of transparency – for large numbers of heart patients in the short term. For though tissue engineered valves might also be of use in the long run for elderly patients, biological valves are generally durable enough for them. The promises of TE are not that relevant.

And if you look at TE and at tissue engineered valves and at what you try to achieve, then you focus on a very small group of children with a congenital malformation. I think we have about ten such children a year in the Netherlands. And then for the pulmonary valve we have about 200 a year. Compare that to elderly people, of whom about 5,000–6,000 a year need a valve prosthesis.

(Cardiothoracic surgeon 1, NL May 2006, translated from Dutch)

For elderly people, possibilities like minimally invasive surgery are much more relevant than TE.

Second, it is not yet clear that TE will indeed constitute transparency. For younger patients, TE may improve embodiment significantly if it indeed works as suggested, but can TE live up to its promises? The practice may also show that the promises are too optimistic, for despite current hopes there might be a need for anticoagulation therapy or for reoperations. And for some patients the heart valve may be just one of the problems, or the heart may be damaged irreversibly. Moreover, though natural valves are seen as the golden standard, these are not workable objectives. Knowledge relating to heart valves is limited, and the question of what is normal is not that easily answered. Even if it can be agreed whose valves in what sense are used as an example, the question remains as to whether it is possible to engineer the desired characteristics. The question of the strength of the tissue is one example where bodies and in some regard also embodiment needs to be negotiated. The strength of the tissue is related to what pressure a person's heart valve needs to withstand during activities. Determining the minimal strength may thus affect what people can do in their daily lives.

The discussion turns to the pressure to withstand. Two pressures are at stake: normal pulsation

(5–10% stretch: elastic without deformation) and high peaks: 20% strain if target is about 250 mmHg (which the talking senior researcher takes to be a reasonable and realisable value; he says that the literature names values up to 2,000 mmHg for people who for example run uphill, but he thinks this is not realisable).

(from notes in English, scaffold meeting January 2004)

It is not just this discussion that determines the final implant. However, as there is a lack of regulation (Heinonen et al., 2005), researchers have to discuss what is technologically feasible in the short term in light of what they consider to be good enough. The norms that are developed also in collaboration with the FDA may affect patient capabilities, at least for the initial period after implantation, and thus the patient's capabilities lived as 'I can' or 'I cannot': for example, run uphill or perhaps go through a vaginal delivery.<sup>7</sup>

Thirdly, linking transparency to 'natural body parts' suggests that normal fleshy embodiment is transparent. In other words, in this way of speaking about 'natural' heart valves we recognise the ideal of health that assumes that we mainly live our body as 'I can'. Both Young and Weiss indicated that this ideal was also expressed in the work of Merleau-Ponty, and they criticised it. They pointed to the fact that these kinds of ideals might be a hindrance to more bodily focussed ways of being in the world, like enjoying dressing up or being pregnant. In this light, we need to look at how the ideal of 'mimicking nature' that is present in the engineering of 'natural' heart valves may negatively affect the embodiment of heart patients. Additionally, we should examine how we can discuss possible pros and cons of TE without speaking in terms of natural/unnatural and without stimulating an ideal that limits embodiment.

### Transparency as achievement

In the light of our framework, we concluded that 'lived integrity' should be an important additional objective next to well-accepted objectives of health care. In the case of heart valve patients, this means that when we develop or use technologies – which, one hopes, means that patients no longer need anticlotting medication or multiple operations – we also pay attention to stimulating living multiplicity and change as being-this-body before, during and after the technological intervention.

Especially for younger patients, it seems worthwhile that doctors work towards relative transparency, while at the same time avoiding a reinforcement of the idea that this is what bodies 'naturally' are. Research on the lived experience of congenital heart disease shows that patients long to be normal (Claessens et al., 2005; McMurray et al., 2001).

For example, David, when asked about his ideal wishes, describes his desire to be normal, not worry, and have no further operations: Probably to not have a heart condition – just to be normal... 'get rid of my scar and have no further operations and just to be able to go and do anything that I want without having to worry'.

(Claessens et al., 2005, p. 5)

Again, we recognise the societal norm of health that Young and Weiss both commented on in the longing for transparency: the body that does not change or disrupt you, that draws no attention to itself. Claessens notes that, in general, surgery on patients born with congenital heart disease improved lived experience, as it restores physical capabilities (Claessens et al., 2005, p. 7). In other words, the body becomes more an 'I can'. For young patients with valve replacements, both mechanical and biological valves make it, as explained, impossible to be 'normal'. If what is promised regarding TE – no anticoagulation or repeated operations – becomes reality, then TE might indeed seem an improvement qua embodiment for patients. However, it seems that as young patients' lived experience is already so much focussed on living up to normality, it would be unwise to reinforce this body ideal by suggesting that TE would give them normal, natural bodies. Presenting TE and in particular the ideal of transparency as natural undermines other ordinary experiences of our fleshy bodies: living a body also entails hurting, scarring oneself and paying heed to one's bodily existence.

The challenge therefore is not to confuse objectives of medical technologies with what constitutes bodies. If the objective of TE is to add to the experience of health, then transparency is, as Svenaeus' analysis makes clear, a valuable objective. However, Weiss' analysis shows that we should be clear that this transparency is engineered, doctored and achieved rather than regenerated by 'natural' bodies. One way to discuss TE would then be as the following doctor-engineer did. He contrasted the objective of TE with what bodies can do by themselves:

So my view has always been to try to take the best of nature but then be clever about changing



to do things that nature does not ordinarily do (...). If she did, we would not have to do this. So if somebody has trauma it heals with a scar, or has an amputation or has a disease that kills an organ, nature tries to repair it but doesn't get very far. So we take advantage of nature and use her but we also have to understand it can change it to (...).

(Senior researcher 4, Boston, June 2006)

TE might therefore be presented as improving bodies by making intelligent use of bodily processes. In this way, patients may benefit from medical technologies, while the body ideals that are materialised in these technologies are not that easily mistaken as easy or obvious. Moreover, staging TE as a body technology rather than self-healing better captures how bodily transformations through medical interventions are lived.

Now that the logic with regard to natural bodies and 'good life' has been deconstructed, we can use and develop the introduced framework to study other examples of tissue engineered body parts. Here it would be useful to include patients' experiences in the analysis. Our preliminary analysis of tissue engineered heart valves shows how for internal body parts a phenomenological perspective is illuminating, but the framework offers the potential to study a wide range of aspects of embodiment. An interesting project may involve tissue engineered cartilage being used to treat knee injuries. On the one hand, such cartilage may mean that damage (e.g. from sports) could become reversible. Will this affect the way people live their bodies as vulnerable: namely, how will they manage their involvement in sports and their concern for their body during activities? On the other hand, there is evidence that TE will only work if the surrounding tissue is quiet. This might mean that treatment should be given when there are not yet any symptoms. Will this affect how we conceive of health and how we live health and illness? Another interesting project involves tissue engineered bladders, where living with incontinence, shame and being in control may be topics to explore. Finally, tissue engineered skin seems a particularly interesting topic for studying aspects such as feeling beautiful and the effects of ideals of beauty.

### **From ideal bodies to good embodied life**

We introduced in this article a phenomenological-ethical framework to reflect on biomedical technologies

from the perspective of embodiment. In developing this framework we studied transparency as an objective for health care. We highlighted that there is a risk in idealising transparency as normal embodiment and we introduced 'lived integrity' as a concept that characterises how 'being able to live bodily focussed experiences, multiplicity and bodily change as oneself' is an important aspect of a good embodied life. In this light, we showed that while transparency is certainly a valuable objective in health care, idealising transparency threatens 'lived integrity' and thereby may negatively affect embodiment. We thus concluded that 'lived integrity' should be a central notion in phenomenological-ethical reflections on the development, introduction and use of biomedical technologies.

When we applied our phenomenological-ethical framework to TE, it became clear that the technology may affect embodiment in two ways: first, clearly and significantly, by amending patients' bodies in terms of 'cutting-and-pasting' body parts. The analysis of biological and mechanical heart valves made clear how different kinds of body prostheses constitute different ways of being-in-the-world; second, by reinforcing body ideals like 'I can', TE may negatively affect embodiment. In the practice of TE, bodily problems are related to mechanical or dead biological substitutes, and transparency is coupled to 'natural' body parts. This kind of reasoning supposes that normal embodiment is transparent and thereby makes it hard to live bodily change and illness as self. In this way, thinking in terms of 'mimicking nature' affects the possibility to achieve 'lived integrity'. Our analysis of TE points to a challenge for health care in general: how to let people best benefit from biomedical technologies that may improve embodiment, while not wanting to reinforce one-dimensional body ideals like transparency.

To highlight the importance of multi-dimensional body conceptions, let us give examples of negative affects of transparency as body ideal. In our discussion of Weiss we encountered two examples: the ideal of health frustrates living bodies that cannot achieve this and it negates bodily experiences like pregnancy, lactation and dressing up, all of which can be enjoyable. In the last section, we considered a third example: transparency as ideal misses out on what it takes to achieve it. Finally, body technologies may change when and how we die, but not that we die, while they also constitute new illnesses. Moreover, these aspects of embodiment, illness and dying may be negatively affected by ideals of health. It is clear that the improvement in embodiment and the

endeavour to engineer ideal bodies do not fully coincide.

We have three suggestions for *integrating* the use of body technologies – in order to improve embodiment – *with* striving for ‘lived integrity’. First, on the level of TE: engineers, physicians and others involved in or discussing TE can make clear that it does not teach us what bodies are, but is one more body technology that may help people to improve embodiment or to find a new balance. By emphasising engineering, work, patient involvement and so on, TE and the embodiment constituted by it may be understood as an achievement. Hence, this also means engaging in discussion concerning engineering flesh and designing bodies, as the short-cut to present TE as natural should be avoided. Second, on a political or ethical level we may discuss other aspects of caring for the body rather than merely trying to regain physiological health. Lived health is already a broader objective, as it does not presume one correct balance. Furthermore, lived health can also be constituted by changing surroundings, with the aid of technologies and by finding new meanings. We argued that lived integrity is an important aspect of good embodied life, and thus should be an additional objective of health care. But are there ways to stimulate it without idealising one aspect of lived multiplicity? Thirdly, for reflexive work on new medical technologies the challenge is to integrate both aspects of body making in the analysis: the improvement of bodies and the affects of body ideals/ interpretations of what bodies are. A phenomenological account of bodies as used here is rich in this respect. It captures how we exist materially and how material changes affect us. In addition, it opens other aspects of situatedness: lived intercorporeality is material, social, political and ethical.

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### Notes

1. Eugene Thacker discusses TE as part of regenerative medicine, pointing out that regenerative medicine might lead us to think of the body as either fully stable or to be changed at will (Thacker, 2002).
2. Embodiment is one of four body-technology relations that Ihde describes. The others are hermeneutic relations (i.e. medical imaging), alterity relations (i.e. robot as quasi-other) and technology as a background (i.e. central heating) (Ihde, 1990, pp. 96–98).
3. Example taken from Svenaeus (2001) and amended.
4. For Varela and Nancy, the cultural-historical aspects of embodiment are a central part of their experience. Ihde recognises cultural effects, but tends to differentiate between the body as described by Merleau-Ponty and the cultural body (Ihde, 2002, pp. 16–34).
5. Transparency here refers to automatic balancing and not total transparency in the sense that body is in the background all the time.
6. Even if someone’s experience of illness is constituted on the basis societal norms, their experience is still relevant (Stoller, 2006).
7. Tissue engineers assume that the tissue will ‘remodel’ in the body: i.e. adapt its structures to withstand the pressures in the body.

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