Wolfgang Jonas 9/2000

Design: the swampy foundation of our conception of man, nature, and the natural sciences

---

«*There is no purer myth than the notion of a science which has been purged of all myth.*» (Michel Serres)

1. The difficulty of locating design- everywhere or nowhere ?

The disciplines of design are often stigmatised for supposedly being non-scientific. At least this is the view held by some of those who also study the theoretical aspect of design. A consequence of this is the existence of a pronounced dualist tendency which, depending on the current state of Zeitgeist or professional preference, tends either towards models based on the natural sciences (such as Cybernetics, Design Methods Movement and many more), or those models based on the human sciences (cf. MARGOLIN, product semantics, product language, and many more). The weakness which such a manner of proceeding entails is however the rash relinquishing of disciplinary autonomy and the all too keen and reverent adoption of an unfamiliar self-conception, which even within the ranks of science no longer remains unchallenged.

Contemporary theory designs often present us with geometrical and structural imagery, but without naming their contingency: this is illustrated by ARCHER‘s triangle, its axes representing the Humanities (words)- the Sciences (numbers)- Design (artefacts); DILNOT‘s (1999) triangle of ‚aesthetics- technology-ethics with design (in a reconciling function) at its centre; HAAVISTO‘s Yin-Yan model; FRIEDMAN‘s pentagon constituting social sciences-technology- art- natural sciences-humanities. From this emerges the phenomenon of oscillation between disciplinary fantasies of omnipotence and impotence: is design to be seen as an agent of reconciliation, as a gapfiller, or is it simply trying to find its niche, a place where it will be tolerated?

This essay sketches a design model which could promote disciplinary equality and autonomy, without laying claim to a status epistemologically equivalent to those of the humanities and natural sciences. Its starting point is the idea of design as the original constructive human activity. One might call it a model of recognition, one which integrates scientific and design-related components in a processual manner. This is about designing a ‚meta-theory‘ of design.

2. Autonomous theory of design is meta-theory – but of limited practical utility

Design theory is a self- reflective undertaking. If it is to describe a part of the discipline and the functioning thereof, then any design theory must be capable of describing its own coming into existence and its own changes without too much difficulty. Therefore, design theory must be able to deal with *self-reference* and *paradox* .The establishing of theory equals the building of models. In the widest sense of the term, model building equals design, in other words the forward-looking modification and configuration of entities for a particular purpose. According to GLANVILLE it is in this manner, that science becomes a specific field of design. So firm a stance can hardly be backed up with evidence, or rather, it is exaggerated; here in this essay the

question surrounds common roots and procedures, which are less far-reaching in their demands. SIMON introduces the lovely meta-term ‚the sciences of the artificial' which may claim a legitimate place *among* the sciences and the humanities:
«Engineering, medicine, business, architecture, and painting are concerned not with the necessary but with the contingent – not with how things are but with how they might be – in short, with design. »
Artificial phenomena are systems which are adjusted to the environment in which they exist, through the purposes or aims which they serve therein. In their ability to be deformed by their environment they show an ‚aura of independence', whereas natural phenomena are more prone to behave deterministically, posessing an ‚aura of necessity'.

The partly justified criticism of SIMON's theory concerns his style, the latter smacking of engineering. Such criticism does not however take into consideration the different levels of his statements. It is absolutely necessary to respect the difference between ‚meta-theory' (concerned with observing the observation of design, level 3), ‚theory/methodology' (the observation of design, level 2), and ‚making' (level 1). As for meta-theory, SIMON is vague, at times metaphorical, and yet convincing . As far as theory/ methodolgy (level 2) are concerned, his arguments are frequently one-sidedly rationalistic, due to his belief in formal procedures of problem-solving- understandably, considering that he is one of the fathers of symbolic AI. Up to now, design theories have always looked at design from ‚half- without', staying on level 2. They adopt particular, attractive partial theories from all fields and then claim to use these to describe the whole, the most prominent example being that of semiotics. But how can semiotics (on level 3) explain its own emergence as a design theory , its transformation and its possible disappearance?
Such theory crises, with their immense frictional losses, are symptoms of this lack in structure. The solution to this (which, incidentally, is my own) is inherent in the view which comes wholly from without. There we regard design as a system, which constantly adapts to its environment in order to fulfil its function.

3. Design as interface discipline - between things and contexts

Design operates ‚inbetween', concerning itself with the relationship between people and things. BONSIEPE sees the interface as lying in the triangle ‚user - action - artefact', whereby the artefact is to reconcile the diverging demands: this is not a new way of looking at things. SIMON goes a step further, describing ‚the artefact as interface between inner and outer environments', and he pinpoints three aspects of artificial things:
1) purpose / aim, 2) composition / nature of the artefact (inside),
3) surroundings in which the artefact is to function (outside). The latter two of these are, according to SIMON, scientifically determined. Design would follow the functional aims , which connect the inner with the outer system, whereby a large number of equivalent means of establishing a fit would arise. JONAS (1999), following SIMON, describes *Design as the interface discipline between artefacts and contexts , between inner and outer system.* This is the wider field in which the BONSIEPEan triangular relationship is realised. Not only does it contain scientific components, but also cultural, social, political ones. The boundary between inside and outside is not fixed, but rather defines itself through the designing authority´s competence to intervene. The inside constitutes all that which can be manipulated.
In view of the notion of an autonomous model of design, we should continue to keep in mind SIMON's reflections on the *processuality*, or rather the fundamental *‚infinite'* nature of design, and on the dilemma of the permanent necessity for planning despite the uncertainty of future contexts. In addition, one should stress his clear orientation of values, which one often disputes him (163):

«The idea of final goals is inconsistent with our limited ability to foretell or determine the future. The real result of our actions is to establish initial conditions for the next succeeding stage of action. What we call ´final´ goals are in fact criteria for choosing the initial conditions that we will leave to our successors.
How do we want to leave the world for the next generation? What are good initial conditions for them? One desideratum would be a world offering as many alternatives as possible to future decision makers, avoiding irreversible commitments that they cannot undo.»

SIMON describes design as ‚a kind of mental window shopping', which does not necessarily have to be bound up with real changes. He emphasises the explorative potential of design, with its possibilities to develop projections, to hold futures in reserve, strategies for dealing with uncertainty.

The meta-theory striven for must describe design as the agent of co-evolution of system and environment, on the interface between the made (artefacts) and the context. Meta-theory therefore has to be dynamic, without thereby becoming amorphous or unrecognisable: it has to master a tightrope walk, finding its balance between fossilisation and dependency on the Zeitgeist. What does the *production process* of design and design theory look like, that is capable of recreating this fit, time and again (be it planned or unplanned)? It is about the description of a pattern which is of dynamically stable identity. A first attempt at describing the theory dynamics, including breaks and crises (view from level 3 onto level 2) can be found in JONAS (1994), central aspects of this again being self-reference and paradox.

4. The separation of nature and society - and what about things ?

What stands out is that the actual object of design, that is the projection of what *could* be and which is conveyed through *artefacts*, does not occur in the sciences in the first instance: the natural sciences concern themselves with nature itself and its laws, human sciences with people and their intricate relationships with themselves and others, semiotics with language and discourse, detached from material and social references. The sought-after meta-theory is not reducible to one of the components (natural sciences, humanities, and since recently semiotics/discourse); neither does it arise out of an integration of the different fields, or out of an insertion of design into a (supposedly fixed) constellation of established fields. This approach does not start out from the momentary situation, the latter fundamentally being incomprehensible or continually giving rise to polarisation, but rather puts into the foreground the ‚having become' and the ‚having been made'. This seems to be suitable for a qualitative redefinition of the relationship and for backing up the autonomy of a field called ‚design'.

Starting out from the differentiation between the eternal order of nature and the chaos of the human world, a classification going all the way back to antiquity and the Middle Ages, LATOUR describes the process of separating the natural sciences and the humanities. Following the example of the natural philosopher Robert Boyle (1627- 91) and the political philosopher Thomas Hobbes (1588-1679), the mobilisation and the strict separation of previously distinguished yet nevertheless highly interlinked fields is described. One can also describe this process of modernisation as the re-introduction of the differentiation ‚natural / social' into one of these sides. Boyle's *Invention of the Laboratory* and the scientific community as factory for the production of facts concerning nature adds to the transcendence of naturalised nature the immanence (feasibility) of socialised nature. Hobbes's *Invention of Leviathan* as representative of the unpredictable mass of citizens, seduced by their passions, adds to the immanence of the social the transcendence of a scientifically substantiated eternal order. It is thus that the first two *paradoxical constitutional guarantees of modernity* arise:

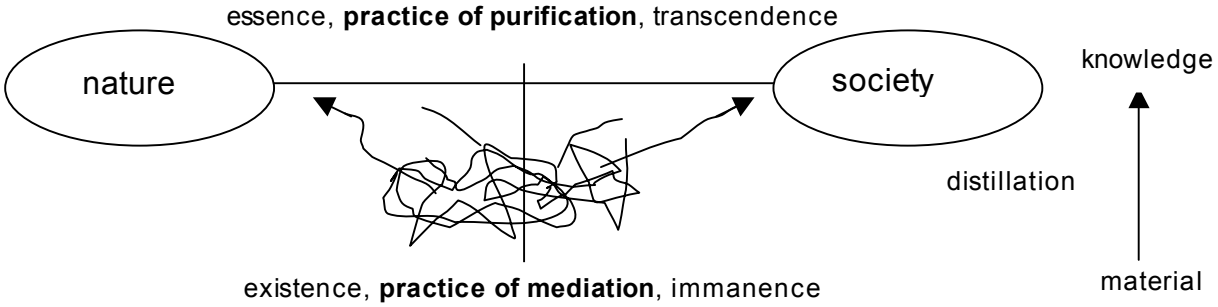
1. Even when we construct nature, it is as if we did not.
2. Even when we do not construct society, it is as if we did.

This three-dimensional scheme of transcendence and immanence (LATOUR adds the dimension of God's transcendence and immanence as a third axis in addition to nature and

society) substantiates the efficiency of modern scientific argumentation with regard to all that which was possible in the ancient constitution. From this emerge clearly defined critical positions (theoretically eight of these) and hermetic scientific buildings. An example of this asymmetrical pattern of argumentation is the explanation of the True through its correspondance with the reality of nature, and of the False through the constraints of social categories, fields of knowledge and interests, or the critique of the feasibility of nature from the position of the transcendence of the social, and so forth.
Ever since then, philosophy has lent itself to being read as a permanent attempt at reconciling the two poles; in reality however, it only manages to create an absolute polarisation between nature and society today, as compared to the still delicate differences at the outset, in the 17th century. Now all variants have been gone through and the recognition dawns that *both nature and society need to be explained.* According to LATOUR, the agents of this *symmetrification* are made things (quasi- objects) and the process of their manufacture.

5. Objects/ things elucidate the relationship nature & society - the space of the hybrid

Up to now, we have only moved along the horizontal dimension between the nature pole and the social pole; the relationship itself remains incomprehensible. This suggests the descent into the ‚swampy underground' of the production of purified scientific knowledge. Here one can trace (more or less laboriously) how an object with a claim on truth comes into existence on the brilliant surface of the sciences. Historical context, the biograhy of the scientist, academic context, conditions of publication, rhetoric / discourse etc. all have an influence, but for purposes of presentation they are neatly separated. From the incomprehensible one-dimensionality of ‚nature - society' (horizontal axis) we get to two -dimensionality through the addition of the (vertical) axis ‚mediation - purification': *the space of the hybrid* opens up. Beneath the surface we have the *practice of mediation*, above the *practice of purification*. The poles of the vertical can be more specifically labelled with ‚immanence / existence / locality' and ‚transcendence / essence / globality'. Processes of distillation take place which transfer the quasi-object from exemplary materiality to the universal essence of knowledge.



On the surface we are dealing with ‚cold' objects, with closed ‚black boxes', components of knowledge which have reached stability (normal science), without connectability, which would go beyond the defined I / 0 relationship of the black box. At least on the side of the natural sciences (due to the stable reference of the object of recognition) they potentially constitute the basis for an advance in discovery. Beneath the surface we have the ‚hot', fertile swamp of the socio-technological jumble. These are unstable, diffuse mixtures, including re-opened black-boxes, with innumerable possibilities of (re-) connection. This multiple ability to be incorporated into networks is the precondition for the propagation of quasi- objects and

- by means of the purification procedure - for the further development (progress) at the poles on the surface. The purification process, which has as its consequence the strict division of nature and the social (the division of the sciences in general), is necessary, in order to be able to work on the propagation of hybrids beneath the surface, unhindered by inhibiting interconnections (e.g. prohibitions and taboos).
The *overfoaming productivity* of modern society stands in contrast with the *tranquil practice* of pre-modern (‚primitive') societies, where (including on the surface) everything is connected with everything else, where natural, human, and divine things are mixed inseparably, and where each change has unpredictable effects almost everywhere. Progress and particularly scientific revolutions / changes in paradigm can only originate in the swamp of potentially unlimited possibilities of connection. This does however presuppose succesful purification; and thereby, according to LATOUR, the third guarantee of the modern constitution comes into existence :
3. Nature and society must remain absolutely separate ; the work of purification must therefore remain separate from the mediation work.

6. The laboratory as location of the hybrid - quasi-objects as mediators

The field of the hybrid which has hereby been opened up can be seen as breeding ground for discovery in its rough state. The hybrid is the locality of the (quasi) objects and their manyfold relationships. On one hand, quasi-objects are scientific hypotheses / theories during the process of their production, at the point where they are still inseperably linked with machines, people, social practices and communication in the laboratory. Within this fluid medium, interconnections of quasi-objects arise, forms come into existence stabilise and (possibly) reach the surface purified and decontextualised. They change from *local events* to *global facts.*
Nevertheless, quasi-object are not just impure / soiled intermediate steps, or temporary transit phenomena on the way up to the surface. In the course of modernisation we experience an explosive propagation of quasi-objects, due to their highly efficient, paradoxically stabilised constitution, and which assume an increasingly autonomous status: the emotionally charged objects / fetiches with which we surround us, the object-oriented social practices which we cultivate as behavioural norms, objectified signs and symbols, by means of which we communicate in highly material-insensive ways, symbolic objects, which we also use like machines, and so forth. And then there are the ‚monsters' of the Industrial Revolution, the gigantic, extensive, unheard of networks of natural, social, communicative aspects: e.g. the Internet (at the same time made + not made + wanted); the Cyborgs (at once people + machines + animals); the hole in the ozone layer (at once made + not made + not wanted). Our problems and our helplessness faced with these stem from the one-sided perspective which modernity has brought us. They no longer fit into any one of the handed down categories. The ‚3rd culture' which SNOW has already aimed at as a way out, can obviously not limit itself to the communication between natural sciences and humanities, and neither can it be reduced to the taking over of the humanities by the natural sciences, but rather must it concern itself with the process / practice of production / new invention of the hybrid in the spirit of symmetrification (HARAWAY). The central question is as follows: What happens there? So-called *laboratory constructivism* introduces the following genealogical perspective: a move *from the ‚what' to the ‚how' of the production of knowledge.* The social process of *laboratorisation* requires the transition from a descriptive to a production logic. KNORR CETINA examines the laboratory as ‚fact-factory of modern science'. It is no longer just social facts , but also , hard' scientific facts which are described as social constructs. From this

perspective, the social is not a source of friction or even soiling, but is seen as constitutive of the process of gaining knowledge:

«Those scientific discoveries which are labelled ‚true' and ‚real' are not results of the un-and discovering of given structures and are therefore not causes on which the technological culture is based, but much rather consequences of scientific research processes. Facts are not simply available, they have to be established. It is only in the process of scientific works that they are produced as ‚independent' and ‚natural' facts.»

Starting off from the concept of science in action, it is now a question of establishing the connection with *design in action*.

7. Design (theory) operates in the hybrid - design-objects are quasi-objects

Scientific discovery is designed in the laboratory with the aid of highly complex (artificial) artefacts, society being a construct of artefacts and communication. The hybrid is the space where objects / artefacts have their legitimate place.

Design opens up the black boxes which it frequently takes over from the sciences, it disregards, often consciously, the rules of their use. Design mixes up the pure, the times / epochs / genres, integrates the different elements, creates new hybrids and demonstrates no interest in purification. This disregard is not a defect or fault, but constitutive of and a necessary prerequisite for the possibility of creating new things. Although design uses elements from the pure, the aim is however different to that of the sciences, namely the creation of new *exemplary artefacts*, and not the development of new, improved, *generalised components of knowledge*. Design does not contribute to the progress of the sciences, because it is active in the hybrid and has its place under the surface.

DILNOT describes design as the process «whereby the limits of the actual are continually formed and reformed» (1998: 69). He describes design as the process of configuring incommensurable factors / demands and of the synthesis (reconciliation) of these factors in the artefact, in propositions concerning artefacts. In this sense one can say: *design objects are quasi objects!* They are functional units, but have not been purified of their contexts, conditions of origin and interconnectedness. The space of the hybrid in design is neither the desk of the theoretician, nor the studio of the practician, nor the workshop of the model-builder. In design the space of the hybrid is the *laboratory* (the place of mixing / mediation of theory / practice / methodology), a place which might have to be newly ressucitated.

Although design transports nothing to the surface, it does provide effects comparable with the purification practice, ‚pseudo-truths': geniuses, stars, styles, ‚schools', cult objects, theories, methods,… purified of all the traces of their manufacture, ownership and context. ´Small theories' and methods pretend to have similarities with scientific truths because they too describe the whole. This is supposed to be progress, but usually it is only partially and temporarily valid. Always inherently present in this is the danger of ideologization, the creation of myths and fossilisation with the consequence of regular, radical changes, which are often showily described as changes in paradigm.

We misunderstand the objects on the surface as truths (‚growing scientific basis of design'). We are however just dealing with exemplary quasi-objects, an *archive*. This archive is the only basis for knowledge of design. It differs fundamentally from the basis of knowledge of the sciences, because it is a construction kit with no strict rules or refined conventions. In view of the creation of new things, infringement against the rules is even imperative.

Design is a ‚historical discipline' in so far as it is based on archives of things / objects, styles, protagonists and theories. It knows no progress, only change. Theories throughout the ages, methods, case studies: these are all testimonies to temporary fits between artefacts and the contexts. What remains useful is the growing layer of the sediments of design anecdotes

(ROXBURGH, BRENNER) which cannot be disproved and which at most go out of fashion, but will undoubtedly crop up again at some point in time.

8. Zooming in on the hybrid network- the self-similarity of design models

How then is it possible to deal with this disquieting situation in a creative and productive manner? WEAVER, in his standard essay ‚Science and Complexity' (1948), introduces the term ‚organised complexity'. He differentiates between the problems of ‚simplicity' (processes of classic physics, with few, mostly reversible variables) and of ‚disorganized complexity' (statistically describable processes with a large number of frequently irreversible variables) and he points out the urgent need for a scientific aid for present problems which arise out of the indivisible network of, in actual fact, incommunserable ‚hard' and ‚soft' factors of social, economical and political nature:

«There is a middle region in between where problems show the essential features of organization … problems which involve dealing simultaneously with a sizeable number of factors which are interrelated into an organic whole.»

JONAS (1999) describes design (theory) as a dynamic network of largely contingent elements, ‚chunks of ideas'. The central idea which is also illustrated by the form of the above essay, is the concept of *self-similarity of design models* on the different levels of the design process. It is always a question of indivisible ‚entireties' related to ‚real' situations:

- the article consists of paragraphs / chapters which may be combined / connected in whichever way suits the intended message / lesson one wishes to convey.
- Real design problems consist of largely contingent, perspective, purpose-oriented networks of factors / variables.
- design theory (on the meta level) is a largely contingent, designed network of theoretical and methodical elements, of fields of knowledge, ideologies, preferences, practices etc. (‚chunks of ideas').

The differentiation between system/ environment for the construction of meta theory is re-introduced into the system / discipline (‚re-entry') and is there used as leading differentiator. Design-problems are treated as system / environment fits throughout. This is a design decision. The central concept of organised complexity provides the tools for dealing with circularity and feed-back, and with the interconnection of hybrid, incommensurable elements. The two main tasks are:

(1) The systemic description of the situations. The recognition of hardly limited possibilities of connection renders possible an equal number of problem definitions. The system boundary inside / outside (the space of design) is a function of design's competence to intervene. The apparently fixed *‚real' problem* thereby becomes a *designed project*. There are then no solutions: the solution is the problem.

(2)Projektive thinking about planned / unplanned development. The outer system cannot be influenced, its development is moreover highly uncertain. The prediction of situations (‚solutions') in the scientific sense of the word is impossible. It is therefore a question of imagination, projection and the explorative exploration and mediation of uncertainties. This process negotiates questions such as : ‚How do we want to live?' and is necessarily value-oriented and discursive. The concept of teleology which had long been scorned is now re-entering the sciences (ROSENBLUETH, WIENER).

9. Summary : design is everywhere - but not everything

Design cannot be substantiated scientifically. In its intentions it is fundamentally different from science, although methods of work and production as well as certain tools are comparable.
We can only understand what we ourselves can manufacture. The aim of making in design does however not lie in generalised knowledge, but the functioning of the made in itself. Design has no paradigmatic core, it is a ‚groundless discipline', and its unsure base constitutes a characteristic pattern of process. Consequences of such a view are further explained by JONAS (1999): there is no such thing as progress, at best there occurs an optimum fit. There are no Archimedean points for criticism in design. And so forth. All this is not a flaw, but the very strength and characteristic nature of design which it is necessary to develop.
A meta-model of science and design has been sketched. Both have a common fluid base, the hybrid with the morphology of the network. This provides (legitimate!) feedbacks and self-references in the development of theories, renders the dynamics of theories in design describable with changing attractors (static, cyclical, chaotic). Explainable? The quasi-objects / artefacts are the agents of knowledge production. The latter moves into the centre of attention and permits us to recognise the pure sciences as extreme positions in the process of mediation. In view of ‚primitive' societies, anthropologists have always practised this point of view. This is also what constitutes the contradiction with GLANVILLE who claims that science is a limited special case of design. The argumentation here describes design thinking / practice as a working method which is also characteristic of science. The envisaged view point enables design, free from the ‚purification compulsion', to abandon the exaggerated reverence for the sciences and to develop its own standards, which, as shown, do indeed use the sciences. This is the hypothesis: design is only capable of life / survival in the hybrid. The gaining of knowledge in design always happens through the disrespectful transgression of scientific rules / handicaps, through the exploitative appropriation of scientific ideas and the immersion into the hybrid. Design has to be unscientific in order to qualify as design. In this sense it is not modern, because it does not participate in the divisin of spheres, or rather cannot participate in it. According to LATOUR it is possible that science is increasingly becoming ‚not modern' again, or in other words that design can convey the relieving idea that we have never been as modern as we always thought. Perhaps design and sciences can learn from one another?

Additional remark: but that is rather disappointing, isn't it? What remains is the tempting question: could design not perhaps after all develop an original authority in the pure, and thus develop a scientific basis different from the archives? Does this meta-theory here fulfil the demands? The ‚small theories' at least do not, for they are invariably condemned to fossilisation / ideologisation, once they rise to the surface and stay there.

10. What are the consequences of this for training and research in design ?
How can these findings be assessed with regard to the current division of research *about/into design, for design* and *through/within design* (cf. FRAYLING)? The hypothetical approach seems to be ‚about design', it contemplates the discipline and what surrounds it from a distance. Research ‚for design' provides the ‚small theories' and methods which design employs as aids. Research through / within design is that which takes place within the hybrid. The question remains: can it be of the same quality as scientific research? Which criteria have to be considered in order to qualify something as design research and not just ordinary design? Is it the widening of the boundary between the existing and the possible? Is it the degree of reflection of activity in the light of theories (and in turn the modification of these theories)? The answers are manyfold and diffuse and it is difficult to reach any agreement, as was

illustrated by the debate recorded in the mailing list of the Design Research Society around the turn of this century.
What follows from this with regard to education? A comprehensively obliging programmatic orientation to, history, theory and criticism‘ (MARGOLIN) are as undesirable as canonical lists of subjects of encyclopaedic character (FRIEDMAN). Methods and theories are no miracle cures / panacea. If they functioned in the scientific sense there would be no demand for design. They only ever serve as the ladders which we leave behind us once we break through onto new ground (but that is already quite something!). What we really require, it seems, are non-specific properties:
- plurality and obstinacy of teachers (reflecting incommensurability),
- alchemical willingness / eagerness to experiment (generating connections),
- transparency of processes (exposing inconsistencies),
- originality, freshness, relevance of results (stimulating interest),
- conveyability of results (producing entities / wholes),
- and so forth.

There we have all the riches of the ressources with which to design the world. It is a question of something like painstakingly reconstructing ‚wild thinking‘ (cf. LEVY-STRAUSS): systems thinking today makes it possible to relate the quasi-object ‚hole in the ozone layer‘ to atmospheric science, to the production of refrigerators, to environmental politics, to the situation of the labour market in underdeveloped regions, etc. Disciplines such as Futures Studies and technology assessment enact with modern means the forward-looking reconstruction of that which takes place in the hybrid. Design contributes to the re-connection of the pole nature with that of society in the medium of the hybrid, by means of the quasi-objects. Design helps in thinking about the consequences of the purification process and the consequences of the unlimited multiplication of hybrids.

Bibliography

Archer, Bruce "Design as a Discipline" in *Design Studies* Vol 1 No 1 1979 pp17-24
Bonsiepe, Gui *Interface. Design neu begreifen* Bollmann, Mannheim 1996
Dilnot, Clive (1998) "The Science of Uncertainty: The Potential Contribution of Design to Knowledge" in *Doctoral Education in Design* International Conference, Columbus, Ohio, Oct. 1998 pp 65-97
Dilnot, Clive (1999) "How should we conceptualize design such that research into it or through it can be ´useful & critical´?" in *HEL99* pp 1-17
Frayling, Christopher "Research in Art and Design" in *Royal College of Art Research Paper* #1 1993/4
Friedman, Ken "Theory in Design" in *HEL99*
Glanville, Ranulph "Why Design Research?" in *Design: Science: Method* Westbury House, Guildford 1980
Haavisto, Virpi "From Still-Life to Real-Life. Towards Real-Life Critical Questioning in Design Research with Holistic and Humanistic Approach" in *HEL99*
Haraway, Donna *Die Neuerfindung der Natur. Primaten, Cyborgs und Frauen* Campus, Frankfurt/M. 1995
HEL 99 *useful and critical - the position of research in design* International Conference, UIAH Helsinki, Sept. 1999
Jonas, Wolfgang (1994) *Design - System - Theorie. Überlegungen zu einem systemtheoretischen Modell von Design-Theorie* Die Blaue Eule, Essen 1994
Jonas, Wolfgang (1999) "On the Foundations of a ´Science of the Artificial´" in *HEL99*
Knorr Cetina, Karin *Die Fabrikation von Erkenntnis* Suhrkamp, Frankfurt/M. 1991 (engl. Original 1981)
Latour, Bruno *Wir sind nie modern gewesen. Versuch einer symmetrischen Anthropologie* Fischer, Frankfurt/M. 1998 (frz. Original 1991)
Lévy-Strauss, Claude *Das Wilde Denken* Suhrkamp, Frankfurt/M. 1968 (frz. Original 1962)
Margolin, Victor "History, Theory, and Criticism in Doctoral Design Education" in *Doctoral Education in Design* International Conference, Columbus, Ohio, Oct. 1998 pp 197-206
Rosenblueth, Arturo; Wiener, Norbert; Bigelow, Julian "Behavior, Purpose and Teleology" in *Philosophy of Science* Vol. 10 January 1943 No. 1 pp 18-24

Roxburgh, Mark; Brenner, Craig "The News from Nowhere" in *HEL 99*
Michel Serres zitiert nach Latour:126
Simon, Herbert A. *The Sciences of the Artificial* MIT Press, Cambridge, Mass. 3rd ed. 1996
Snow, C.P. *The Two Cultures* Cambridge University Press, Cambridge 2nd ed. 1963
Weaver, Warren "Science and Complexity" in *American Scientist* 36 1948 pp 536-544