# Contents

# Introduction

‘Building is cooperating with the Earth.’
*Marguerite Yourcenar.*

## Motivation

*Activating senses*

Sun, wind, water, earth and life touch our living senses immediately, always, everywhere and without any intervention of reason. They simply *are* there in their unmatched variety, moving us, our moods, memories, imaginations, intentions and plans.

*Mathematics next to senses*

However, the designer transforming sun into light, air into space and water into life, touches pure mathematics next to senses. Mathematicians left alone destroy mathematics releasing it from senses, losing their unmatched beauty and relief, losing their sense for design. To restore that intimate relation, the most freeing part of our European cultural heritage my great examples are Feynman’s lectures on physics, D’Arcy Thomson’s ‘On Growth and Form’ and Minnaert’s ‘Natuurkunde van het vrije veld’ (‘Outdoor physics’). Minnaert elaborated the missing step from feeling to estimating.
I am sitting in the sun. How much energy do I receive, how much I send back into universe?
I am walking in wind. How much pressure do I receive and how much power my muscles have to overcome? It is the same pressure giving form to the sand I walk on or giving form and movement to the birds above me! I am swimming in the oldest landscape of all ages, the sea. How can I survive?

*Re-constructing behaviours*

No longer can I escape from reasoning, from looking for a formula, a behaviour that works. But this reasoning is next to senses and once I found a formula I can leave the reasoning behind going back into senses and sense. The formula takes its own path in my Excel sheet as a living thing. It ‘behaves’. Look! Does it take the same path as the sun, predicting my shadow? Put a pencil and a ruler in the sun. Measure, compare, lose or win your competition with the real sun as Copernicus did.
Mathematics have no longer much to do with boring calculations. Nowadays computers do the work, we do the learning. They sharpen our reasoning and senses. We see larger contexts and smaller details than ever before discovering scale. Discovering telescopic and microscopic scale we find the multiple universe we live in, freeing us from boredom forever, producing images no human can invent. We do not believe our eyes and ears, we discover them. It challenges our imagination in strange worlds no holiday can equal. Life math is a survival journey with excitement and suspense.

*Science as design*

But do we *understand* the sun? No, according to Kant (1976) we *design* a sun behaving like the sun we feel and see from our position and scale of time and space we live in. We never know for sure whether it will behave tomorrow in the same way as our sheet does now. But we have *made* something that works *here* and *now*.
‘Yes! It works.’ That is a designer’s joy.

## How to use this book

This book is not a reader. It contains original texts by the authors from our school and one civil engineer to understand how specialists think, supporting our profession as urban designers.

*Systematic encyclopaedia*

It is ordered in an systematic encyclopaedic style. It is accessible by its table of contents (elaborated in more detail at the beginning of each chapter), and by a key word list containing some 6000 key words at the end of the book, including other authors we refer to. Full references to other authors are given in a reference list, also to be found via the key word list. Direct references into publications and websites to look up immediately as a result of reading are given as foot notes ([a]) indicated by letters in the text and listed at the bottom of the page. Questions for exercise are indicated as numbered end notes ([1]) by numbers in the text listed at the end of the book (see page 711). However, these questions don not yet cover the whole content of the book.

*A conditional sequence: physics first*

The chapter titles start as the title of the book indicates: Sun, Wind, Water, Earth, Life, Living and Legends for design. These subjects are ordered this way, because it is the conditional sequence we experience them directly outdoor and gradually can understand them best.

The sequence of the chapters follows the range of abiotic, biotic and conceptual phenomena with apparently increasing complexity. The simulation of these phenomena is firstly approached by supposing a causal sequence (effect follows cause: $c \Rightarrow e$) usual in physics. Even life, living and legends for design obey the boundary conditions of physics. So, we firstly try to simulate these phenomena by purely causal simulation. After all, we can not imagine living systems (B) without an abiotic environment (A), as we can not imagine conceptual systems (C) without a living environment (B). Let us call that 'ABC-model' (see *Fig. 1*).

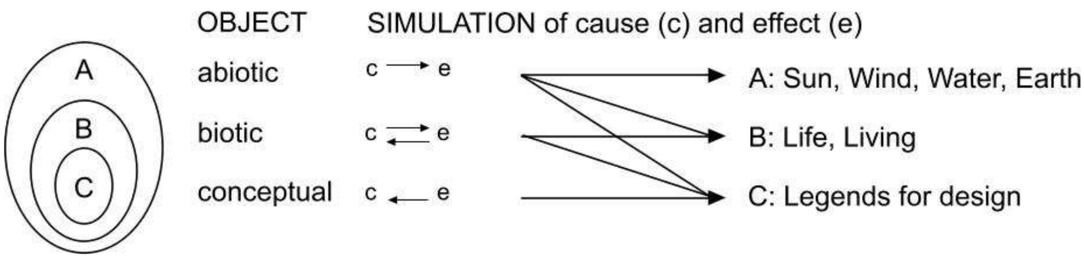


*Fig. 1 Simulating reality by different approaches according to the 'ABC-model'*

*Biotic feed-backs included*

However, biotic phenomena (including humans) and some human artifacts seem to take the effects of earlier behaviour into account, adapting next behaviour ('empirical cycle'[a]). A one way causal simulation of such a phenomenon should contain its history from second to second including the evolutionary history of its ancestors from the very beginning. It should not exclude details that might have been crucial. That long description to predict behaviour would require too many gradually changing cycles finally solving chicken-and-egg questions typical for biology. But you can understand the pattern and process of an egg in a shorter way if you suppose what will come out (for convenience, without additional teleological assumptions). In that approach the effect also 'precedes' the cause (see *Fig. 1*). The main 'experience' of a species is stored in its genes and in other chemical substancies steering action, completed by increasing 'experiences' of a specimen born in a specific context. We still do not understand much of all feed-back loops in any organism. But, we can simplify the description of its behaviour by drawing a black box and looking what is going in (input) and what is coming out (output) in a determined period. That is called 'systems approach'.[b] By a systems approach you design a model with the same input and output as observed to predict behaviour. In the algorithm of such a model many 'if … then …' statements will appear connecting the possible branches of causal behaviour in different circumstances. If the behaviour of the model is much the same as observed we are inclined to suppose the model represents reality, which is not the case.

*Conceptual projection added*

For our purpose, the most satisfying description of the difference between humans compared to other animals is their ability to represent a larger range of activities beforehand[c]. It is the very basis of making artifacts serving further purposes (if I will do this first, then I can do that later) and the very basis of task division (if you do this, I can do that). So, humans are supposed to simulate internally a longer range of 'causes' (actions) and 'effects' before they come into action ('look before you leap') than routinous animals. As soon as action and utilising its effect are connected by an intermediate (interfunctional) action, such as making an instrument, the whole range can be noted as an algorithm. Designing is such an intermediate activity in a range of activities 'planned' beforehand. That kind of 'conceptual' behaviour completes many unconscious components of behaviour stored in an organism as biotic routines. That is why in this paper we leave out the supposed 'cognitive' part of human

[a] Groot, A.D. de (1970) Methodologie. Grondslagen van onderzoek en denken in de gedragswetenschappen ('s-Gravenhage) Mouton & Co)
[b] Emery, F.E. [ed.] (1969) *Systems thinking* (Hammondsworth) Penguin Books Ltd,
[c] Harrison, G.A. (1964) *Human biology* (Oxford) Clarendon Press

behaviour as long as we can simulate (understand) it sufficiently by a black box. But, there comes a time these biotic simulations do not fit reality any more. Then, we have to add new suppositions about the 'plan' humans have in mind before they act. Many 'plans' (earning a living, finding a partner, getting children) look the same. But the question is, if these are really 'plans' or simply the 'conceptualisation' of predictable biological inclinations afterwards to justify them socially. What we can simulate by less suppositions we will do ('razor of Ockham'). Interpreting humans as mere animals clarifies an increasing amount of behaviour[a]. But, there are still unpredictable behaviours apparently following a 'plan'. The question is, if we ever could predict that kind of behaviour. In that case we have to give up our supposition of free will (supposed in democracy) after all. In this paper we will not do so, because it is the core of design to find unexpected possibilities (necessary in an ecological crisis). If these possibilities could be expected it would be predictions, not designs. In *Fig. 1* is expressed that conceptual projection can not be used to simulate abiotic and biotic phenomena.

*Levels of scale*

A principle of ordering we aimed for in any separate chapter is the level of scale. So, you can choose the sub-chapter concerning the level of scale you focus on in your study. We have tried to start every chapter on the highest level of scale. There are arguments to start with the lowest level, most directly related to our senses, but we chose the other way round, because lower levels of scale are better understood knowing their context. This way, you may get a feeling for contextual factors determining a particular environment and its mathematical modelling with parameters stemming from that context. In design practice you can reason the reverse way or both ways. But, to know how to design 'throught the scales' you have to be aware of scales, the frame and grain of legend units, the scale specific inferences and the danger of using conclusions from an ather scale.

## Design related use

So, you do not have to read everything before you can use it making inventories for design (like a local atlas of thematic maps), while designing or reflecting on your designs. Reflecting on your design work is what we ask in the assignments of the course accompanying this book: how did you apply Sun in your earlier design work, what could you have done, how do you apply Sun in your actual design work and what could you do with it in the future? The same is asked for Wind, Water and so on. A growing number of computer programs for experiments and calculations per section is downloadable from *http://team.bk.tudelft.nl* publications 2008.

*Non-disciplinary combinations like Sun, energy and plants*

The chapter 'Sun' contains sub-chapters on energy, entropy, temperature, light, the history of our territory dependent on solar fluctuations, man-made plantation (written by Prof.dr.ir.C.M. Steenbergen and Drs. M.J. Moens), shadow and vision as well. These subjects are often related in design or better comprehensible in the offered context. Perhaps in your design you can connect things in another way than the usual scientific and specialist's distinctions of disciplines suggest. For the same reason we did not aim for a distinction between natural and man-made phenomena in the sequence of chapters. It is rather a conditional sequence of growing complexity in cycles of inductive observing, deductive understanding and practical application. So, any chapter is better understood knowing something about the subject of the preceding chapter.

*Wind, sound and noise*

The chapter 'Wind' contains sound and noise as well, because both are movements of air. These flows are more complex than those of mere energy and light.

*Water, networks and crossings*

The chapter 'Water' is primarily based on the lecture notes Prof.dr.ir. C. van den Akker offered us for use when he retired from the Faculty of Civil engineering. Ir.D. de Bruin, drs. M.J. Moens and ir. M.W.M. van den Toorn added many subjects relevant for design. However, it contains traffic as well, based on the book of ir. B. Bach[b], because the combination of these different flows on the Earth's surface and their resulting networks are an important part of urban and regional design. So, we did not primarily make a distinction between natural and man-made networks. The comparison of their characteristics is interesting, instructive, and may be a source of new design ideas.

[a] De Waal …
[b] Bach, B. (2006) …

*Earth and site preparation*

The chapter ‘Earth’, primarily written by Drs. M.J. Moens and elaborated by ir. M.W.M. van den Toorn , is better understood if you know something about wind and water. The division of its sub-chapters starts strictly with levels of scale, but then sub-chapters follow about soil pollution and preparing a site for development.

*Life, ecology and nature*

The ecological chapter ‘Life’ supposes sun, wind, water and earth. These conditions are discussed earlier in the book, so the chapter can focus on the distribution and abundance of life itself. Biology is physics with numerous feed-back mechanisms, not te be modelled so easily in a mathematical sense. However, it introduces approaches of system-dynamics, demography, useful in human environments as well. Life contains human life. So, this chapter tries to consider man as a species between other species (syn-ecology), while the next chapter ‘Human Living’ concentrates on human species only (aut-ecology). However, there are sub-chapters on valuing and mananging nature by man in your plan, and on the role of an urban ecologist.

The subject of this chapter is not very familiar to designers. So, you can think it is not very relevant. But in my opinion ecology, the science of distribution and abundance of species, is the very core of urban and regional design. Design changes predictable distributions. Local vegetaton and wild life clarifies much about what designers feel as a mysterious ‘genius loci’. Ecology is a neglected source of local identity. Evolution of life has something in common with design thinking: its course of trial and error into diversity and order. The evolutionary taxonomy of plants and animals, types of life, their distribution and adapation into different environments, accommodating and modifying them, give examples of the same problems any design task stands for. Your typological repertoire of design solutions selects environments and the reverse different environments select different types of design.

*Living, human density and environment*

The chapter ‘Living’ shows the history of human occupation in general and in The Netherlands in particular. That piece of land in between France, Belgium, Germany and Great Britain contains both lower and higher grounds, combining many characteristics of its neighbours. Its delta gives an impression of a development known from many densely populated lowlands in the world, the spatial composition of ecological, technical, economic, cultural and administrative components. A sub-chapter is devoted to urban density on different levels of scale. The sub-chapter ‘Environment’ discusses some consequences of living in high densities like environmental problems, environmental norms, gains and losses.

*Legends for design*

The chapter ‘Legends for design’ stimulates to consider these phenomena of urban physics as innovative components, legend units, spatial types given form in a design composition. It raises philosophical questions on unusual types, their suppositions, combinations and consequences.

## Simulators accompanying the book

Every chapter is accompanied by Excel sheets[a] programmed with Visual Basic Language to exercise mathematical relations described in this book. These simulators show the hidden suppositions of specialists in yellow sliders by which you can change the model and see the results without own calculations. By doing so, you can ask the right questions if specialists criticize your design with mathematical certainty. They often show counter-intuitive results. If you do not believe them, then Excel allows you to show the formulas en their relations to criticize their inference. That will make you less vulnerable in the company of many specialists you will meet in practice.

[a] sun*.xls*, sound and noise *.xls* energy*.xls*, wind*.xls*, water*.xls*, precipitation *.xls*, traffic*.xls*, earth*.xls*, life*.xls*, living*.xls*, environment*.xls*, legends*.xls*, math functions*.xls* downloadable from *http://team.bk.tudelft.nl/* > Publications 2008

# 1 Sun, energy and plants

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