4 Diversifying form

4.1 Distribution of content in space

Perception and construction of form

In this thesis, 'form' is a distribution in space. *What* is distributed only has to be different from its background. Without 'content', there is no 'form'. Its perception by your retina or skin is primarily flat. The imagination of a three-dimensional form then must have been constructed from different flat images. You can reconstruct the form mentally from a sequence of 2D impressions from your retina and skin, with additional information from other senses (motoric impressions, pain, audition, smell). To imagine an existing building 3D, you have to walk around it (or, with some experience, to study its two-dimensional elevations and cross-sections). Without motoric experience, a 3D concept seems to fail.[a] That experience is recalled as 'change', but change is simply a simultaneously recalled difference between the primarily planar diversities. In this Chapter, I will restrict myself to the diversity of forms in a plane (or a plan) and their change, (*diversification*) as a kind of difference.

One dimensional descriptions of form

Expressions in verbal language are one-dimensional. They report experiences (impressions embedded in mental reconstructions) in a strict sequence that cannot be understood backwards. Any sentence reduces these experiences into words that represent sets of similar objects and actions, which are recalled from earlier experiences. Verbal language produces strongly reduced (re)constructions of form. It reduces a four-dimensional experience into one-dimensional sentences. A picture can be read in any direction, and report many possible stories. Reading a picture, you may step sideways from your main story any time you want. By doing so in a text, you would get your wires crossed, and 'lose the thread'. To cover all the possible stories that can be read from a picture, you would need numerous footnotes, endnotes, attachments, references or links. Even then, however, you may catch only partly its content in a tree-like web. Even a computer screen, which builds its pictures through one line of pixels, can not include these cross-references.

Variables are words

The variables and their values discussed in the previous section are words. A variable is a construction, a ranked sequence of values. The source of any separate value may be a set of forms, which is abstracted into an idea (ειδοσ, image), and named as a word. Forms in-form, words re-mind. However, liberated from any particular observed dispersion in space, any value may obtain different imagined forms. Imagined 'form', then, becomes a construction. By inter- or extrapolating impressions, you may extend them into *possible* forms through design. 'Form', then, becomes a second-order variable, which is applicable to any content. Content can be distributed in space any way you want.

---

[a] Held;Hein(1963) *Movement-produced stimulation in the development of visually guided behavior* (Journal of Comparative and Physiological Psychology) 56 5 p 872-876

Ranking forms

'Form' includes the states of distribution of at least two values in space (e.g. black and white, 'form' and 'counter-form'[a] in *Fig. 91*) and contours (see *Fig. 92*).
A combination of both is called 'shape'. However, 'shape' requires sufficient accumulation of some content to observe a contour. 'Shape' does not fully cover the concept of 'form' if you want to include gradients such as the distributions of trees in a landscape, the built-up area in a district or the 'form' of a conurbation. Could you rank forms as values of variables such as 'State of distribution' and 'Contour'? And if so, what is their absolute value (a fixed standard, a 'zero-point') to determine the distance of any form to that most simple one?

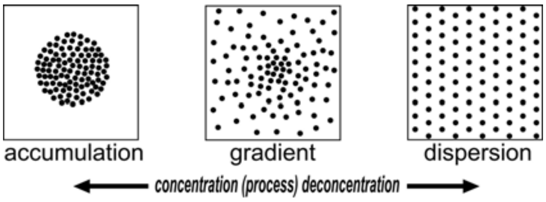


Fig. 91 Extreme states of distribution[b]

Fig. 92 Contours circumscribing equal surfaces

To rank forms, 'total accumulation' (minimal mutual distance) is a candidate for an absolute value of 'State Of Dispersion', and 'circle' is one for 'Contour'. After all, you cannot imagine a value that is more concentrated than 'totally accumulated', or a contour with a smaller perimeter / surface proportion than a circle. In *Fig. 92*, the surface of the triangle seems the largest, but it is equal to the surface of the circle and the square. Their contour lengths, however, are different. Triangles and squares have a larger contour length than a circle, but the minimum contour length will not be my final argument to identify the circle as an absolute value of form. The question is, whether all other forms can be described as deviations of 'totally accumulated' and 'circle' with a determined distance from these zero-values. Are there extremes at the other side (e.g. 'total dispersion' and 'square')? And if so, are these extremes perhaps more suitable to serve as an absolute value of 'form'?

Extreme values of distribution in space

According to nearest neighbour analysis, the regular hexagonal pattern of 100 dots of *Fig. 91* is even more 'dispersed' than a random one with its accidental local concentrations. Regularity, repetition, and equality is often concerned as 'order' (low disorder, near to zero entropy). But then, the 'total dispersion' of a hexagonal distribution would be the highest 'order'. That is contradictory to the thermodynamic concept of entropy, where concentrated solids have a higher value of 'order' (a lower entropy) than dispersed gases. The problem may be hidden in the level of scale that is taken into account, which leads to different meanings of 'order' and 'disorder' at different levels of scale (see *Fig. 7 Scale-paradox* on page 21). You can concentrate built-up areas in a radius of R=3km, and in the same time, de-concentrate it, at a radius of R=10km (see *Fig. 95*). 'Distribution in space', then. is scale-sensitive. If so, then 'form' and 'order' are scale sensitive too. Anyhow, 'total dispersion' is also an absolute value. You then can choose between 'total accumulation' and 'total dispersion' as a starting point to rank 'form'. Let us first look at extreme values of contour, and then come back to that choice and the issue of scale.

Extreme values of contour do not differentiate sufficiently

You may doubt that taking the circle as a starting point for producing deviations of other more diverse contours is the only or most effective possibility. The least number of *directions* that are needed to circumfer a surface is 2, resulting in a rectangle. Why not take the triangle, the square or the cube, then, as a starting point? The circle (or globe) and any

[a] If everything would be black, then there would be no observable form. That is why 'form' supposes at least two values. The inference is further focused on one of them as 'form'. If necessary, the other is referred to as 'counter-form'.
[b] 'Accumulation' and 'dispersion' will be used for the state, 'concentration' and 'de-concentration' for the change of state.

smoothly closed shape represent infinite directions in their perimeter deviating infinitely from the square. The number of directions, then, does not distinguish smooth shapes without sharp angles mutually. Any smooth shape has infinite directions in its perimeter.
The least number of *changes* of direction that are required to encircle a surface may be more effective. A circle has the least changes of direction (1), followed by a triangle (3) and a rectangle (4). The number of changes of direction plays a role in traffic engineering. For example, to describe a circle with your car, you only have to keep your steering wheel in the same position. If you are driving around in a triangle or a rectangle, you have to change direction 3 or even 4 times (see *Fig. 92*). You then may prefer a minimal *change* of direction as an absolute value, instead of a minimal number of the directions themselves. It has less suppositions. 'Direction' itself requires an external standard, e.g. 'North' to determine the other directions, such as 'East', 'West' and 'South', as deviations from 'North'. A *change* of direction is independent from any external orientation. It is a comparison in itself. However any smooth form deviating from a circle also has an infinite number of direction changes not distinguishing smooth shapes mutually.

An absolute value of the form variable

If contours are 'filled' with some content, the content of a triangle or square is more dispersed than that of a circle. If you consider the contour lines as a set of dots, then these dots are also more dispersed. 'Distribution in space', then, may also rank contours. In that ranking (otherwise than in *Fig. 92*), the triangle is more dispersed than the square. Since any contour also can be ranked by 'Distribution In Space', you can take that variable as the main variable of 'form', and even as its definition. 'Form', then, is the state of distribution of two values in space, in any case. That applies for dots, lines, surfaces and volumes.
Total accumulation also should have a circular contour, because any deviation of that form is more dispersed. If you accept the circle as the zero-point of Contour for different reasons, then total accumulation should be the most suitable starting point for ranking forms.

Contours determine the containing capacity

Different contours encircling the same surface may contain different quantities of equal circles. In *Fig. 93* left above and in the middle below, the shape of the containing circle causes an irregular packing, increasingly leaving space open into the centre. The square and the triangle leave space open at the boundary.
The capacity of the square is 80, but it would be 68 if the circles would be only little larger. The triangle could keep its capacity of 78 longer. A hexagonal packing is not always the most efficient packing depending on the contour. For the circle it would be less efficient (73, see *Fig. 93* left below). In any case, the relative size of the contained circles and the shape of the container determine the containing capacity.
Diversifying the size can optimise the capacity (see *Fig. 93* right below).
A Voronoi diagram[a] of the central points of the circles would transform them into surfaces-filling polygons with different surfaces and forms. Many natural patterns diversify cell sizes, in order to obtain a total coverage of the surface or the total filling up of a volume between the external boundaries (see *Fig. 94*). Non-hexagonal regularities appear at the boundaries, or along longer lines.

[a] Try http://www.pi6.fernuni-hagen.de/GeomLab/VoroGlide/index.html.en

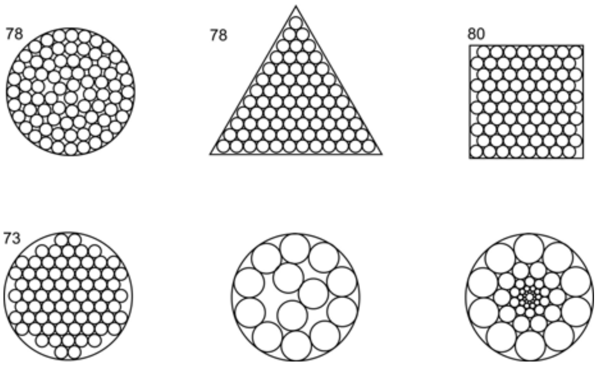


Fig. 93 Closest packing and maximum coverage of a contour with equal circles

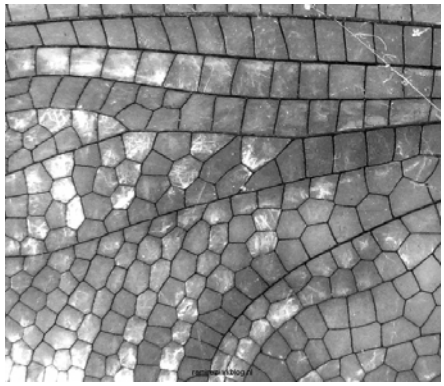


Fig. 94 The wing of a dragonfly[a]

Morphological outward or inward self-ordering should not be named as ‘self-organisation’, since ‘organisation’ implies a functional diversification between ‘organs’ or ‘organisms’.

Form and counter-form

Architectural drawings of a building show the dispersion in space of building materials, and a counter-form of air. An elevation may show a contour which is totally filled with building materials, against a background of air. A cross section shows an interior which is mainly filled with air, and is enclosed by the outer wall, the roof and the lowest floor. If you neglect the inner walls and inner floors, then the elevation and cross section, respectively, look nearly the opposite of each other: mass in space and space in mass. In the cross section, the air is central and the building material is accumulated in the periphery. The building material, then, may be more dispersed than the air of the inner space. But, it is still more accumulated than if the air and the building materials would have been dispersed and mixed into a ruin by demolition. Rebuilding the ruin primarily means accumulating the dispersed building materials, in order to restore the boundaries of an inner space. The building materials do not have the minimal mutual distance to characterize them as ‘total accumulation’, but they are still linearly accumulated as walls and floors. If the building would have the form of a globe, then the enclosed air would be ‘totally accumulated’, and the building materials a little less ‘accumulated’. The building materials are assembled, and eventually collected from an earlier dispersed state.

Drawing concentrates

The result, then, is *a concentration of both form and counter-form*. In a black and white drawing one of both colours primarily represents the form to be transferred (mainly black) with some visual coherence against the more dispersed background of the other colour (mainly white) as its counter-form. But, it also concentrates the remaining imaginable white dots, compared to the initially total dispersion of white, on the blank paper.
Architects often talk about giving form to *space* as a central issue, even if they only locate the bounding building materials in their drawings. That seems contradictory to thermodynamics, where solids are more concentrated than gases, by definition. But, that is reasoning at another level of scale, taking the molecule as a grain. Architects have a different legend, with a much larger grain than that of a molecule. Thus, distribution in space (i.e. form) is scale sensitive.

[a] Marrewijk(2012) http://ramireziblog.wordpress.com/2009/09/13/ramirezi-art-glazenmaker-in-lood-2/, coloured by a garden background.

4.2 Different forms at different levels of scale

Scale sensitive distributions in space

Fig. 95 shows four alternative methods to distribute 1 000 000 people in a radius of R=30km, from the most accumulated (aa) into the most dispersed (dd).

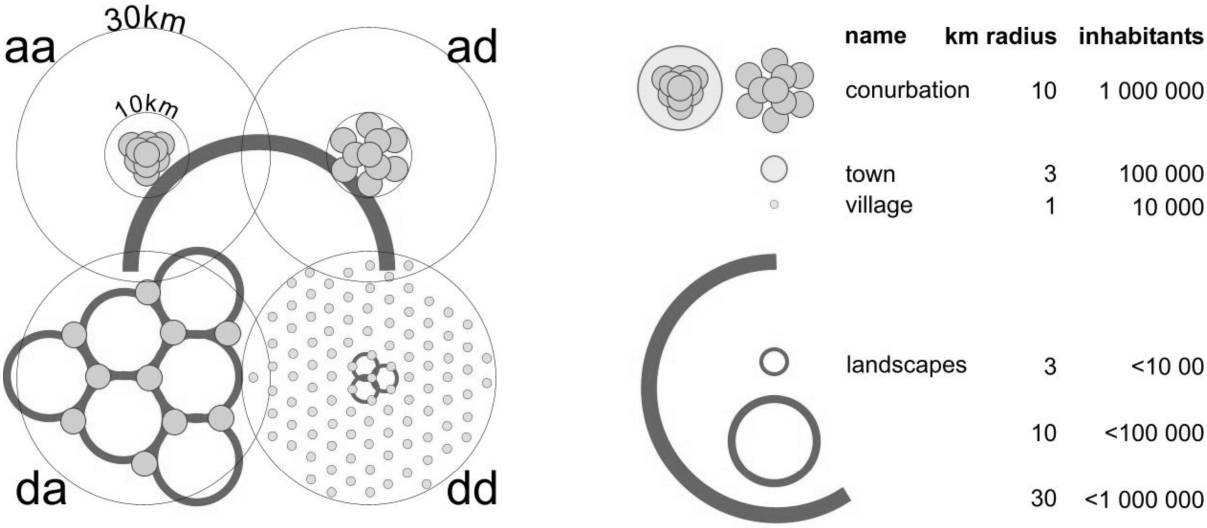


Fig. 95 Accumulation (a) and dispersion (d) at two levels of scale

The counter-form of open landscapes in between the urban areas follow that dispersion in increasingly smaller fragments. The intermediate distributions $a_{30km}d_{10km}$ and $d_{30km}a_{10km}$ show that dispersion at one level of scale can appear simultaneously with accumulation at another level (distribution accord). If you add a smaller grain (e.g. $hamlets_{300m}$), or a larger frame (e.g. a $region_{100km}$ with an accumulation or dispersion of conurbations), then the alternatives of form may extend into aaa, aab, aba, abb, baa, bab, bba and bbb (2^3 alternatives). I name these alternatives 'concentration accords' related to the 'variety accords' mentioned on page 21. These primary possibilities of Distribution may be combined into a Christaller- or Lösch-landscape[a], with their theoretical hierarchy of central places producing a higher $density_{30km}$.

Gros dots in order to compare Paris, London, Randstad

Paris, London and Randstad in that sequence show an increasing dispersion at two levels. To distinguish these levels, their actual form is reduced to the legend of *Fig. 95* in *Fig. 96*. The surface of a circle R=10km ($\pi 10^2 \approx 300km^2$) represents 1 000 000 inhabitants at $300m^2$ urban surface/inhabitant[b]. A circle R=3km ($\pi 3^2 \approx 30km^2$) represents 100 000 people.
This dot map represents the number of inhabitants, much like a table would represent, but distributed in space as form. It is decimal. Any circle or dot can be divided into ten smaller dots, with a radius $\approx$1/3 of the larger one, representing 1/10 of its surface and inhabitants. In reverse, you can collect 10 concentrated smaller dots into a larger one. In *Fig. 96*, the inhabitants of smaller dispersed settlements are collected in virtual units of 100 000 inhabitants (R=3km). The resolution of the drawing, then, is limited to 3%, since it is the proportion between grain and frame (nominally R=100km, only partly shown in the figures). That resolution is appropriate to distinguish relevant differences of distribution (form) at two levels of scale. Accumulation is characterized by overlapping circles, dispersion by the circles' mutual distance.

---

[a] Christaller(1933) Die zentralen Orte in Süddeutschland: eine ökonomisch-geografische Untersuchung über die Gesetzmässigkeit der Verbreitung und Entwicklung der Siedlungen mit städtischen Funktionen (Jena) G. Fischer
Lösch(1938) The Nature of Economic Regions (Southern Economic Journal)5 1 p 71-78

[b] $300m^2$/inhabitant is approximately the average use of urban space per inhabitant in the Netherlands (different per region), of which $160m^2$ residential area including primary facilities (such as primary schools) and $140m^2$ other urban functions.

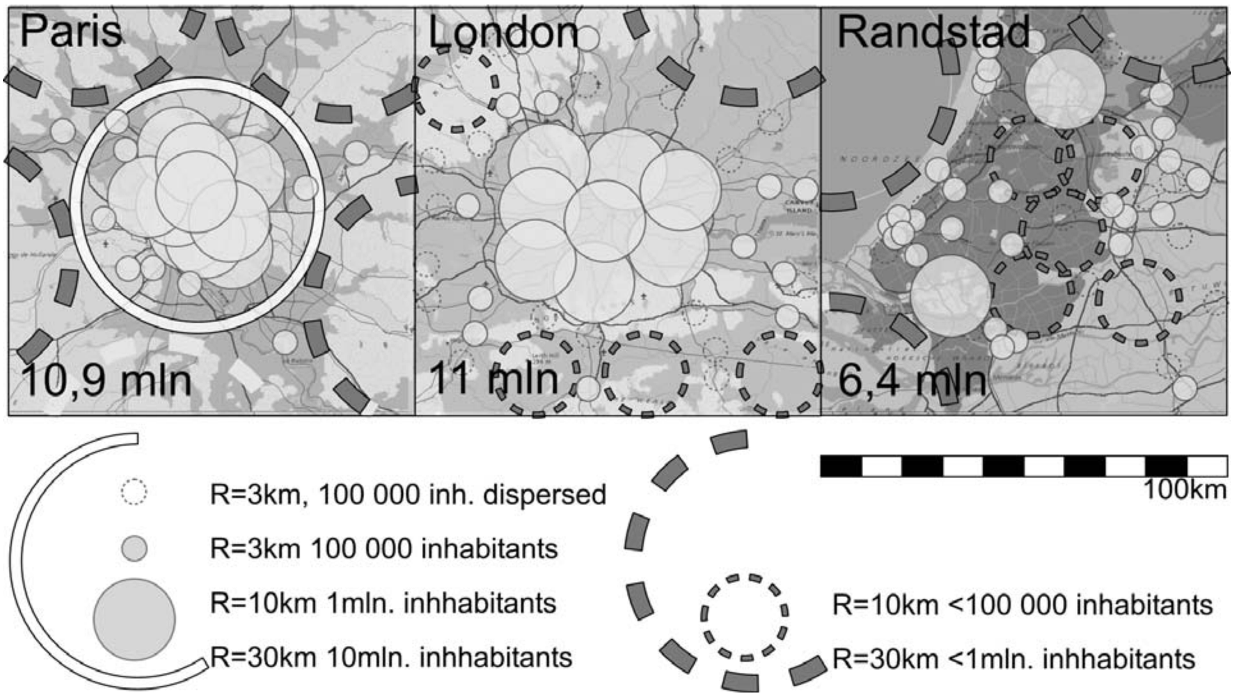


Fig. 96 Paris, London, Randstad 2000 in gross dots, also used in Fig. 55 on page 100)

The Randstad shows two conurbations that are separated by approximately 60km. They are then dispersed in a radius of 100km, but are still accumulated in a radius of 30km: $d_{100km}a_{30km}$. Paris and London are accumulated (overlapping dots) at both levels: $a_{100km}a_{30km}$. To approach the real form of the conurbations and towns more precisely, you may divide any circle further into 10 smaller ones, and repeat that operation to be even more precise.

Net dots in order to compare forms inside an urban area

Inside an urban area, however, the counter-form is no longer a landscape, but public space. The form, then, should identify the private space. This can be approached by smaller 'net dots' that represent *floor space*[a] for 1000 inhabitants (r_n=100m, see *Fig. 97*) or accordingly, 10 000 inhabitants (300m), 100 inhabitants (30m), 10 inhabitants (10m) or one person (3m).

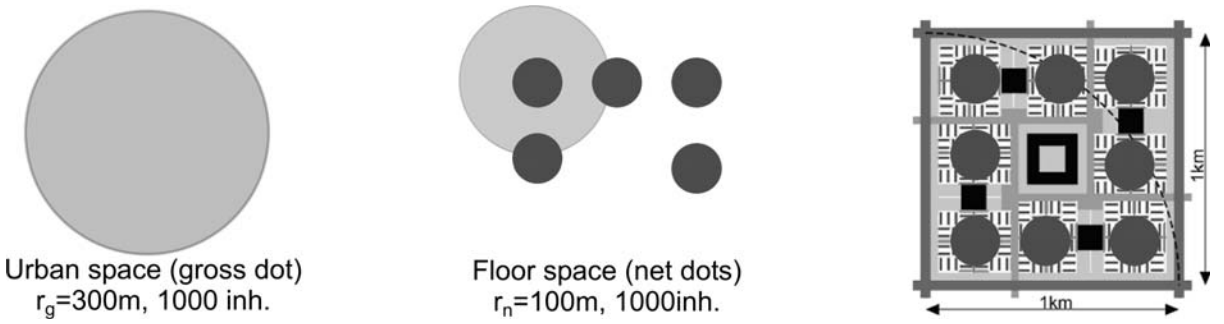


Fig. 97 Distribution of floor space reduced in net dots used in Fig. 56 and Fig. 62 on page 101

Choosing the proper grain at any level of scale makes the form of conurbations, towns, districts, and so on until even utensils comprehensible in their own right. For designing, a resolution of 3% (a sketch, the precision of *Fig. 96*, possibly colouring approximately 1000 locations) is sufficient. It prevents applying form legends and grammar at the wrong level of scale. Detailing and changing scale changes the legend, and changes the way of designing.

[a] 30m^2/inhabitant is approximately the average floorspace/inhabitant.

Net dot maps for early impact analysis

Fig. 56 on page *100* and *Fig. 62 on page 101,* show the distribution of inhabitants in more detail than *Fig. 96*. By doing so, it unveils aspects of the actual and proposed forms that are still hidden in the rough representation of *Fig. 96*. A further subdivision of the net dots would have been superfluous for an impact analysis at that level of scale. The resolution is precise enough to predict ecological impacts and traffic flows, to plan the location of schools and other public facilities. From a dot map, you immediately can find the optimal location for any facility requiring 1000, 10 000, or any other number of inhabitants in a radius of 300m, 1000m, or in any other radius. If designers would draw dots instead of lines first, they would get a better feeling for numbers and distances. That is what form does. It determines numbers and distances, with impacts at many fields of interest. Moreover, it allows one freedom to connect or separate these located quantities by lines in a second stage.

Forms deviating from total accumulation

Detailing a distribution of quantities, by locating them more precisely, shows the actual deviation from total accumulation (shaped as a circle).
Fig. 98 shows the residential and job floor space of 1 000 000 inhabitants in Rotterdam, and some adjacent municipalities, as a conurbation. The 1000 *net* dots (100m radius each) represent the floor space of 1000 inhabitants each (supposing 30m^2/inhabitant). The grey dots tentatively locate 1000 jobs each.
The dispersed form of small net dots shows an elongated distribution that is caused by the river. The lines in *Fig. 98* divide the image in equal numbers (500) of black dots at both sides.The central R= 10km grey circle would be the totally accumulated gros dot of *Fig. 96*, including the urban space / inhabitant, according to the Dutch average (300m^2 / inhabitant).
In *Fig. 98*, we may distinguish separate groups of dots as components in a composition.
At any scale, compositions acquire their own variables (see *Fig. 63 – Fig. 68* at p102 – 102).

Fig. 98 The distribution of inhabitants of Rotterdam conurbation 2010 showing its form

4.3 The distribution of lines

Hexagonal patterns

Paul Klee suggested a line to be a walking point.[a] The dots in the previous section represent surfaces (or volumes in cross-sections). They are usually designed and drawn by contours and lines, representing walls (separations), roads (connections), an effort to build, or an investment, which should be minimised. The smallest perimeter/surface proportion can be achieved through the use of a circle. A primary probability, then, is that the least length is built at the lowest costs. If adjacent surfaces share a common boundary, then a hexagonal pattern of boundaries is the second best.[b] This phenomenon is clearly shown by patterns of soap bubbles (see *Fig. 99*). Buchannon (1963) once proposed to pack neighbourhoods (R=300m) in a *hexagonal* pattern of neighbourhood roads.

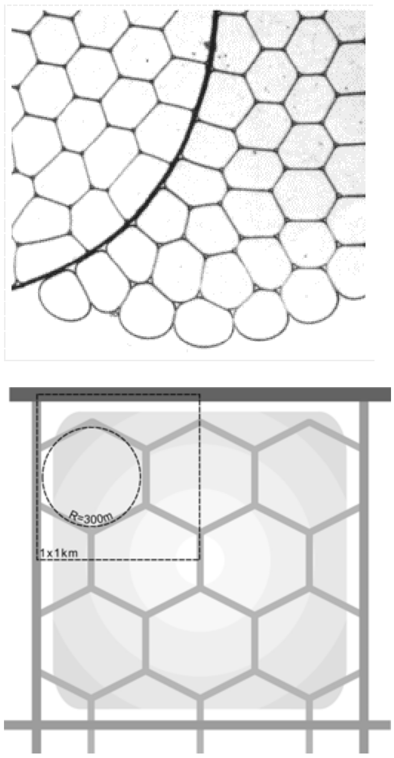


Fig. 99 Hexagonal network[cd]

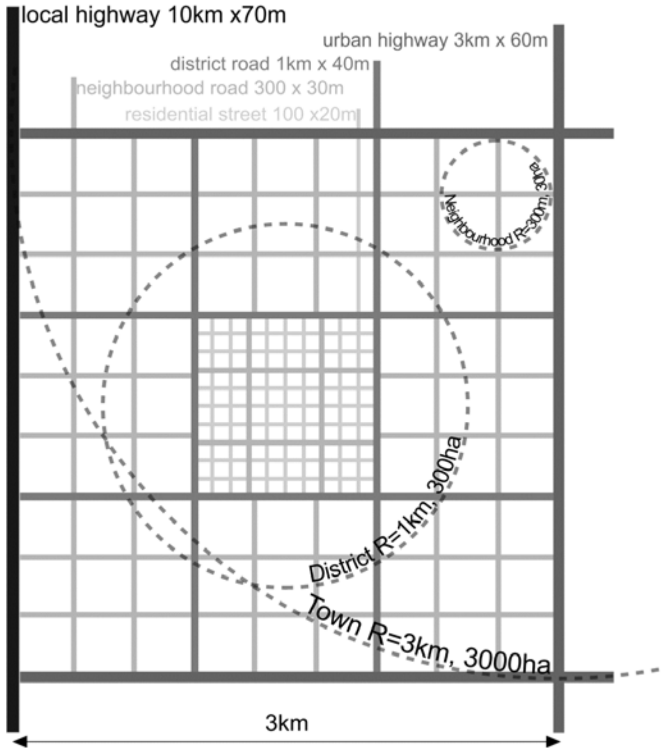


Fig. 100 Orthogonal network

Orthogonal preference

Why, then, does the third best *orthogonal* distribution of lines appear to be the most usual? At the urban level, stretched roads of a higher order for faster thru-traffic introduce a primary probability of rectangular connections, just as soap-bubbles re-arrange themselves into a rectangular pattern along a stretched line in *Fig. 99*. Morphological hierarchy straightens.

[a] Spiller, J. (1961) *Paul Klee Notebooks Volume 1 The thinking eye* (New York) Wittenborn pages 78, 106, 123, 125 and 382
[b] In 3D there are many space-filling polyhedrons, see http://mathworld.wolfram.com/Space-FillingPolyhedron.html .
[c] Hildebrandt;Tromba(1985) *Mathematics and optimal form* (New York; Oxford) W.H. Freeman and Company
[d] Buchanan(1963) *Traffic in Towns. The specially shortened edition of the Buchanan report* (Harmondsworth, Middlesex, England) Penguin Books

Hierarchy

A road hierarchy often follows the principle that every third road acquires a higher order.[a] This seems also valid for wet connections. The semi-logarithmic range of nominal radiuses of *Fig. 18* (R = {1, 3, 10 … 300 000m}), classifies urban environments and variables. It also fits well with the mesh-width hierarchy of Dutch roads and waterways (see *Fig. 101*). Metropolises, conurbations, towns, districts, and neighbourhoods are divided by dry and wet connections. The mesh-widths of their main roads approximately equal their radius. An urban highway, then, may cross a town through its centre, in order to open it up radially or tangentially, and separate the peripheries.

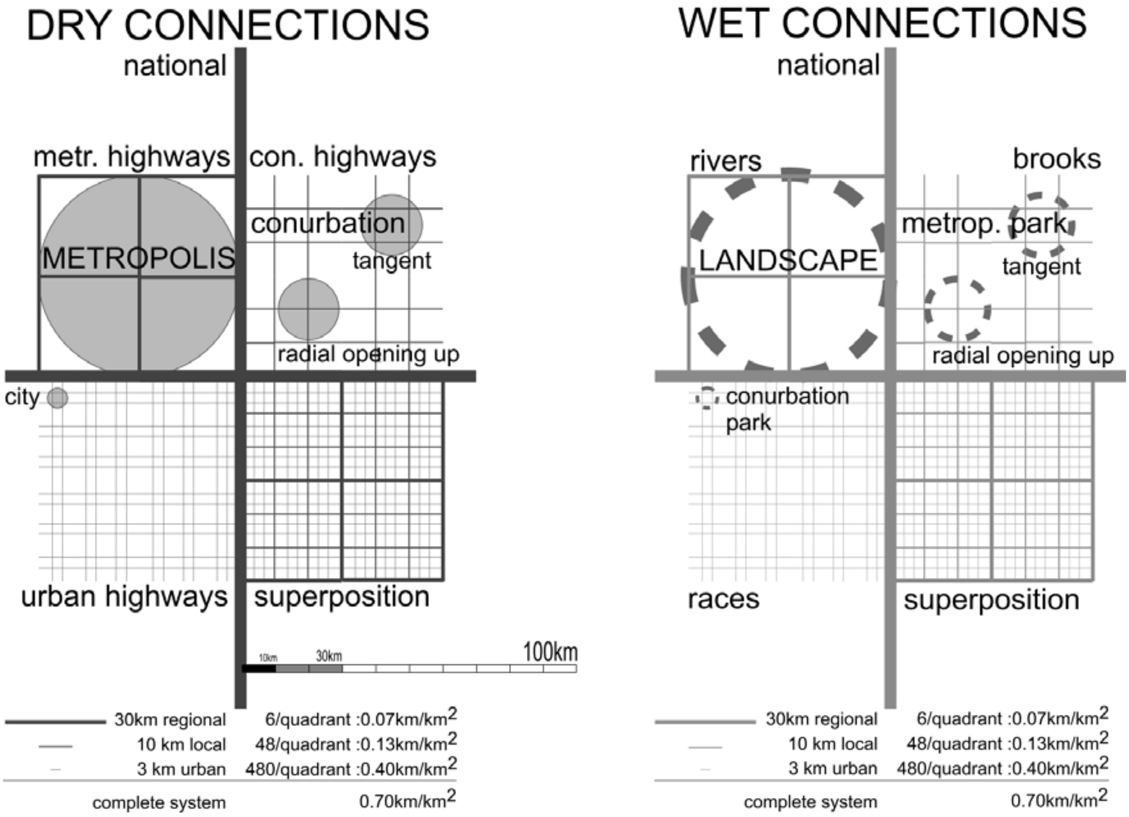


Fig. 101 Dry and wet connections

Superposition

The higher order is superimposed on the lower one, reducing the density of lower orders. For example, a neighbourhood road may replace a residential street. If the primary density of residential streets with a mesh-width of 100 x 100m is 20km/km^2, then that density has to be reduced into 13km/km^2 by the density of neighbourhood roads, which is 7km/km^2.

Elongating

Network density is approximately proportional to the network investments. By keeping the network density (and the investments) the same, you can elongate one side of the mesh, and accordingly decrease the length of the other side that is perpendicular to the first, into an elongated mesh (see *Fig. 102*). The curve represents any alternative that deviates from the square, and these deviations have asymptotes where parallel roads without crossings reach the same density. Any closer arrangement of lines, then, would produce a higher network density. Elongation of meshes reduce the number of crossings.

[a] Nes;Zijpp(2000) *Scale-factor 3 for hierarchical road networks a natural phenomenon?* (Delft) Trail Research school

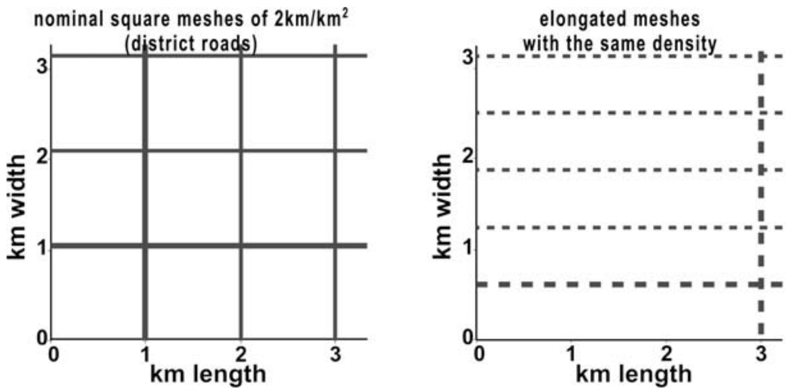


Fig. 102 Equal network densities

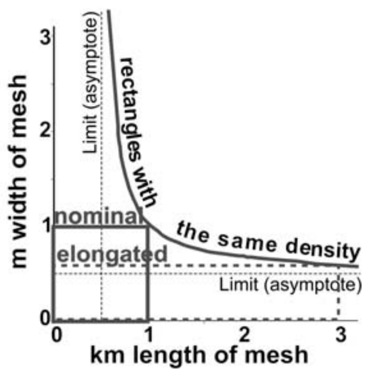


Fig. 103 Equal density elongations

Interference

Different networks, e.g. dry and wet networks, may interfere. That interference separates urban areas even more in segments, and it produces crossings between the different networks, such as bridges. Elongating the meshes, then, may reduce the number of bridges required. The substantial investments for bridges, then, can be reduced through design.

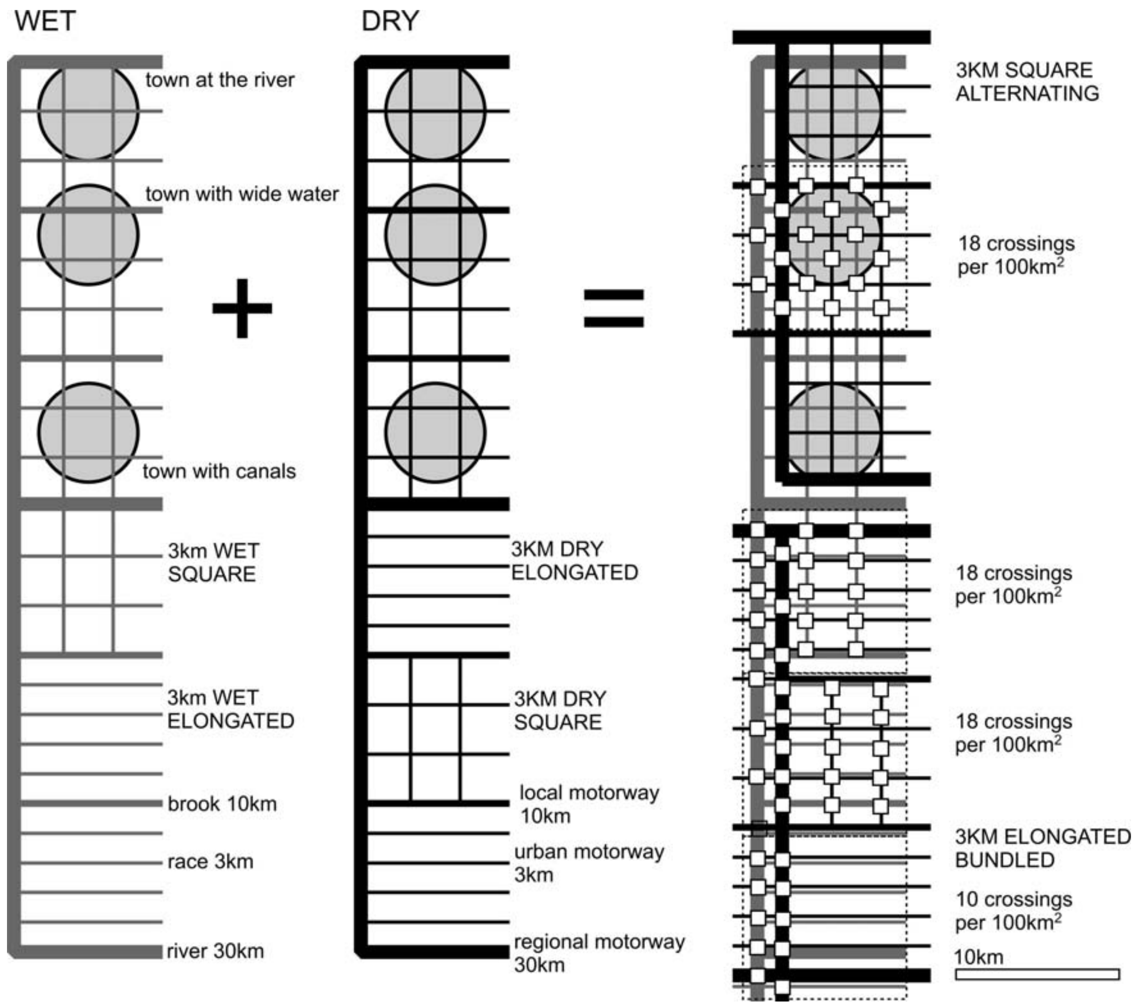


Fig. 104 Interference and reducing crossings

Composition on grids

Fig. 63 – *Fig. 68* on page 102 – 102, show compositions with a limited number of components. The components differ in content and form. At the same time, however, they should have something in common, in order to obtain a recogisable composition between other compositions. Separating or crossing lines may strengthen or weaken that composition.
For example, the identity of urban islands within an ensemble, of ensembles within a neighbourhood and so on, is supported or disturbed by street patterns. A regular grid of residential streets *divides* a district R=1km into equal urban islands R=100m (see *Fig. 105*). This still may characterise the district as not having any environmental diversification of neighbourhoods at R=300m, between R=1km and R=100m.

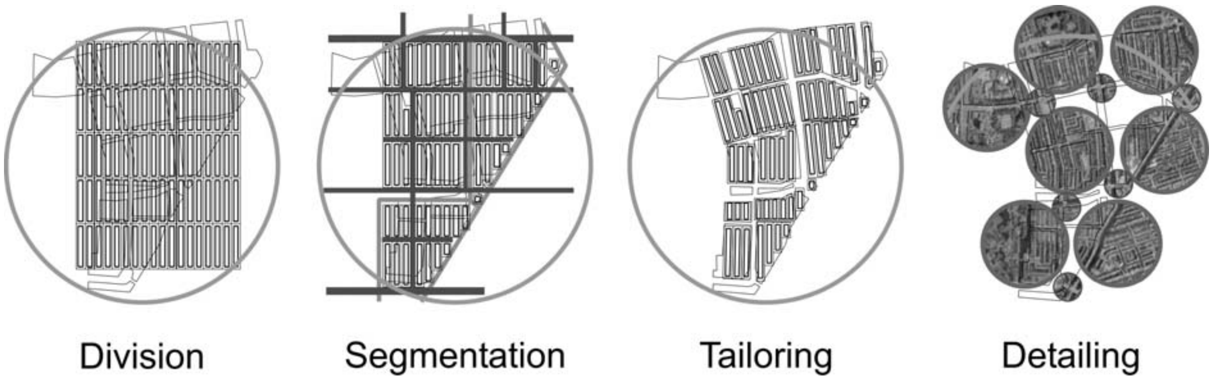


Fig. 105 R=1km Division, segmentation, tailoring and detailing De Baarsjes, Amsterdam[a]

Wider roads of a higher order, such as neighbourhood roads and district roads, may *segment* the district into bounded, more diverse areas. *Tailoring* them according to the existing topography and external boundaries adds some deviations from the original division and segmentation. *De-tailing* them further may connect and separate segments into a recognisable composition, with components and connecting details. The connecting details, then, are mainly crossings. They deserve detailed attention to distinguish the adjacent components (neighbourhoods) for orientation. Roads *between* neighbourhoods, then, may obtain different façades at both sides, while *within* neighbourhoods, opposite façades may become more similar. Division, segmentation, tailoring and detailing may be interpreted either as a design sequence, or as a compositional analysis of an existing district, in order to improve the quality of its image. It is a formal basis for further environmental diversification.

Environmental diversification of components

Further environmental diversification may give each component (such as a neighbourhood) its own identity (difference with the rest and continuity in itself). The difference from other components may contain a different content, form, structure or function, which can be represented by *characteristic*, *crucial* or accidentally *marking* details (see page 102). Differences in content may consist of different values of any variable that was identified in Chapter 3. For futher environmental diversification, you primarily may add content.

[a] Jong;Ravesloot(1995) *Beeldkwaliteitsplan Stadsdeel 'De Baarsjes' Amsterdam*. (Zoetermeer) assignment Stadsdeel De Baarsjes Amsterdam to MESO.

Content obtaining a form

In the previous sections, the examples of spatial distribution concerned values of 'Land Use', such as net residential 'floor space', 'gross residential urban space' or 'roads'. Land Use may be related to many other variables, but the distribution of their values can be drawn and studied separately. You may draw the distribution of light, furniture, windows, walls, buildings, pedestrians, cars, different types of allotment, horizontally and vertically articulated architecture, high and low places, to name only some of the values that are named in Chapter 3. The result is comparable to the thematic maps in atlases (see *Fig. 26* on page 67). Atlases, however, show a reality, or *probability*, while design studies intend to show *possibilities*.

Quantitative legends

If you distribute one of the values (or any intermediate value) of Chapter 3 as a legend unit in a map, you may give its surface a realistic size, which indicates a possible future.
The legend that is drawn according to the intended quantities, then, may serve as a programme. *Fig. 106* shows a part of a map that was published in the context of a Dutch national plan[a], suggesting zoning quantities. 'struggle for space' are postponed, instead of solved through planning. That solution involves recognising and obeying forces of separation, adhesion, cohesion, and combination, at different levels of scale. There was no other indication of quantities in the plan than this map. If you translate that map in real size dots, and represent the claims that should be added to the existing urban and rural land (see *Fig. 107*), then it seems obvious that such claims cannot be fulfilled easily in the available space. Without quantification of the claimed surfaces, conflicts remain hidden.

Fig. 106 Space demand suggested

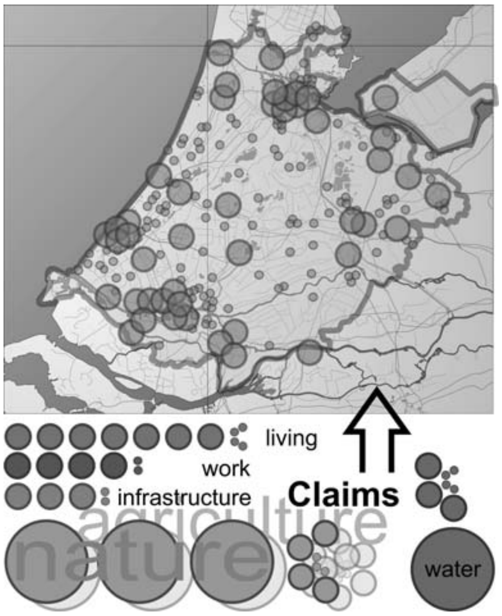


Fig. 107 Claims to add in dots r = {1,3,10km}

[a] VROM(2001) Ruimte maken, ruimte delen - Vijfde Nota over de Ruimtelijke Ordening 2000/2020 (Den Haag) SDU Uitgevers. The plan was never accepted by Parliament since the government changed shortly after its publication.

4.4 Morphogenetic forces anticipating structure

Attraction and repulsion

In physical chemistry, scale sensitive attraction between the different or the equal are named adhesion and cohesion. Repulsive forces may add to form colloids. emulsions or flocculations by aggregation.

This section may anticipate the next chapter concerning structure. Designers are able to develop form and structure separately, but nature mainly alternates the development of form (morphogenesis) and structure (structuring), in a nearly inseparable way. Scale sensitive forces of attraction and repulsion between different or equal values (i.e. legend units for a designer) will re-arrange the intentions of a design by use. An experienced designer will anticipate these natural forces. It may tacitly limit its imagination.

Self-ordering combinations by adhesion, cohesion, resulting in colloids and gels may be reminiscent of physical chemistry, but they show remarkable similarities with spatial morphogenesis at the larger scales.[a]

Cohesion and adhesion

Cohesion and adhesion clearly demonstrate the scale paradox of *Fig. 7* on page 21, at any level of scale. *Cohesion* tends to *accumulate* one value, but at a larger scale it tends to *separate* that value from other values. For *adhesion,* you cannot conclude the opposite. Adhesion tends to *combine*, but at a larger scale, it tends to *disperse* both values. For example, the legend of *Fig. 107* contains a doubtful suggestion that nature and agriculture could be *combined* , in order to save space. *Separating* them would *cost* space. However, if farms should combine nature and agriculture, then they would anyhow divide their area into nature and agriculture at a smaller scale, thereby reducing the surface of both areas as well. *Equal* values may attract each other (*cohesion*), if there are economies of scale. Larger farms may obtain a better efficiency, larger urban areas may support more facilities, and larger natural areas may support more animal species and recreational opportunities (see *Fig. 108*).

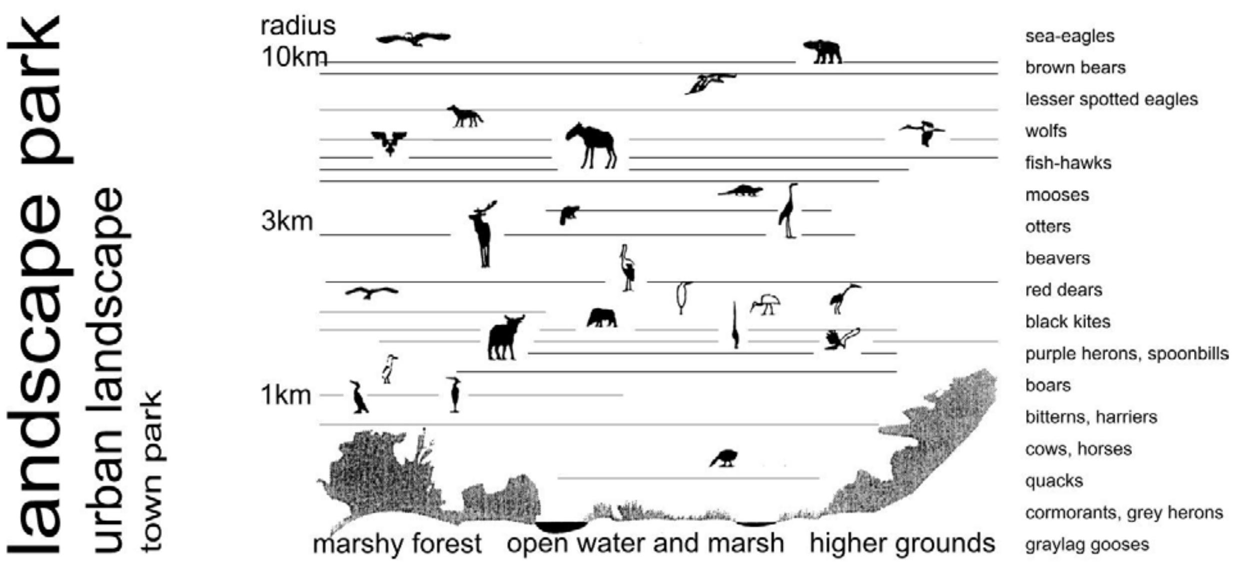
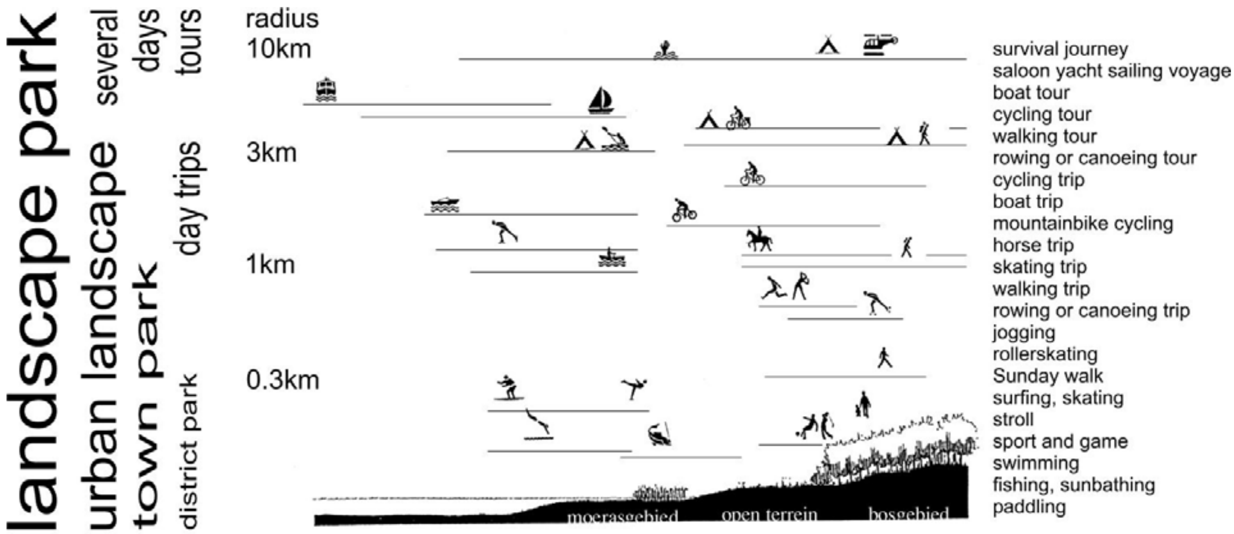


Fig. 108 Ecological advantages of cohesion(economies of scale) and …

---

a A spatial designer may recognise many concepts in Atkins(1995) *Concepts in Physical Chemistry* (Oxford) Oxford University Press



… recreational opportunities differ per landscape and increase per radius[a]

Adhesion, combination, dispersion

Adhesion and attraction between *different* values may exceed their internal *cohesion*.
For example, parks are positively related to the residential area (adhesion), and consequently, dispersed within that area. At a smaller scale, however, parks still require some coherent, and consequently, accumulated surface themselves (cohesion), in order to obtain the opportunities illustrated in *Fig. 108*.
To balance both forces of adhesion and cohesion, you may design a distribution of parks.
In a radius R = {0.3, 1, 3, 10km}, you may propose central neighbourhood~, district~, town~, and conurbation parks with a radius of r = 1/3R = {0.1, 0.3, 1, 3km} respectively (see *Fig. 109*).

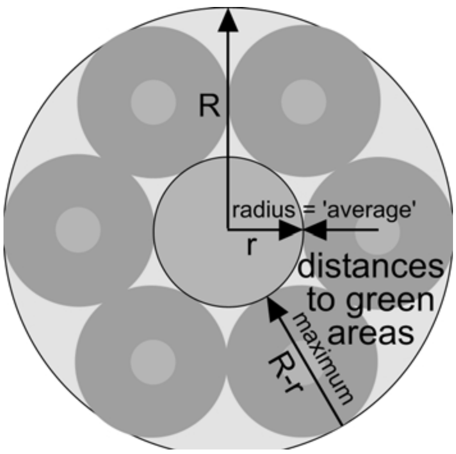


Fig. 109 Standard Green Structure

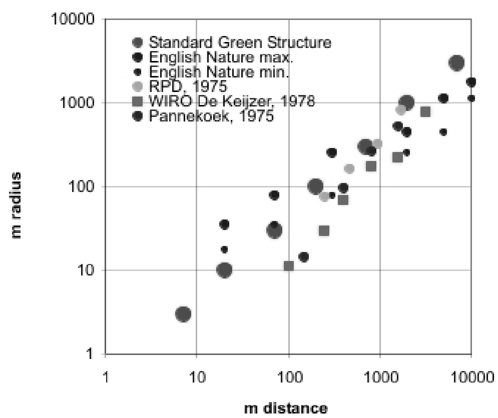


Fig. 110 Some standards for green area

A neighbourhood park r = 100m, then, may require on average 100m walking distance, in order to reach that park. For a district park of r = 300m, that distance would be 300m, for a town park 1km and so on. The average walking distance to a park, then, equals its radius. The maximum walking distance each time measures R-r, or approximately twice the average walking distance. Let us call the hierarchical distribution of parks and smaller greenery in an urban area 'Standard Green Structure'. It comes down to approximately 10% substantial green area for every level of scale that is considered separately.

[a] Schemes adapted from Hoog;Sijmons(1995) *Groene Hart? Groene Metropool!* (Utrecht) H+N+S

Accepting some suppositions[a], usual standards for parks and greenery fit rather well around this Standard Green Structure (see *Fig. 110*). The deviations of these standards from the Standard Green Structure show their emphasis on either more small parks close to your home, or larger ones at a larger distance. The reality deviates from these standards by eccentric locations and consequently, larger walking distances. The distribution of green space between the built-up area determines, to a large extent, the 'form' of the urban area.

Degrees of attraction

The adhesion of shopping areas and schools to residential areas, which are at a different level of scale, results in similar hierarchic distributions. The increased means of transport, however, make inhabitants choose for the quality of schools and shops at some distance rather than for their presence in the neighbourhood. It decreases their *adhesion* to residential areas. At the other hand, their internal *cohesion* increases by the functional diversification of schools and shops, and their economies of scale. Corner shops and neighbourhood schools, then, disappear from the smaller scale in favour of the larger scales. Jobs show a locational hierarchy that roughly follows the economic cycle of production, *dis*tribution, consumption and *con*tribution. Economies of scale accumulate agricultural and industrial production at coherent agricultural and industrial areas (see *Fig. 98*). Consumption (including home production, café's, restaurants) disperses, and is adhesive to dispersed residential areas. Distribution has its own connections between auctions and shops. *Con*tribution (i.e. collecting and concentrating, the opposite of *dis*persion) of labour (workshops, offices) products (stores) and money (banks), show a reverse hierarchy, with a substantial adhesion in city centres (see Fig. 98). However, many forces of cohesion, adhesion and repulsion influence the balance between accumulation and dispersion. Easy access to information and transport networks facilitates the dispersion of every type of job. However, dispersion without adhesion could break up any existing cohesion. Ideas to incorporate agriculture in urban areas completely, would require at least 1000m^2/inhabitant. It would break up the approximately 300m^2/inhabitant urban area into hamlets.

Repulsion

Cohesion and adhesion are *attractive* forces between similar and different values, respectively. They may be negative, also, resulting in *repulsion* between similar or different values. The space that is required around an individual element (the spot of a dot) is a repulsive force. The more void space individual elements require, the less cohesion a set of similar elements obtains. For example, detached houses may have less 'cohesion' compared to row-houses. The more distance a legend unit has to keep from a different legend unit, the less 'adhesion' they mutually have. For example: industrial areas with environmental zones and adjacent residential areas may have less mutual 'adhesion' than parks and residential areas.

Functional, structural and morphological 'attraction'

The examples above only concern *functional* attraction and repulsion for reasons of clarity. In the beginning of this section, I referred to physical chemistry as a source of the terms 'cohesion' and 'adhesion'. On the one hand, physical chemistry keeps some distance from chemical specifications (*content*), and on the other hand, it keeps them from their *function* in a larger whole (e.g. in biology). It clarifies supra-molecular *structures,* such as colloids, and their processes, such as flocculation and coagulation. It restricts itself to *structural* attractive and repulsive forces. Forces, however, are not observable. They have to be concluded from

[a] Standards for greenery are often expressed in m^2/inhabitant instead of walking distance. The relation between walking distance and m^2/inhabitant greenery depends upon suppositions about the size of the urban area and the population density of its residential areas. For a village R=1km you may not need town~, conurbation~ and metropolitan parks. The required surface of greenery expressed in m^2/inhabitant then would be smaller for villages than for towns, conurbations or even metropolitan areas. However, the population density of residential areas in a village is mainly lower than of the larger urban areas, providing more green surfaces such as gardens and dispersed public greenery at the lowest levels of scale closer to your home.

observations of developing accumulations and dispersions, and developments of *form*. Describing morphological diversity, then, concerns exclusively studying any stage of such developments between total accumulation and dispersion, avoiding the functional and structural suppositions that will be added in the next chapters.

Appropriate categorisation

Verbal language collects physically different phenomena in words. That categorisation primarily facilitates the description of sequences in time through sentences. This tacitly assumes a linear structure between generalised categories.
For example, the sequence of production, distribution, consumption, contribution may describe an economic cycle. Verbal language cannot facilitate the description of adjacent differences in the different directions of space, and the environments of any point (particularly their form), as easily as a drawing. The spatial realisation of intermediate deliveries, as they are simulated in meso-economic input- output tables is neglected in the generalisations of variables of macro-economic models, but they cause substantial urban traffic-flows.
The legend of a drawing is the vocabulary of design. Its categorisation, however, may be different from what is possible by words. Forcing a designer to express legend units in words may hamper the development of an appropriate design. It is often better to explain the legend units through images. Images as legend units may show differences that are not expressible in words. They may split up similarities that are hidden in words, avoiding their prejudiced categories.
A designer, however, also has to collect physical phenomena of a smaller radius into the legend units of a larger radius. Designing an allotment does not require one to draw all the rooms, with all their furniture. It can be collected in the legend unit ‘building’. Drawing a district does not require one to draw all the buildings; these can be collected in the legend unit ‘built-up area’.

4.5 Diversity of forms

Diversity through distribution

In *Fig. 111* , ten squares are filled with a hundred black dots differently, but at the same overall density. The pictures are tentatively ranked from total accumulation into total dispersion. The extremes of total accumulation and total dispersion seem to show the least *diversity* of form. Any deviation from these extremes increases the morphological diversity. Could you then indicate a maximum somewhere in between? Is the 'shaped' form less diverse than the 'gradient'? How to measure 'diversity' then? I do not pretend to have found a satisfactory measure to rank the diversity values in between. But, I would like to give some considerations that are possibly relevant for the environmental diversification (a *change*) of form, which is the core of design.

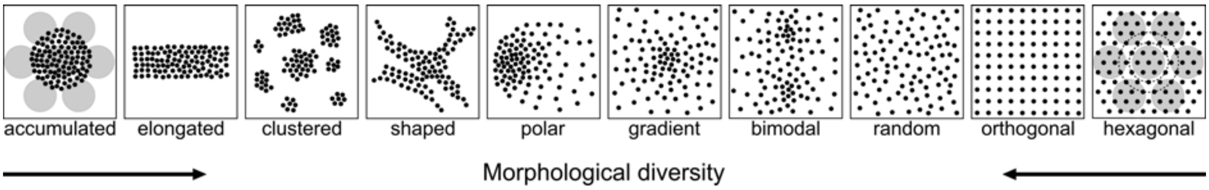


Fig. 111 Increasing and decreasing morphological diversitytentatively related to distribution

Diversity of distances

Fig. 58 on page 100 showed how 'form' can be represented as distances between dots. If you take the environment of each singular dot into account, e.g. the central dot in the 'hexagonal' (most right) scheme of *Fig. 111*, then the 6 nearest neighbours[a] are found at the same distance in 6 equally dispersed directions. In a little larger radius (the drawn inner circle), you will find again 6 dots at the same distance in between the primary directions.
A third larger radius counts 6 dots, this time in line behind the first nearest neighbours.
A fourth larger radius (of the outer circle), counts 12 dots, which introduces new directions. If the pattern is supposed to extend infinitely, then this counts for any other dot. These quantifications are enough to conclude that the environmental diversity in many directions around any dot is low. The same conclusion is valid for any circular *set* of 7 dots.
In the 'orthogonal' scheme (see *Fig. 112*), any dot counts less 'nearest neighbours' at an equal distance compared to the 'hexagonal' scheme (see *Fig. 113*), but its view into different directions counts more dots at larger distances ('the commander can see more soldiers').

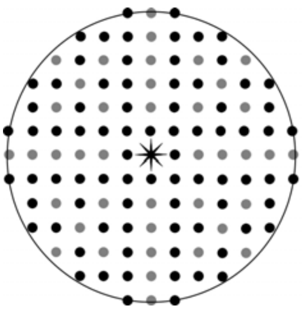


Fig. 112 Orthogonal arrangement: 120 dots, 80 (black) dots visible from the centre

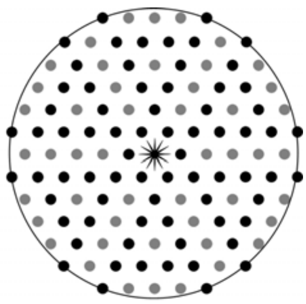


Fig. 113 Hexagonal arrangement: 120 dots, 72 (black) dots visible from the centre

This exercise raises some questions about the hidden suppositions of its conclusions.

[a] See for example http://geographyfieldwork.com/nearest_neighbour_analysis.htm

Which 'environment'?

Speaking about 'environment' (particularly if it concerns its diversity) hides a supposition about scale. How far does the concept of 'environment' extend? You may choose arbitrary 'elastic' boundaries such as R = {1, 3, 10 …. 300 000m}, but even then, there is still a difference between close by and far away, from the reference point of what you call its 'environment'. The larger the distance, the less it may count as 'environment'. You may reduce the weight of every larger distance from that point, until it reaches a zero value at the chosen boundary. This has been done implicitly in the section above, where I stated 'These countings are enough …'.

Which 'form'?

Form cannot be described fully by absolute distances between elements and their directions. It is an outward approach from the element into the whole. You then observe the form of an environment as if you were one of the dots in a plane yourself, looking from inside outwards. If you look at the images of *Fig. 111* as a whole from outside inwards, then you do not observe 100 times an environment. Rather, you observe patterns with larger regularities, larger shapes with boundaries, and compositions with larger components. You immediately notice regularities as a repetition: as a line (a repeating adjacency), as a shape in contrast with its counter-form (repeated in any direction) or as a composition of shapes. The size of the dots in *Fig. 111* measures 4% of the size of the frames within which they have been drawn. This resolution reduces many possible forms by the resolution of a sketch. Details such as thin lines are neglected. Boundaries are only suggested by contrasting densities, if you take larger sets of dots into account. This reduction is chosen on purpose, in order to avoid mixing too many levels of scale. Any level of scale has its own forms. A microscopic view of human cells does not assist an understanding of the human figure.

Which 'diversity'?

The morphological diversity of environments that is intended here is not the set of differences *between* the schemes of *Fig. 111*. The set of differences between the schemes is the general variable of average distribution between accumulation and dispersion. The intended diversity is a set of differences *inside* their frame. It is, however, also not the diversity of environments of every separate dot. It is the set of differences between components of a size between the frame and the grain (the size of the smallest dots) of the images. It concerns the *composition* of the schemes (see the grey shaded components drawn in the extremes of *Fig. 111*). It is the diversity between distinguishable *sets* of dots as 'components' of the image, as intended in *Fig. 63* on page 102. There are differences of content, contrast, mixture and proportion between components in a composition. *Fig. 66 – Fig. 68* on page 102 demonstrates that it can be applied at different levels of scale. That diversity, however, depends upon the way you may choose the location, the size and even the shape of the components. It is not easy to standardise that choice, in order to obtain an appropriate measure of environmental diversity.

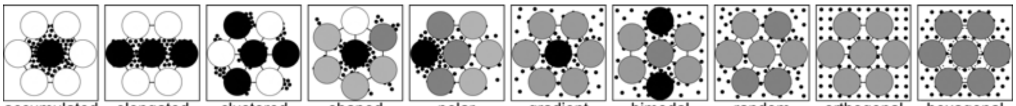
Which 'components'?

If a child draws a human figure, then you mainly will distinguish six components in its drawing: a head, a body and four limbs. In its most primitive form, it contains two circles and four strokes. Their sizes do not differ much, and there is a central component between the others. Adult paintings and photographs may allow a closer look from different directions, in order to discover many different forms at different levels of scale. To comprehend the composition as a whole, you may take some distance and look through your eyelashes to get an overview, and to discover components that tell the general pictorial story through their mutual differences and relations. Suppose, that the number of filled components that are distinguishable vary between 2-10, and their sizes between ½ – 1/10 of the frame.
The average of that model comes close to the pattern of circles used in *Fig. 63 – Fig. 68* on page 102 – 102, in *Fig. 105* on page 167, and to the grey shades in the extremes of *Fig. 111* on page 173. If you take that hexagonal pattern as a modifiable starting point, then you may

look for the most similar components first. This will allow you to arrive at the lowest possible value of heterogeneity of the composition, before you can evaluate the amount of contrast, mixture and proportion. In the hexagonal extreme of dispersion in *Fig. 111*, all the components are equal. The consequence is, that there is also no contrast, no mixture or proportion to report. It is a zero-point of morphological diversity.

Roughly quantifying morphological diversity

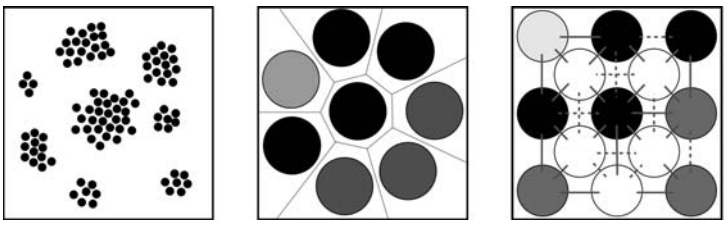
As I stated on page 158, ‘form’ includes the states of distribution of at least two values in space: ‘filled’ and ‘empty’. The components of extreme dispersion are equally filled and empty, but the components of total accumulation are not. One component is filled, the others are not. Consequently, there are 2 colours, with a maximum contrast (say 10), but there are only 6 differences between the components, out of 12 possible ones (the adjacencies in *Fig. 114* most left). If you multiply the intensity of contrast with its number, then you acquire a rough morphological diversity score, as shown in *Fig. 114*. It fits rather well with the preliminary impression of increasing and decreasing diversity in *Fig. 111*, if you adapt the ‘clustered’ image by a slight rotation, in order to distinguish the alternating filled and empty spaces.

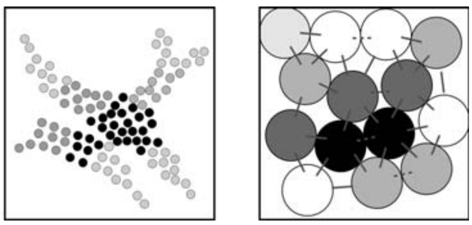


	accumulated	elongated	clustered	shaped	polar	gradient	bimodal	random	orthogonal	hexagonal
#colours x	2	2	2	4	3	2	3	2	1	1
max. contrast x	10	10	10	10	8	6	6	2	1	1
#differences	6/12	8/12	9/12	6/12	10/12	6/12	6/12	7/12	0	0
≈ diversity of form	**10**	**13**	**15**	**20**	**20**	**6**	**6**	**2**	**0**	**0**
			adapted							

Fig. 114 Roughly quantifying form diversity of form by reduction into 6 components

The simple hexagonal template has a clear centre and a clear periphery. It distinguishes 6 potential ‘radial’ differences of the central component with the peripheral ones and 6 ‘tangential’ differences of the peripheral components mutually.
An interpretation, restricted to a regular hexagonal template may benefit some forms and harm others. The only freedom to get (subjectively) a better fit is to rotate it (as done for ‘shaped’ and ‘bimodal’), to adapt reality into a prototypical one (as done for ‘clustered’) or to increase the resolution. At this resolution, however, the interpretation of the images ‘clustered’ and ‘shaped’ are unsatisfactory.





#colours x	3	3		5
max. contrast x	8	10		10
#differences	8/14	21/32		24/28
≈ diversity of form	**14**	**20**		**43**

Fig. 115 8 and topological 8+ components ‘clustered’

Fig. 116 10+ components ‘shaped’

The resolution of sampling

The hexagonal template does not cover the obvious 8 clusters, and the 'shape' image is reduced into an unrecognisable scheme. The 'clustered' image would fit much better in a template of 8 components. Such a slightly higher resolution increases the number of colours (you now can distinguish more than 10, 5 or 0 dots covered in different shades of grey instead of less and more than 5), but it decreases the contrast (still neglecting the obviously empty spaces) and the number of differences (see *Fig. 115*). The resulting score, then, is 14. Releasing the actual locations topologically allows one to add empty components. It would result in a score of 20 (see *Fig. 115*).

The location of samples

To do more justice to the 'shaped' image, you may increase the resolution into 10 filled components, release the template and add as many empty ones as you can (see *Fig. 116*). To locate and colour the components, you may start counting dots at the periphery. Give any successive set of 10 dots a colour, ranked according to their density. Replace these sets by components with this colour. The 'shaped' image of *Fig. 111* ,then, seems to be the most diverse. Another shape, however, would produce a different value. Slightly vaguer boundaries mainly would produce the same result. At a higher resolution, however, the 'gradient' images, (including 'polar' and 'bimodal' without clear boundaries at all) would measure even more colours and differences than any 'shaped' image. A very low resolution at the level of dots, however, would remove the recognition of density-transitions of sets that are required to recognise forms and shapes. Anyhow, the resolution influences the ranking. The choice of sample locations remains a subjective element. There may be many ways to improve or refine this rough approximation of morphological diversity (including directions, weighting distances or just neglecting them in a topological way and so on), but I doubt whether it is necessary in the context of environmental *diversification*. A *change* of diversity primarily requires the comparison of 2 forms, only in a way that depends on the purpose.

Diversity of form facilitates different functions

The intention to reduce or add diversity may be, to make your design more recognisable (less chaotic) or more surprising (less boring), in the balance that is depicted in *Fig. 64* on page 102. That is functional, but form conditions more functions than the quality of the image. The adaptation of a utensil to your hand, of clothes or furniture to your body, or a house to the requirements of your family, all condition their function and your use. Even the form of a conurbation facilitates or hampers ('conditions') your contacts, your travel time, and its function. If it has a high density in its centre and lower densities in its periphery as the 'gradient' image of *Fig. 111*, then it saves time in its centre, but it offers space in its outskirts. Diversity offers freedom of choice. Family people with children will prefer more space to live, and consumers and careerists will prefer more time to act outdoors. This functional diversification may follow the form of the conurbation, but in the long term, the form may be adapted to the function through planning and design at different levels of scale.

Structure between form and function in biology

In biology, the formation of enclosures conditions the operation and performance of cells. The cell wall is a primary enclosure$_1$. It separates an interior from the outside world, thereby allowing processes of a higher order (lower entropy). Embryology describes the beginning of any vertebrate organism as a cell cleaving repeatedly until an accumulation of cells, a 'morula', has been formed, which is large enough to produce an enclosure$_2$ of a second order, a 'blastula' (see *Fig. 117*). The second order interior$_2$ is surrounded by cells, allowing the inner cells to operate differently from the outer cells. The outer cells will develop into skin and nervous tissues (ectoderm), the inner cells into blood, bones and muscular tissues. Operational conditions, then, prepare the performance of functions.

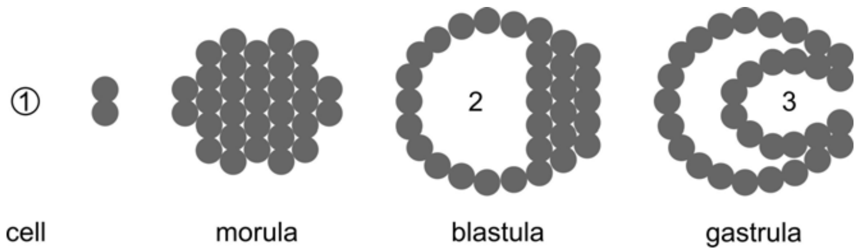


Fig. 117 Gastrulation producing interiors of a second and third order R=10-30μm

The next stage of development shows an invagination$_3$. It will develop into the inner surface of the digestive and respiratory system, as the liver and pancreas (endoderm). It creates a third order of interior$_{3,}$ a gastrula, with a selective access (mouth, nose) into the outside world. New operational conditions prepare digestive and respiratory functions. These functions, then, are possible through a structure of separations and connections, and that structure has become possible by a specific distribution of cells (form). In its further development, the bilateral symmetry about an axis (form) provides the body with a polarity (structure), ending in a head with its mouth, nose and sensory systems, which is selectively open to the outside world, and a dorso-ventral polarity between the front and backside of the body. Bilateral (two polarities), radial (one polarity) and spherical (no polarity) symmetries distinguish different taxa of the animal kingdom. Structure (enclosure, polarity) is not caused (made probable), but conditioned (made possible) by form: its local adjacencies in lines and surfaces.

Structure between form and function in design

In a radius of R = {30, 100m} , a kind of blastula and gastrula is recognisable in old defence systems (see *Fig. 118*) or closed building blocks with invaginating courts (see *Fig. 119*).

Fig. 118 Muiderslot R=100m[a]

Fig. 119 Oudemanhuispoort, Amsterdam R=100m[a]

Structure has a form. It supposes a distribution in space within a larger form, but it supposes more than enclosure or symmetry. A blastula is not operational if the enclosing cells do not have a firm, mutual coherence. Structure, in a more general sense, is any set of connections and separations. If locations are separated by distance, then they may be connected by roads. If locations are connected through adjacency, then they can be separated by walls. Structure changes the probabilities of form. It may stabilise improbable forms. If the structure of a building fails, then its improbable vertical distribution of building materials will return to its more probable horizontal dispersal of a ruin.

[a] Google Earth(2012)

4.6 Diversification of form

A change of distribution and quantity

Clouds continuously change their form, through their distribution of drops in the air. But, they also shrink or extend in different directions. Some drops evaporate, and others appear through condensation, or fall down as rain. A change of quantity necessarily changes the distribution. A change of quantity, thus, is part of the diversification of form. But, the force responsible for that part is different. In clouds, the *quantity* changes through a balance between molecular movement (temperature) and the concentration of water molecules (humidity). The other part of distribution changes through the wind and its local deviations.
In organisms, these forces are the cleaving and the movement of cells.
In architecture they are the addition of building materials and their positioning.

Which distribution and quantity changes?

You may describe the *change* of any cloud in a strict sequence of words (sentence), or as a sequence of variables and operators (formula), but the particular cloud itself, the subject of change, its state of distribution, the 'image'. has to be stored in an xyz-database and *drawn*. It requires a different kind of understanding. This way of understanding is also required for other kinds of difference than change and a sequence of repeating changes (behaviour). What is the initial state of diversity in the sky *from which* you can successively distinguish its changes? What is the origin of that diversity, the cohesion and separation of singular clouds you observe, instead of a homogeneous fog? There is no initial state. Παντα ρει, anything changes. Your image is an unrealistic still. The distribution of clouds in the sky is a consequence of their history. The mechanism of selection and regulation of particles is dispersed and changing. You may point to the heterogeneous surface of the Earth, where the wet parts produce clouds as soon as the sun shines (determined by other clouds, other histories). There, the water evaporates, moisture ascends as long as the surrounding air is colder. This, however, replaces the question. The surface of the Earth itself changes in the long term, and the local evaporation changes through conditions caused by other clouds in the short term.

The origin of a cloud

The pressure, and mainly the temperature in the atmosphere, decrease by altitude. Ascending moisture extends, cools off and starts to condensate as soon as it reaches the condensation level (at a temperature called 'dew-point', which is related to %humidity). At that altitude, a cumulus cloud grows like a cauliflower with a flat bottom.

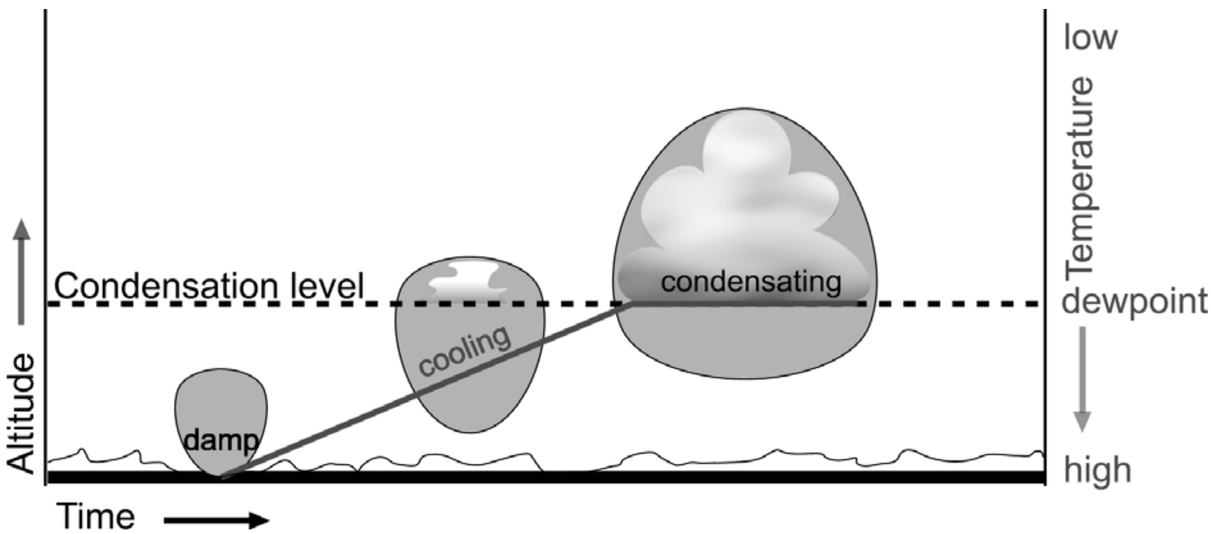


Fig. 120 The origin of a cloud

This flat bottom indicates the point where condensation begins, the dew-point. Losing its coldest parts through condensation, the remaining reheated moisture ascends further, until its temperature equals that of the surrounding air. An occasional wind, its temperature, and moistness, immediately starts to move and change the clouds, until they appear above you. This raises the question: where does that diversity come from?

Time scales of change

If you point to the diversity of the Earth's surface to clarify the diversity of clouds, then you refer to a slower process, to a different time scale of change, repeating the same questions. If the Big Bang initiated a history of dispersion of matter, then the question where its diversity comes from remains. Was it already hidden in the inconceivable accumulation of matter 'before' the Big Bang? *Fig. 111* suggests total accumulation as an example of low diversity. There is, however, no sense to wait for an answer, if it is your task as a designer to change the distributions of matter, which is functional at the limited time scale of the use itself. It is enough to realise that the main trend is dispersion with local accumulations through gravity, which remains in an overall expansive movement. The main trend is increasing thermo-dynamical disorder, which is entropy with local exceptions through enclosures. The actual state of distribution is your initial state as a designer. If it is more stable than clouds, than it will select and regulate your possibilities of change, through design. Solids change their form slower than gases; buildings are less mobile than people; cell membranes are more stable than the water they repel at both sides.
Less changing components (structure) select and regulate the mobile ones.

Selection and regulation

A mechanism operates through combinations of stability and change. The cells of a blastula must join firmly together as a stable skin, in order to enclose the vulnerable, still moving, and changing cells inside. The external structure enables their own diversification into blood, muscles and bones, to develop their own selectors and regulators, and ever more restricted movements and changes at a smaller scale. Selectors and regulators separate and connect in different directions (see *Fig. 8* on page 29). If the connections and separations (structure) are stable, than your blood can flow in the right direction through your arteries, and your impressions can reach your muscles to perform the right action through the nervous system. A stable environment seems to produce more diversity (form), complexity (structure) and specialisation (function), than in a unpredictably changing environment. In ecosystems, you may recognise an even more general relation between difference and continuity on one side, and equality and change on the other side (see *Fig. 10* on page 36). In this scheme, equality is the absolute ('zero') value of difference, and stability as a zero-value of change.[a] Equality, thus, is a special case of difference, and stability of change. This is very convincing for designers, but it is counterintuitive using a verbal language.[b]

The reduction of impressions by verbal language

Words are supposed to be generalisations of special cases, expressing some of their equalities, not the other way around. Words primarily represent equalities, which are subsequently specified (diversified) by adjectives, attributive adjuncts or further specifying sentences. Verbal language, then, starts at the largest sets, in order to arrive at smaller overlaps and subsets. This is a primarily deductive way of distinction. The diversity of your inductive impressions is reduced to traditional categories (words) beforehand, if you attempt to express them in words. The reconstruction of any diversity that way fundamentally must overlook diversities that may be expressed in images. It may be the role of art to become aware of other categorisations.[c]

---

[a] Jong(2007) *Connecting is easy, separating is difficult* **IN** Jong;Dekker;Posthoorn, *Landscape ecology in the Dutch context: nature, town and infrastructure* (Zeist) KNNV-uitgeverij

[b] Sloep(1983) *Patronen in het denken over vegetaties. Een kritische beschouwing over de relatietheorie* (Groningen) Stichting Drukkerij C. Regenboog. a mathematically oriented thesis rejecting Van Leeuwens theory

[c] Jong(2008) *Art's task for science* (The Hague) Royal Academy of Visual Arts Opening course Art Science 2008-2009

The direction of distribution

The Earth meets its atmosphere at a horizontal boundary between solids and gases. Vertical elevations (mountains, trees, buildings) are improbable exceptions, which are equalised in time through erosion. Building (vertical dispersion of solids) is difficult, destroying (horizontal dispersion) is easy. Gravity operates as a selector, by concentrating (separating) vertically and de-concentrating (connecting) horizontally. Building a space station requires different statics than architecture. The direction sensitivity of selectors in *Fig. 9* concerns dynamics. They demonstrate a perpendicularity paradox which is also valid for statics. A dynamic connection in 1, 2, 3, 4, 5 directions supposes separation in 5, 4, 3, 2, and 1 directions, and the other way around. A wall may separate in 2 directions, if it is firmly connected in 4 directions. Gravity concentrates vertically, at the cost of horizontal de-concentration. A column, and de-concentrating floors against gravity, must concentrate their material horizontally (resist strain).

Design as distribution of content

Spatial design supposes a change of probable distributions of a content into useful possible distributions. It requires some insight in horizontal (maps, floor plans) and vertical (cross sections) distributions. Designing horizontal distributions requires *concentrating* within a natural trend into dispersion, while vertical distributions require *de-concentrating* in a probable accumulation by gravity.

In *Fig. 121* , a very common building allotment is redrawn in units of floor space per inhabitant. In the Netherlands, there is approximately $30m^2$/inhabitant residential floor space available at average, which is represented here as circular dots of R = 3m. A total de-concentration would fill the available surface of 60 x 100m nearly completely. Necessary space for public access and parking reduces this surface at its boundaries. Visual access at two sides of a dwelling unit (at least 2 dots) is a supposed requirement that regulates distribution. The concentration of dwellings at the boundaries encloses an outdoor space. Enclosing an outdoor space is a first step of morphological diversification at this level of scale, which polarises the dwelling into a public front and a private back.

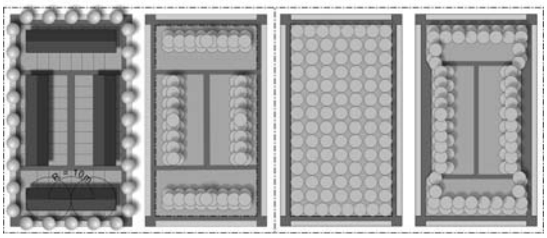


Fig. 121 Distributions of floor space for 100 inhabitants in $30m^2$ circles R = 3m

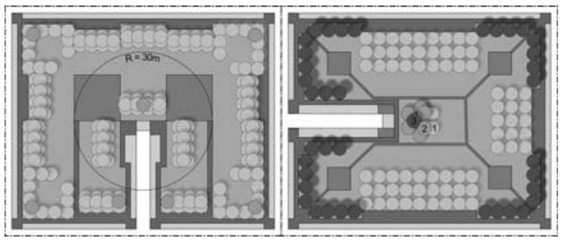


Fig. 122 Redistributions for 200 inhabitants at equal density (darker colours ~ more floors)

Fig. 122 shows a second step, creating more values between public access and private enclosure, and saving space for public access by invagination at one side. It requires a lager surface, but polarises the allotment as a whole, from ‘open’ into ‘closed’. The representation of quantities in dots is an intermediary between the text of a quantitative programme and a final design, which disperses these quantities in space. Further refining the design, dividing any R = 3m ($30m^2$) dot into 10 even smaller R = 1m ($3m^2$) dots, and so on, is an effort of architectural elaboration and detailing. This representation clarifies design as a distribution in a technical and social context, selecting the possible connections and separations as structure. The vertical distribution requires even further structural diversification.

Redistribution

In 2008 I was asked to advise the Chinese conurbation of GuiYang (3 million inhabitants) in the province Guizhou concerning an North-Eastern sustainable extension where the river Nanming turns into the North for approximately 200 000 inhabitants. The existing master plan proposed a dispersion of residential towers in a nominal radius of 1km. A rough analysis of the drawings into nearly 2000 stacked dots r=30m (3000m^2, say 100 people) indicated a capacity of approximately 6 km^2 floor space (see *Fig. 123*).

R=1km

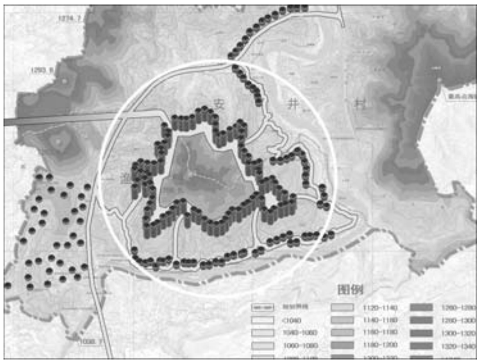


Fig. 123 Analysis of the Master-plan

Fig. 124 Redistribution around the central hill

A simple redistribution of dots, concentrated on the altitude line of 1160m would produce a 'Chinese wall' on the central hill (1260m high) as a crown on its head. The remaining capacity could be found in low rise buildings along the river. As a sketch r/R=3%, it shows a design that can be characterised as distribution of quantities in space. The flexibility of this design can be expressed in a distance of interpretation of the sketch. You then may state that every dot may be interpreted in a radius of 100m around its centre (dot tolerance). The R=300m concentration of these quantities in *Fig. 124* reduces the length of landscape fragmenting roads. It reduces the paved surface, the length of cables and pipes. It supports public transport, and at its stops, it provides new opportunities for facilities. It emphasises the existing topography of altitude lines saving the different landscape views of the majority of the inhabitants. They will defend the open spaces in the future making the plan sustainable. At the altitude line of 1160m a terrace of 80m wide must be cut out of the mountain, giving space for high rise building, parking space and a strictly horizontal access road to stimulate cycling and walking, supporting the elderly. The outer 30m delivers the surface for building. Multiplied by 50 stories, that is 5km^2 floor space, it covers nearly the entire capacity of the master plan (6km^2). The mountain has got a 'crown' hiding its forest top from outside, but daily seen by 160 000 people as a mysterious centre of their borough. On the other side they are awarded by a view over a landscape, unspoiled by high rise buildings. A second strictly horizontal road along the altitude line of 1040m produces the remaining 1km^2 floor space with a view on the river. The natural area of the hill top should be connected by corridors with its roots and the river in favour of concentrated water runoffs and ecological exchange. The Northern part of the 'wall', however, is located on an unattractive North slope attacked by cold Northern winds, probably diversifying the price of dwellings. The Eastern access road coming from the core of a metropolis enters strange emptiness suddenly followed by a complete city on a hill.

The Diversification of form

The possible diversity of form between the simplest cases of total accumulation and total dispersion is inconceivably large. For example, if a programme of 47% built-up, 24% pavement and 29% green has to be divided over 17 locations, then there are more than 3 million possibilities to do so (see *Fig. 125*). Our imaginations restrict ourselves to the known distributions and many kinds of supposed selections and regulations. But ,you may obtain some inspiration by accident that extends your imagination. *Fig. 125* is a screen copy from a computer programme[a] , which is used to explore the number of possibilities. It produces six new alternatives by pressing a button.

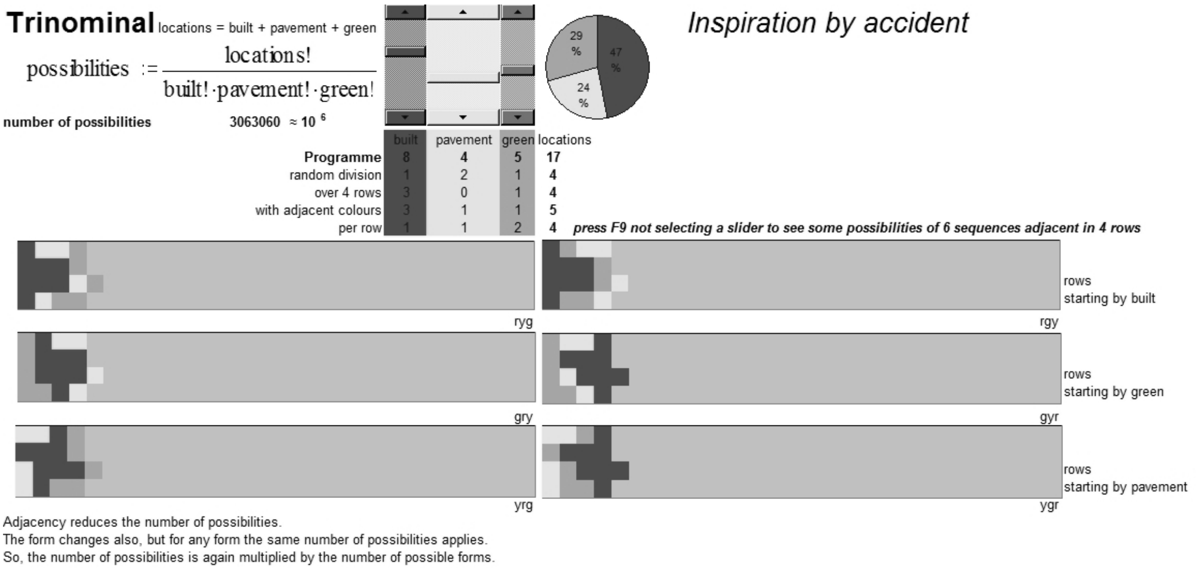


Fig. 125 Some examples of three quantified colours distributed of over 17 locations[a]

Many of the random distributions may be useless, but if you are unaware of sufficient alternatives, you may overlook possibilities. Your suppositions about many kinds of structural and functional restrictions hamper your ability to study the possibilities of form as it is. Culture is the set of shared suppositions in a community.
It is difficult to discover your silent suppositions, if they are commonly shared in a culture.
It is difficult to explain to a fish what water is, unless it is pulled out of its natural environment. Creativity is leaving out at least one of these common suppositions. This chapter attempted to get an overview of *all* possible forms, without other suppositions. Observing biological processes of morphological *diversification*, however, forced me to take selecting and regulating structures into account. They have a distribution in space, with its own diversity. That distribution selects and regulates the other components, their composition, their form and the possibilities of their use. This anticipated the subject of the next chapters.

[a] Downloadable from http://team.bk.tudelft.nl/Publications/XLS/07Legends.xls .