Alphabet of Life

Nature’s Learning Lab

Research—Education—Exhibition

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Alphabet of Life

An alphabet is a fantastic system which enables us to communicate, and to learn to understand the world in which we live. The "Alphabet of Life" is a metaphor for learning from the best of all teachers: from Nature. Why not just ask Nature upon which principles life works and what strategies are best to create a life-friendly and sustaniable world? The goal of this project is to evolve a new vocabulary of design which is deeply connected with Nature and inspired by her genius.

Nature's Learning Lab

The transdisciplinary Learning Lab brings together scientists with designers, architects, engineers, craftspeople and artists, professionals with students and laypeople, and business people with inventors. A pioneering program of research and education constitutes the quality and characteristics of the Learning Lab where Nature is the guide through the cosmos of challenges. What are Nature's best designs and how can we emulate them? How do ecosystems function and what can we learn from biological processes? What methods can we apply to take Nature as a model for innovation and design?

In order to explore the potential of Nature-inspired design and innovation the Learning Lab investigates different Nature-based approaches, methods and philosophies. During the first research phase the focus was on "Biomimicry". Other approaches will be subject matter for further research activities in the near future, such as "Cradle to Cradle", "Circular Design", "Permaculture" etc.

Biomimicry

Biomimicry is an approach to innovation that seeks sustainable solutions to human challenges by emulating nature's time-tested patterns and strategies. The goal is to create products, processes, and policies—new ways of living—that are well-adapted to life on earth over the long haul. The core idea is that nature has already solved many of the problems we are grappling with. Animals, plants, and microbes are the consummate engineers. After billions of years of research and development, failures are fossils, and what surrounds us is the secret to survival. (Biomimicry 3.8, Dayna Baumeister)

26 Life Principles

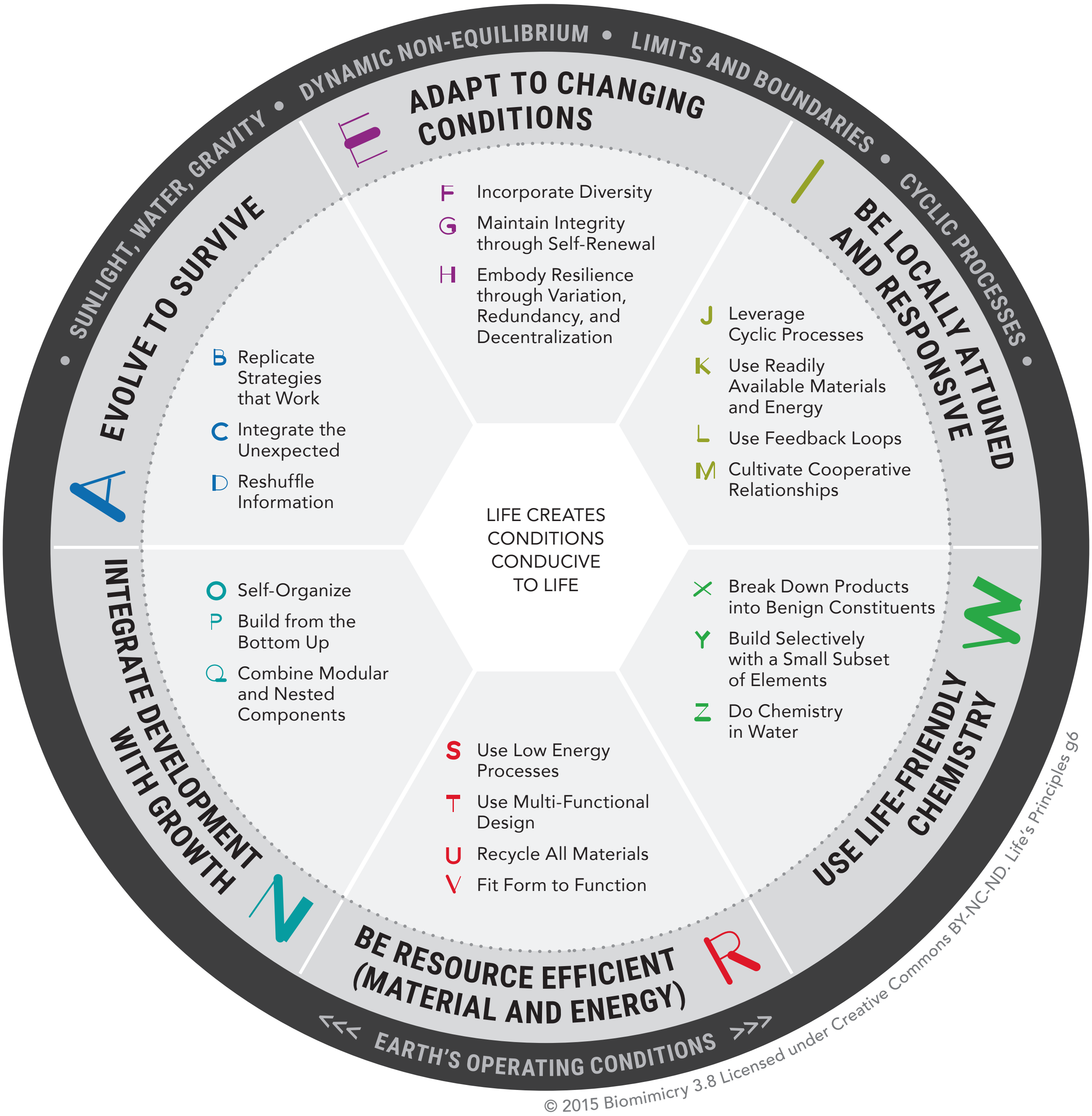
Based on the recognition that Life on Earth is interconnected and interdependent, and subject to the same set of operating conditions, Life has evolved a set of strategies that have sustained over 3.8 billion years. Life's Principles represent these overarching patterns found amongst the species surviving and thriving on Earth. They are lessons from Nature and represent the sustainability benchmark as part of the Biomimicry Thinking Design Process.

The Alphabet of Life in the Ecosystem of a Tree

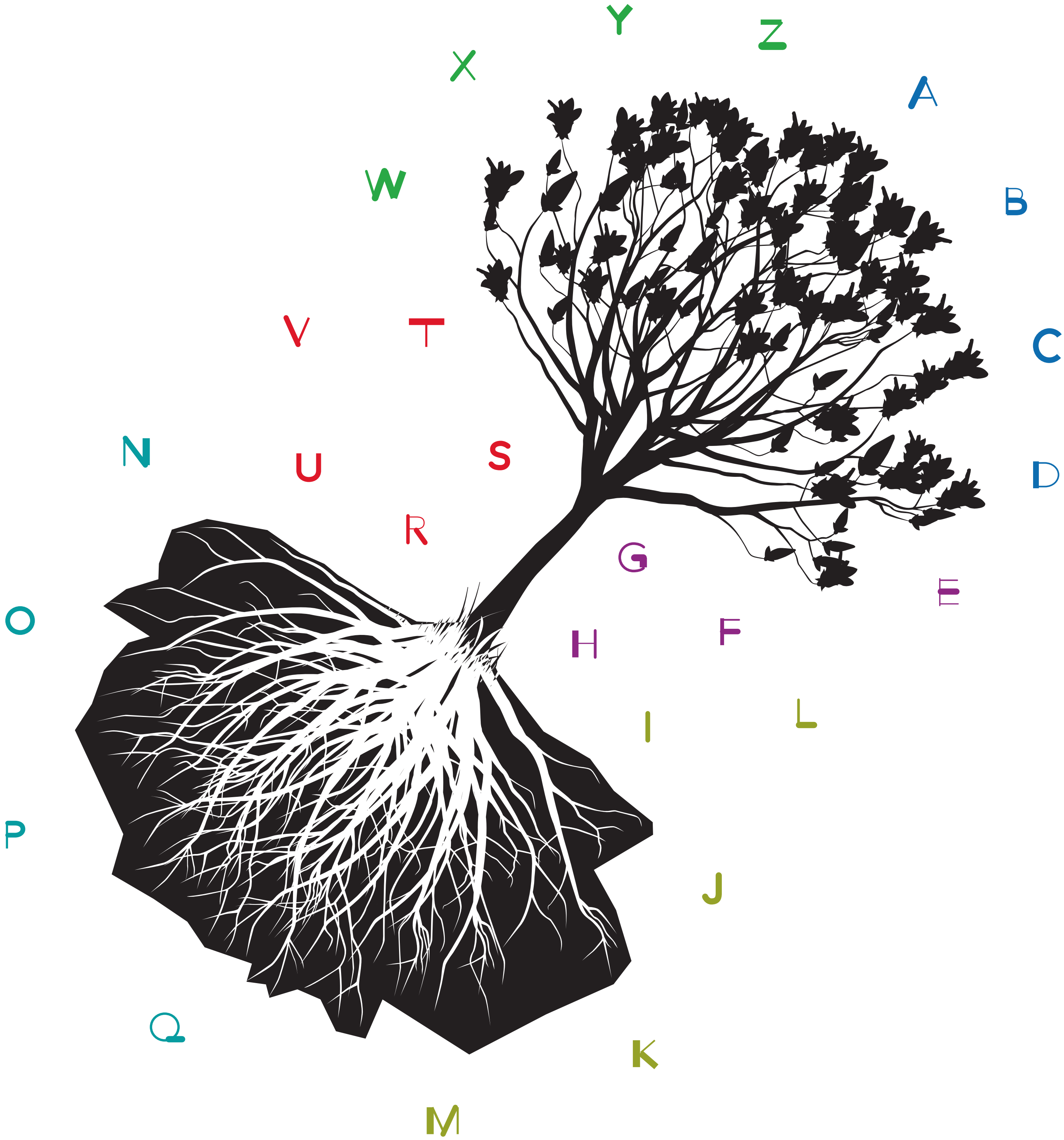
Evolution is a history of change and adaptation, and Nature offers a gigantic repertoire of life strategies. But what are the principles that make it possible for organisms to survive and thrive? In order to illustrate Life's Principles the Learning Lab team of scientists, designers and Biomimicry experts have searched for examples in the ecosystem of a tree.

26 Life Principles

Biomimicry DesignLens



26 Life Principles
in the Ecosystem of a Tree



A tree lives mainly from water, light and air and is a prime example in terms of waste disposal. It also offers a habitat and nourishment for an immense variety of species of fauna, flora, fungus and microorganisms. Hence the tree is a symbol of an intact eco-system, in which every living creature plays its role and in which the cycles of nature are perfectly optimised – the young sapling and the decaying organism image the whole of life.

26 Champions
in the Ecosystem of a Tree

Z
Tree — Xylem and phloem
Do Chemistry in Water

Y
Autotrophs — Photosynthesis
Build Selectively with a Small Subset of Elements

A
Flying insects — Evolution of wings
Evolve to Survive

X
Spiders — Poison
Break Down Products into Benign Constituents

B
Wasps — The Bates-Müller hypothesis of mimicry
Replicate Strategies that Work

W
Nectar-producing plants — Energy in return for pollination
Use Life-Friendly Chemistry

C
Aculeata — Sting as tool
Integrate the Unexpected

T
Woodpeckers — Beak tool
Use Multi-Functional Design

V
Rose chafer — Wing form
Fit Form to Function

D
Aphids — Sexual reproduction
Reshuffle Information

S
Tree sponges — Use of catalysts
Use Low Energy Processes

R
Wood-nesting wild bees — Brood strategie
Be Resource Efficient (Material and Energy)

F
Polylectic bees — Diversity and co-evolution
Incorporate Diversity

N
The Big Four: Beetles, Hymenoptera, Flies, Butterflies — Holometabolism
Integrate Development with Growth

E
Tree — Positive and negative geotropism
Adapt to Changing Conditions

G
The tree hollow system — Micro-life community
Maintain Integrity through Self-Renewal

U
Anthills — Circular economy in the woodland soil
Recycle All Materials

I
Peppered moth — Pattern and colour
Be Locally Attuned and Responsive

O
Naturally growing mixed woodland — Mixed woodland instead of mono culture
Self-Organize

L
Bat — Sonar orientation
Use Feedback Loops

P
Forest soil — Soil formation
Build from the Bottom Up

H
Soil system — Countless living creatures
Embody Resilience through Variation, Redundancy, and Decentralization

J
Deciduous trees — Falling leaves
Leverage Cyclic Processes

Q
Tree — Branch and root ramifications
Combine Modular and Nested Components

K
Decomposer system — Decomposers
Use Readily Available Materials and Energy

M
Tree and mycorrhiza — Fungus-root-symbiosis
Cultivate Cooperative Relationships

The 26 selected examples of Nature live all over the tree's habitat: in the soil, the root system, the trunk, the branches, the leafes and in the airspace all around the tree. And the tree itself together with its fellow trees in the woods are outstanding examples for some of Live's Principles.

A is for **Arrival on Land**

Life’s Principle (Master)

Evolve to Survive

Example in Nature

Flying insects *(Pterygota)*
Evolution of wings

The most probable theory of origin (epicoxal hypothesis) proposes that around 400 million years ago wing-type structures developed on water insects out of appendages between the second and third pairs of legs. In order to cope with the ever more complex habitat on terra firma and to optimally exploit recently conquered air space, wings and flight motor functions continuously evolved.

Design Guideline

Constantly continue to integrate and process information in order to ensure sustained functionality.

Flying insects in the tree habitat

Insects play a major role in the pollination of trees, and many use trees as habitat also far beyond their span of life. For instance, more than 500 wood-dwelling beetles and 179 large species of butterflies have been documented in domestic oaks.

B is for **Being Müller or Bates?**

Life's Principle

Replicate Strategies that Work

Example in Nature

Wasps *(Vespula)*
The Bates-Müller hypothesis of mimicry

Many types of wasps use warning colours and warning patterns to signal to potential predators the danger of their poisonous sting. Using resembling warning signals reinforces the effect (Müllerian mimicry). Many defenceless insects without stings like sawflies and above all flies imitate the same colour pattern in order to deceive their enemies (Batesian mimicry).

Design Guideline

Repeat successful methods.

Wasps in the tree habitat

Trees are frequently dwelt in by damaging insects. Wasps are very efficient predators, which decimate and cull plant parasites. Furthermore, wasps contribute to the vitalisation of tree hollows.

C

is for

Celebrate the unexpected

Life's Principle
Integrate the Unexpected

Example in Nature
Aculeata *(Aculeata)*
Sting as tool

As time went by certain hymenoptera developed the strategy of intensive brood care by setting up brood cells equipped with nourishment. This made the ovipositor of the female superfluous. The latter then developed a poisonous sting serving as hunting and defence tool *(Aculeata)*. Among them are the species of bees, ants and several types of wasp.

Design Guideline
Integrate mistakes so that new forms and functions are created.

Aculeata in the tree habitat
Aculaeata populate different areas of the forest and have different tasks. On one hand there are the pollinators, but also the predators (pest control), and inhabitants of tree hollows (energy suppliers). Ants provide for high nutritional concentration in the ground (anthills) and serve as nutritional basis for predatory fauna such as woodpeckers.

D is for **DNA wants Sex**

Life's Principle
Reshuffle Information

Example in Nature
Aphids *(Aphidoidea)*
Sexual reproduction

Aphids can reproduce sexually and asexually. In asexual reproduction *(Parthenogenese)* genetically identical clones are created from the unfertilised eggs of the female. In sexual reproduction the parental genes mix and new combinations of the characteristics of two individuals are produced in the next generation.

Design Guideline
Exchange information and modify it in order to create new options.

Aphids in the tree habitat
Aphids are plant parasites that feed from vegetal sap. To do this, they prick their proboscis into the main vascular system of the hosts. Therefore the aphids' activity indirectly fosters the resistance of tree populations. Moreover, aphids live in close cooperatives with ants – you scratch my back and I'll scratch yours: aphids are kept by ants like "dairy cows". Ants milk the aphids, which make their honeydew available to them. In return, the ants offer protection from predators and mould infestation.

E is for **Every way up, every way down**

Life's Principle (Master)
Adapt to Changing Conditions

Example in Nature
Tree
Positive and negative geotropism

Trees are perceptive of many different environmental stimuli and react to changed conditions therein. When a tree tends to grow in an oblique position for instance because of underground shifts, the tree corrects its growth direction by orienting itself on the Earth's gravitation. The main trunk of the tree accordingly grows away from the Earth centre (negative geotropism) and the main root grows towards it (positive geotropism).

Design Guideline
Appropriately respond to dynamic contexts. *

The habitat of the tree
Geotropism ensures access to light, the tree's stability and thus its competeiveness. Snow-covered slopes foster eccentric growth forms, like the so-called "sabre growth". Heavy masses of snow force tree trunks to grow crooked in their lower parts. A few metres above the ground they become almost straight again because the tree balances out the physical forces.

* Dynamic contexts
Earth's operating conditions: sunlight, water, gravitation, dynamic balance (imbalance), boundaries and transition, cyclic processes

F is for **Form and Diversity**

Life's Principle
Incorporate Diversity

Example in Nature
Polylectic bees
Diversity and co-evolution

Polylectic bees (*poly:* many, *legere:* gather), particularly the honey bee, are capable of gathering pollen from a great diversity of flowers from many different plant families, which gives them multiple options when the nutritional options change or bottlenecks develop.

Design Guideline
Integrate multiple forms, processes and systems to fulfil functional demands.

Polylectic bees in the tree habitat
Pollination of many trees is often performed by bees. These include tree species with high nectar and pollen supplies such as mountain and Norway maple, wild cherry, rowan and various sorts of lime tree. In contrast, coniferous trees rely on wind pollination, dark, dense spruce forests are only useful for bees as nutritional plants in the form of the honeydew of aphids. Dead trees are the most important habitat for wood-nesting types of bee.

G is for **Group hollows**

Life's Principle
Maintain Integrity through Self-Renewal

Example in Nature
The tree hollow system
Micro-life community

Tree hollows develop because of broken branches or are hollowed out by fauna and fungus. They are settled by specialised tree-hollow residents and the detritus (decaying biomass) serves the complex tree-hollow community as nourishment and habitat. An attractive milieu thrives for other fauna like owls, woodpeckers, songbirds, dormice, martens, bats and paper wasps, which move in temporarily. This produces nest material, food and waste material in the hollow. This permanent supply from outside preserves the micro-climate, and the community thrives.

Design Guideline
Preserve, repair and improve the system by constantly adding energy and material.

Hollows in the tree habitat
Even small tree niches, but particularly big, fully developed ones, offer many specialised organisms the necessary basics for life and enhance the biodiversity of the tree as total habitat.

H is for **Half as bad but twice as wild**

Life's Principle

Embody Resilience through Variation, Redundancy, and Decentralization *

Example in Nature

Soil system *(pedosphere)*
Countless living creatures

Natural soils are complex configurations teeming with life, having developed over millennia. High-level diversity and extreme concentration of individual types of soil-inhabiting fauna and flora pervade all soil levels (variation). The number of small fauna like mites, insects and worms (mesofauna) can attain a value of 1 million individuals per square metre. Faunal, unicellular creatures and tiny thread worms surpass this value hundredfold and the number of microorganisms (fungus, bacteria and viruses) cannot be gauged. In 1 cm^3 of soil, mushroom threads can be found making up a total length of one kilometre (redundancy).The most important functions in the soil system are secured through different organisms (resilience), and the decentralisation of important cyclic processes guarantee the maintenance of living conditions in times of crisis.

Design Guideline

In disruptions, maintain life functions by integrating multiple and similar forms, processes and systems, whose existence is not mutually dependent on one another.

The soil in the tree habitat

In mixed woodland, around 20 tons per hectare of vegetal matter fall to the ground in autumn in the form of foliage and needles. An overwhelming host of decomposers from the topsoil (debris level) close the food chain for the entire woodland eco-system. The soil is also the anchoring substrate for the tree.

* **Resilience:** ability to resist, the ability to overcome crises
Variation: measurement for deviation from mean value, Dispersion
Redundancy: superfluity
Decentralisation: not centrally controlled or regulated

is for **Industry and Genius**

Life’s Principle (Master)
Be Locally Attuned and Responsive

Example in Nature
Peppered moth *(Biston betularia)*
Pattern and colour

Peppered moths are nocturnal; during the day they linger motionless on the trunks of birch trees. They usually show a light-coloured basic hue, which is why they are perfectly camouflaged on the white birch bark against predators. Caused by air pollution and the resulting darkening of the tree bark, within a few generations the localised population of the peppered moth changes its predominant colour from light to dark.

Design Guideline
Adapt to the immediate environment and integrate yourself.

Peppered moth in the tree habitat
The nocturnal caterpillars of the peppered moth feed on the foliage of domestic trees and bushes. Among these, besides the birch, are poplar, willow, oak, ash, elm, sloe and black alder. At first glance their absence would seem to be advantageous for trees, but they are part of the food chain and therefore important for the ecological balance in their habitat.

J is for **Just in time**

Life's Principle
Leverage Cyclic Processes

Example in Nature
Deciduous trees, e.g. beech *(Fagus sylvatica)*
Falling leaves

During winter frost trees can absorb hardly any water from the ground, which is why they have to cast off their foliage. Prior to this in autumn important substances such as chlorophyll are transported from the leaves into storage organs. The foliage then takes on a yellow or red hue. The fall of leaves is an effective protection against condensation and also disposes of residue products from the tree's own metabolism and – of particular significance today – of absorbed pollutants and poisonous substances.

Design Guideline
Take advantage of phenomena that repeat themselves.

Blattfall im Lebensraum Baum
The autumn fall of leaves in domestic deciduous trees not only prevents dehydration in winter but also branches breaking through heavy masses of snow. In the following spring new leaves sprout and can be re-arranged by the tree in order to ensure an efficient provision of sunlight.

K is for **Kitchen under ground**

Life's Principle
Use Readily Available Materials and Energy

Example in Nature
Decomposer system
Decomposers

We can compare the teeming community of individuals and species in the soil with a recycling and reprocessing plant. One after the other, feeding communities exploit waste products and excreta. The faunal faeces form a substrate for microbes, which ultimately creates a nutrition-rich humus for new plant growth. The microbial activity generates heat energy which benefits the entire decomposer system.

Design Guideline
Work with materials that are in rich supply and make use of freely available energy.

Decomposers in the tree habitat
The death of old trees and the leaf-fall in autumn form a detritus stratum on the woodland ground. In cool climate zones its decomposition occasionally occurs slower than the parallel production of organic material. This produces massive layers of organic material in which important foodstuffs remain bound that are imperative in providing for the plants that live here. The greater the diversity of species and number of individual bacteria and fungus types (microorganisms), also woodlice, millipedes, springtails, oribatid mites and worms, the more efficient the transformation of the organic material into humus and thus the release of the nutrients.

L is for **Lust and prey**

Life's Principle
Use Feedback Loops

Example in Nature
Bat *(Microchiroptera)*
Sonar orientation

The bat has specialised in exploiting the air space at night. To orient itself spatially on its breakneck hunting flights and to target its prey exactly, it transmits regular acoustic signals, measures the returning echo signals, and so monitors distances, forms and movements. Based on this information it controls its flight.

Design Guideline
Engage in cyclic information flows in order to modify reactions appropriately.

The bat in the tree habitat
Bats live in tree hollows etc. and contribute to their regulation by hunting for insects. Among these is the owlet moth which has special acoustic sense organs and can perceive the bat's orientation sounds. The moths escape this danger by dropping onto the ground. When seeking females, the male owlet moths follow their pheromones and likewise target their objective in a feedback loop.

M is for Making friends

Life's Principle
Cultivate Cooperative Relationships

Example in Nature
Tree and mycorrhiza
Fungus-root-symbiosis

Besides anchoring the tree in the ground, roots function to collect water from the earth and to procure minerals and nutrients dissolved in it. These are mainly absorbed through finely ramified root ends. The reach of roots is magnified fourfold when the tree enters into symbiosis with special funguses in the ground. In exchange for better and more stable water, nutrient and mineral provision, the fungus receives its nourishment from the tree – the sugar from photosynthesis.

Design Guideline
Find value through win-win interactions.

Mycorrhiza in the tree habitat
Greek *mýkēs* fungus and *rhiza* root
Mycorrhizal funguses enhance the tree's competitiveness and provide for high-level resistance to dehydration. They act as health police by preventing aggressive fungus types and bacteria from invading the tree. In favourable locations, some trees can survive if necessary without the symbiotic relationship with ground funguses, for others the relationships to the mycorrhizal partners are indispensible.

N is for **New Form—New Life**

Life's Principle (Master)

Integrate Development with Growth

Example in Nature

The Big Four *
Holometabolism
(Ancient Greek *holos* complete and *metabolé* change)

Most insects bear the trait of holometabolism, which means they go through a complete metamorphosis from the juvenile stage to the adult. The larval phase is devoted to eating and growing. During the following pupal stage in which no nourishment is consumed, a complete remodelling of the body takes place (metamorphosis). After the last shedding of the cocoon a fully mature and reproduction-capable insect emerges (imago). The Big Four are mega-diverse insect orders and comprise 77 percent of all animal species in Austria. Their way of growing and developing in separate phases can thus be seen as an extremely successful model of nature.

Design Guideline

Invest optimally in strategies that promote both development and growth.

The Big Four in the tree habitat

Because of the enormous number of species in the four largest insect orders, beetles, hymenoptera, flies and butterflies are formatively involved in all processes in the tree system: pollination, dissemination, defoliation, parasite control, decomposition of residues and of the wood, and working-in of organic matter into the ground (humus formation).

*** Number of species in Austrian and the most important known families:**
Beetles *(Coleoptera)* **8.000:** weevils, leaf beetles, stag beetles, ladybirds, longhorn beetles, bark beetles, rose chafers
Hymenoptera (Hymenoptera) **12.000:** leaf wasps, ichneumon fly, ants, potter wasps, bees
Flies *(Diptera)* **10.000:** hoverflies, gall midges, gnats
Butterflies *(Lepidoptera)* **4.000:** owlet butterflies, swallow tails, wall browns, geometer moth

O

is for **Orgy in the woods**

Life’s Principle
Self-Organize

Example in Nature
Naturally growing mixed woodland
Mixed woodland instead of monoculture

In locations with different microclimates (light, water, temperature, ground, stones and rocks, exposure, vegetation density, etc.) each tree type adapted to the respective climate germinates and thrives accordingly. Under natural conditions this encourages the growth in lower-lying locations of species-rich mixed woodlands with diverse fauna and flora. The development from bush land to young forest and then to a climax community happens according to a natural temporal sequence of plant communities (succession) and guarantees highly resistant eco-systems.

Design Guideline
Create conditions that foster the interaction of components in order to enrich the system.

The habitat of the tree
Natural mixed woodland is rarely found in Austria. Usually there is intervention into the stock of woodland trees through forestry and aspects of profit (silviculture, monocultures). Self-organising woodland features a heterogeneous combination of ages and richly diverse structures (dead wood, roots, water runnels, boulders, small hollows and caves). This is the prerequisite for a rich faunal, floral and fungus biotope and subsequently for a low liability to system-threatening disruptions, such as the mass multiplication of damaging insects, fungal maladies or storm damage.

P

is for **Pure Stone and Naked Life**

Life's Principle
Build from the Bottom Up

Example in Nature
Forest soil
Soil formation

Domestic woodland soil formed on post-Ice Age bedrocks inhabited by the simplest forms of life (sand-stone mixture on rock). Frost and the root strength of the primary inhabiting plants caused the granulation of minerals (stones and rocks). Soil animals and microorganisms transformed vegetal matter into humus, and over the millennia a mighty soil complex accumulated (1 cm per 100 years). Various soil horizons gradually became differentiated: the detritus layer (dead plant material) lies on the soil surface, under it in the A horizon is the richly nutritious humus layer, while in the B horizon the transformation of minerals takes place, and in the lowest C horizon the granulation of the parent rock. With increasing complexity of the soil structure the potential is enhanced for interaction with organisms, producing rich soil eco-systems.

Design Guideline
Assemble components one after the other.

Woodland soil in the tree habitat
Soils form the anchoring substrate of trees and supply water, minerals and important nutrients. Organic residues of trees (leaves, dead wood) are degraded in the ground in a complex system of decomposition (fungi, fauna, microorganisms), transformed into humus, and nutrients are again made available for the plants (cycle). Besides countless microorganisms, intact soils can harbour up to 1 million animals visible to the human eye and are a refuge for the woodland's species diversity.

Q

is for **Quest after the Fractal**

Life's Principle
Combine Modular and Nested Components

Example in Nature
Tree
Branch and root ramifications

The tree continually forms ramifications in its crown and roots, a fractal structure that takes up more and more space. The most important task of the aboveground part of this structure is photosynthesis, while the subterraneous root system functions as anchor and for provision of nutrients and water. The investment in the biomass of the tree's crown relates directly to the ramification of the roots.

Design Guideline
Füge mehrere Einheiten schrittweise von einfach zu komplex ineinander.

Trees
The tree layer is the top "storey" of the forest; in Austria it reaches up to 30 metres. Heavy tree trunks can weigh several tons and exercise considerable stress on their roots. In addition there is the weight of the entire crown of the tree, which is conspicuously greater in summer than in winter.

Я is for **Resources**

Life's Principle (Master)

Be Resource Efficient (Material and Energy)

Example in Nature

Wood-nesting wild bees
Brood strategies

Wood-nesting wild bees choose their nesting place and the amount of provisions for the larva according to criteria of the shortest flights to supply the necessary resources. They live solitary; each female gathers pollen as victuals for the larva in their brood cells, which the bees fashion in the already existent mines made by the larva of the longhorn beetle. They use moist clay as intermediate walls of the single cells and to close off the nest. This building material and the larva provisions have to be procured from the environment with great energy and time investment; short flights and low material requirements therefore favour propagation success.

Design Guideline

Skillfully and conservatively take advantage of resources and opportunities.

Wood-nesting wild bees in the tree habitat
Wood-nesting wild bees like the solitary mason bee *(Osmia rapunculi)* breed in dead trees. Several types of the species Osmia are known for efficient pollination, especially in cultivated plants like apple and pear trees.

S is for **Spongy Tricks**

Life's Principle

Use Low Energy Processes

Example in Nature

Tree sponges or agarics, e.g. white rot fungi *(Ceriporiopsis)*
Use of catalysts

Fungi depend on procuring nutrients from their direct surroundings. Tree sponges are capable of digesting wood, an ability that only few living creatures possess. With the help of enzymes (catalysts) they macerate the almost indigestible lignin stored in the tissue of trees. The enzymes enable this procedure at low temperature. In this way the fungi ensure that dead wood decomposes and yet again becomes the basic nutrition for many other living creatures.

Design Guideline

Minimize energy consumption by reducing requisite temperatures, pressures, and/or time for reactions.

Tree sponges in the tree habitat
The white rot fungi play a leading role in the woodland eco-system. Without their metabolic activity enormous amounts of organic material would pile up in the shortest time imaginable. Lignin-digesting fungi mostly inhabit fallen trees.

T

is for **Tom-tom-, hack and grip design**

Life's Principle

Use Multi-Functional Design

Example in Nature

Woodpeckers *(Picidae)*
Beak tool

The versatility of the woodpecker's beak offers multifunctional options of use as a gripping, hacking and drumming tool. It is used for hacking when searching for fodder, in building nest hollows and in quarrelling and fighting, as tweezers for picking up food, as a tool for plumage-grooming, and to turn its eggs in its nest; it also enables the bird to produce a loud drumming sound, a self-promotional signature tune to gain attention. And last but not least, the woodpecker feeds, drinks and sings with its beak.

Design Guideline

Meet multiple needs with one elegant solution.

The woodpecker in the tree habitat

Abandoned woodpecker holes play an important role In the woodland ecosystem: owls, tits, tree bumblebees, bats and squirrels use them as sleeping place, nursery, and hibernation quarter or seek shelter and refuge in them. In this way woodpeckers support species diversity of the forest.

U is for **Use & re-Use**

Life's Principle
Recycle All Materials

Example in Nature
Anthills of the red wood ant *(Formica rufa)*
Circular economy in the woodland soil

Hill-constructing wood ants play a pivotal role in the material cycle of woodland. They construct nest hills made of residue materials from trees (mostly spruce needles and small twigs) of a height of up to one and a half metres, with the nest also attaining the same dimension under the earth. It is a junction for trading building materials, and, in a labyrinth of tunnels and chambers, they maintain their nurseries, fodder depots and refuse disposal storage. The nutrients concentration yielded by long years of accumulating organic material thus forms a favourable basis for the growth of new trees.

Design Guideline
Keep all materials in a closed loop.

Ants in the tree habitat
One of the central tasks of wood ants is to regulate the host of insects in the tree crown. They protect and cultivate the aphid colonies, whose honeydew is an additional source of food for numerous species of insects. Alone through the overwhelming density of individuals (more than 100,000 per colony) they assume one of the most important roles in the overall eco-system.

V is for **Versatility**

Life's Principle

Fit Form to Function

Example in Nature

Rose chafer *(Cetonia aurata)*
Wing form

A slight change in form at the edge of the rose chafer's wing cases allows it to spread its rear wings for flight without having to lift its protective armour from its body. This avoids the disturbing braking effect through the lifted wing cases during flight. The result is impressive. Despite its considerable body size of 1.4 to 2 cm it is one of the best flight acrobats in the beetle kingdom, which is essential for it as a day-active bloom visitor.

Design Guideline

Select for shape or pattern based on need.

Rose chafters in the tree habitat

Rose chafers are found at the edge of woodland, also in meadows and gardens, frequently on blooms. The larvae grow up to 5 cm (chafer grubs) and develop in rotten wood, a habitat with extreme species diversity. Thus they are also an important member of mature tree-hollow communities. As large insects they are an abundant nutrient source for insectivores.

W is for **Worth millions and sweet**

Life's Principle (Master)

Use Life-Friendly Chemistry

Example in Nature

Nectar-producing plants, e.g. small-leaved lime *(Tilia cordata)*
Energy in return for pollination

To appeal to pollinators plants produce energy-rich substances which they barter for their pollination. Small-leaved limes bear an enormous number of blossoms in summer – up to eleven blossoms hang on clusters on one bearing leaf. Their nectar and pollen are accessible at the base of the sepals. The pollinating insect uses the nectar as fuel for locomotion. As soon as a blossom was pollinated the tree stops nectar production in this blossom.

Design Guideline

Use chemistry that supports life processes.

Nectar and pollication in the tree habitat

Without pollination by insects 80 percent of blossoming plants would not be able to form fruits or seeds and therefore not propagate. Vice versa, approximately half of all fauna in Austria are dependent on the availability of sufficient amounts of nectar.

X

is for

X-FIles: poison disappeared without trace

Life’s Principle

Break Down Products into Benign Constituents

Example in Nature

Spiders *(Araneae)*
Poison

Although spiders kill their prey with poison, they themselves are not harmed by it. They make use of chemicals that break down into non-harmful chemicals when they digest their prey, which can yet again be integrated into their own metabolism.

Design Guideline

Use chemistry in which decomposition results in no harmful by-products.

Spiders in the tree habitat

Spiders hunt insects and have a regulating effect on predators of trees. They also play an important role themselves in the balance of nature and the food chain as the prey of birds, frogs and lizards, which benefits the tree as well.

Y

is for **Yess to less**

Life's Principle
Build Selectively with a Small Subset of Elements

Example in Nature
Autotrophs (plants)
Photosynthesis

Plants store solar energy in the form of sugar molecules. They simply need water and carbon dioxide from the atmosphere, meanwhile simultaneously release oxygen. The sugar produced by this process plays a key role in building up plant cells. This means that plants are able to create organic material out of anorganic substances (H, C, O). They therefore do not depend on other living creatures as food, but are "self-providers" and thus autotrophic. The three chemical elements of hydrogen (H), carbon dioxide (C) and oxygen needed for photosynthesis are omnipresent and available in abundant quantities.

Design Guideline
Assemble relatively few elements in elegant ways.

Photosynthesis in the tree habitat
Even the metre-high trees of our domestic woodland start their lives with germination from a tiny seed. The metabolism is at first based on existing internally stored reserves. A fragile radicle and the first tender green leaves then grow and can thus start the process of photosynthesis and acquire water via fine root hairs. The entire vegetal substance of woodland is formed through photosynthesis and is the foundation of life for all fauna and microbial life.

Z is for Zest through Water

Life's Principle
Do Chemistry in Water

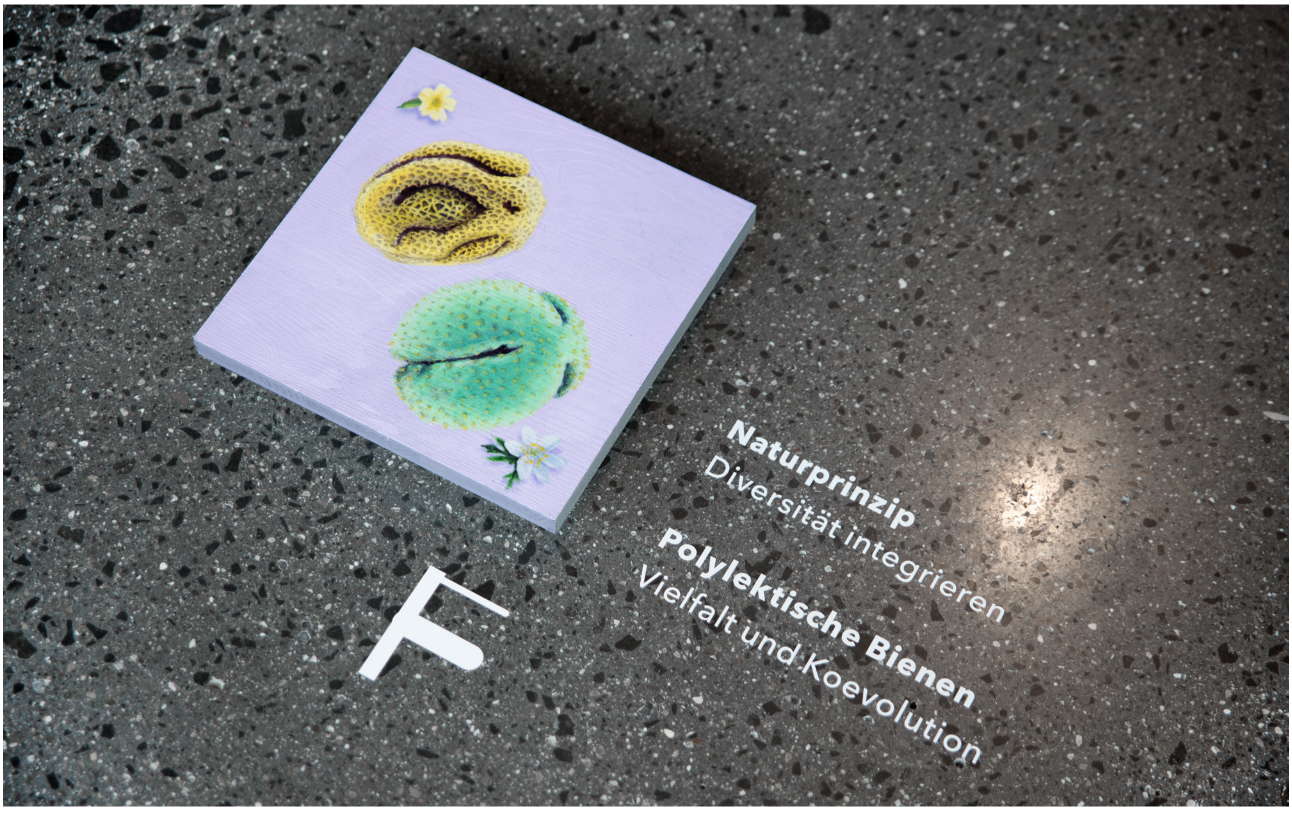
Example in Nature
Tree, e.g. grey alder *(Alnus incana)*
Xylem and phloem

The tree transports the products of photosynthesis (sugar) and substances from the soil dissolved in water through two transportation systems that are separate from each other, xylem and phloem. Xylem ensures that vital substances are transported from the root area into the tree crown. It fills up with water from the ground through capillaries and maintains the water flow by constant condensation in the foliage area. Phloem enables sugar translocation from the leaves to the storage cells in the roots. This is effected by force of gravity. No energy is consumed for the total process of translocation.

Design Guideline
Use water as solvent.

Xylem and phloem in the tree habitat
The conducting cells ensure substance translocation within the organism of the tree and enable growth in voluminous dimensions.





Naturprinzip
Diversität integrieren
Polylektische Bienen
Vielfalt und Koevolution
F


Rund um den Baum von A bis Z
26 Prinzipien der Natur
Der Baum als Lehrmeister


Naturprinzip
Unerwartetes integrieren
Stechimmen (Aculeata)
Werkzeug Stachel
C
Naturprinzip
Alle Materialien wiederverwenden
Ameisenhaufen
U


Naturprinzip
Resilienz erlangen durch Varianz
Redundanz und Dezentralisierung
System Boden (Pedosphäre)
Unzählige Lebewesen
H

EVOLVE TO SURVIVE

Continually incorporate and embody information to ensure enduring performance.

Replicate Strategies that Work
Repeat successful approaches.

Integrate the Unexpected
Incorporate mistakes in ways that can lead to new forms and functions.

Reshuffle Information
Exchange and alter information to create new options.

ADAPT TO CHANGING CONDITIONS

Appropriately respond to dynamic contexts.

Incorporate Diversity
Include multiple forms, processes, or systems to meet a functional need.

Maintain Integrity through Self-Renewal
Persist by constantly adding energy and matter to heal and improve the system.

Embody Resilience through Variation, Redundancy, and Decentralization
Maintain function following disturbance by incorporating a variety of duplicate forms, processes, or systems that are not located exclusively together.

BE LOCALLY ATTUNED AND RESPONSIVE

Fit into and integrate with the surrounding environment.

Leverage Cyclic Processes
Take advantage of phenomena that repeat themselves.

Use Readily Available Materials and Energy
Build with abundant, accessible materials while harnessing freely available energy.

Use Feedback Loops
Engage in cyclic information flows to modify a reaction appropriately.

Cultivate Cooperative Relationships
Find value through win-win interactions.

INTEGRATE DEVELOPMENT WITH GROWTH

Invest optimally in strategies that promote both development and growth.

Self-Organize
Create conditions to allow components to interact in concert to move toward an enriched system.

Build from the Bottom Up
Assemble components one unit at a time.

Combine Modular and Nested Components
Fit multiple units within each other progressively from simple to complex.

BE RESOURCE EFFICIENT (MATERIAL AND ENERGY)

Skillfully and conservatively take advantage of resources and opportunities.

Use Low Energy Processes
Minimize energy consumption by reducing requisite temperatures, pressures, and/or time for reactions.

Use Multi-Functional Design
Meet multiple needs with one elegant solution.

Recycle All Materials
Keep all materials in a closed loop.

Fit Form to Function
Select for shape or pattern based on need.

USE LIFE-FRIENDLY CHEMISTRY

Use chemistry that supports life processes.

Break Down Products into Benign Constituents
Use chemistry in which decomposition results in no harmful by-products.

Build Selectively with a Small Subset of Elements
Assemble relatively few elements in elegant ways.

Do Chemistry in Water
Use water as solvent.

werkraum bregenzerwald

Alphabet of Life – Nature's Learning Lab
Werkraum Bregenzerwald, 23 June – 6 October 2018

Curators
Elisabeth Kopf (Project and Communication Designer), Regina Rowland (Biomimicry Expert)

Curatorial advisory board
Timo Kopf (Zoologist), Claus Schnetzer (Architect), Alfred Ruhdorfer (Building Biologist), Andrea Zraunig (Botanist), Albert Gerlach (Innovation Coach)

Managing Director Werkraum Bregenzerwald
Thomas Geisler

Scientists-at-the-design table
Günther W. Amann-Jennson (Sleep Researcher), Karin Grafl (Environmental Physician), Birgit Gschweidl (Botanist), Theresa Heitzlhofer (Ecologist), Ulli Kammerzell (Tree and Wood Scientist), Johannes Kisser (Chemist), Christian Rammel (Human Ecologist)

Craftspeople-at-the-design table
Members of the Werkraum Bregenzerwald: Jodok Felder (Metalworker), Helmut Fink (Woodworker), Andrea Hager (Bed Constructor), Simon Hofer (Boat Constructor, Carpenter), Daniel Meusburger (Horticulturalist), Stefan Mayer (Stone Carver), Johannes Mohr (Upholsterer), Thomas Mohr (Carpenter), Anna Claudia Strolz (Lamp Maker), Leander Vögel and Peter Willi (Electricians); other craft industries: Martin Rauch and Clemens Quirin (Loam Builders), Anika and Anton Machnik (Pest Controllers)

Exhibition organisation and construction
Pia Ammann, Heike Kaufmann, Samvel Baghumyan, Simon Hofer

Exhibition architecture
Claus Schnetzer, Gregor Pils / SchnetzerPils ZT

Graphic design, typography and illustration
Design Buero Baustelle, Gesine Grotrian, Johannes Lang, Andreas Palfinger

Paintings
Monika Ernst, University of Applied Arts Vienna, Class for Graphic Design

Artistic productions
Dominik Einfalt, Barbara Anna Husar, Joohyun Lee, Suzy Kirsch, Luc Kopf, Günther and Loredana Selichar / Wolfgang Mitterer, Astrid Seme, Masha Sizikova, Katharina Triebe

Photography and video
Balint Bíró, Lucas Breuer, Matthias Dietrich, Sabine Dreher, Daniel Hager, Daniel Kozma, Barnabás Tóth-Justh

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