«ABOUT FOLDED AND CRUMPLED MODELS IN NATURE»

By VINCENT FLODERER & CRIMP

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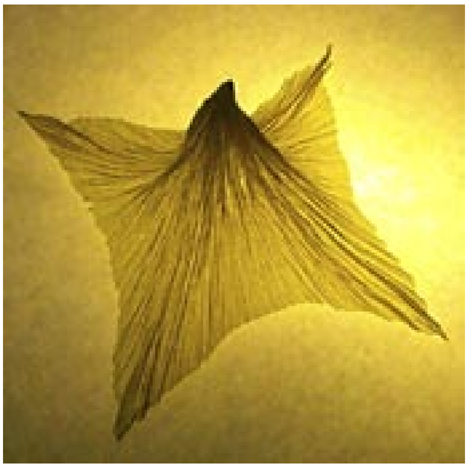
.Following abstract is a resume of the last ten years researches with the crimp team based on paper crumpling techniques, inspired by observation in Nature, where folds, creases and associated dynamic processes are to bee seen at many -sometimes unexpected-places.

Contents have been presented in :
- Bauhaus (Dessau- Germany-2004)
- International Symmetry Festival (Budapest -Ungary -2006)
- Architecture University (Venice-Italy- 2006)
- Rosupak exhibition (Moscow-Russia-2007)

1. BASIC RADIAL PATTERN



Starting from the centre, repeatedly crumple and open a piece of thin paper, such as a paper napkin, then turn it inside out several times.... and you'll get a 3D conical shape.

The radial crease pattern obtained is related to the so-called «explosion model», to be seen almost everywhere in nature. This work was inspired by Paul Jackson's ideas on crumpling techniques.
Bibl.: Peter S. STEVENS «Patterns in Nature».

PAPER MUSHROOM MODELS

watch video instructions for basic mushroom model here: >

Created in 1997, the basic model can be folded/crumpled with all types of thin papers (brown wrapping paper from 25 to 40 gsm; tissue paper; paper napkins....) The first models were inspired by the study of the shapes of different mushrooms. Since then some elements of their architecture, a possible evolution process (Phylogeny*) for certain families and sometimes their consitency could be reconstructed.

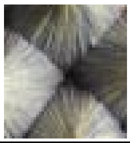
**Phylogeny (or phylogenesis) is the origin and evolution of a set of organisms, usually a set of species.Bibl: Georges Becker in «Champignons»-Gründ*

«Philogeny of pezizales.»by Vincent Floderer - 1998
This study verifies partly through folding the phylogeny of this family of mushrooms.
Washi, nepal and chinese papers, wrapping paper. inks and watercolours
Photo: Jean-Marie Nozerand - Artist's collection

«Tremella Foliacea.» by Vincent Floderer - 1998
This model reproduces the gelatineous consistency of these mushrooms
Washi Paper
Photo: Jean-Marie Nozerand - collection: France

2. MULTI-PLYED RADIAL SIMPLE PATTERNS

see multi-plying method here: >



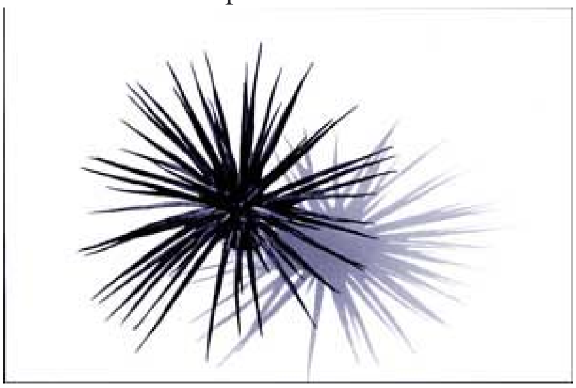
Multiply can mean to fold many times in many languages.
(French: multiplier, German: vervielfältigen, etym: Latin: multiplicare...)

2A. REGULAR PATTERNS

A rectangle is first folded in half, crumpled from the centre, then unfolded. In this way, two points are created. When folded into quarters, four points are obtained. The same process continues when the rectangle is repeatedly folded in half to get 16 or 32 sections... and so on, with an equivalent number of points being formed. Multi-cap Mushrooms have been first folded this way.

Other geometric basic forms can be «copied» this way: squares, equilateral triangles, hexagons... these patterns are related to so-called tessellations, in which a small number of shapes are repeated over and over to fill a plane. In theory, the pattern can be repeated forever. Up to 256 points in a square can be folded with this basic method.
Acceptable models of flowers, buds, sponges, sea urchins, sea anemones, and corals have been developed.

«Multi-plyed square pattern» - 2001- by Vincent Floderer
16 sections out of a square prefolded in sixteenth
Tissue paper :20gr/m² - Paper size:50 X 50cm -Photo: Jean Marie Nozerand



«Big blue» - 2001- 64-pointed see-urchin by Vincent Floderer
Tengu-jo paper :6gr/m² - Paper size: 200 X 200cm - Model size : +_20cm
Photo: Romain Chevrier - Collection :USA

«Red Star» - 2001-36 tentacles sea anemona by Vincent Floderer
tissue paper :20gr/m² - Paper size: 160X160cm - Model size : +_15cm
Photo: Romain Chevrier - Collection :USA

2B. CENTERED PATTERNS

The same patterns can be folded in the middle of a sheet The surface at the edges will form a «trunk». This method allows better control on models with large numbers of points, and prevents the edge points being damaged during the crumpling process.

«White coral» - 2001- folded by Anne-Cécile Planck
100 sections out of a square centered in the middle of the sheet
Tengu-jo paper :6gr/m² - Paper size:100 X 100cm - Model size: +_10cm
Photo: Suzann Dugan - Collection :Austria

3. MIXED PATTERNS

Patterns mixing different geometric shapes are also possible. For example, after being crumpled and unfolded, the classical origami bird base shows a pattern with squares and octagons. Closing the model, an orchid-like flower appears.

Crumpling a multi-layer tetrahedron gives a pattern with hexagons and equilateral triangles and creates a pollen-like 3-D structure.

«Pollen» by Vincent Floderer- 2001 - Crumpled multi-layer tetrahedron tissue paper - Photo: Jean-Marie Nozerand

4. PROGRESSIVE PATTERNS

Others patterns with regular polygons - triangles, squares, hexagons, and the like - can be produced showing the same motif repeated over and over on bigger and bigger scales.
Classical and complex origami sequences have been tested by the Crimp team over many years. Models made out of a «sunken waterbomb base» give square and trapezium patterns that make branched corals.

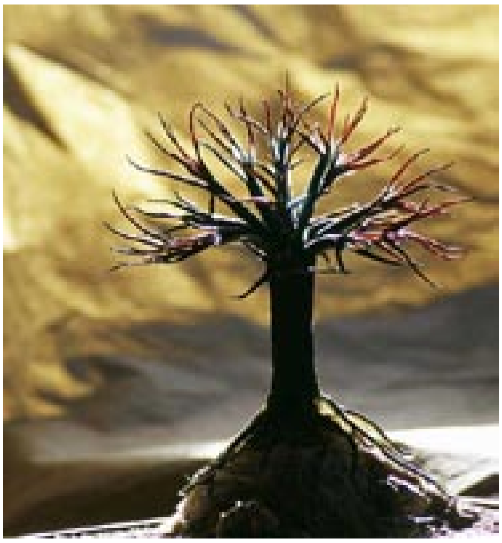
«89-pointed base»
by:Vincent Floderer 2007
This base shows :
5 groups of 9 points
4 groups of 5 points
4 groups of 3 points
8 points on edges
4 intersections

Bolloré paper 12gr/m², Paper size: 80x80cm
Photo: Alain Hymon

«Big Blue Splash»
folded by:Patricia Gueyrad & Vincent Floderer- 2004

This model is made out of 16 groups of 5 points, folded out of the center of the sheet

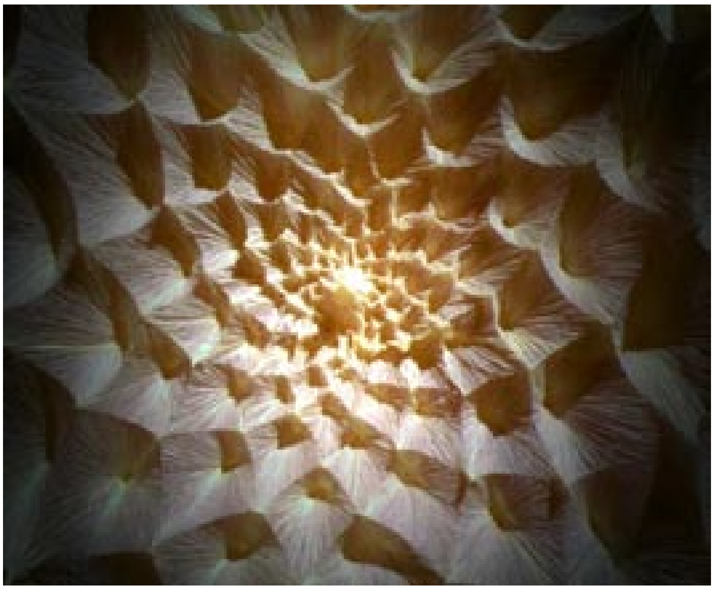
tengu jo paper 6gr/m², watercolour
Paper size: 180x180cm
Model size: 25cm +_
Photo: Romain Chevrier



Kite crease patterns organized in logarithmic spirals were obtained by folding a classical rabbit ear sequence, repeated ad infinitum. *(*Ernst Blaüenstein)*
These curves approach the «zero» center of origin but never reach it. This mathematical model, well known as «Fibonacci series», describes the properties of the Golden Section. Nature shows many examples of this organization model in sea-shells, arrangement of leaves on plants or seeds on flowers (sunflowers and other composed flowers..), pine cones, Romanesco cabbage, horns of different animals, galaxies...

**Bibl.: . 1rst german edition «Endlose Hasenohr»by Ernst Bläuenstein in:«der Falter» N°9 -August 1992-«Oreille de lapin sans fin» Ernst Bläuenstein in«le PLI» N°52 -Autumn 1992*

pre - crumpling method by Sebastian Kirsch.
http://sites.inka.de/moebius/origami/

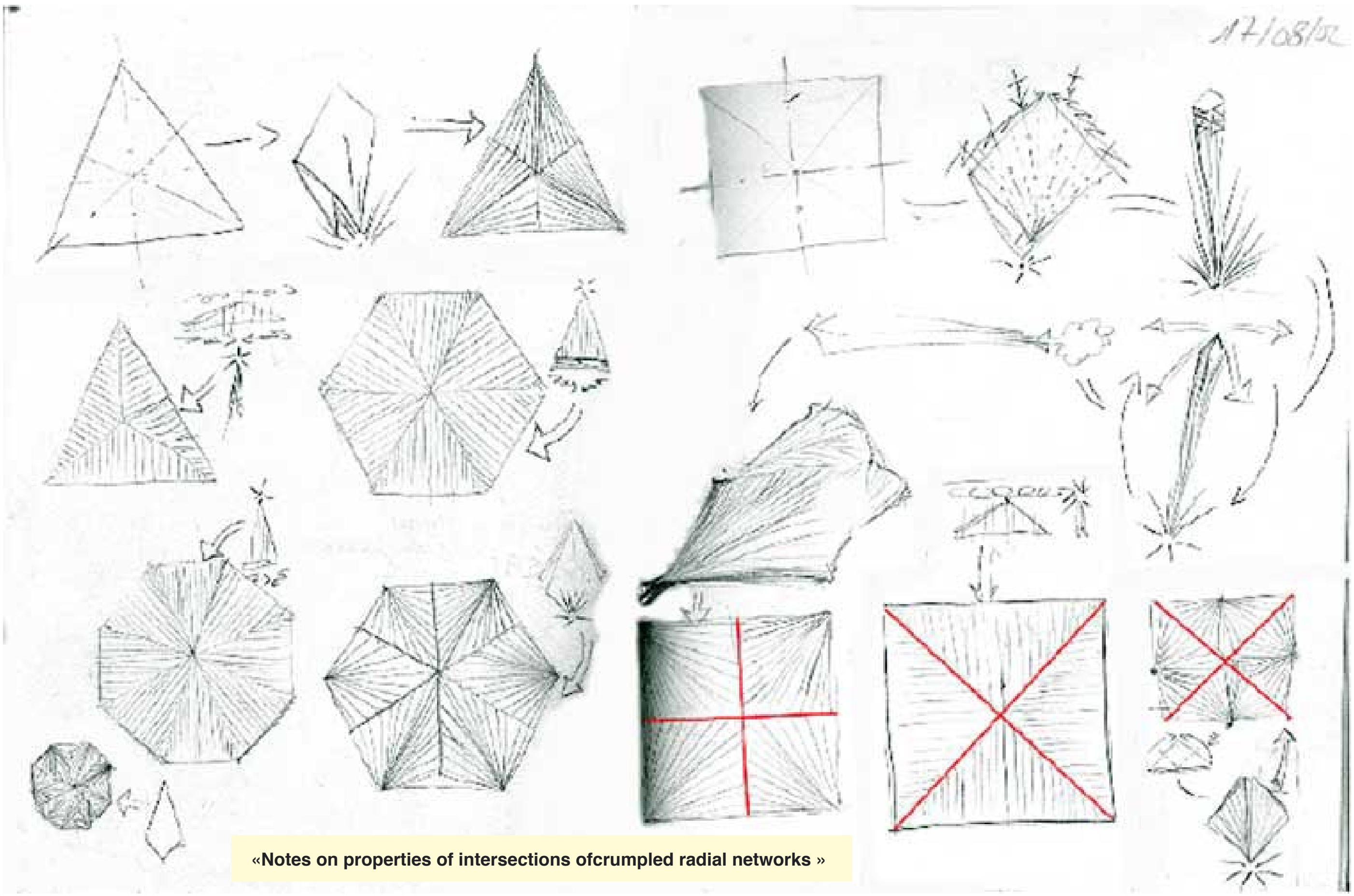


«Endless rabbit ears»
by Sebastian Kirsch & Vincent Floderer-2000
tengu-jo paper10gr/m² Papersize: 90 X90cm - Model size : variable
Photo: jean marie Nozerand - Collection :France

5. INFLATABLE MODELS

5A. PROPERTIES OF INTERSECTIONS

Considering multiplied radial patterns at their intersection, you can see an inflatable structure.This particularity was used to create so-called Unidentified Flying Origami or U.F.Origami.
A simple intersection of 4 sections (on a square) or 3 sections (on a triangle) can be folded using a squashed preliminary or waterbomb base.



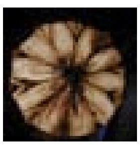
«Notes on properties of intersections ofcrumpled radial networks »

5B. EFFICIENT LOCKS

Folding sequences allowing the closure of these «balloons» are developed from classical origami processes, and spontaneously create leaves, spines and other natural details. Other results are seed pods and other natural structures. (Convergent evolution means that unrelated organisms independently acquire similar characteristics, while evolving in separate and sometimes varying ecosystems)
One of these closures -a specially modified petal fold- can «seal» two edges of paper together at almost any angle. This fold can also be used to create modular or one sheet polyhedra models. It can be repeated elsewhere on the sheet to create sculpted surfaces.
(see models by Alain Giacomini)

«Blowing an U-F-0»
at the SEOF 2002 in Charlotte-NC
one of the first models this type
crumpled from a blintzed bird base
brown wrapping paper:40gr/m²
Paper size:140X140 cm

watch vidéo «UFORIGAMI»



6. TWIST AND SPIRALLING PHENOMENA

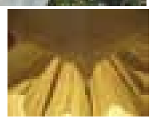
Many things in nature grow in the same way, spiralling out from the centre in larger and larger layers, for example a seashell, an artichoke, a sunflower. The crumpling technique has shown surprising self-twisting processes. One unexpected result is that pre-twisted models actually don't twist and some of the regular radial models do!

Some models, based on twist-fold constructions, partly or completely loose their twisting properties if crumpled. The crumpling process will change the one diagonal system into a radial network. (e.g. DNA molecule by Thoki Yenn; Spring into Action by Jeff Beynon...)

Conversely, an eighty-square pattern on a long rectangle did twist automatically to show a realistic pine cone structure. This phenomenon seems to be related to large numbers of sections or layers. Inflatable structures built on the traditional frog base seem to find their best organization when twisted. They get bigger, spiralling out when inflated.

7. MULTIPLYING METHODS AND PROPERTIES

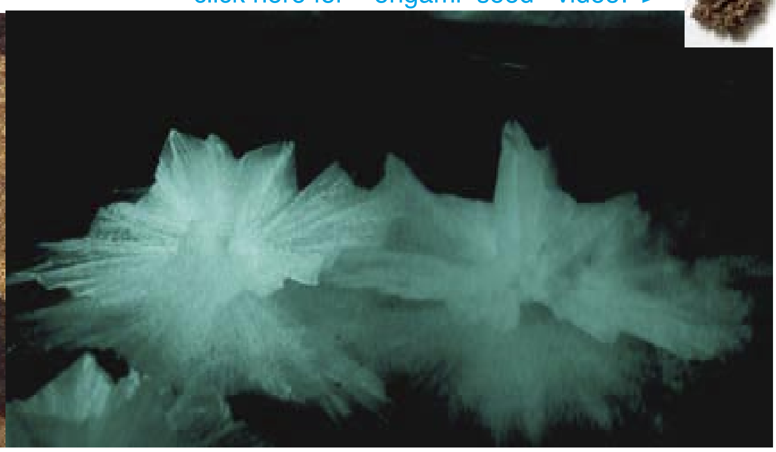
watch video on properties here : >



Different methods of multiplying, using classical origami sequences, can be used, and they lead to the same result. The choice of the method depends on the complexity of the model, on its size, and on the quality of the paper.

- •Models are elastic, extensible and reversible.
- •Most patterns can be changed in a variety of sometimes unexpected models.
- •Non-symmetrical models can appear after lengthy crumpling on symmetrical patterns (breaking symmetry phenomenon).
- • A reversible self-attaching phenomenom of layers is efficient
- •All crumpled models can be squashed strongly under water. Each model changes then into a particular shape of «seed», determined by its geometrical make-up. These «seeds» have the strange property to open out in water and stay several weeks without opening completely.

click here for « origami seed» video: >



8. CONTROLLED RANDOM PATTERNS

«Random» treebase
study for «Victoire!»
collection:France
hand made thai paper:10gr/m²
Paper size:60X50cm-Model size : +_15cm

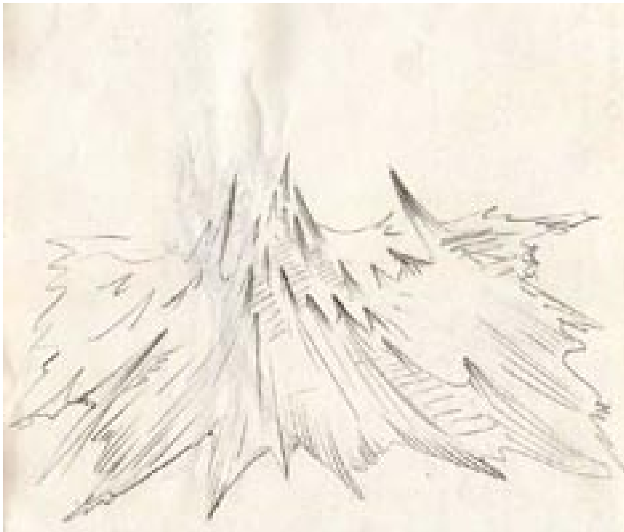
Paul Jackson wrote about this technique which he originated:
«A sheet of paper full to bursting with as many creases as it could hold. Actually, the sheet must be crumpled in a precise and controlled way, but when done well has extraordinary elastic properties.»

Numerous points stretched from the centre and edges of the crumpled paper will first create a landscape-like structure, with realistic mountains and valleys. After being strongly squashed under water, points are separated and re-crumpled wet to create branches and roots.

Tree models are the most difficult to fold. Different «bases» have been tested to produce different tree geometries.

«Salem tree» by V. Floderer
Tengu-jo paper :10gr/m²
Paper size: 200X200 cm-Model size : +_35cm
Photo: Angéline Lassaga
Collection :USA

A type pattern could be described as a «3D boxpleat structure».
The newest tree models developed by Fritz Junior Jacquet are actually first boxpleated.



«Landscape» tree base & note
by :V. Floderer
brown wraping paper :25gr/m²
Photo: Jean marie Nozerand

«3 trees»
by Vincent Floderer
brown wraping paper :25gr/m²
Base : traditionnal coootie catcher
brown wraping paper :25gr/m²
Paper size: 65 X50cm
Model size : +_15cm
Photo: Romain Chevrier
Collection :USA

9. TUBULAR CRUMPLING

Originated by Romain Chevrier, this very elementary technique produces extremely strong models, and enters the world of shells. A close-up look at the models reveals a waterbomb base pattern.
Other interesting mechanical properties belong to this technique, which is not much explored yet.
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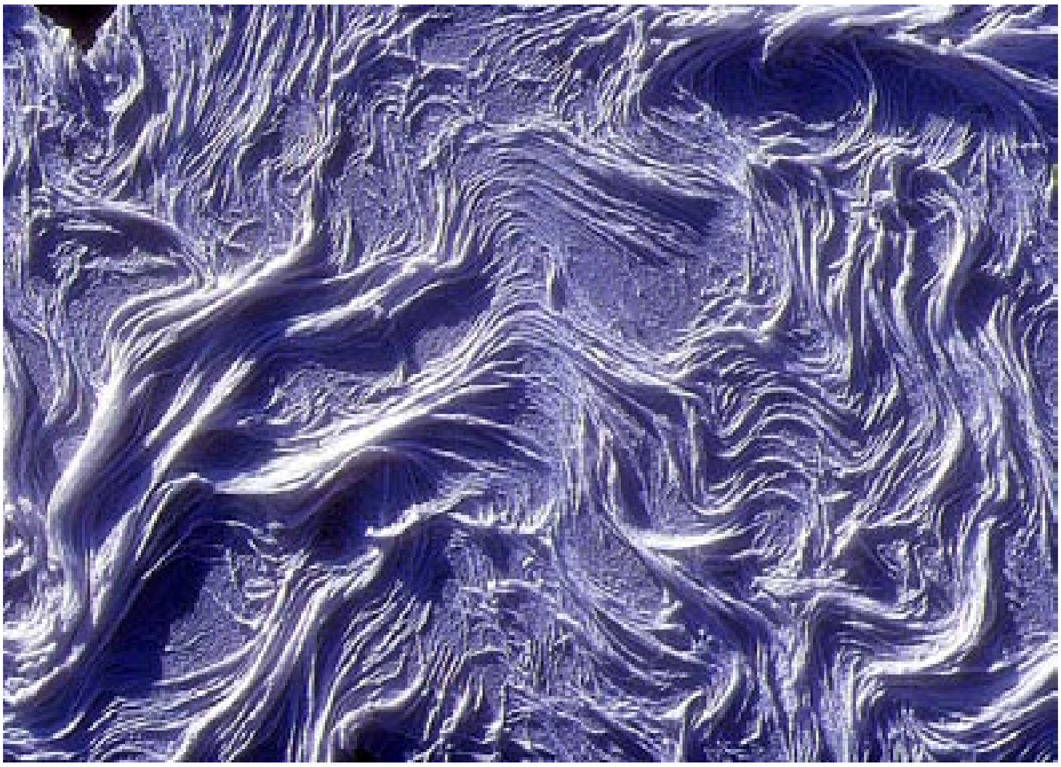
«Tubular models»
by Romain Chevrier -Paper: kraft alios 25gr/m² - Papersize :strips-
Photos: Lee chang- Alain hymon- Collection:Crimp

10. MEMBRANES -Folding-unfolding processes

10a WET PAPER

Certain natural objects - like leaves, wing-membranes of insects, cellular tissues, or brain structures- show nerves, reliefs, and superimposed layers on their surface. These characteristics give the objects their shape and properties. Really, they are concentrations of organized folds.
A sheet of paper is set flat or crumpled on a glass surface, smooth movements are applied on it to create complex networks, that can be changed at will. The networks are able to conduct fluids, just like veins.



«Dans l'éther» by Vincent Floderer- paper tengu-jo 6gr/m² -
Papersize: 90 X45cm - Model : +_A3 - Photo: Jean-Marie Nozerand - Collection :France

10b ALGAE

watch video «unfolding algae» here : >

This variety of algae grows in still waters. It produces a strange paper-like fabric, made of very long and thin fibers, that can have zero to n layers.
When spread out wet on a glass surface, folding and unfolding movements can be applied to it. This naturally generates organically-organized and complicated fluid interconnected networks. They reveal vein patterns and biological tissues, and they can be put in motion and stretched or modified as much as one likes. The shapes of other more evolved algae also appear spontaneously.

«Green algae» Photo:Jean pierre Bonnebouche

«Paysalg» unfolded by Vincent Floderer - 2004 - artist collection - Photo: Alain Hymon

11.

PERSPECTIVES

After 10 years of exploring the crumpling technique, only a small part of the possibilities have been tested. Many patterns that have been already worked out can probably lead to other models. Many origami sequences have not been worked on at all.
Complex master models like Hermann van Goubergen's Seashell or Jeff Beynon's "spring into action" , are

«Seashell»
created by :Hermann van Goubergen-
folded by : Manuel Madaleno 2007
«elefant skin» paper :130gr/m²
Paper size: 70X70 cm
-Model size : +_20cm
Photo: Alain Hymon - Collection :Crimp

«Spring into action»
created by : Jeff Beynon
folded by:Romain Chevrier 2004
«Popset paper» paper :90gr/m²
Paper size: 70X70 cm
Model size : +_20cm
Photo: Jean pierre Bonnebouche
Collection :Crimp

explored by Manuel Madaleno(see models by Manuel Madaleno) and techniques such as boxpleating, accordeon folding, or knife pleat sequences are now being tested by members of the Crimp .They all seem to lead to astonishing new models.
The growing complexity of the folding sequences leads the Crimp team to develop a particular notation system, a kind of «genetic code», described in abstract short formulas, allowing a precise reproduction of the folding method.
D'Arcy Thompson's book, On Growth and Form (1910) explores the degree to which differences in the forms of related animals could be described by means of relatively simple mathematical transformations. He pointed out example after example of correlations between biological forms and mechanical phenomena.
To my mind, this book, in which Science and Art meet, is one good example for a possible evolution of future origami. ◊