

# THE ART & SCIENCE OF FOLDING

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MA, Univ Coll London

[www.origami-artist.com](http://www.origami-artist.com)



# What is Folding?

Folding is ubiquitous, an essential part of nature and manufacturing.

A world without folding is beyond our imagining.

# What is Folding?

Folding is ubiquitous, an essential part of nature and manufacturing.

A world without folding is beyond our imagining.

*“The mystery of folding is one of the universe's deep secrets.”*

-- Chris Anderson, Curator, TED Conference

# Examples of 'Folding' Words

*From 'pli, 'plicare' and 'plex' (Latin)  
and 'plectos' (Greek)*

Diploma

Plywood

Explain

Pliers

Genuflect

Complex

Application

Multiply

Perplex

Flax

Complicate

Compliment

Simplify

Deflect

Replica

...and 400 others!

# Examples of 'Folding' Expressions

*'The idea **folded**'*

*'The story **unfolded**'*

*'They returned to the **fold**'*

*'She **folded** the eggs into the mixture'*

# Examples of 'Folding' Words

So, 'folding' is not just a word which describes 'paper folding' or 'origami'.

It is a complicated word which describes ideas, emotions, situations and objects.

## Folding is ...

... folding, creasing, bending, flexing,  
twisting, pleating, scoring, curling,  
crumpling, oscillating, wrapping,  
gathering, knotting, collapsing, wrinkling,  
faceting, corrugating, draping, hingeing ...

and

unfolding, uncreasing, unbending ...



**Folding is ...**

**Folding is ...**

**...neither additive nor  
subtractive.**

**It is transformative.**



Additive



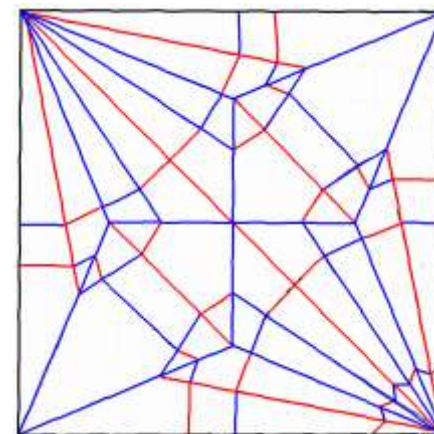
Subtractive



Additive



Subtractive



Transformative

There are three types of folding:

There are three types of folding:

1. One-dimensional

There are three types of folding:

1. One-dimensional
2. Two-dimensional

**There are three types of folding:**

1. One-dimensional
2. Two-dimensional
3. Three-dimensional



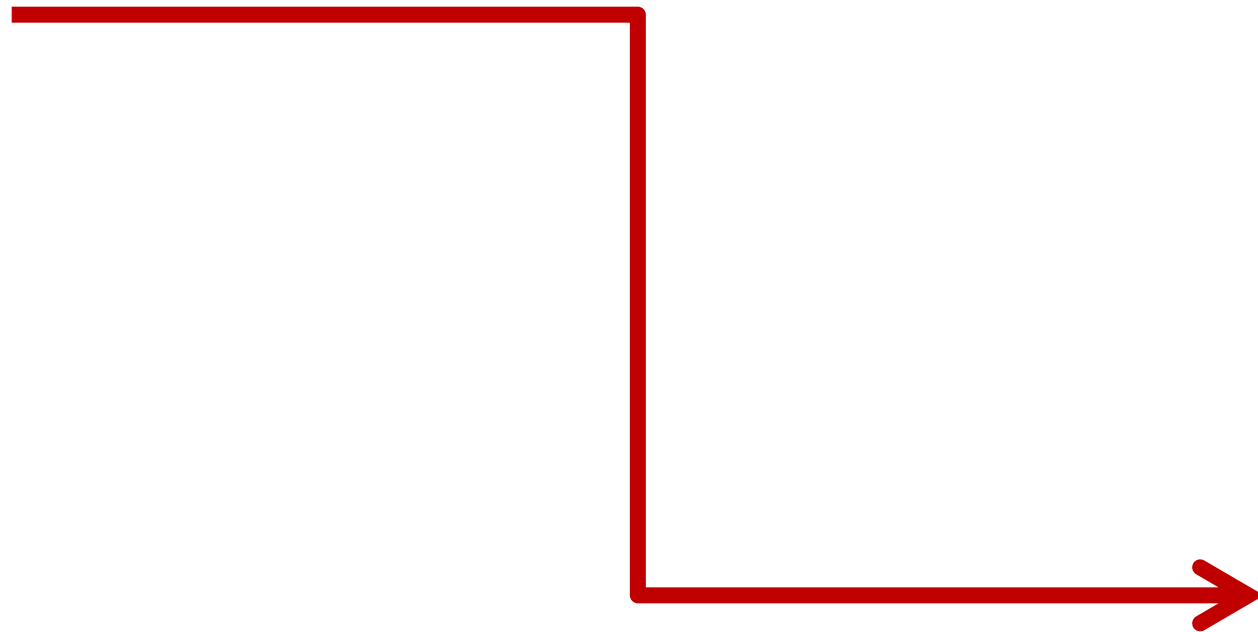
1.  
One-dimensional

1.

One-dimensional

-- the folding of lines

1.  
One-dimensional  
-- the folding of lines



the folding of lines

**In Nature**

**a**

Short region of  
DNA double helix



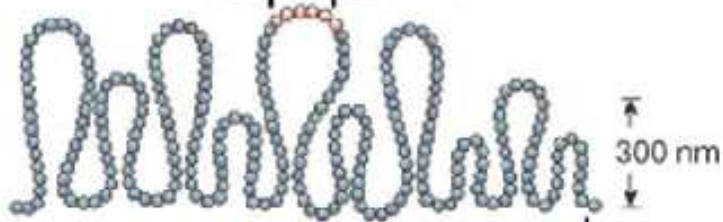
"Beads on a string"  
form of chromatin



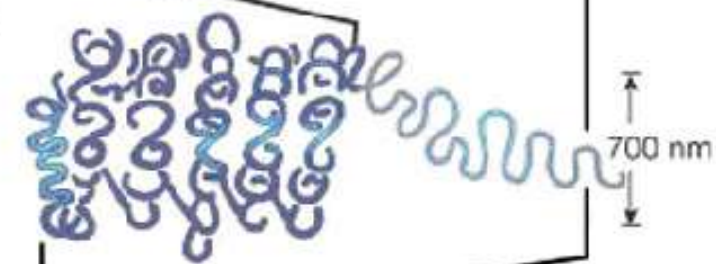
30-nm chromatin  
fibre of packed  
nucleosomes



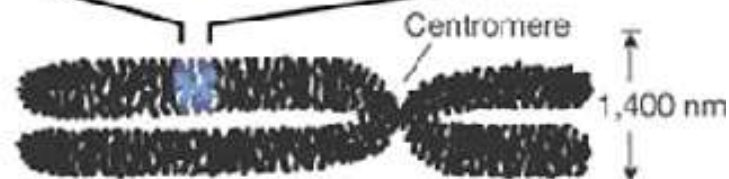
Section of  
chromosome in an  
extended form



Condensed section  
of chromosome



Entire mitotic  
chromosome



A



B



C



D



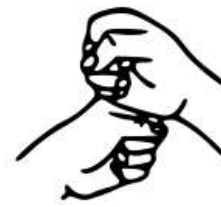
E



F



G



H



I



J



K



L



M



N



O



P



Q



R



S



T



U



V



W



X



Y



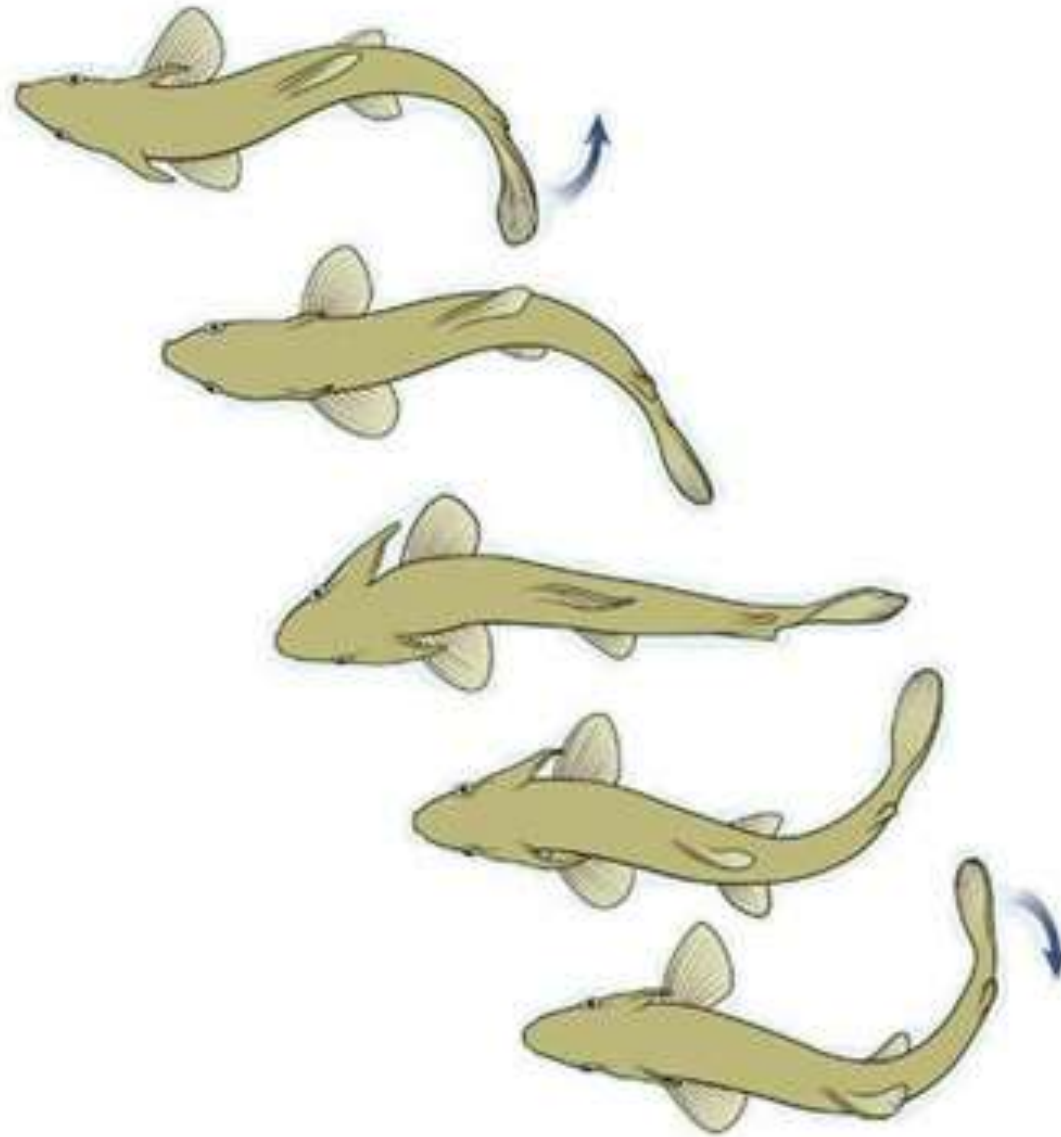
Z













**In Every-day Use**



# FORTY KNOTS

## A VISUAL AID FOR KNOT TYING

OFFICIAL EQUIPMENT—BOY SCOUTS OF AMERICA

The Scout Seal is Your Guarantee of Quality, Excellence and Performance



OVERHAND KNOT



SAILOR'S KNOT



SQUARE KNOT



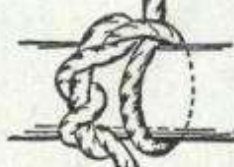
LARK'S HEAD



FIGURE EIGHT KNOT



STEVEDORE'S KNOT



KILICK HITCH



SHEET BEND



SHEET BEND DOUBLE



TIMBER HITCH



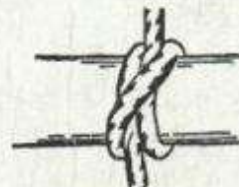
LARIAT LOOP



OVERHAND BOW



CAT'S PAW



CLOVE HITCH



BLACKWALL HITCH



GRANNY KNOT



FISHERMAN'S KNOT



DOUBLE CARRICK BEND







Robbie -- Music Stand for Bands









## 2. Two-dimensional

2.

Two-dimensional

-- the folding of planes

2.

Two-dimensional

-- the folding of planes



**In Nature**





Leaf-rolling Weevil  
(*Apoderus coryli*)





















## **In Every-day Use**

**1.**

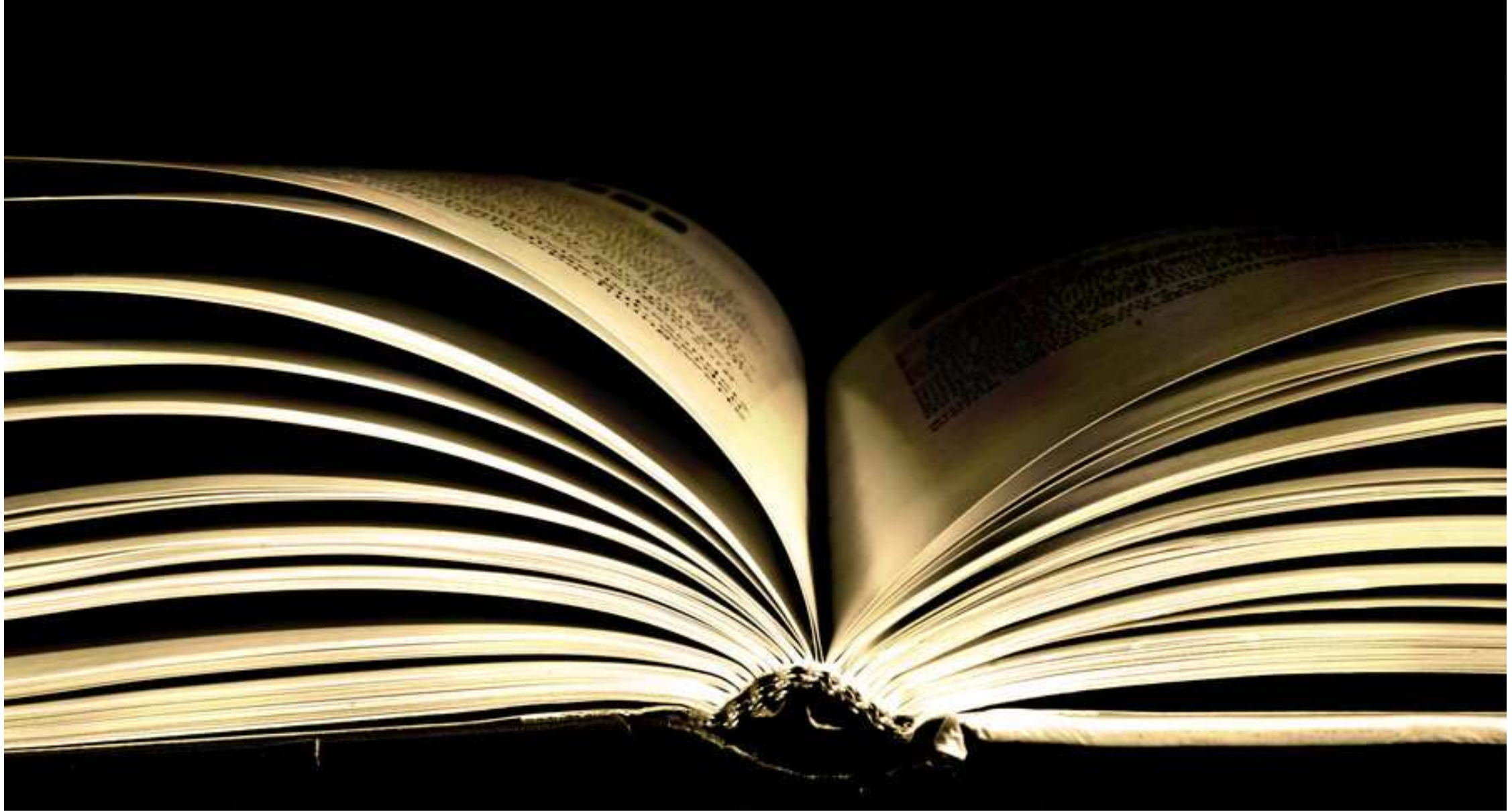
**Dynamic Folding**





[sheeshamwood.com](http://sheeshamwood.com)









**In Every-day Use**

**2.**

**Passive Folding**

















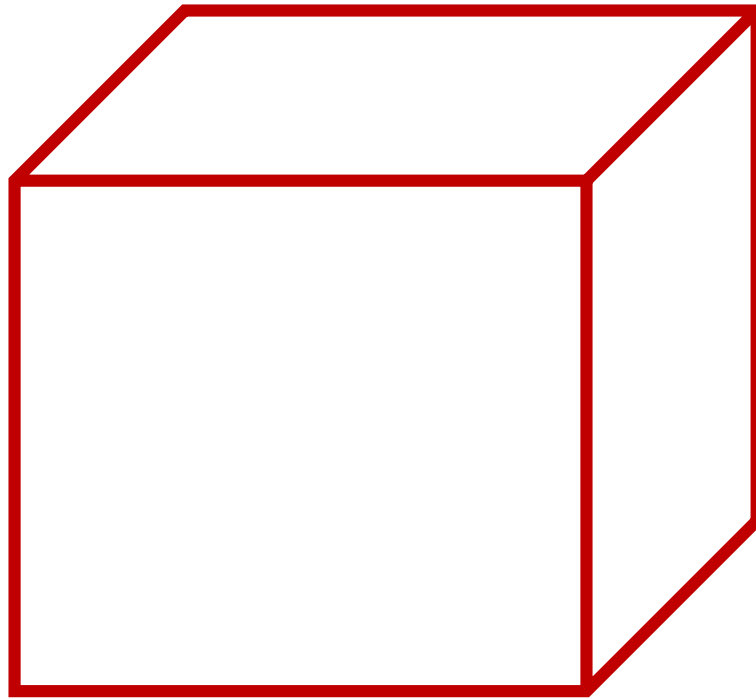
### 3. Three-dimensional

3.

Three-dimensional

-- the folding of volumes

3.  
Three-dimensional  
-- the folding of volumes



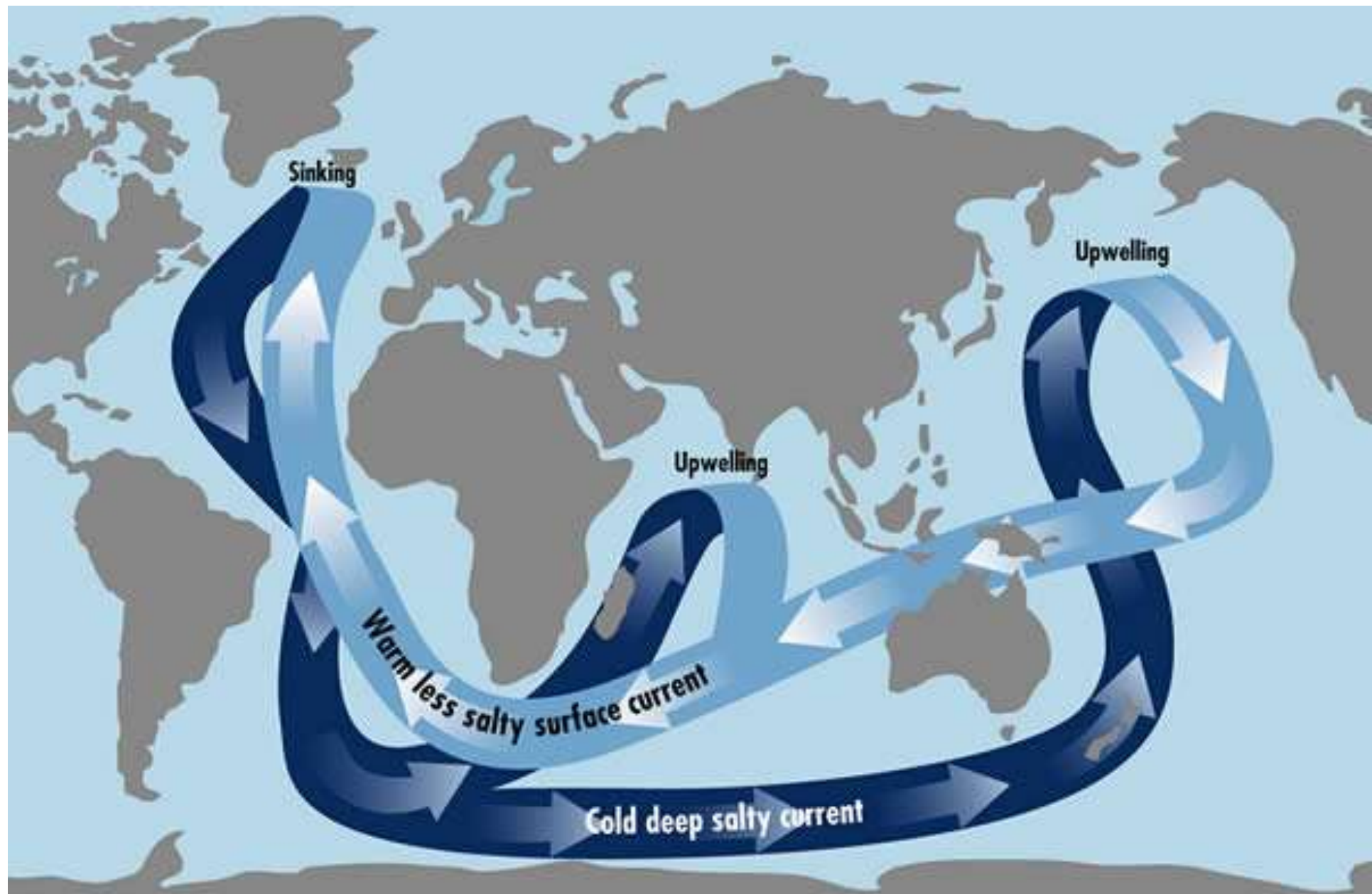
**In Nature**









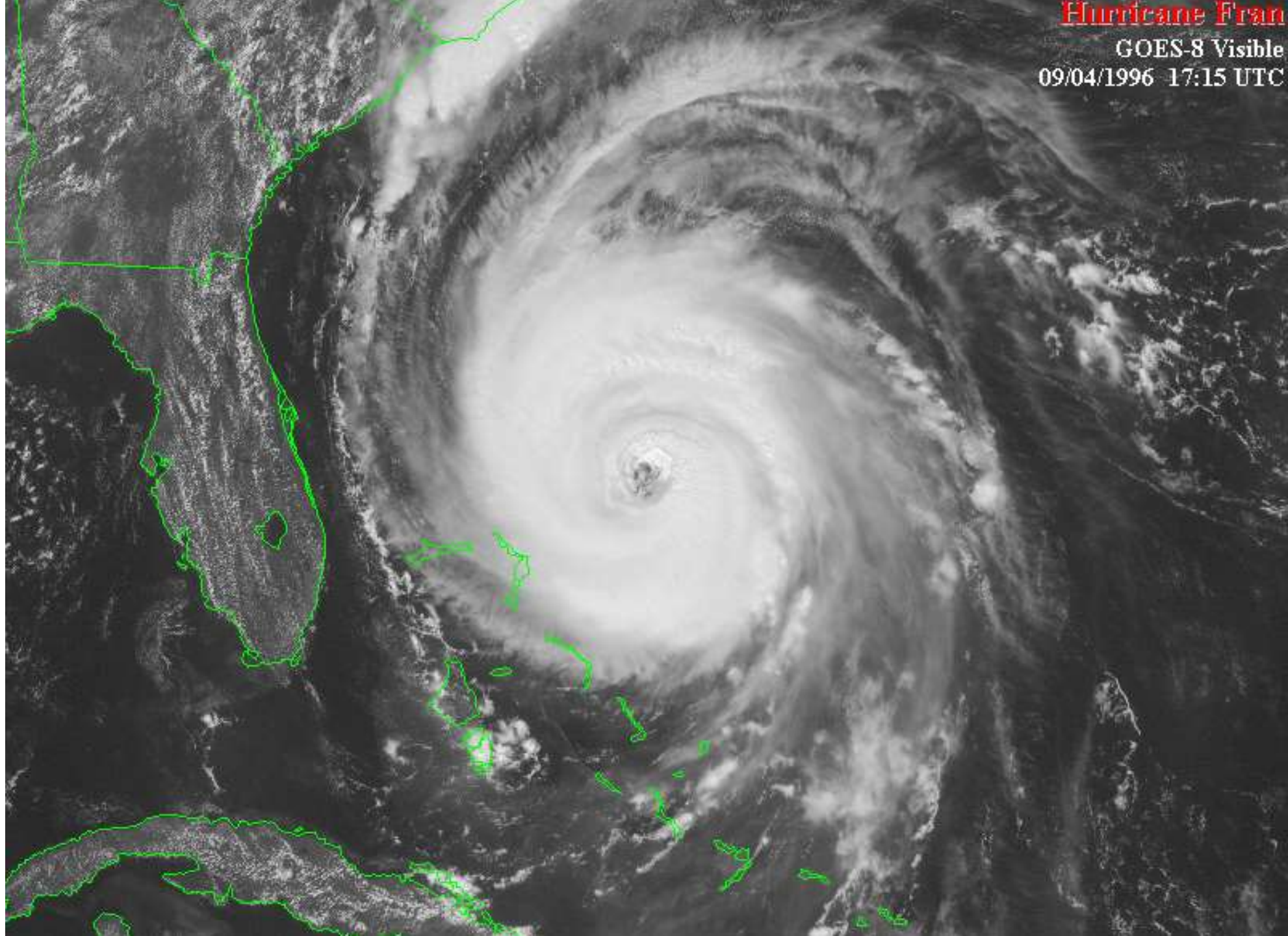


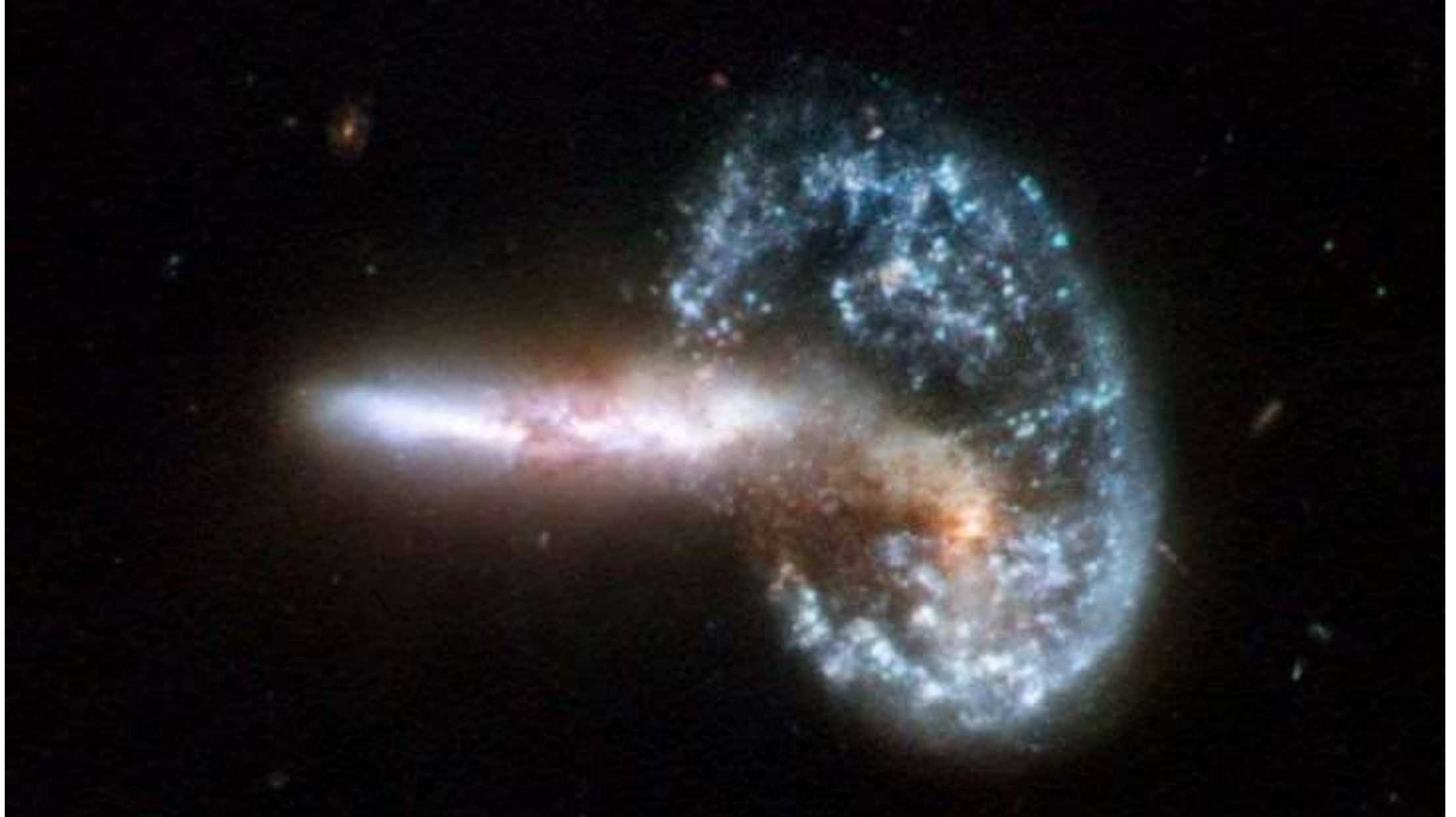


**Hurricane Fran**

GOES-8 Visible

09/04/1996 17:15 UTC





HUBBLE TELESCOPE

**In Every-day Use**









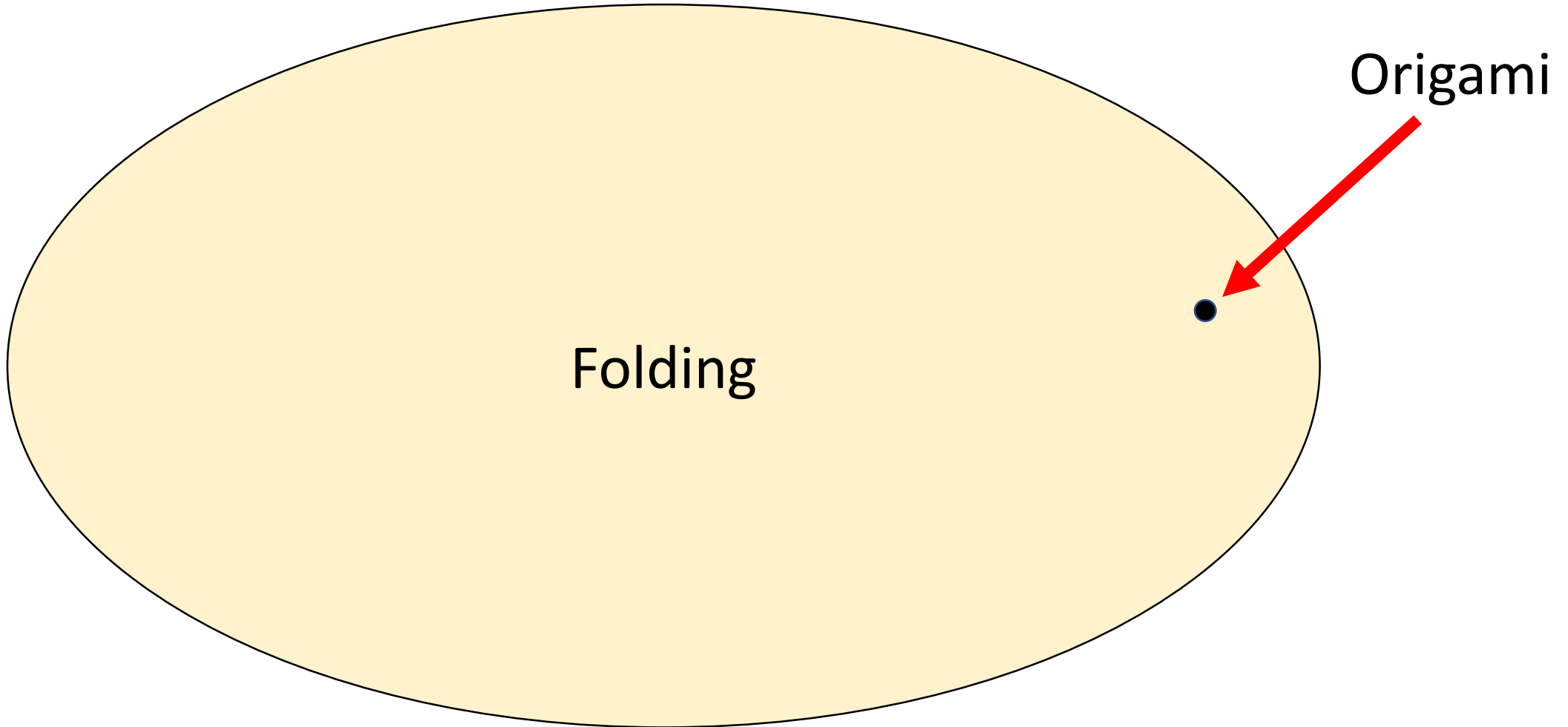


lydburynorth.com'

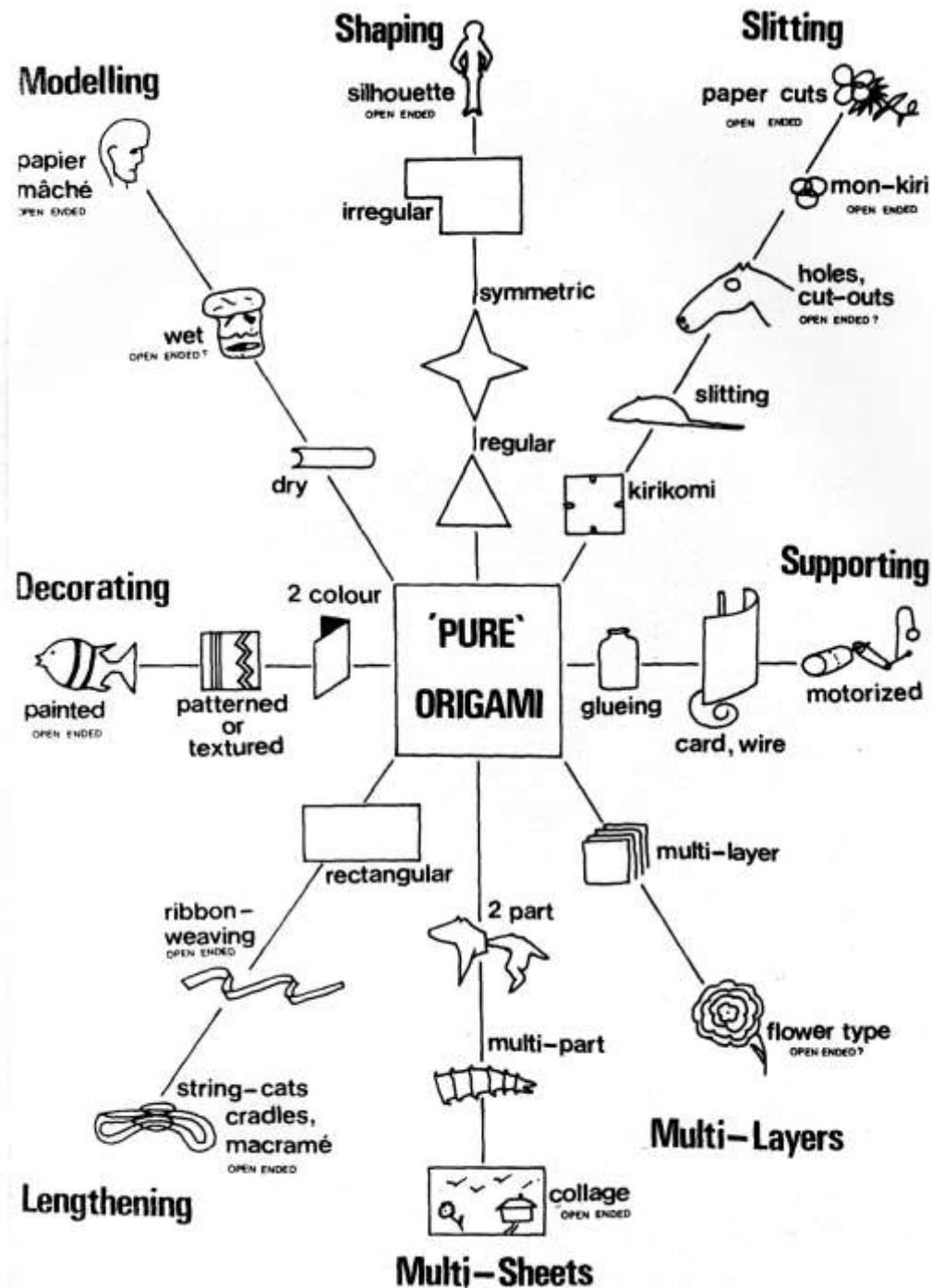
# What is Origami?



# What is Origami?



# What is Origami?



John S Smith  
 'Origami Profiles'  
 British Origami Society Magazine  
 June 1976

# What is Origami?

*“Origami is to folding,  
as music is to sound.”*

-- PJ

# Is Origami Art?



**Is Origami Art?**

**...or Craft?**

**Is Origami Art?**

**...or Craft?**

**...or Model Making?**

**Is Origami Art?**

**...or Craft?**

**...or Model Making?**

**...or Puzzle Solving?**

**Is Origami Art?**

**...or Craft?**

**...or Model Making?**

**...or Puzzle Solving?**

**...or What?**



*'Instrumentalists'* Robert J Lang

<http://www.langorigami.com/art/gallery/gallery.php4?name=instrumentalists>





*'The Pianist (after Robert J Lang)'* by Matt Johnson, 2005  
Blue tarp paper, stainless steel  
147 x 340 x 198cm



“Matt Johnson’s sculptures delightfully explore the paradox of visual forms through unorthodox and surprising materials. *The Pianist (After Robert J. Lang)* pays tribute to the American physicist and master origami artist who has astounded with his mathematically complex objects crafted from creased paper. Rendered life-sized, Johnson’s giant origami masterpiece is made from one 50 foot piece of tarp folded into the shape of a concert piano and player, humorously honouring genius with floppy monumentality. Johnson’s choice of blue wrapping is a clever reference to Yves Klein – whose signature International Klein Blue (also a scientific marvel) is synonymous with sublimation and glamour – theatrically elevating his wonky musician to iconic design status.”

[http://www.saatchi-gallery.co.uk/artists/matt\\_johnson.htm?section\\_name=abstract\\_america\\_painting\\_sculpture](http://www.saatchi-gallery.co.uk/artists/matt_johnson.htm?section_name=abstract_america_painting_sculpture)



Lang v Johnson







Lang v Johnson

Who is the primary artist?





Lang v Johnson

Who is the primary artist?

What constitutes the art?





Lang v Johnson



Who is the primary artist?

What constitutes the art?

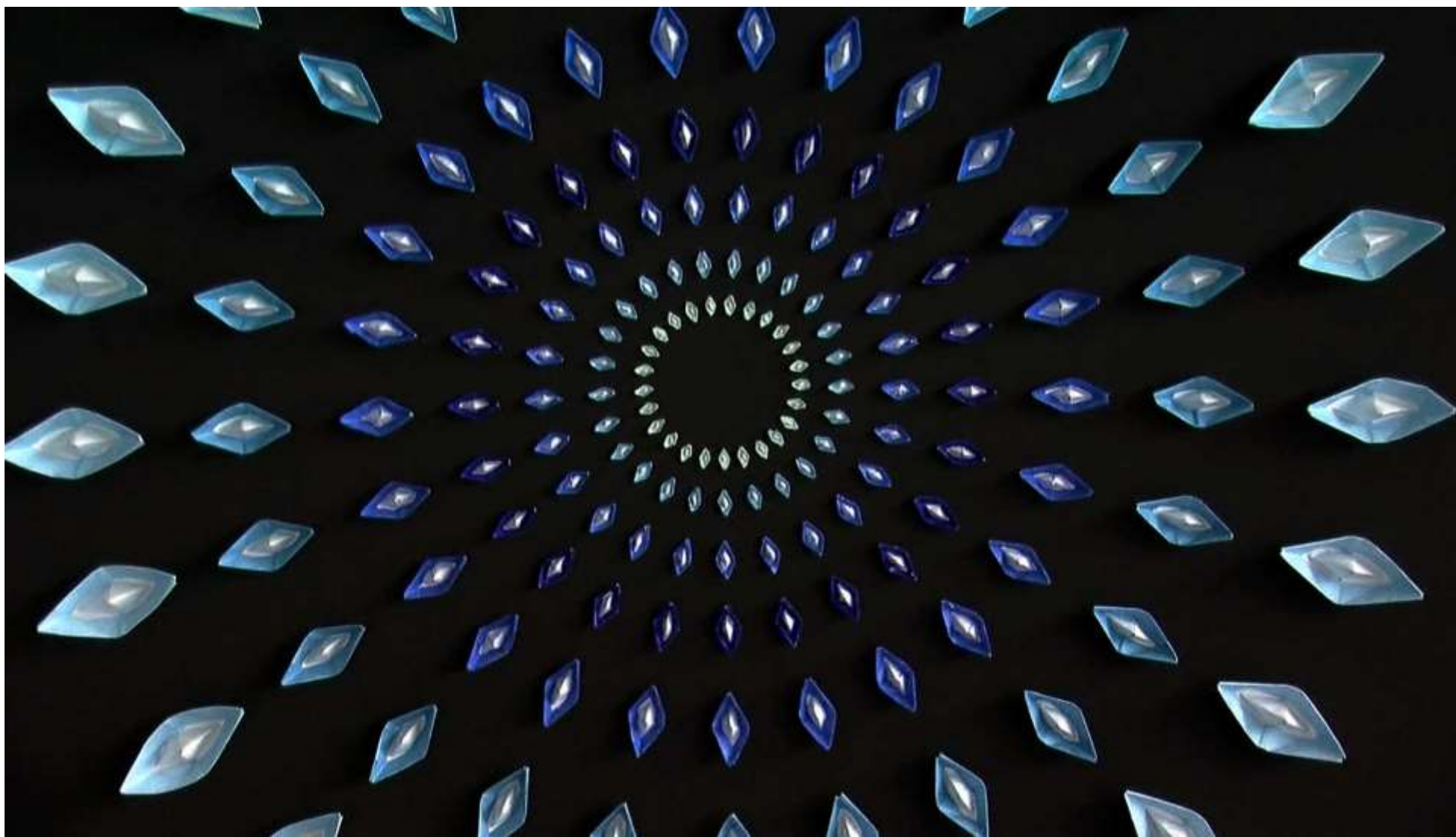
How do the pieces differ in context?

## Other Examples









*Microships* Peter Koppen





Unknown installation, UK.





*'Vent'*  
Heatherwick  
Studios, 2006  
Stainless steel.  
Central London





# Origami as Art

(in my opinion)



Jean-Claude Correia



Vincent Floderer



Richard Sweeney

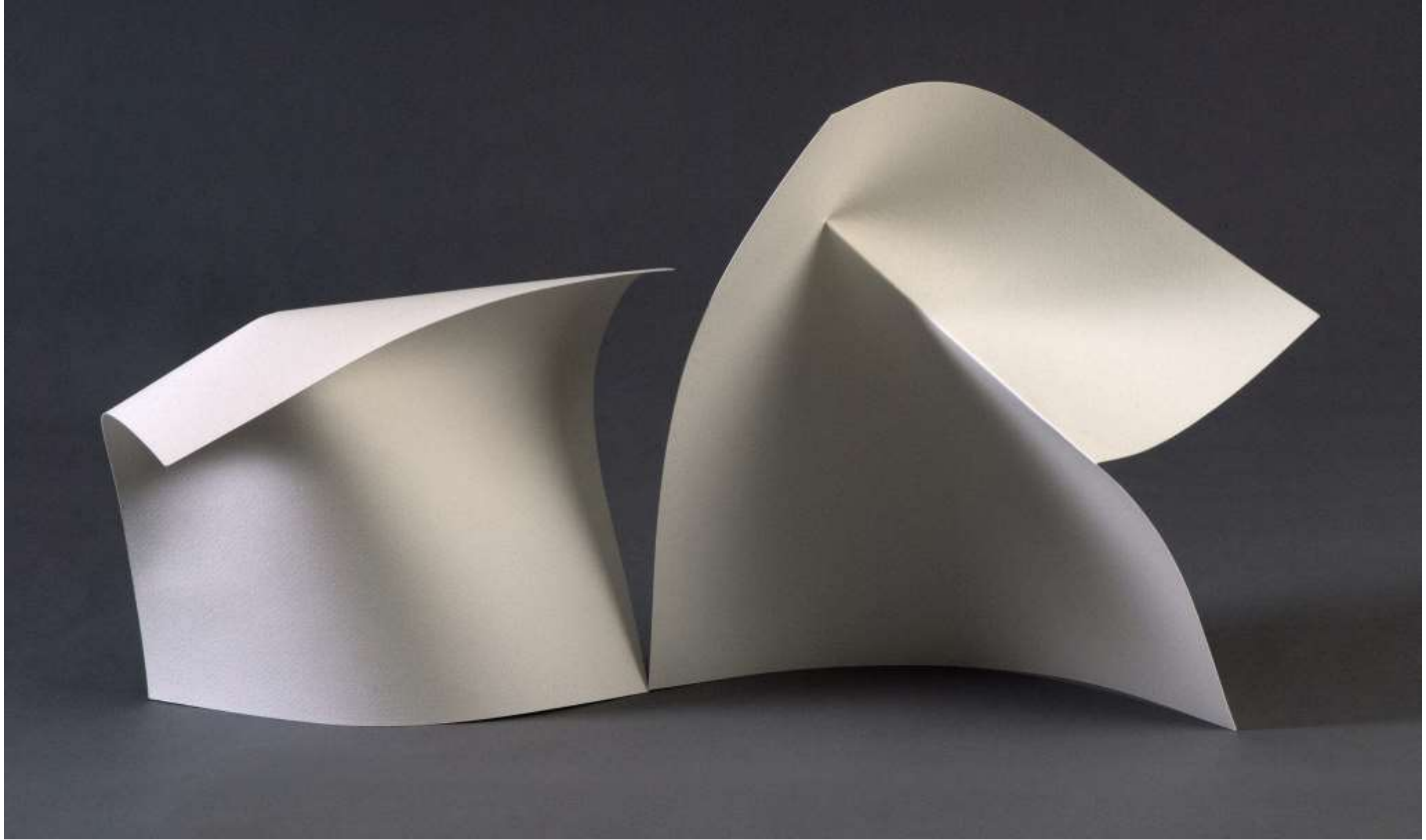




Erik & Marty Demaine



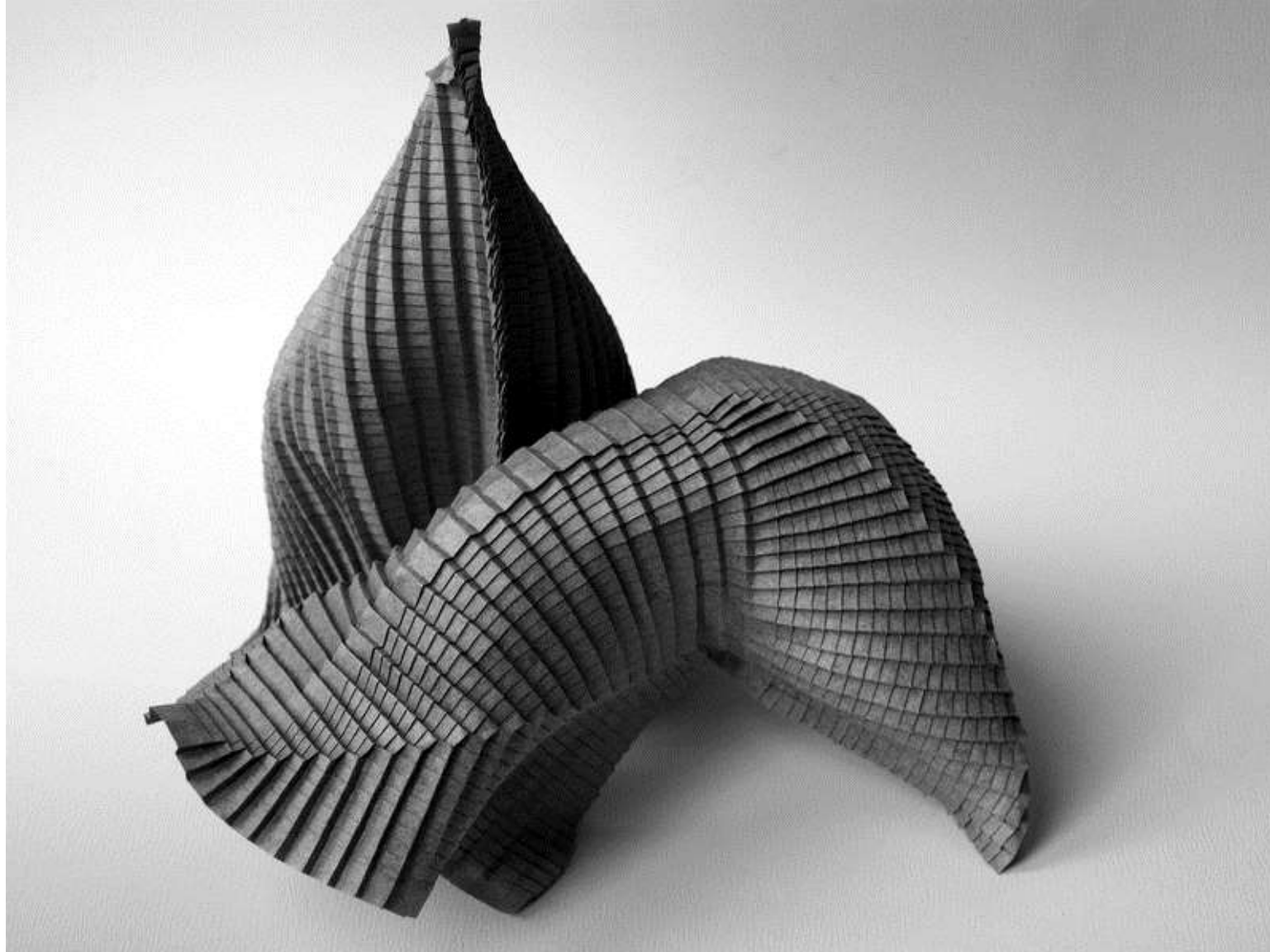
Victor Coeurjoly



Paul Jackson



Sipho Mabona



Goran Konjevod

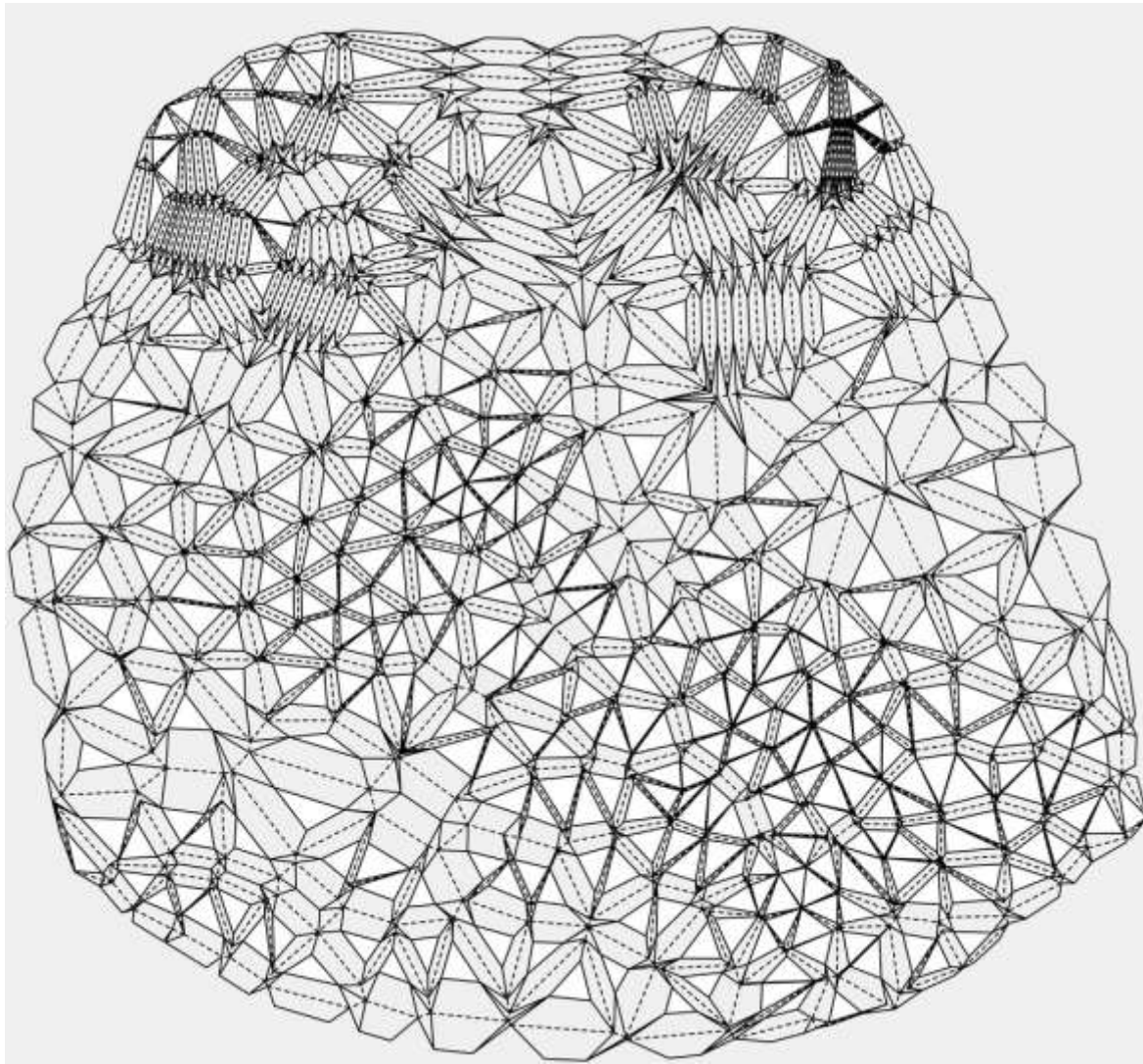




Miri Golan

# Origami that's not Art

(in my opinion)

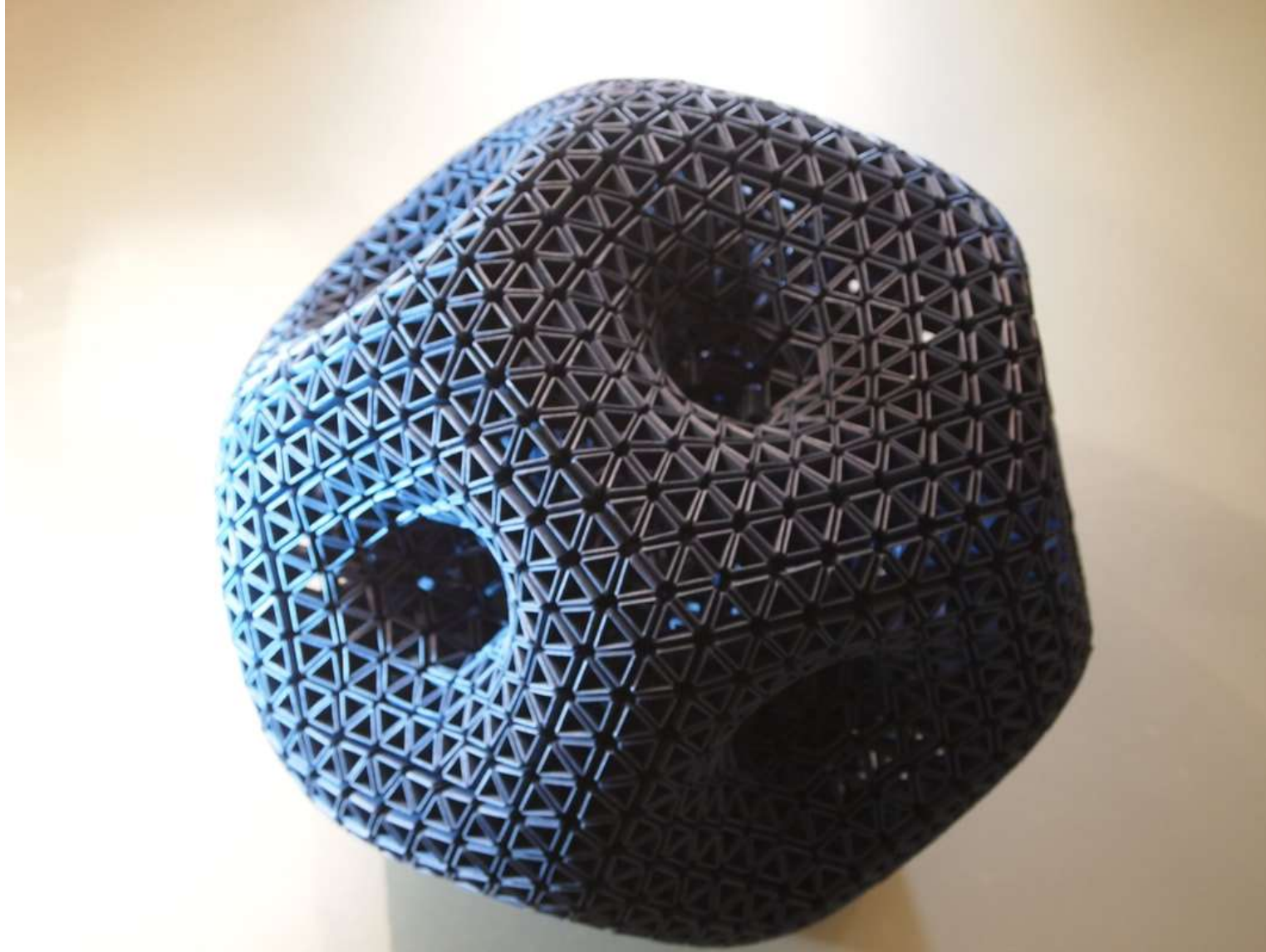


Tomohiro Tachi





Brian Chan

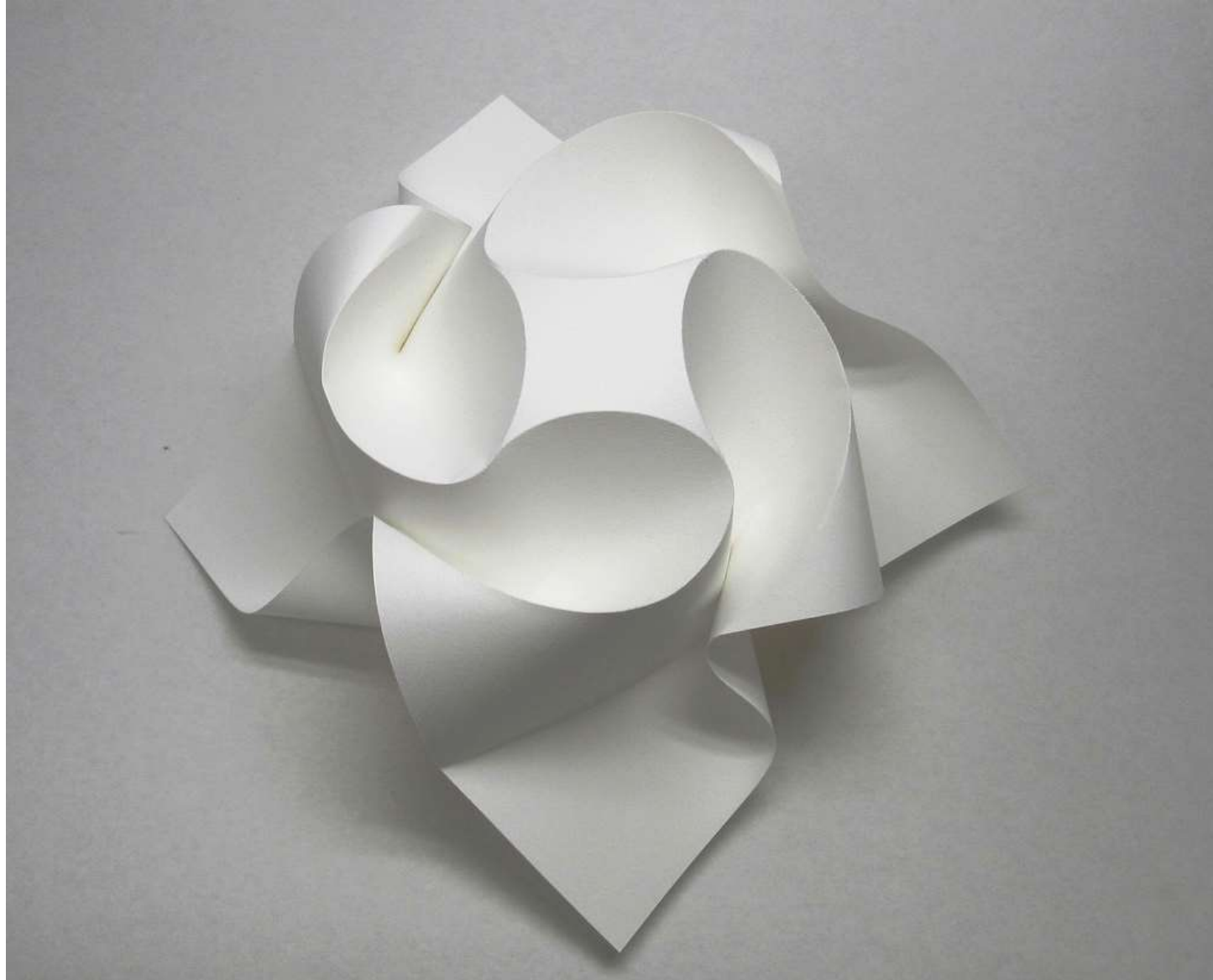


David Patrick ('Snapology' concept by Heinz Strobl)





Satoshi Kamiya



Jun Mitani

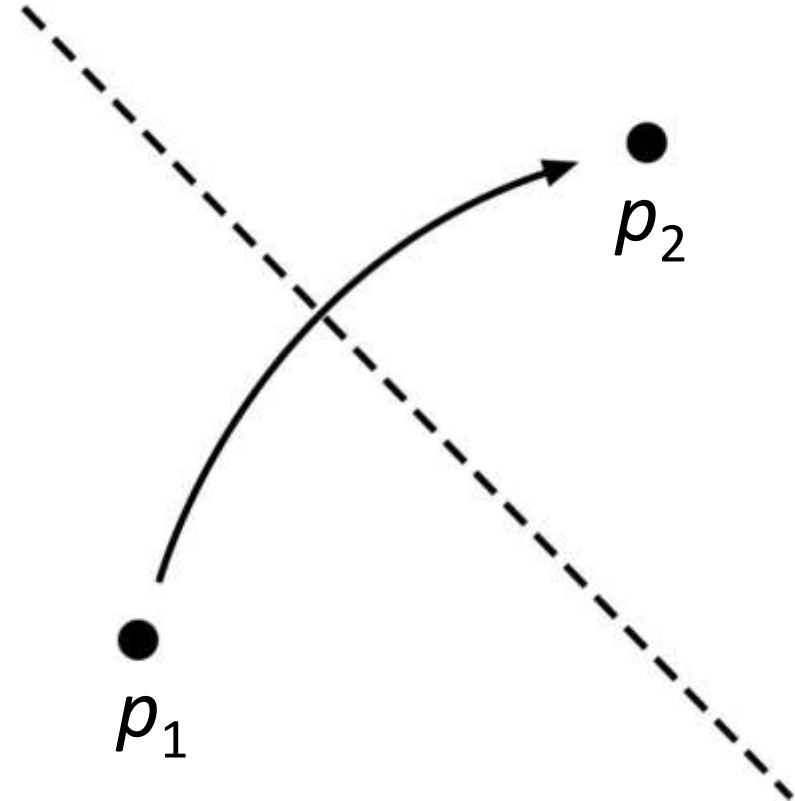
# Math and Origami

It is often remarked that because the position of each fold can be plotted, origami is an intrinsically mathematical artform.

“Given two points  $p_1$  and  $p_2$ , there is a unique fold that places  $p_1$  onto  $p_2$ ” (this fold is the perpendicular bisector of  $p_1 p_2$ ).

*Justin-Huzita-Hatori Axioms: No 2\**

*\*sometimes called the ‘Huzita-Hatori Axioms’, ‘Huzita-Justin Axioms’ or ‘Justin-Huzita Axioms’*



There are 7 Justin-Huzita-Hatori Axioms

they are ...



**Axiom 1**

Given two points  $p_1$  and  $p_2$ , there is a unique fold that passes through both of them.

**Axiom 2**

Given two points  $p_1$  and  $p_2$ , there is a unique fold that places  $p_1$  onto  $p_2$ .

**Axiom 3**

Given two lines  $l_1$  and  $l_2$ , there is a fold that places  $l_1$  onto  $l_2$ .

**Axiom 4**

Given a point  $p_1$  and a line  $l_1$ , there is a unique fold perpendicular to  $l_1$  that passes through point  $p_1$ .

**Axiom 5**

Given two points  $p_1$  and  $p_2$  and a line  $l_1$ , there is a fold that places  $p_1$  onto  $l_1$  and passes through  $p_2$ .

**Axiom 6**

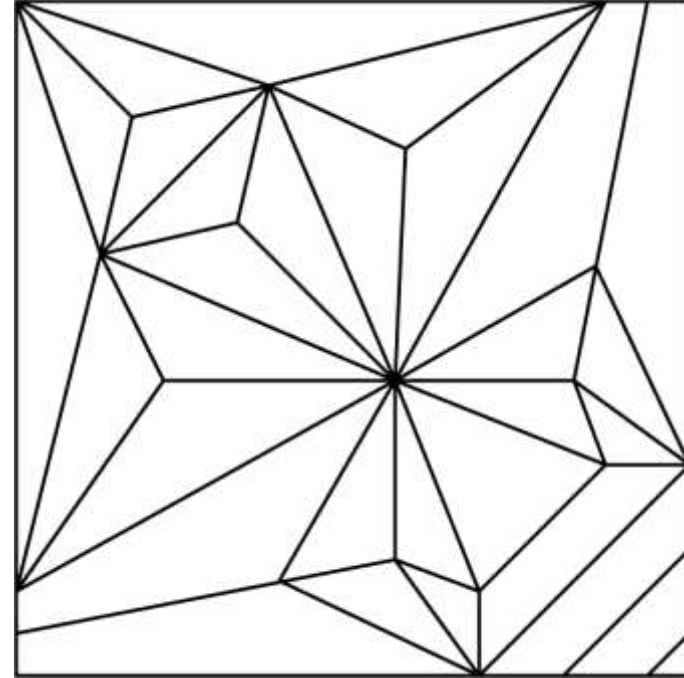
Given two points  $p_1$  and  $p_2$  and two lines  $l_1$  and  $l_2$ , there is a fold that places  $p_1$  onto  $l_1$  and  $p_2$  onto  $l_2$ .

**Axiom 7**

Given one point  $p$  and two lines  $l_1$  and  $l_2$ , there is a fold that places  $p$  onto  $l_1$  and is perpendicular to  $l_2$ .

The seven Axioms define what is possible to construct by making sequential single creases formed by aligning combinations of points and lines.

Together, the 7 Axioms form the mathematical basis of origami.



Pegasus: Guspath Go

The Axioms are considered more powerful than the traditional methods of geometric construction, which use an unmarked straight edge and a pair of compasses.

For example, the 7 Axioms can ...



1.

Solve all quadratic, cubic, and quartic equations with rational coefficients.

2.

Trisect an arbitrary angle (also discovered by Hirashi Abe).

3.

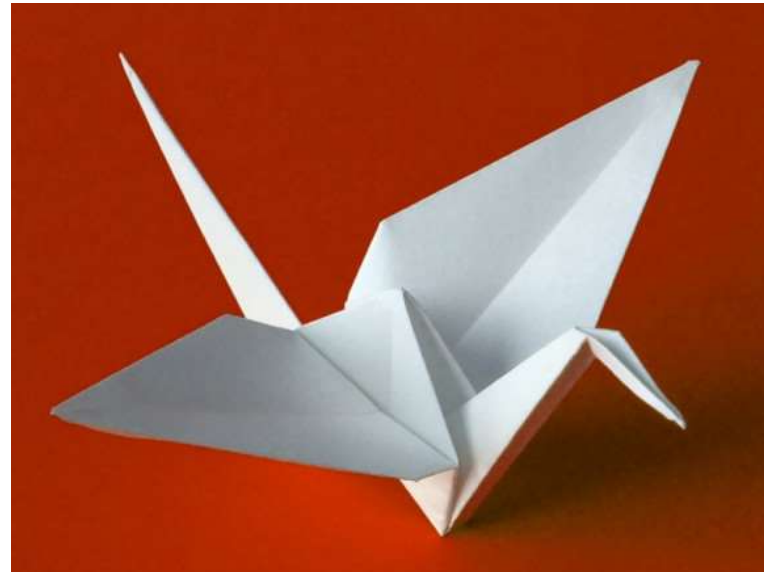
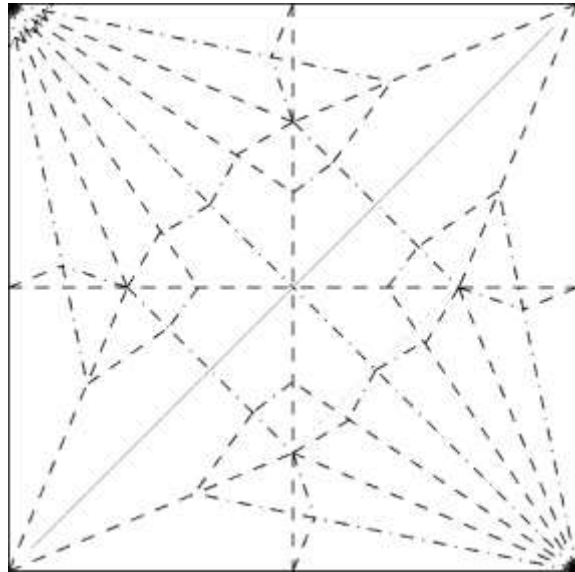
Construct cube roots, including the famous problem of "doubling the cube".

4.

Construct a regular  $N$ -gon for  $N$  of the form  $2^i 3^j (2^k 3^l + 1)$  when the last term in parentheses is a prime (a so-called Pierpont Prime).

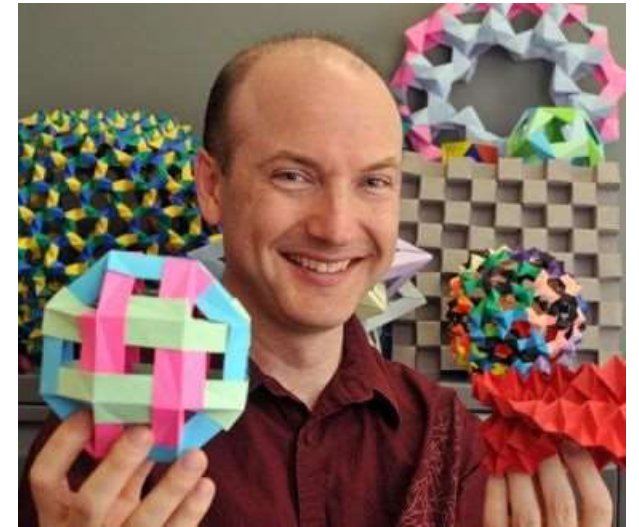
*'If music is math made audible,  
origami is math made visible'.*

-- PJ





*“It’s just amazing how pervasive origami is throughout all of math, whether it’s number theory, calculus, algebra, geometry, combinatorics, topology, even really hard things like differential geometry. It’s enough to make me religious about math and origami!”*



© The Republican: Mass USA.

**Prof Tom Hull**, Western New England University, Mass, USA  
Quoted from a British Origami Society video, November 2012.  
<http://youtu.be/aJ7OUaQEbOk>

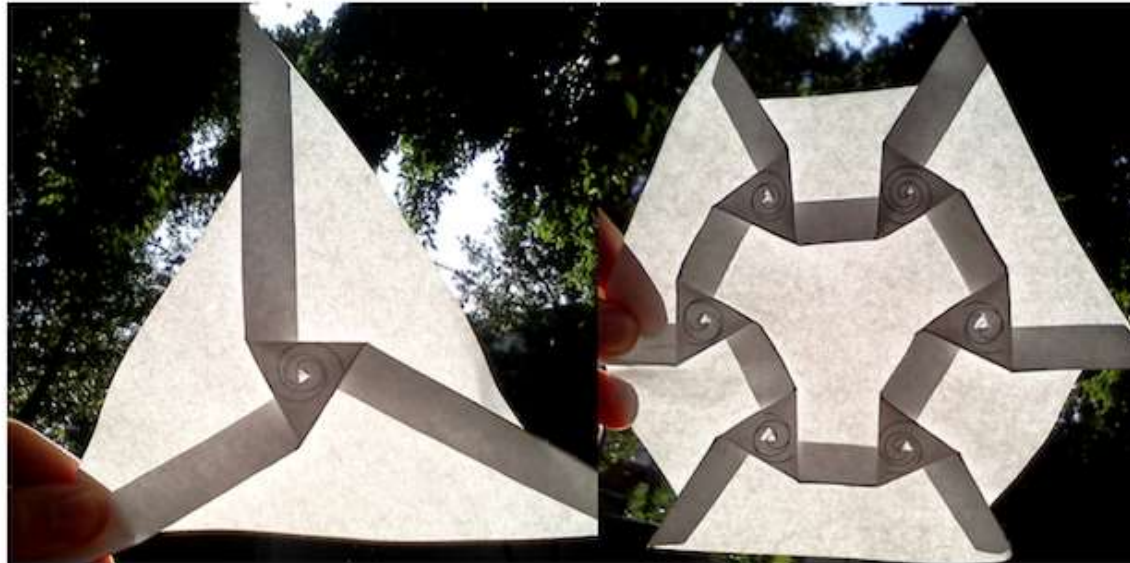
# Origami and Science



## ASTRONOMY

In October, 2012, Johns Hopkins University scientists, Mark Nevrinck and Miguel Aragón-Calvo, were awarded the 'New Frontiers Award' for work on "Origami Universe".

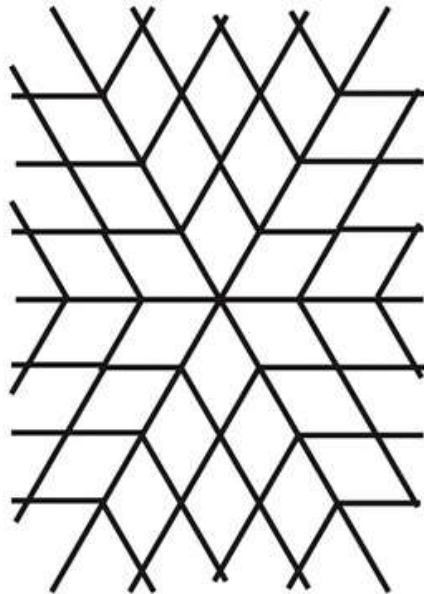
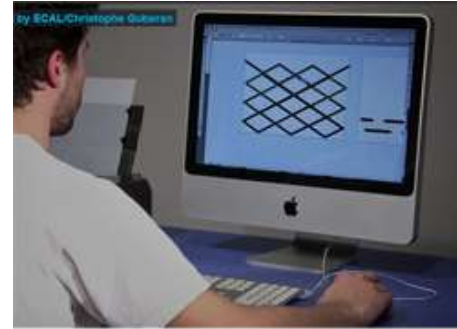
The researchers compared origami tessellations to the formation of cosmic structures from dark matter. Dark-matter is described as a "flat sheet" and the force of gravity "folds" the dark matter in a way similar to paper folding in origami. The folds in dark-matter tessellate into stream regions which can be conceptualized through origami tessellations.



## SELF-FOLDING PRINT TECHNOLOGY

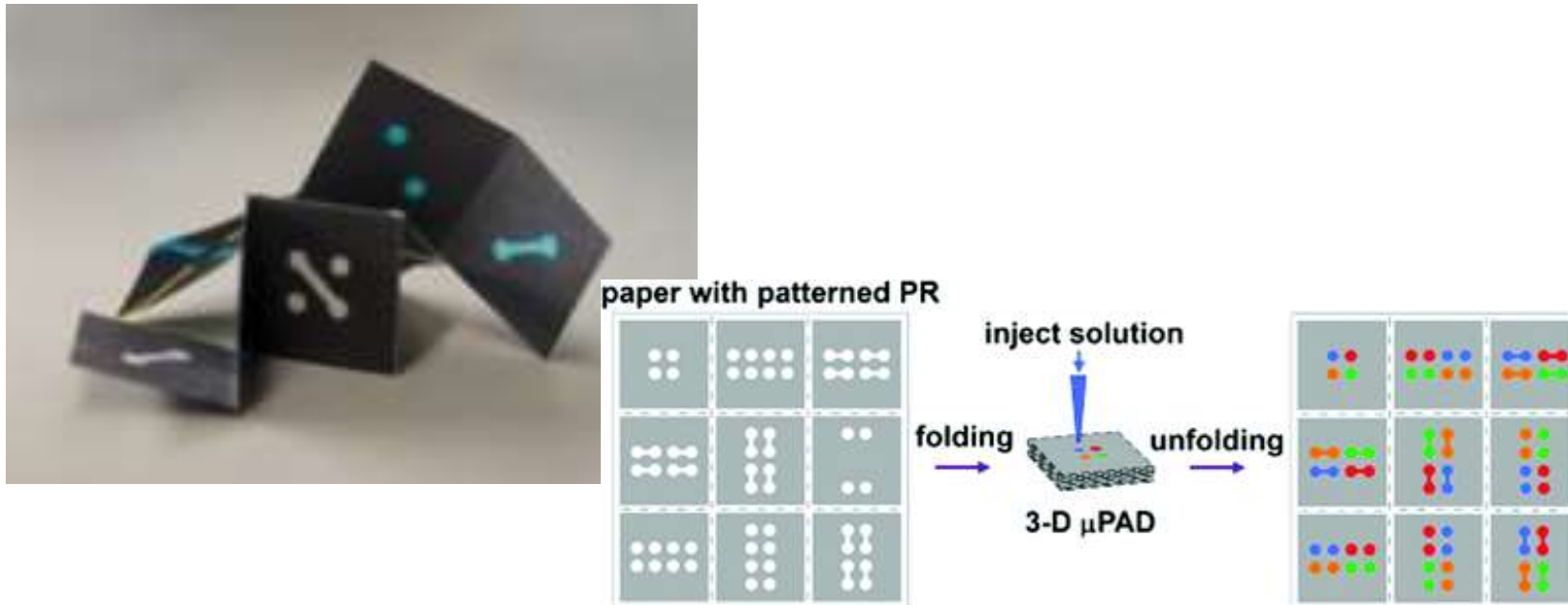
Industrial Designer Christophe Guberan has developed a process whereby a sheet of paper will self-fold when water/ink is printed on the paper.

The process is as simple as 1-2-3



## MEDICINE

Prof Hong Liu and Prof Richard M Crooks from the Department of Chemistry and Biochemistry, Center for Electrochemistry, and Center for Nano- and Molecular Science and Technology, The University of Texas at Austin, have developed an "origami Paper Analytical Device" (oPAD) which may be used to detect diseases such as malaria and HIV. The oPAD may be able to analyze body fluids such as blood, saliva, or urine to give a quick diagnosis without technical skills nor costly laboratory analysis.

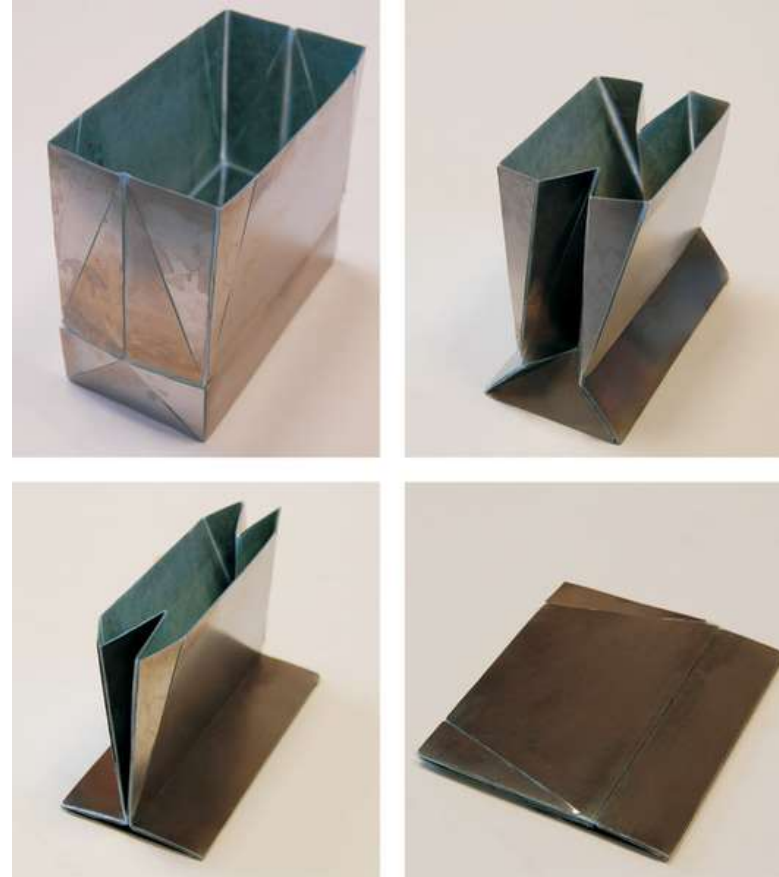




## PACKAGING

Engineers Zhong You and Weina Wu of the University of Oxford, have designed a collapsible, origami box made out of steel.

It is unique because it can be folded down flat without opening the bottom panel. This design can save a lot of time especially in the manufacturing & packing industry.

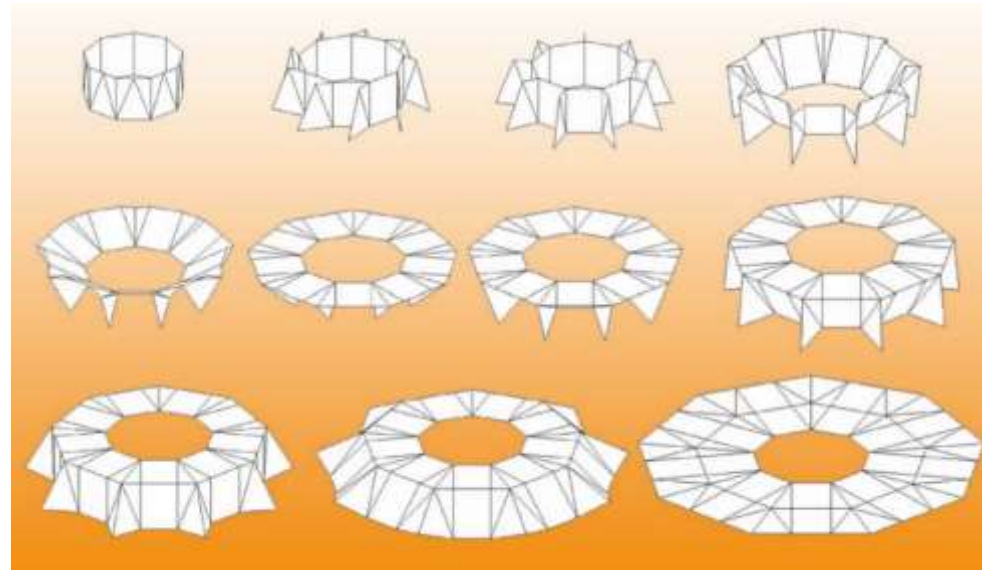


## OPTICS

Dr Robert J Lang helped scientists at the Lawrence Livermore National Laboratory (Livermore, California) to design a method for folding a space telescope so that it can be packed into a space shuttle and then easily deployed when in space.

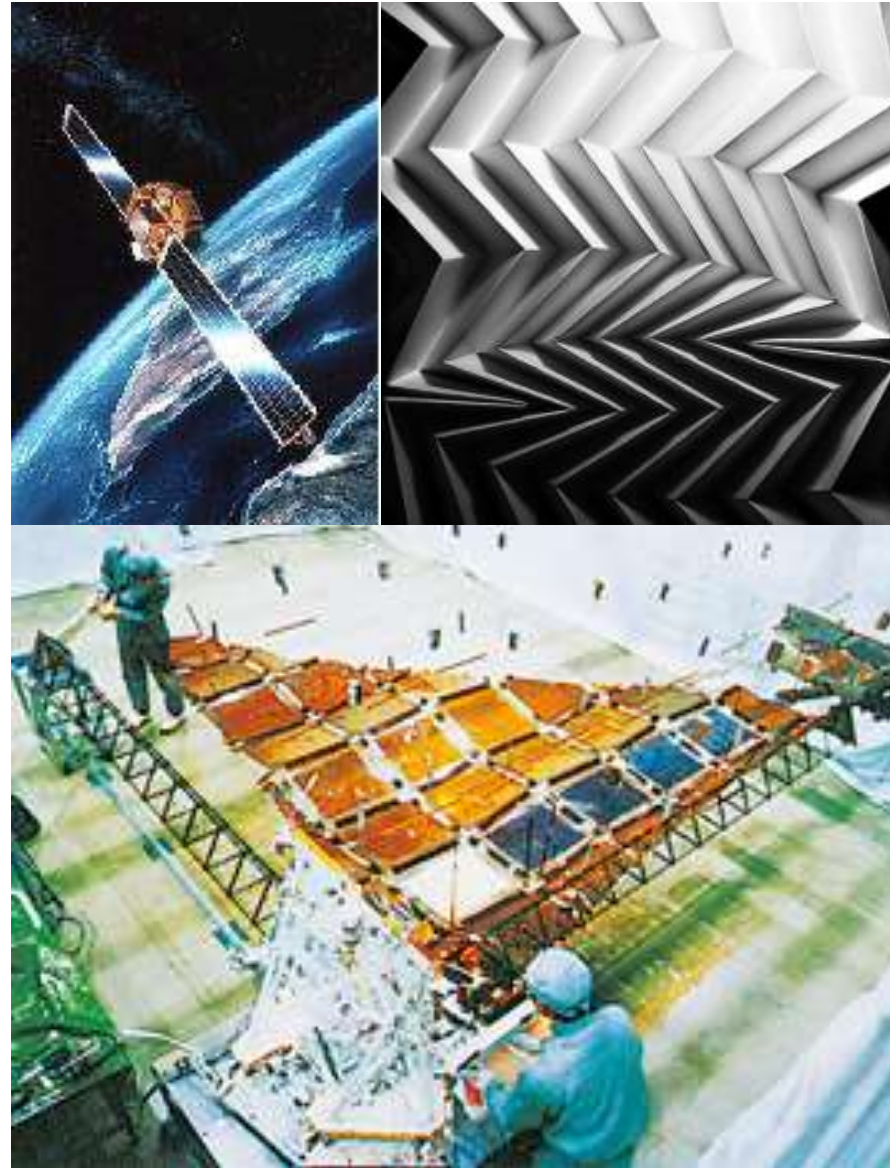
The foldable telescopic lens is called “Eyeglass”.

In early 2002, a telescopic lens measuring over 3 meters in diameter was constructed. When folded origami style, it was 1.2-meter in diameter and shaped like a cylinder. By early 2004, a 5-meter prototype lens was constructed and shown to concentrate light as expected.



## SPACE TECHNOLOGY

The 'Miura-ori map fold, developed by Prof Miura of Tokyo University, was used as the solar power array on the SFU spacecraft, launched In 1995 by Japan





## ARCHITECTURE

National Mosque, Kuala Lumpur, Malaysia (1965)



## PRODUCT DESIGN

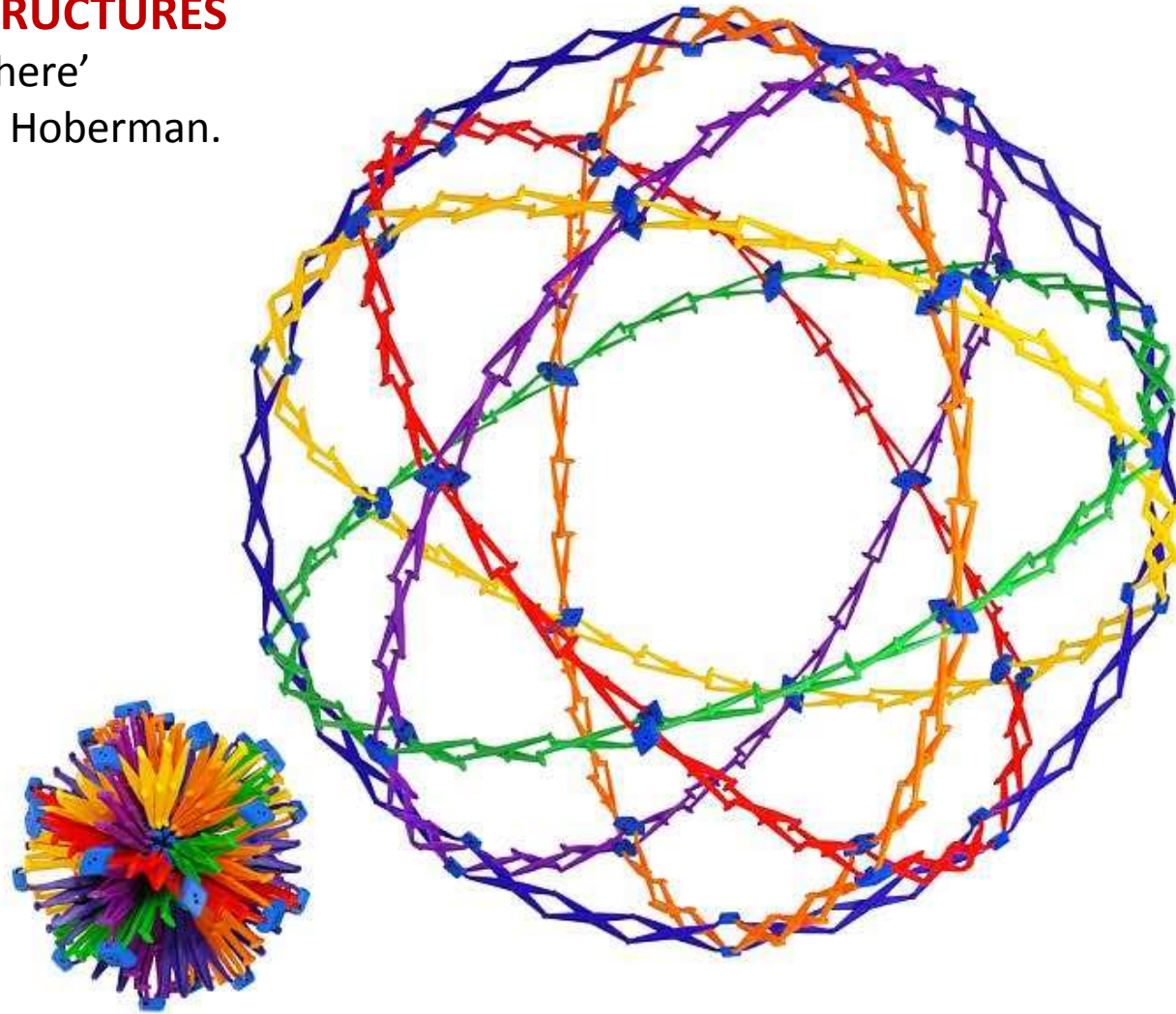
Collapsible lights by the  
Japanese designer  
Issey Miyake.





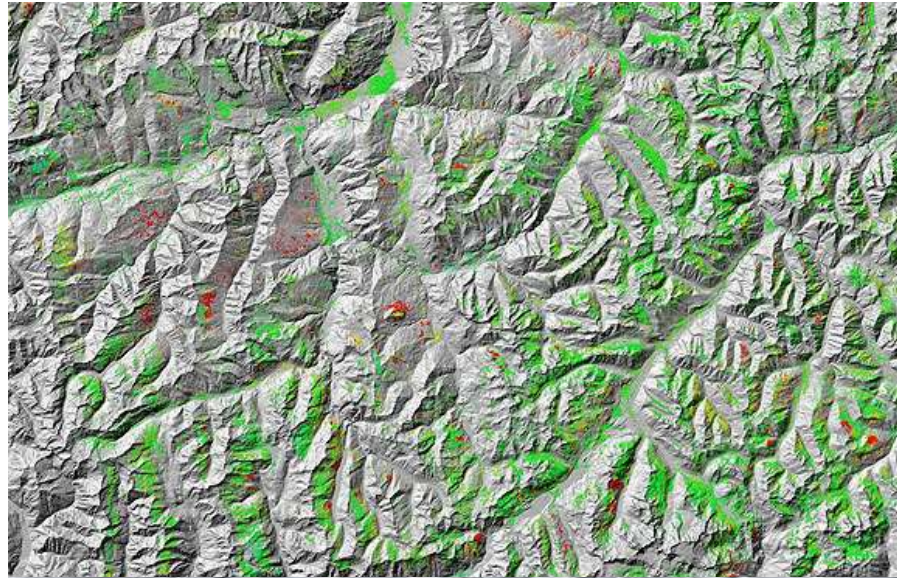
## DEPLOYMENT STRUCTURES

The 'Hoberman Sphere'  
Designed by Chuck Hoberman.



## **GEOLOGY**

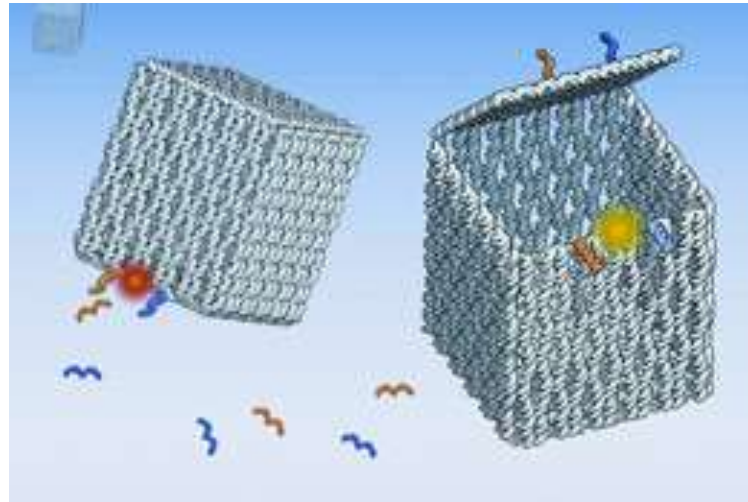
The action of crumpling paper is similar to the crumpling of the earth's crust through plate tectonics (and erosion).



## DNA ORIGAMI

Developed by Prof Paul Rothemund of Caltech, the term describes the nanoscale folding of DNA to create 2- and 3-dimensional structures.

Among many applications, the technique is used to assemble nano-scale objects by folding strings of DNA proteins, to transport drugs into otherwise inaccessible structures within the body, then disassemble to deliver the drug.





## PHYSICS

Prof Narayan Menon of the University of Massachusetts, Amherst, is studying why a crumpled paper ball, although 90% air, is so rigid. After several years of experimentation and simulation with powerful computers and X-ray scanners, he is not close to a definitive answer. “The mathematics is nasty”, he says.







THE MEANINGFUL BIT AT THE END



THANK YOU!



THANK YOU!



Paul Jackson

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