PINO TROGU – SAN FRANCISCO STATE UNIVERSITY, USA

BIO-INSPIRED MODELS OF ROTATIONAL GEOMETRY

MODELS BASED ON GIORGIO SCARPA'S WORK IN TOPOLOGY, BIO-INSPIRED DESIGN, AND ROTATIONAL GEOMETRY

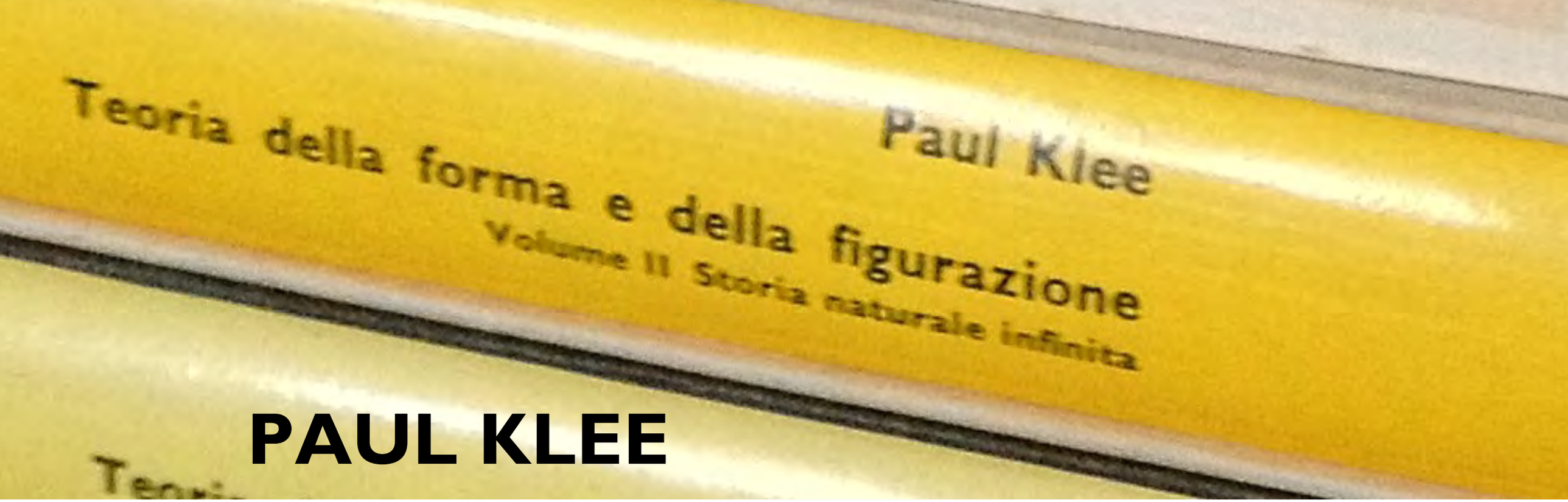
TU DELFT – FACULTY ROOM (LAGERHUYSCH) AT 3ME

THURSDAY, 21 DECEMBER 2017 – 12:45 PM

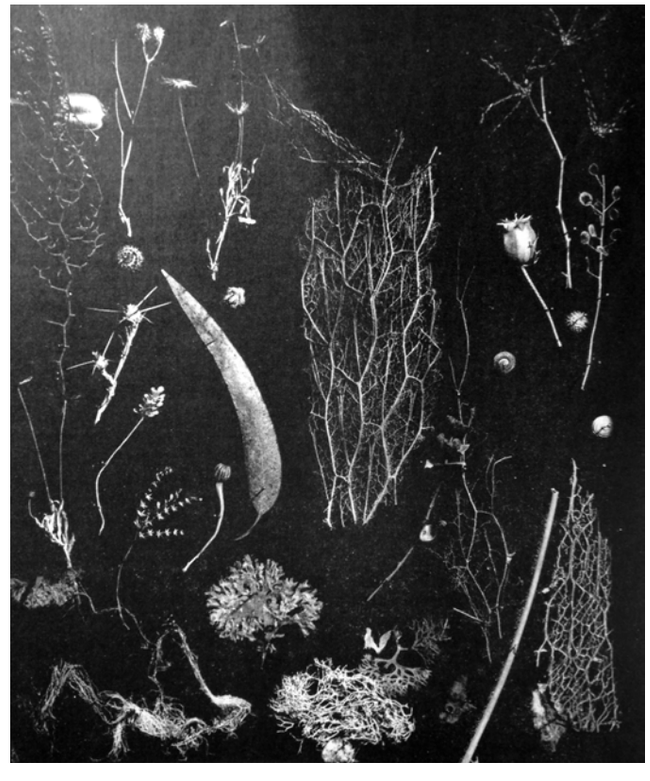
go to last slide

ORIGINS AND INFLUENCES

G. Scarpa


Teoria della forma e della figurazione
Volume II Storia naturale infinita
Paul Klee

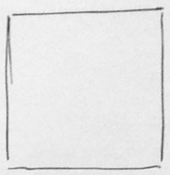
PAUL KLEE



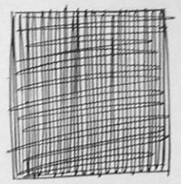
important screws, as feed or lead screws, are copied.

Body

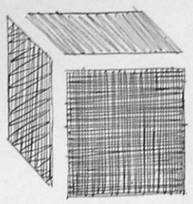
Body
two-dimensional,
marginal or middle
(body-limit)

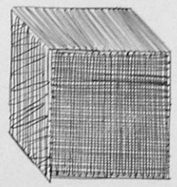


Body
two-dimensional.
External-material,
active-planar
(outer surface
of a body)



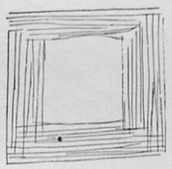
Body
three-dimensional
(body-outward)



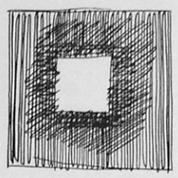


Spatial

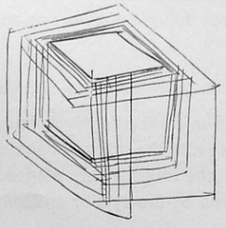
Spatial
two-dimensional
encompassing
(activated passive)

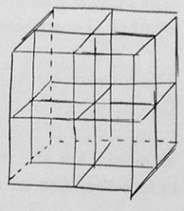


Exotopic
encompassing
(without body)



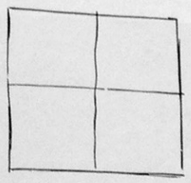
Spatial
three-dimensional
and transparent



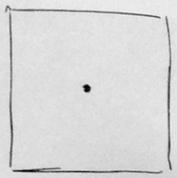


Inward

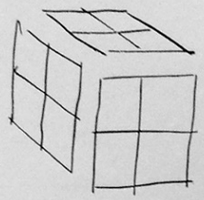
Inward
two-dimensional
(content)



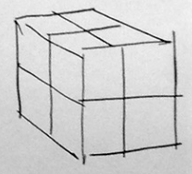
Most-inward
(centre)



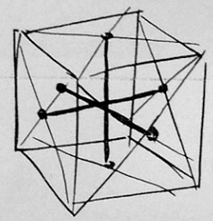
Inward
two-dimensional,
inward
representation
of outer planes



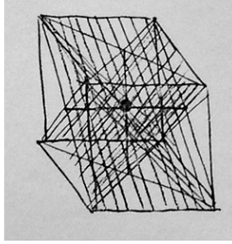
In contrast
to the inside and
outside of a body



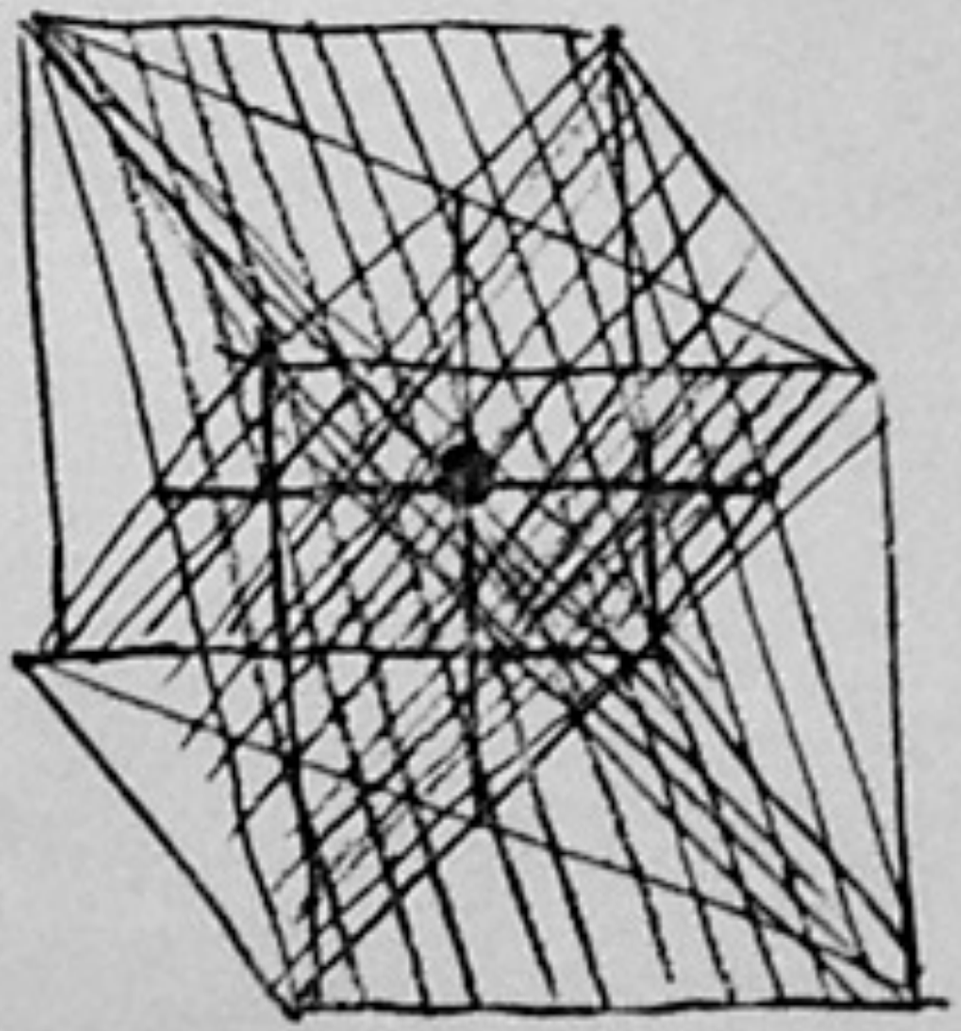
Inward
three-dimensional,
body inside



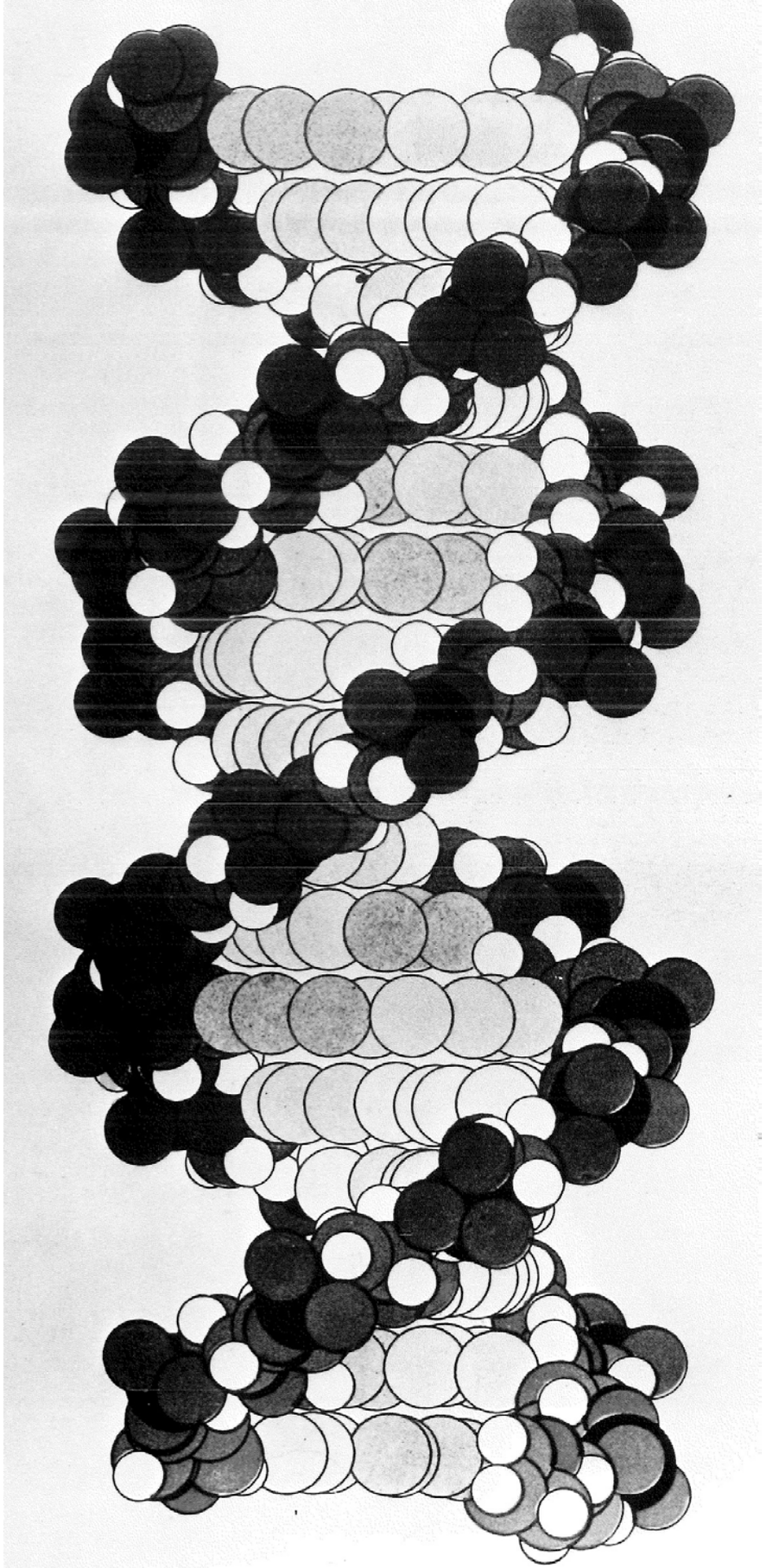
Purely inward,
body innermost

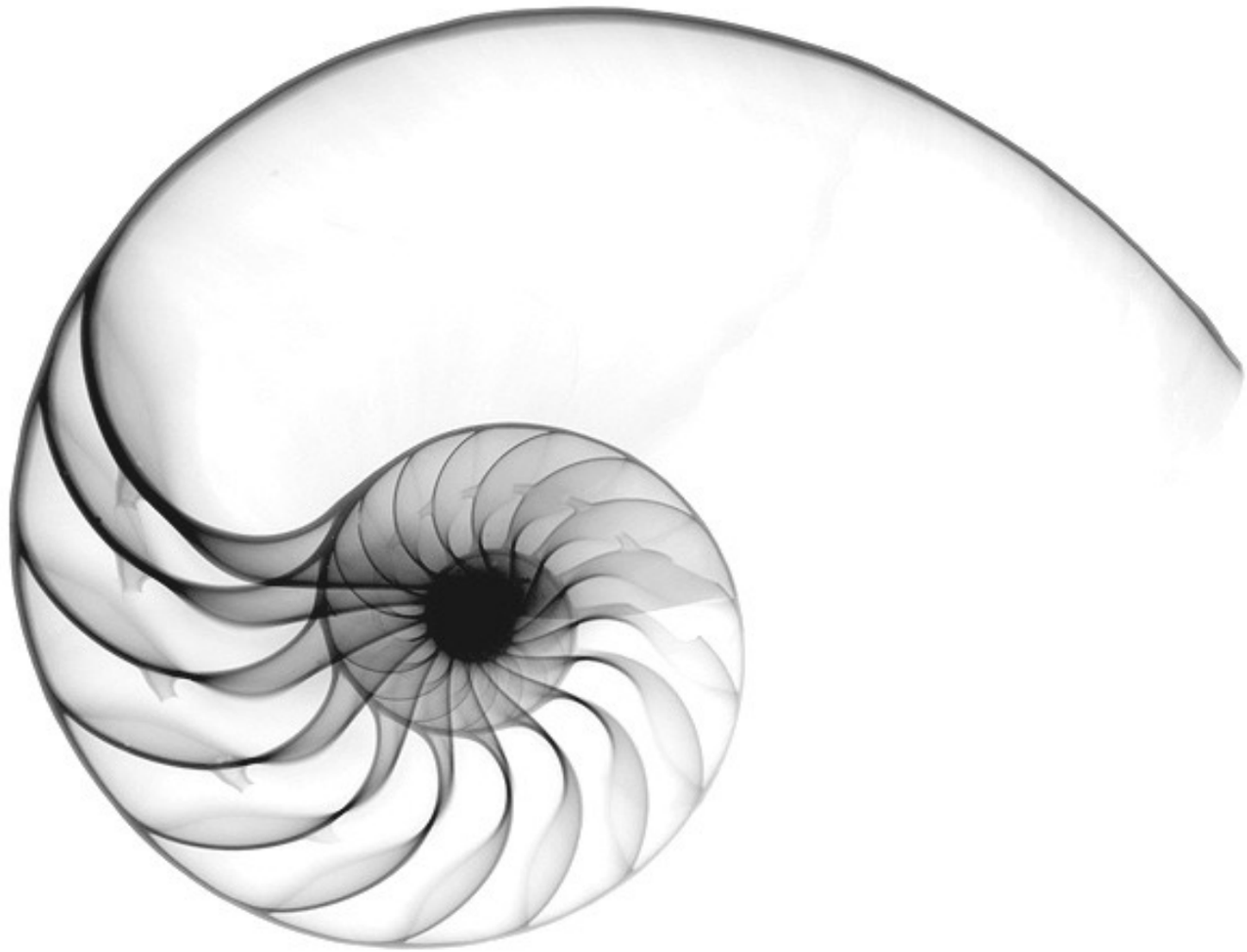


The inward
plays the dominant part.
The whole inward territory
designated by the word 'content'



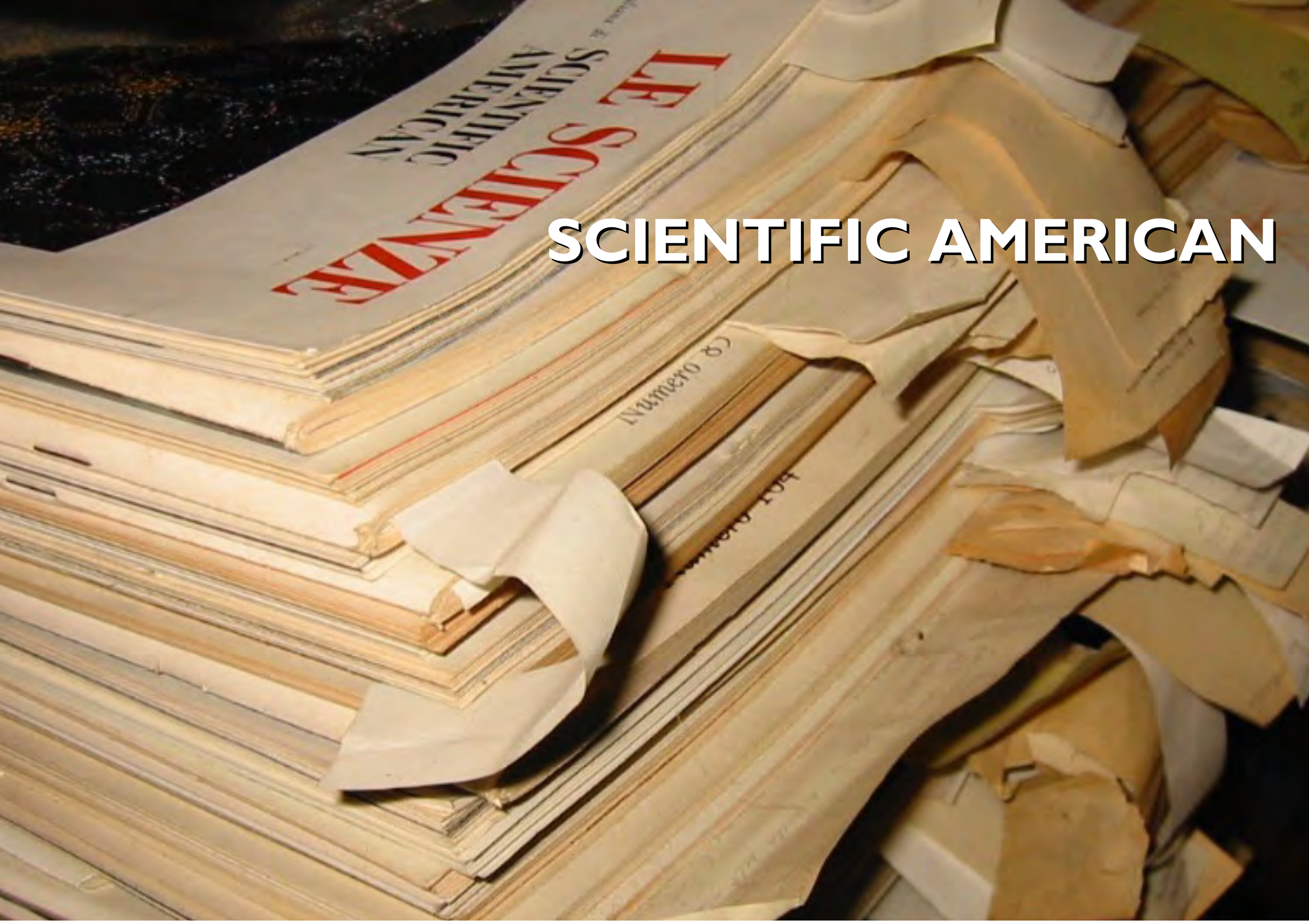
The inward
plays the dominant part.
The whole inward territory
designated by the word ‘content’



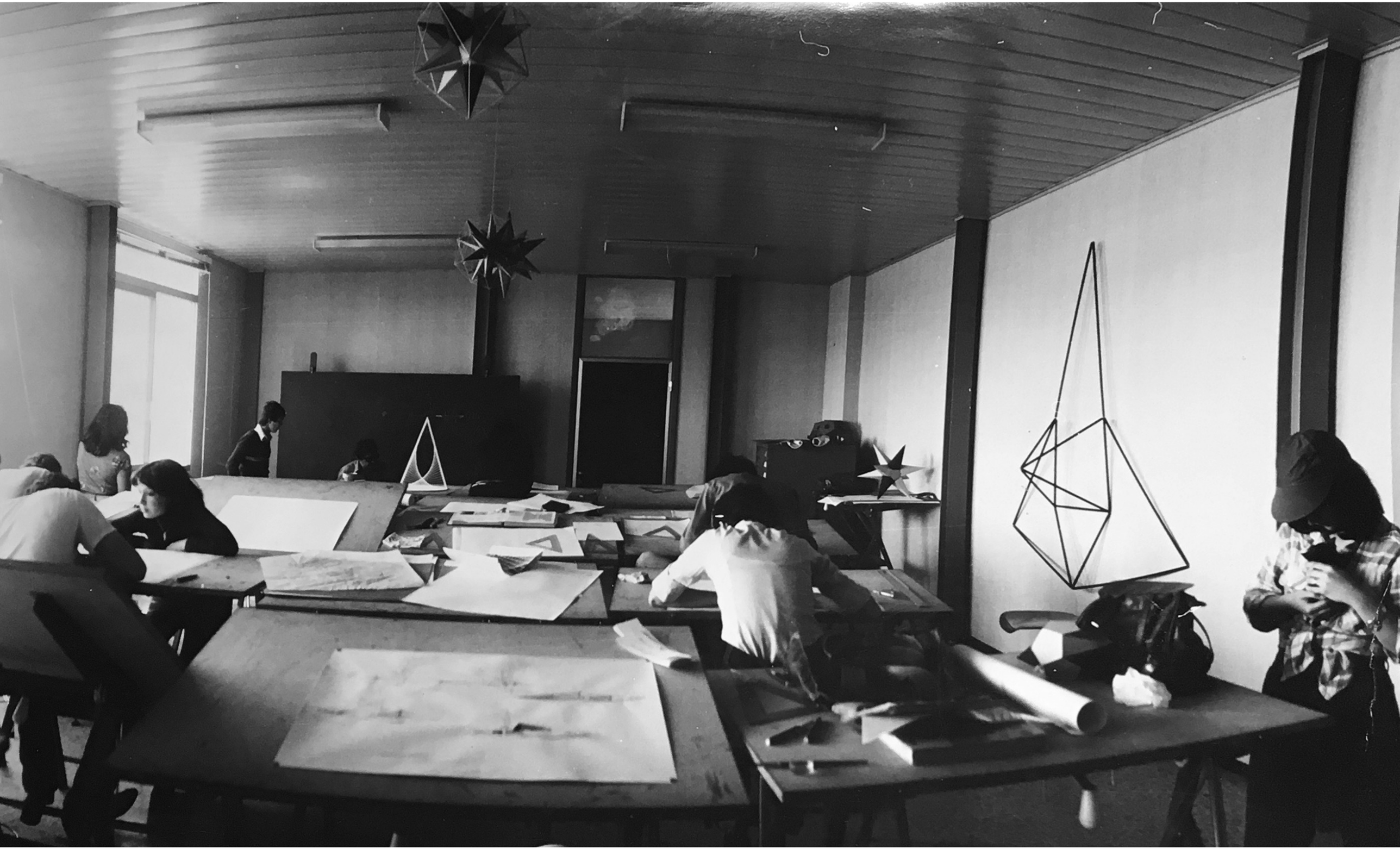


"If you are going to do research in bionics, don't forget to study seeds, for the knowledge that nature displays in their creation, and for the originality and unpredictability of some of their self-dispersal mechanisms."

Giorgio Scarpa, 1988



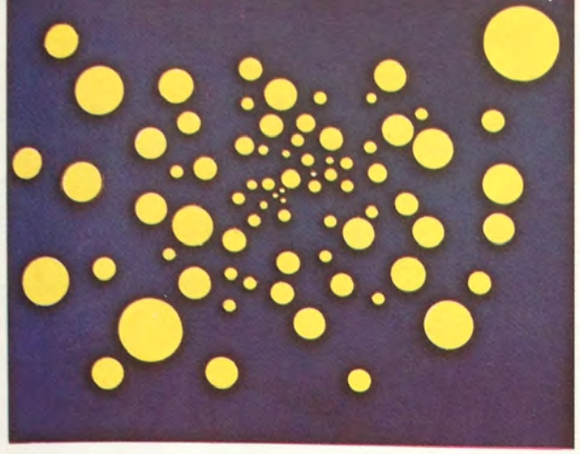
SCIENTIFIC AMERICAN



avviene nel cervello dell'uomo che esegue un disegno

a matita e la mente

GRUPPO V
CIBERNETICA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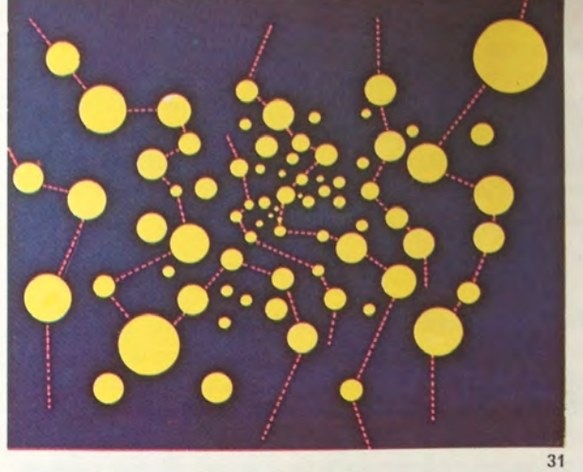
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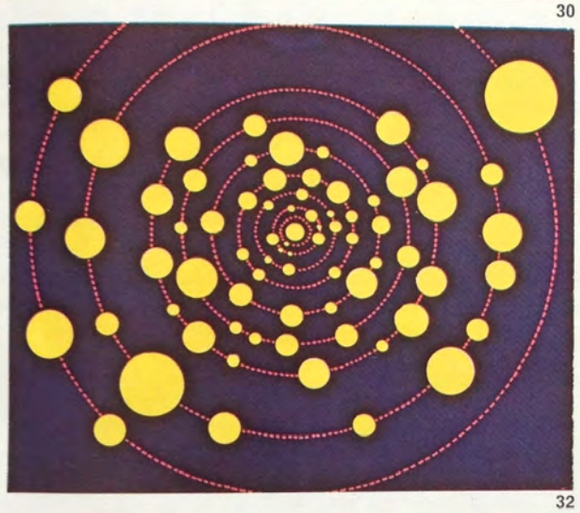
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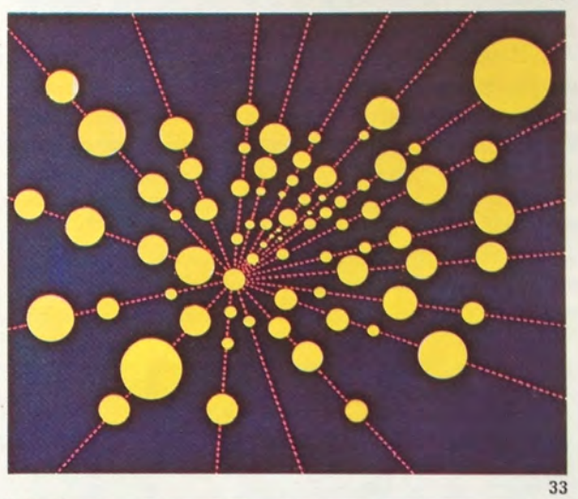
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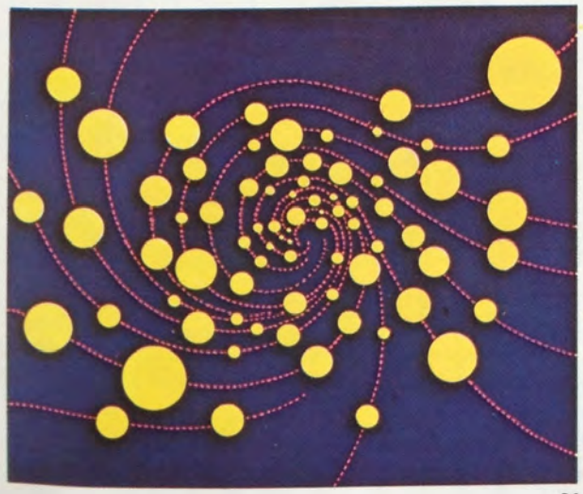
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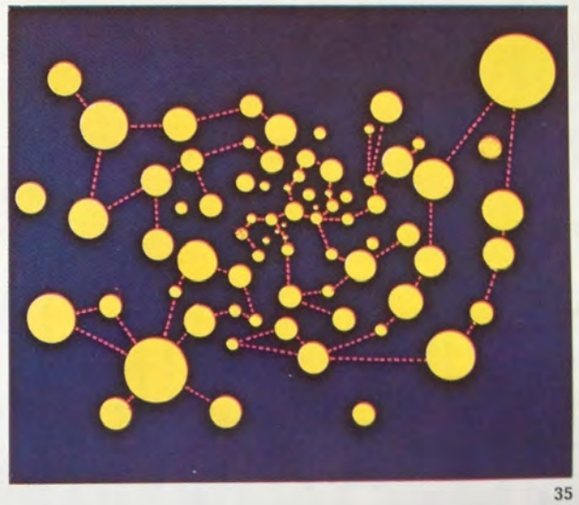
35

rimento possiamo vedere i dischi allineati lungo i raggi che partono da questo centro (fig. 33). Ed ecco apparire l'immagine di un universo che si « espande ».

Possiamo però stabilire altri collegamenti fra i vari dischi, formando, ad esempio, una struttura a spirale che ci dà l'immagine ormai classica delle galassie, di un turbine che trascina con sé i mondi (fig. 34). Oppure con la nostra immaginazione potremo isolare alcuni gruppi di dischi e organizzarli nelle forme di costellazioni fantastiche (fig. 35).

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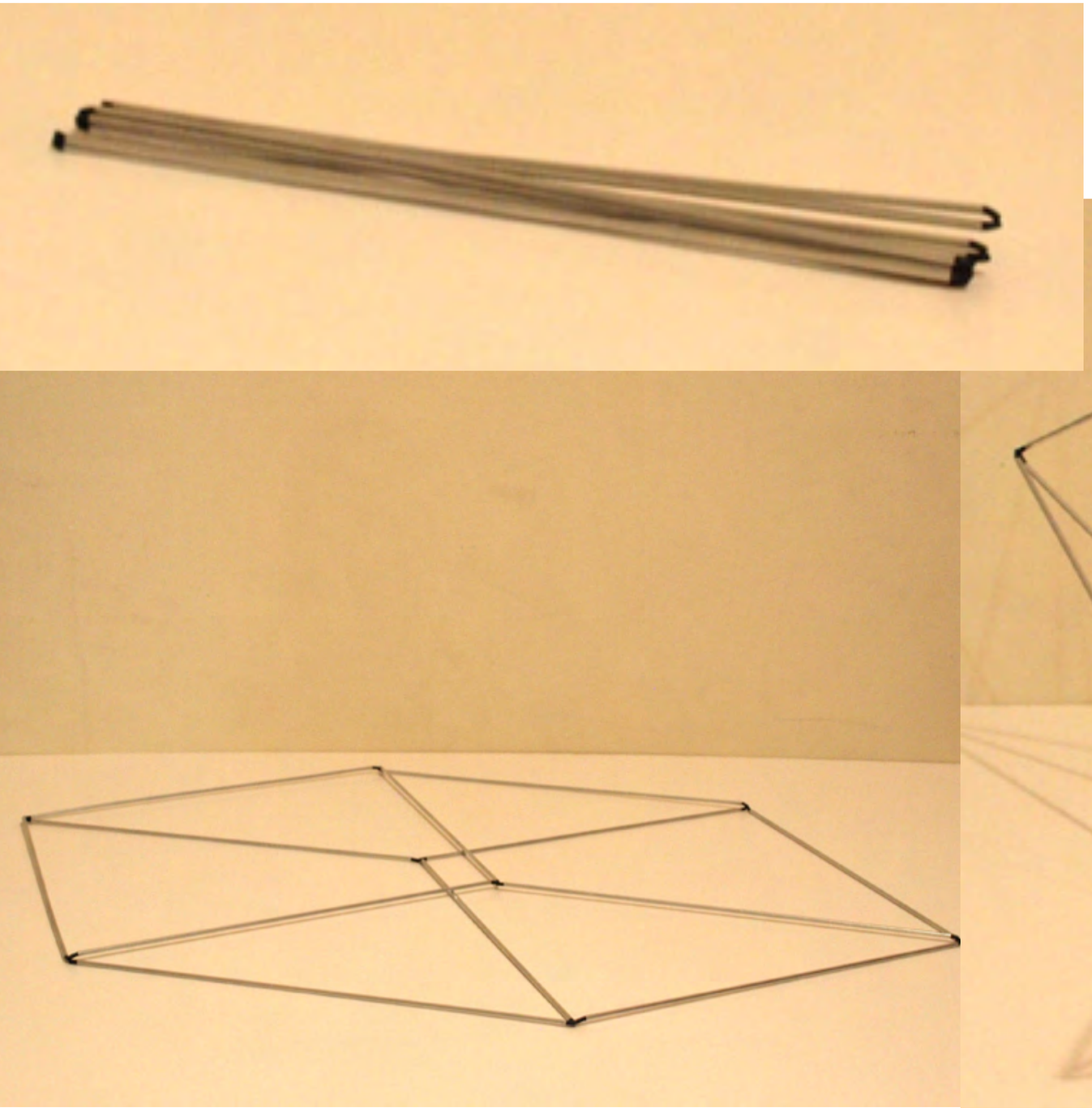
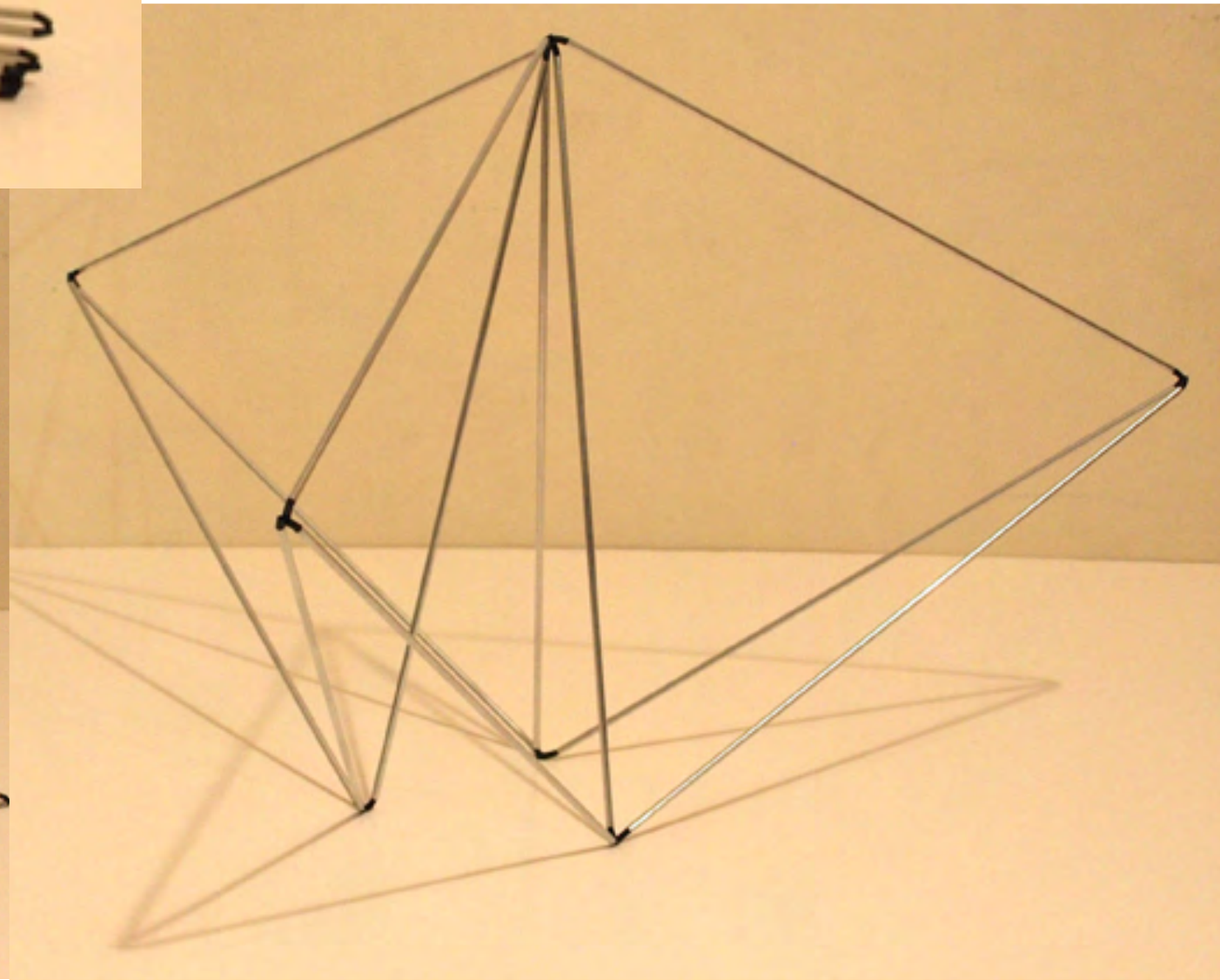
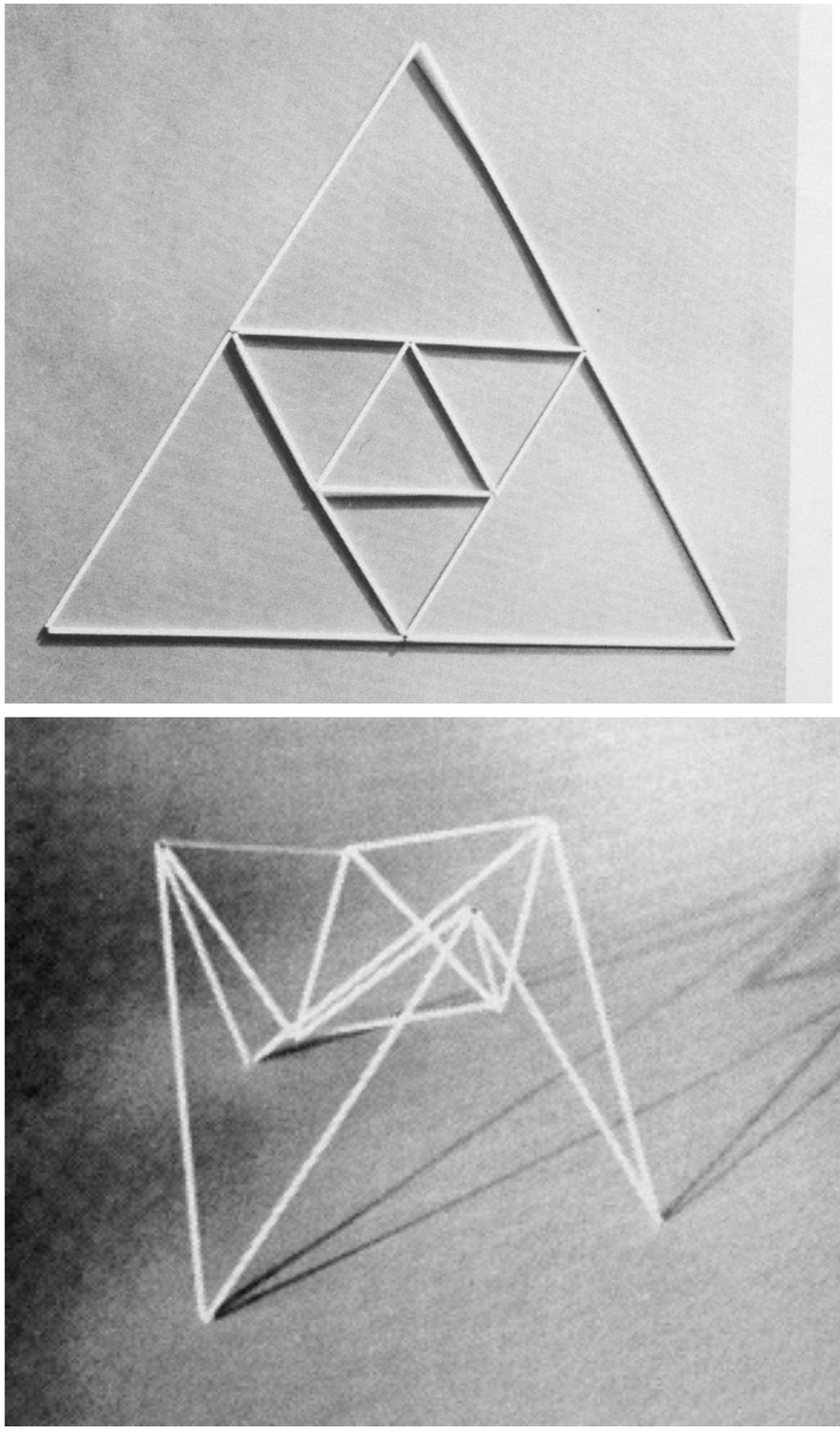
ISIA FAENZA

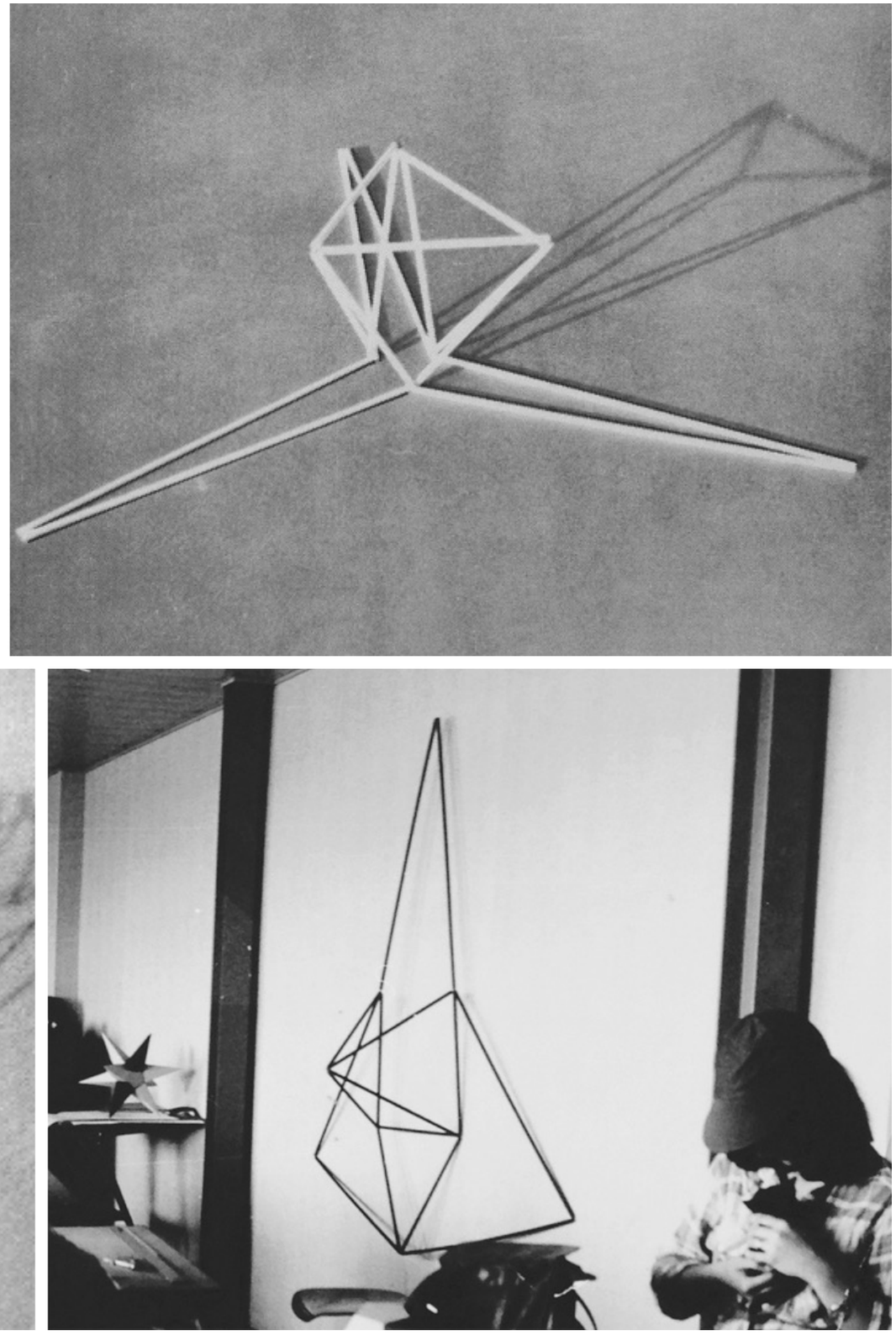
TRANSFORMABLE CUBE , 1965.



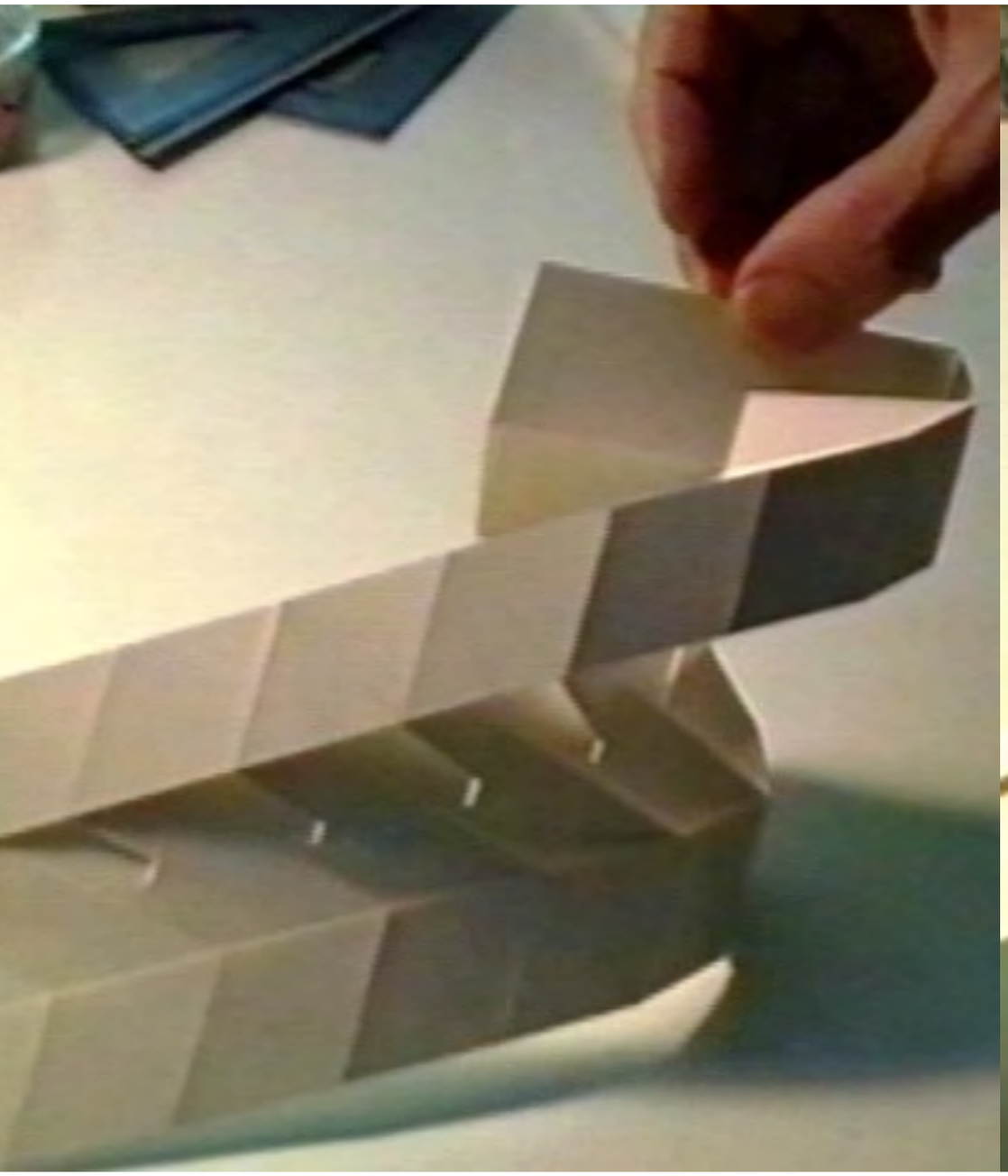


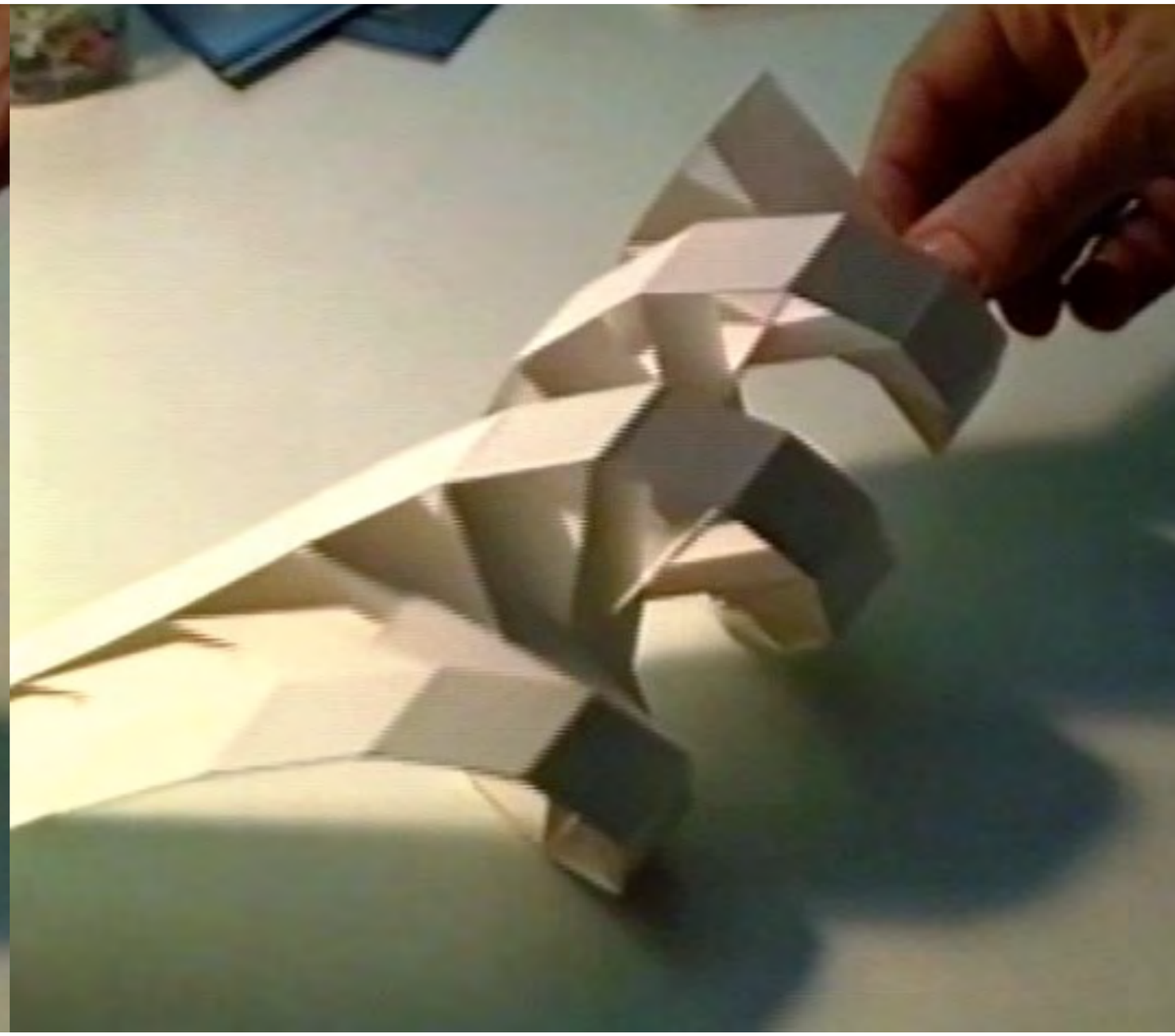
TRANSFORMABLE TRIANGLE , 1965.



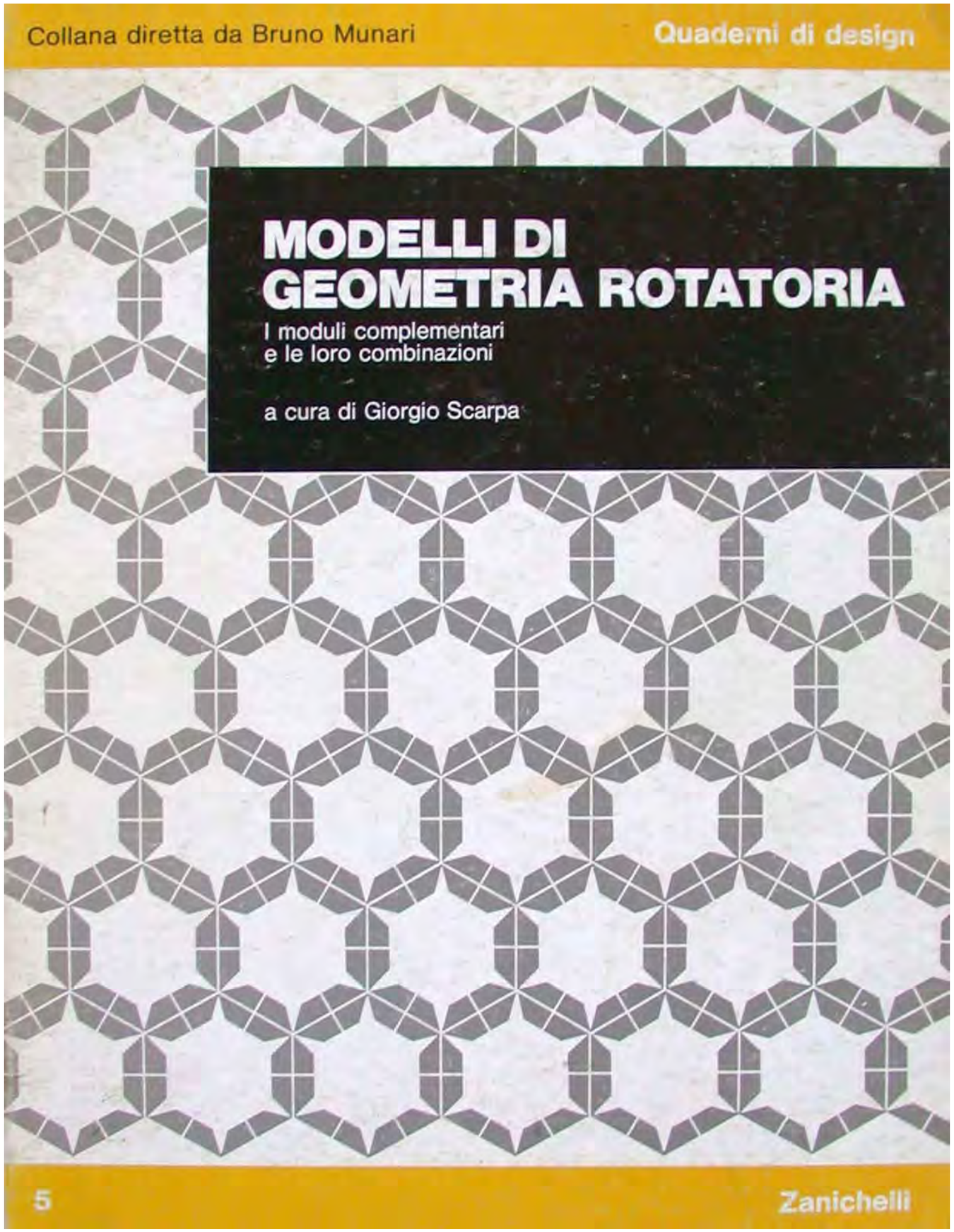


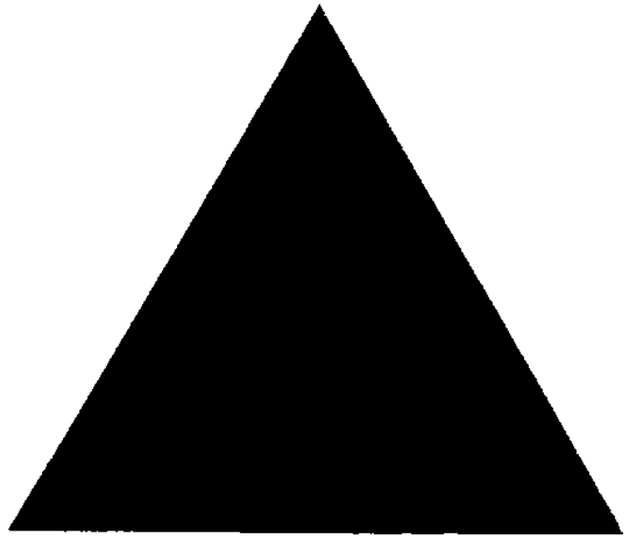
DNA MODEL, C. 1985.



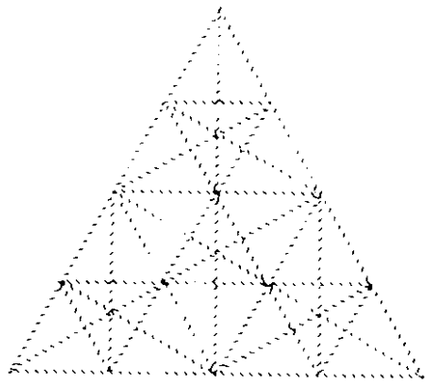


RESEARCH AND TEACHING

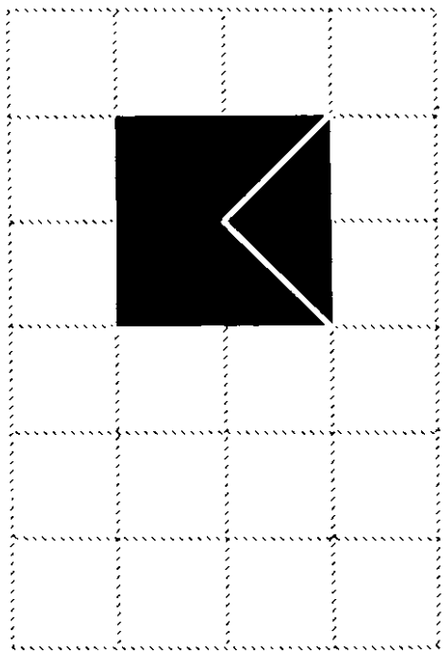

Collana diretta da Bruno Munari
Quaderni di design
MODELLI DI GEOMETRIA ROTATORIA
I moduli complementari e le loro combinazioni
a cura di Giorgio Scarpa
5
Zanichelli

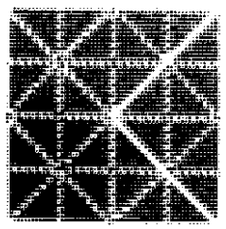


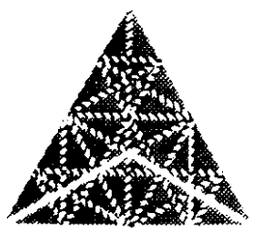
The two basic forms.

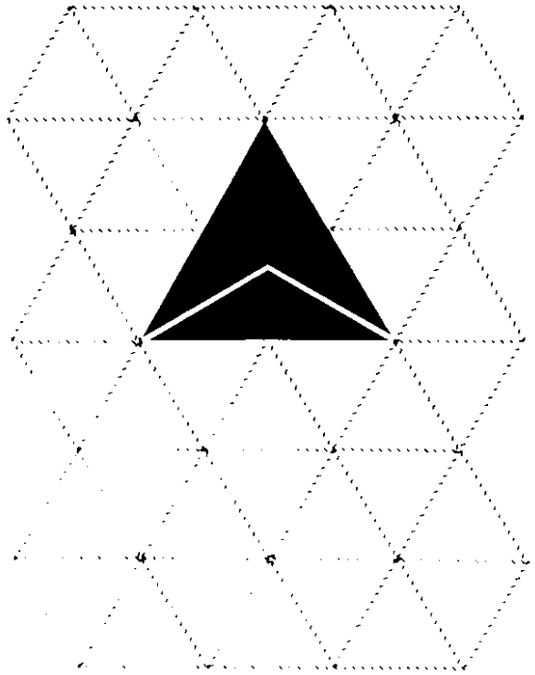


We will then put the two figures derived from the section of the square in a structure constituted of square modules, and the forms derivated from the section of the equilateral triangle, in a structure constituted of equilateral triangles. The forms will be cut out of paper board and we will put them on the modulated surface. The sides of the figures must be the same or a multiple of the basic module that forms the structure.



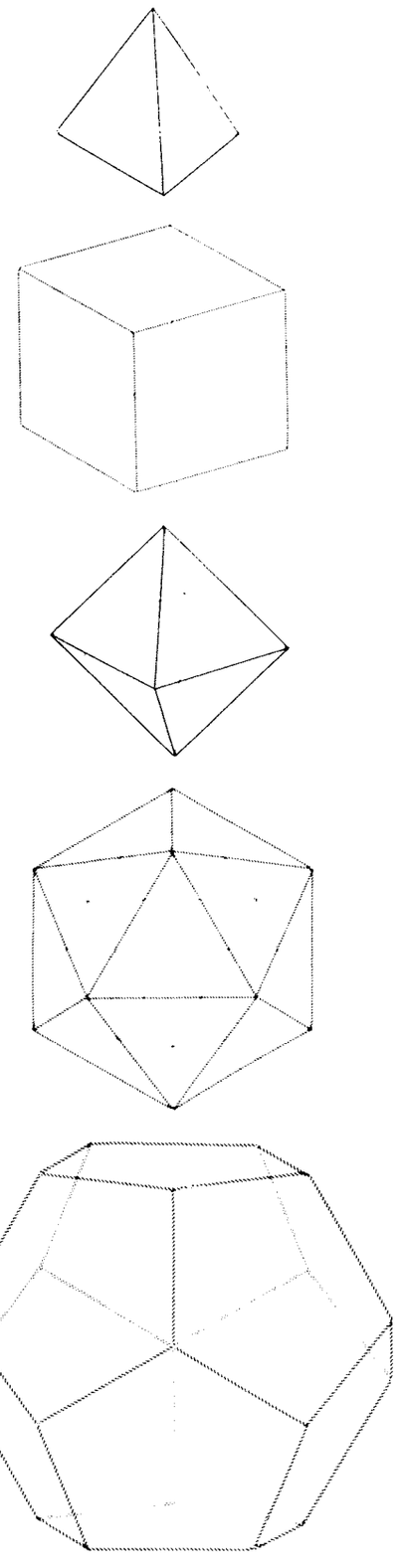




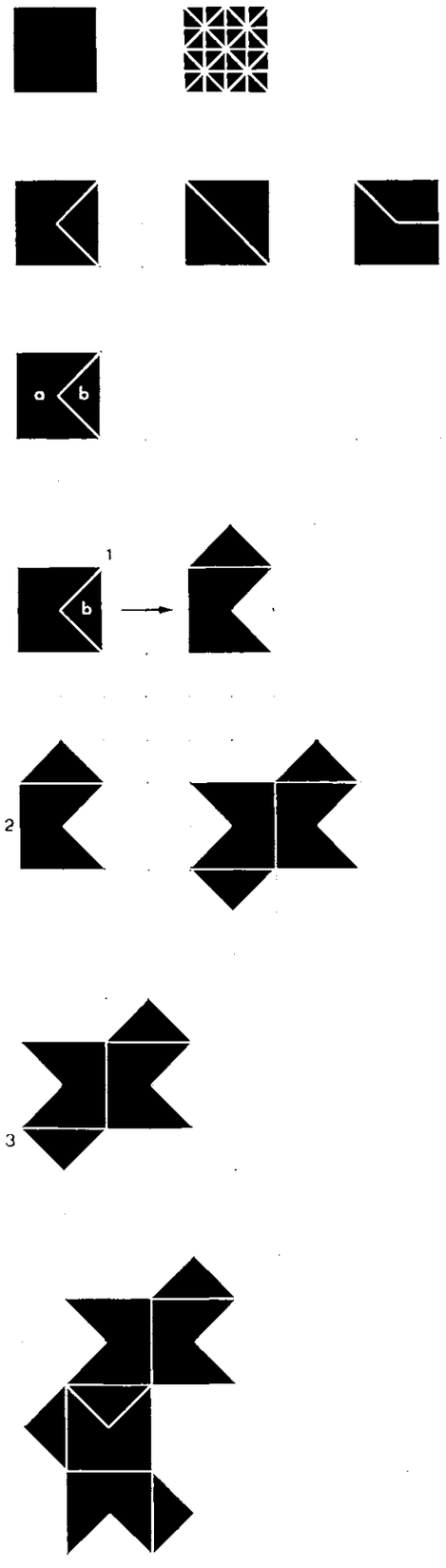


PLATONIC SOLIDS

(REGULAR POLYHEDRA)

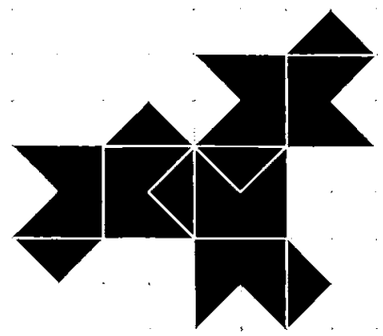


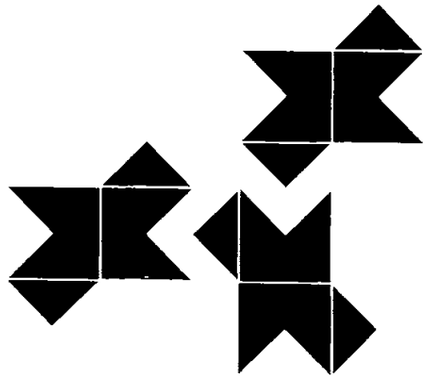
The five Plato polyedrons.



out) is defined by 4 rotations around 3 centers c
symmetry, and is articulated in 3 distinct fold-ou
plane groups, each being constituted by two
squares (4 parts). The first rotation tranforms th
bisected square, which has a specular symmetr
a new figure that is no longer symmetric. Startin
from this sequence, all the following ones show
operations of cyclic rotatory symmetry.

2D –> 3D

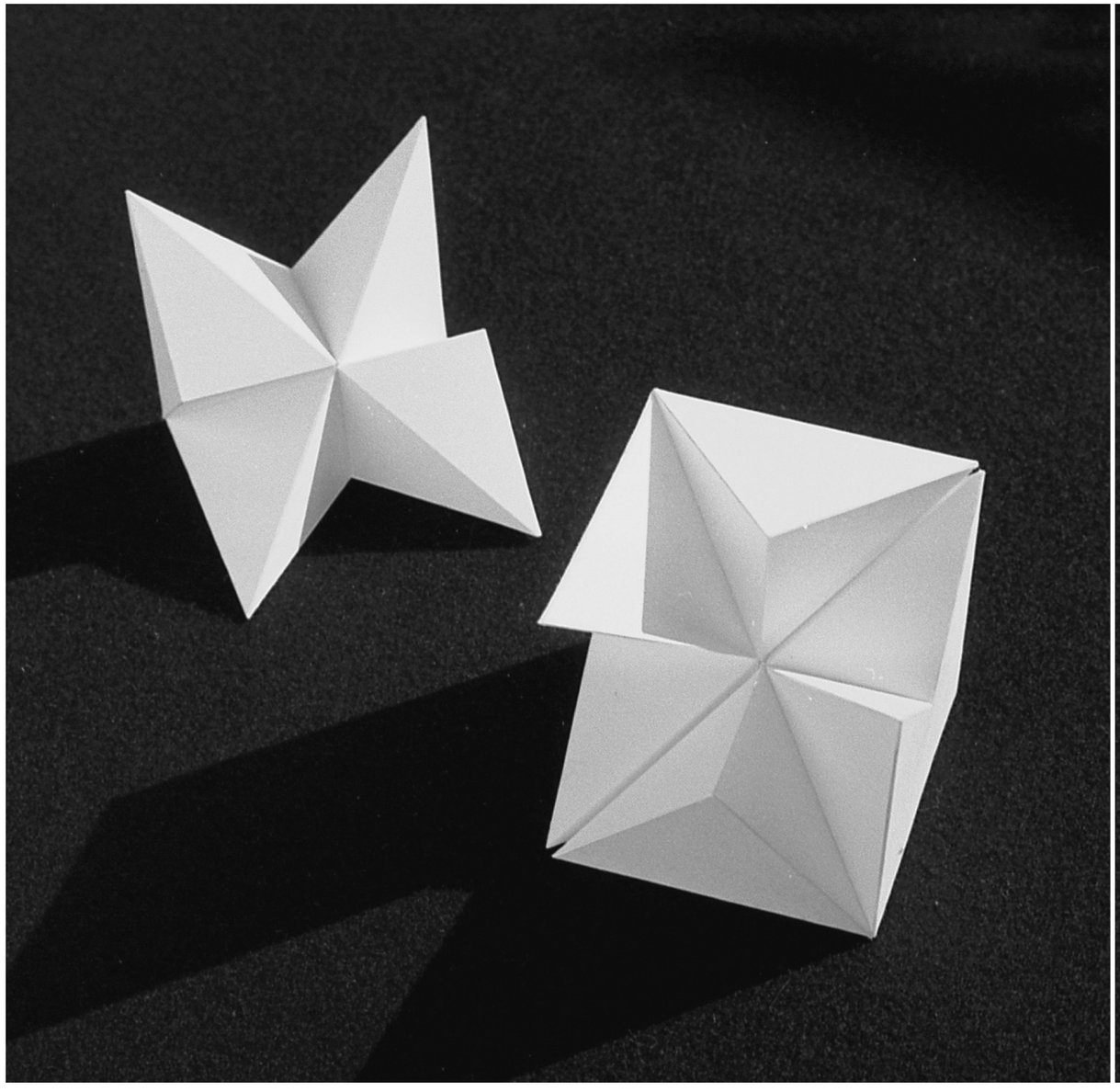


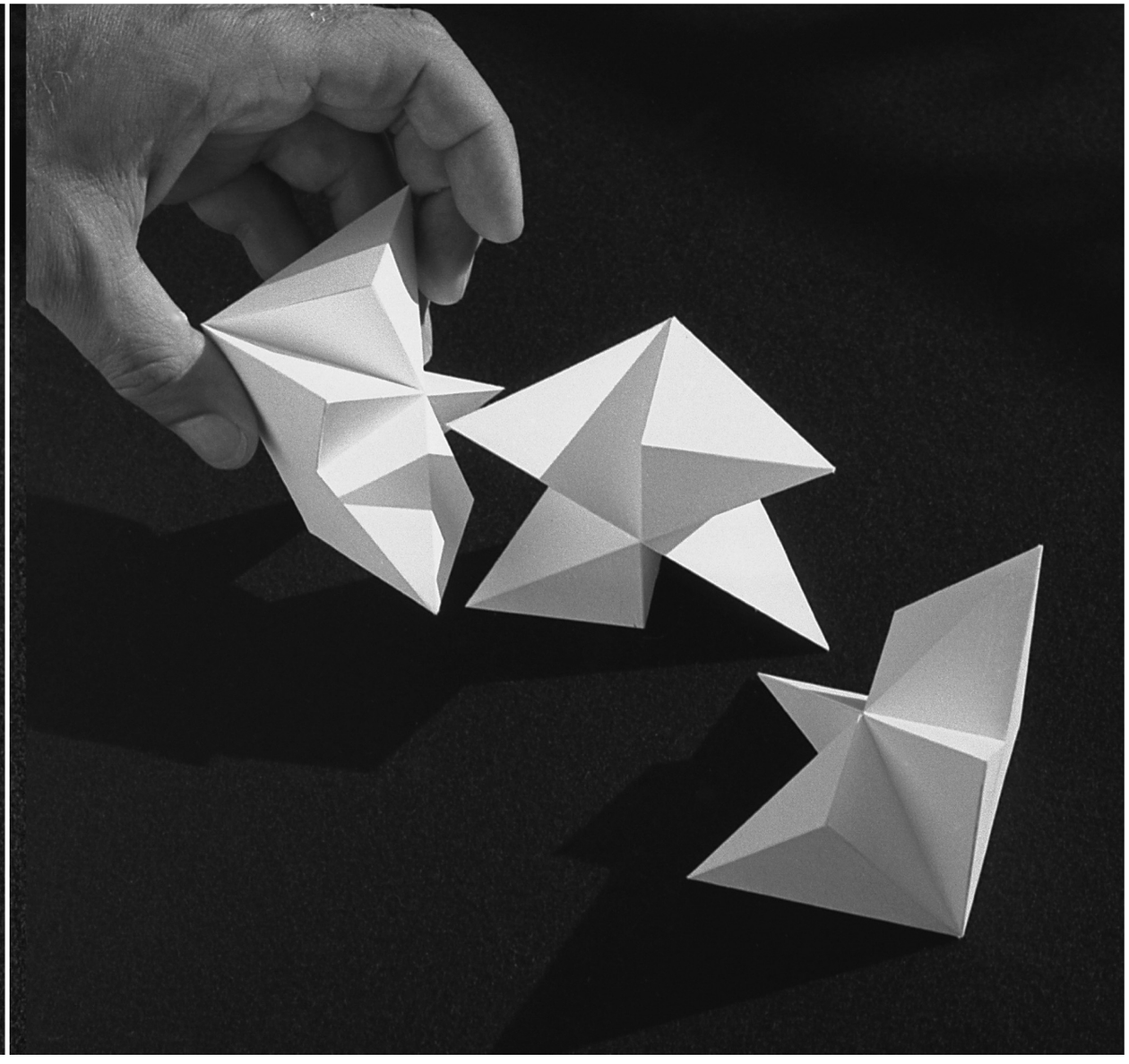


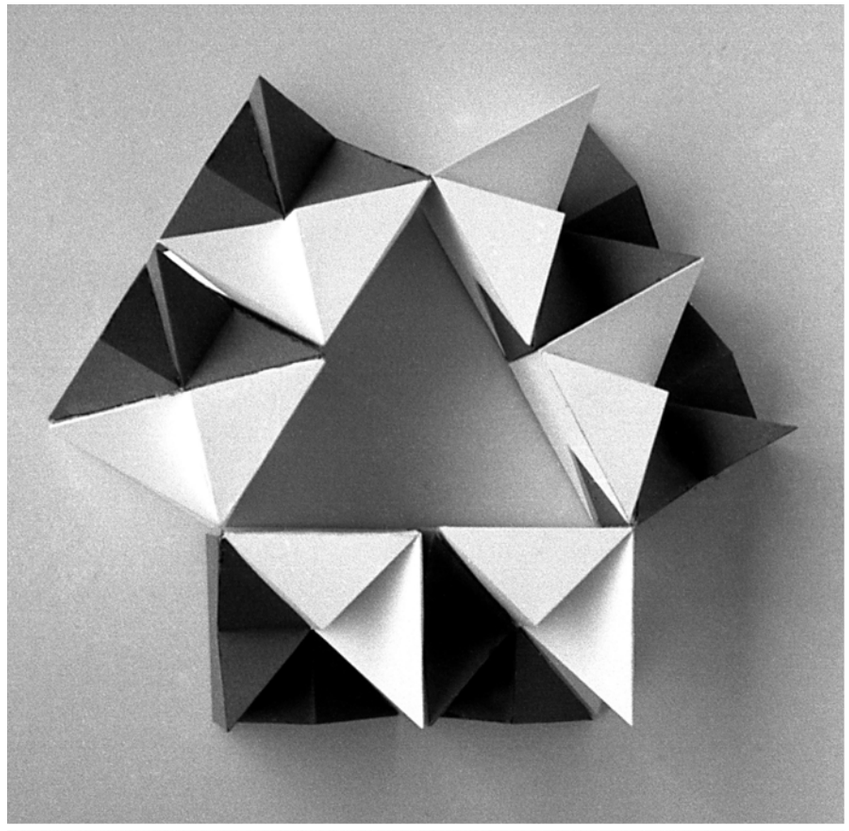
Geometric operations:

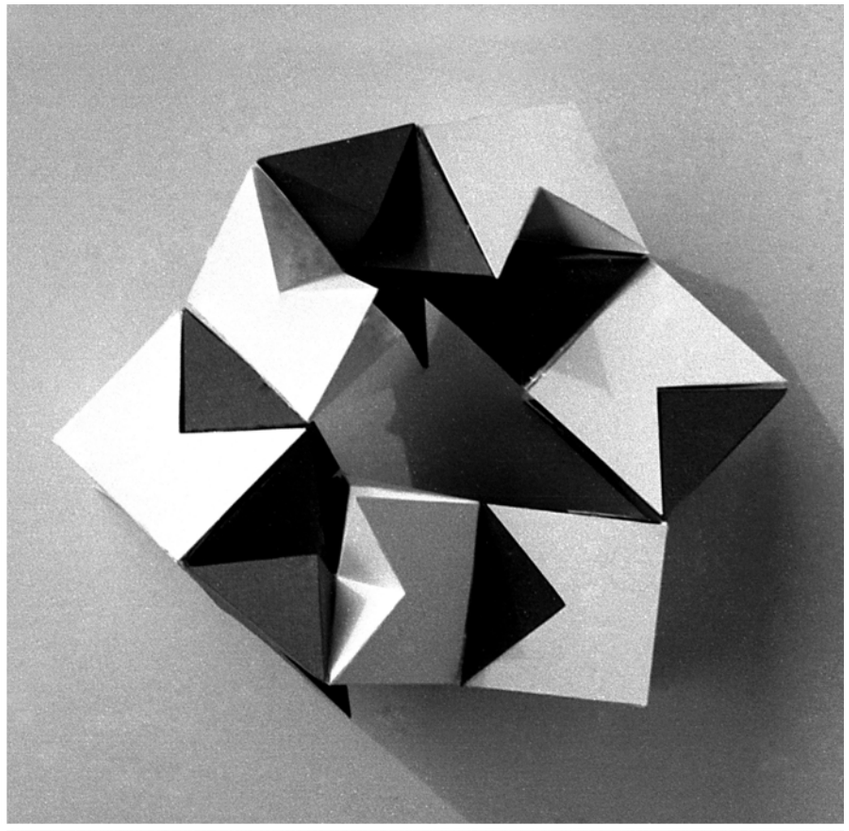
Sections
Rotations
Translations
Flips
Foldings
Joining
Hinges

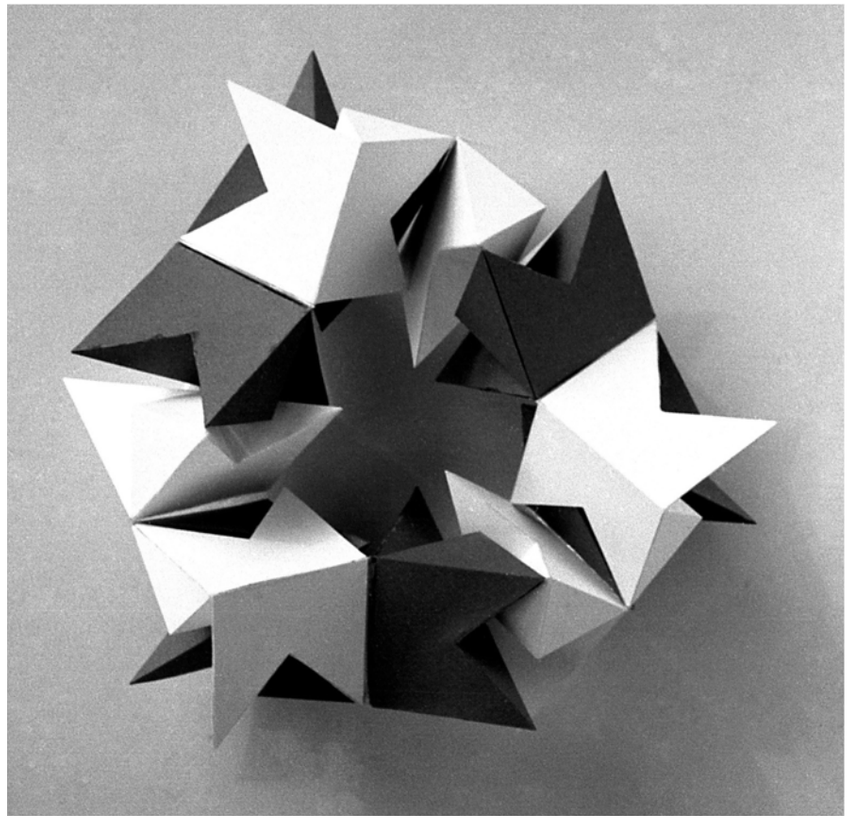
2D –> 3D

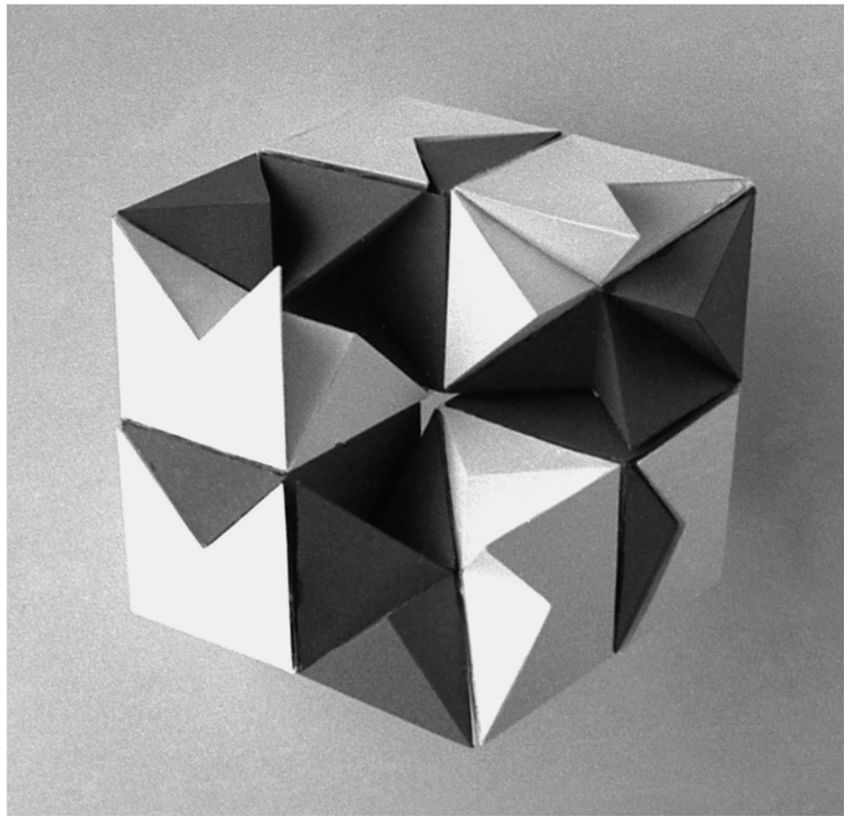


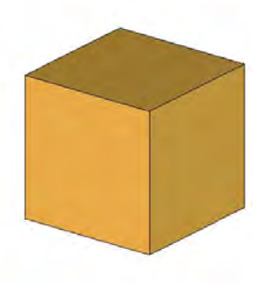




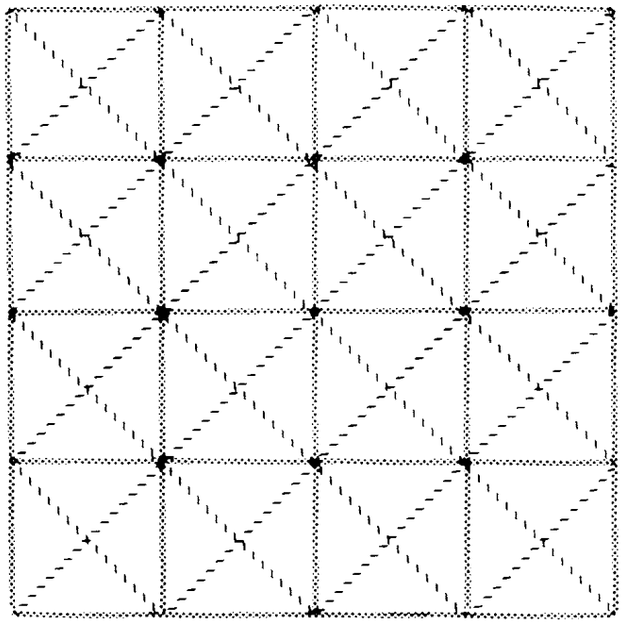


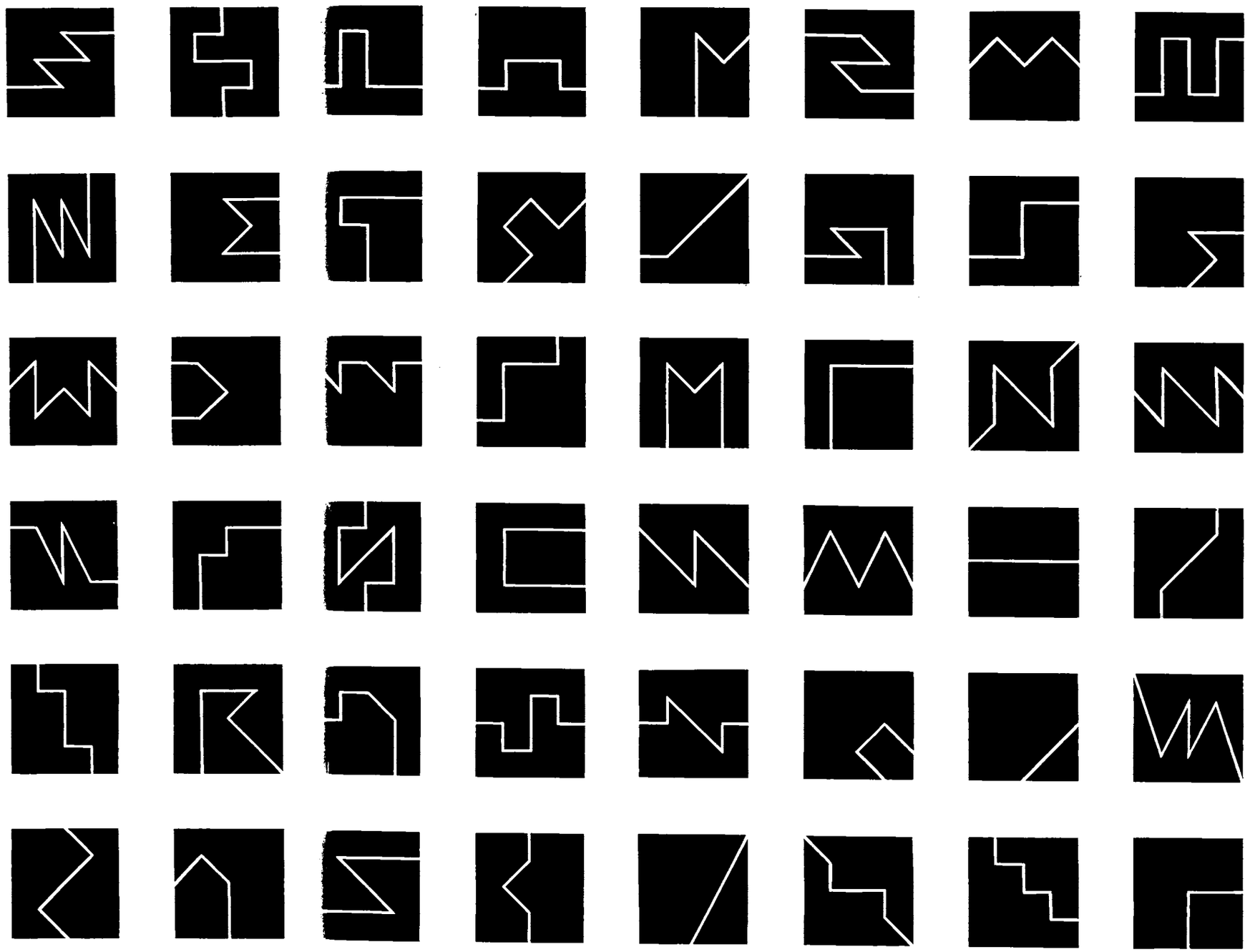




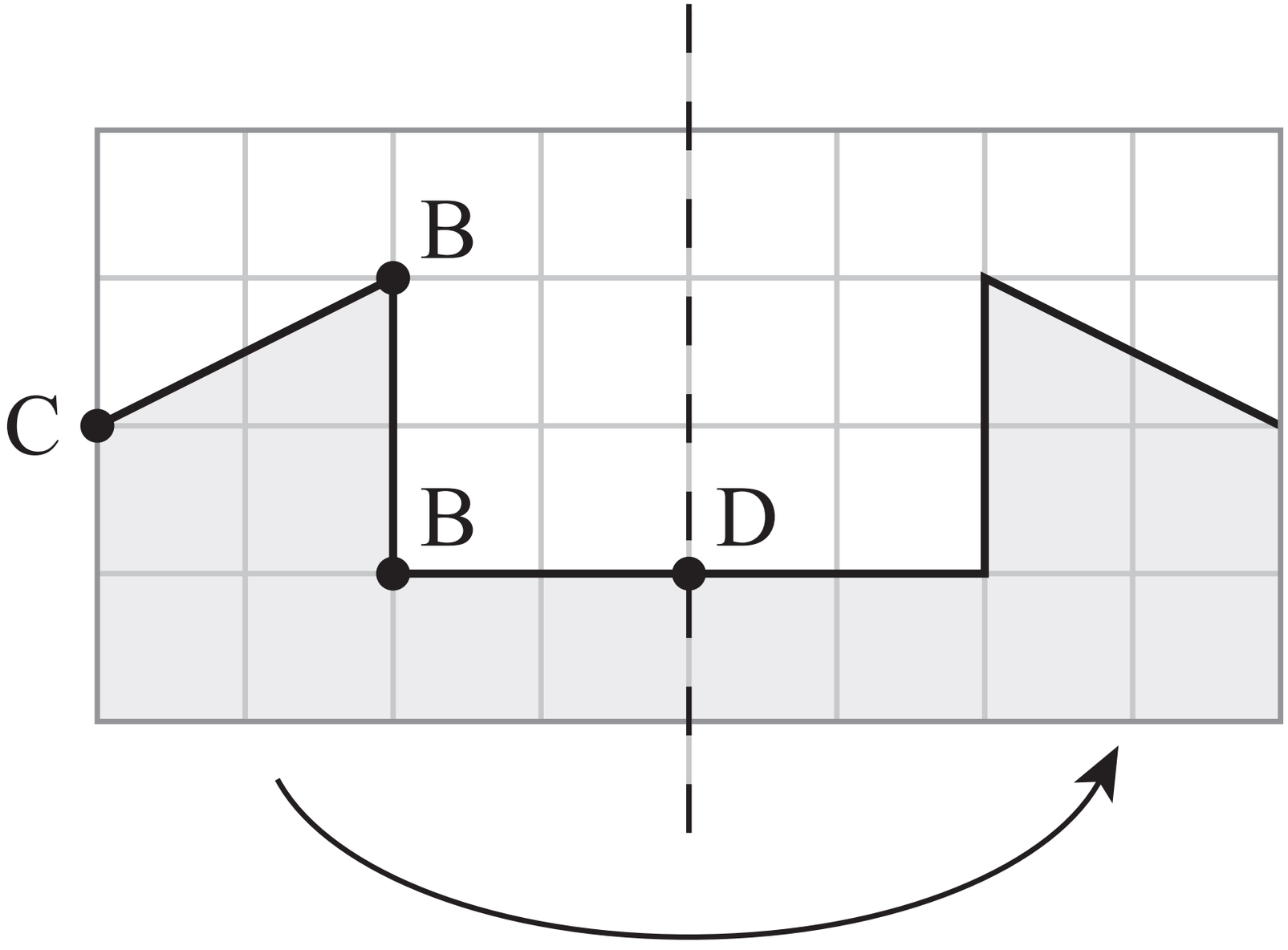


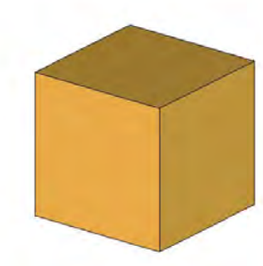
SECTIONS





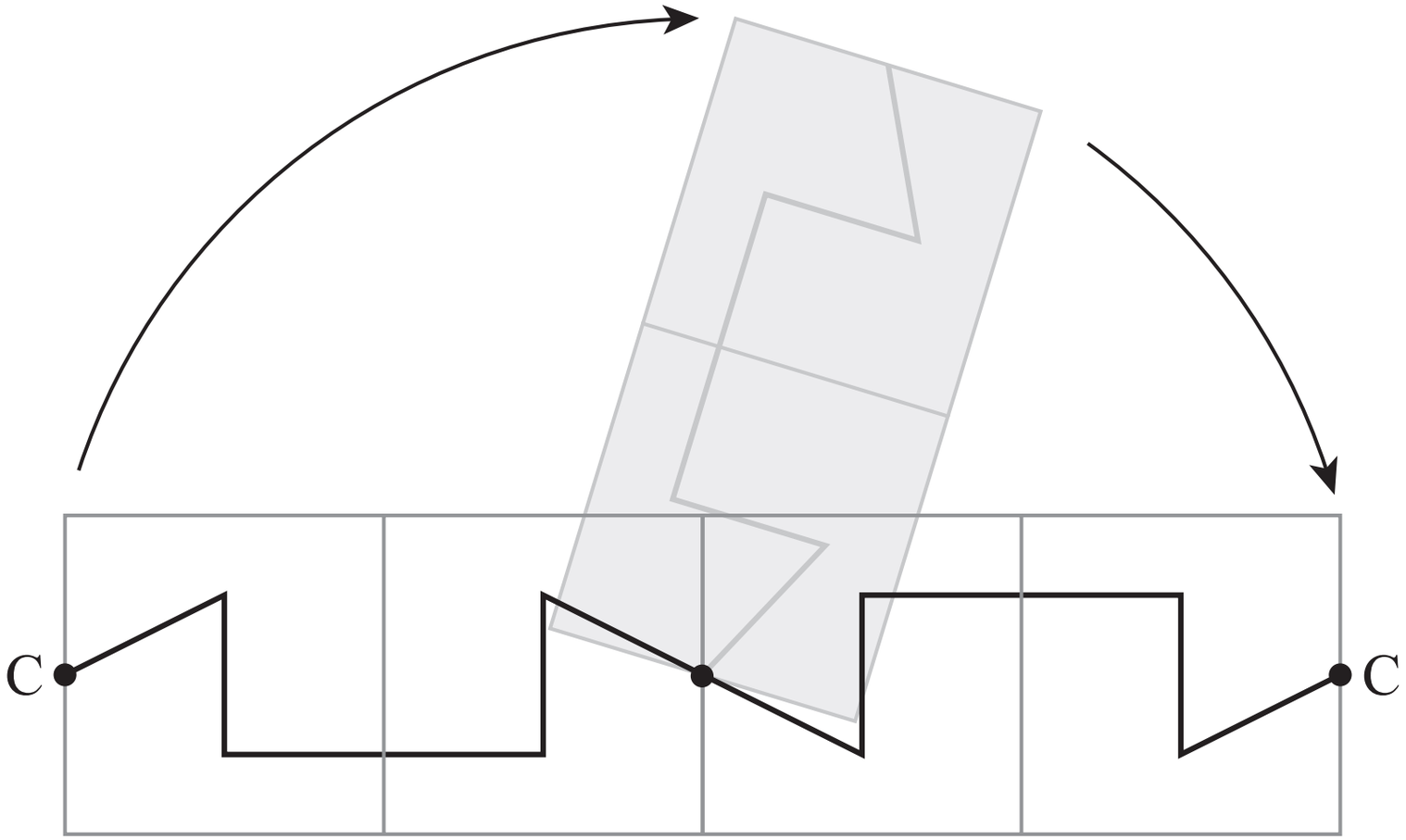
CUBE DIVIDED IN TWO PARTS

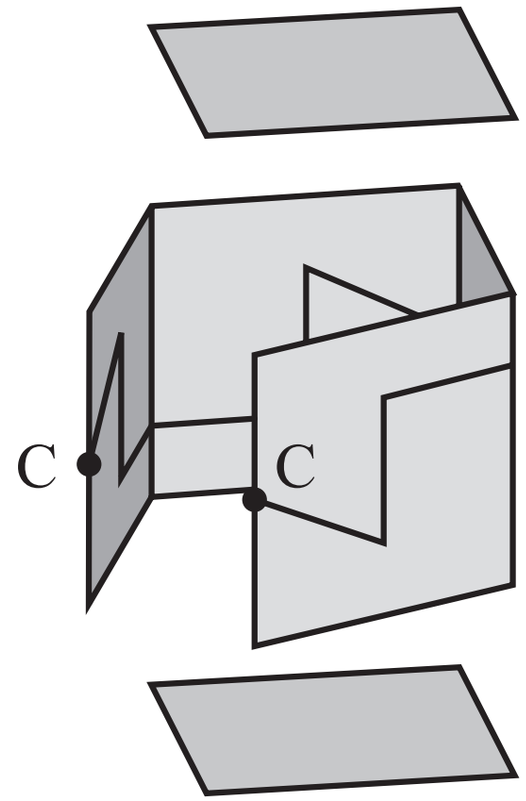




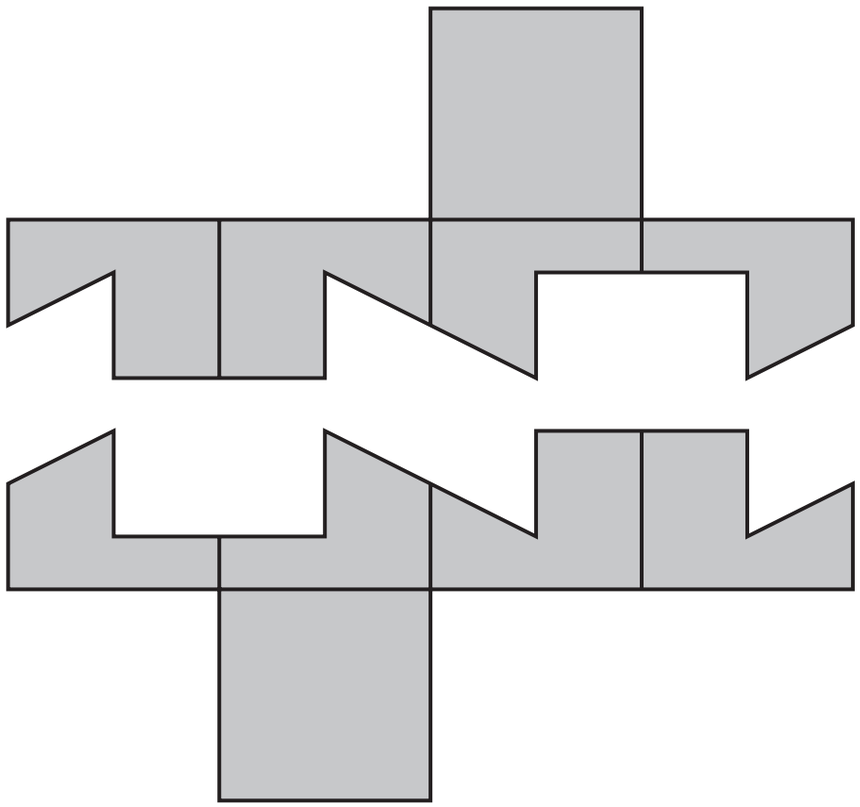
MIRROR SYMMETRY

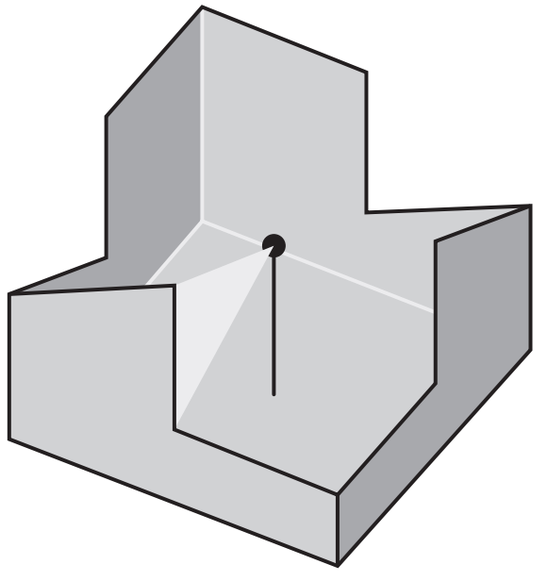
ROTATION OF 180°

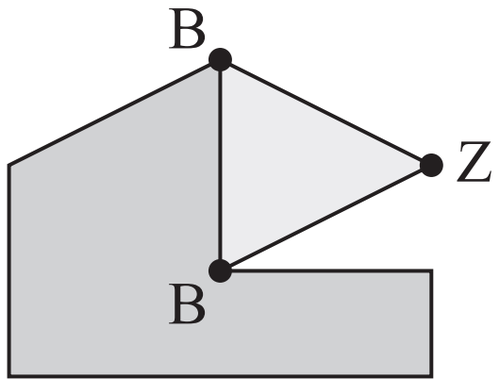


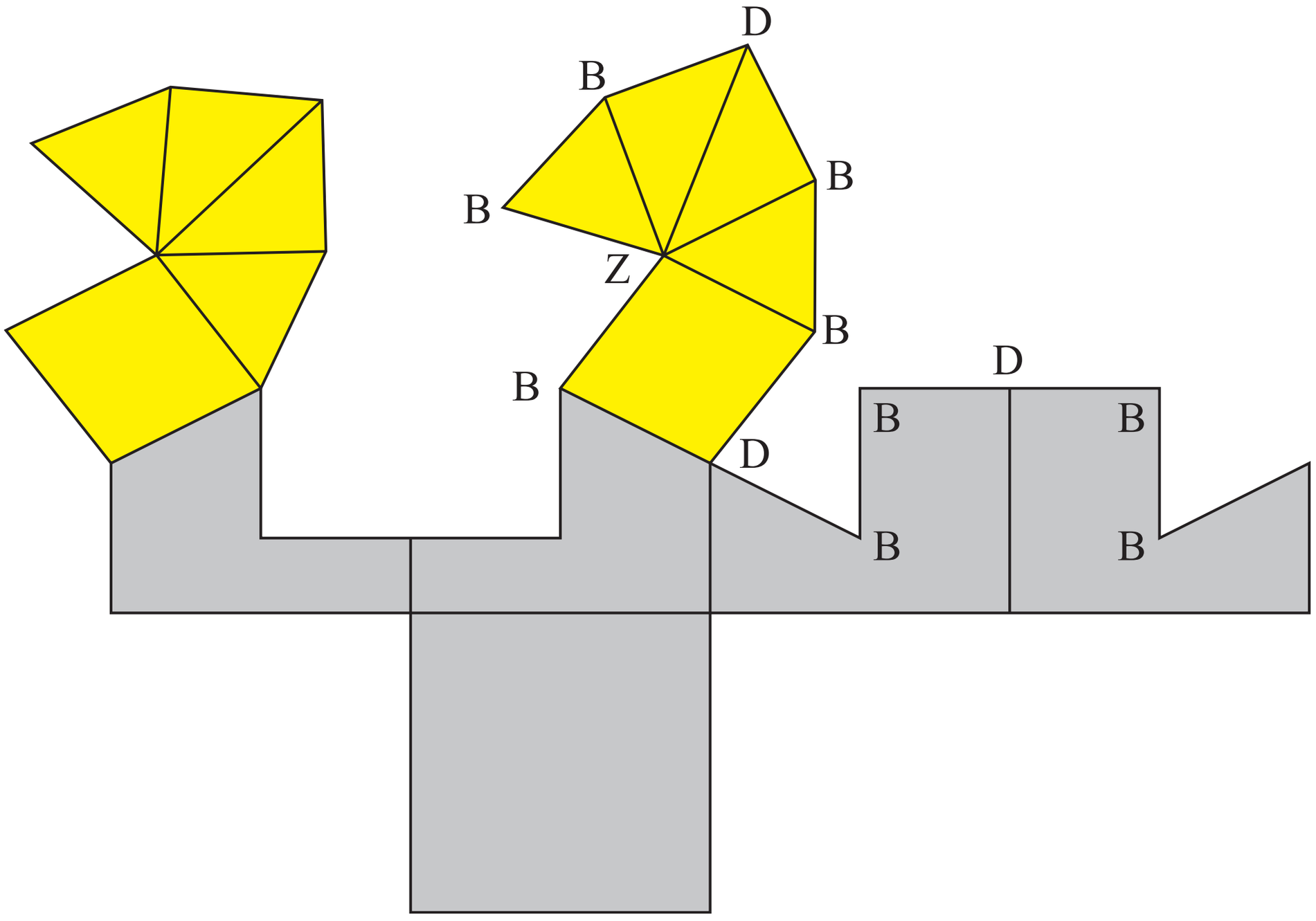


INTERNAL PLANES





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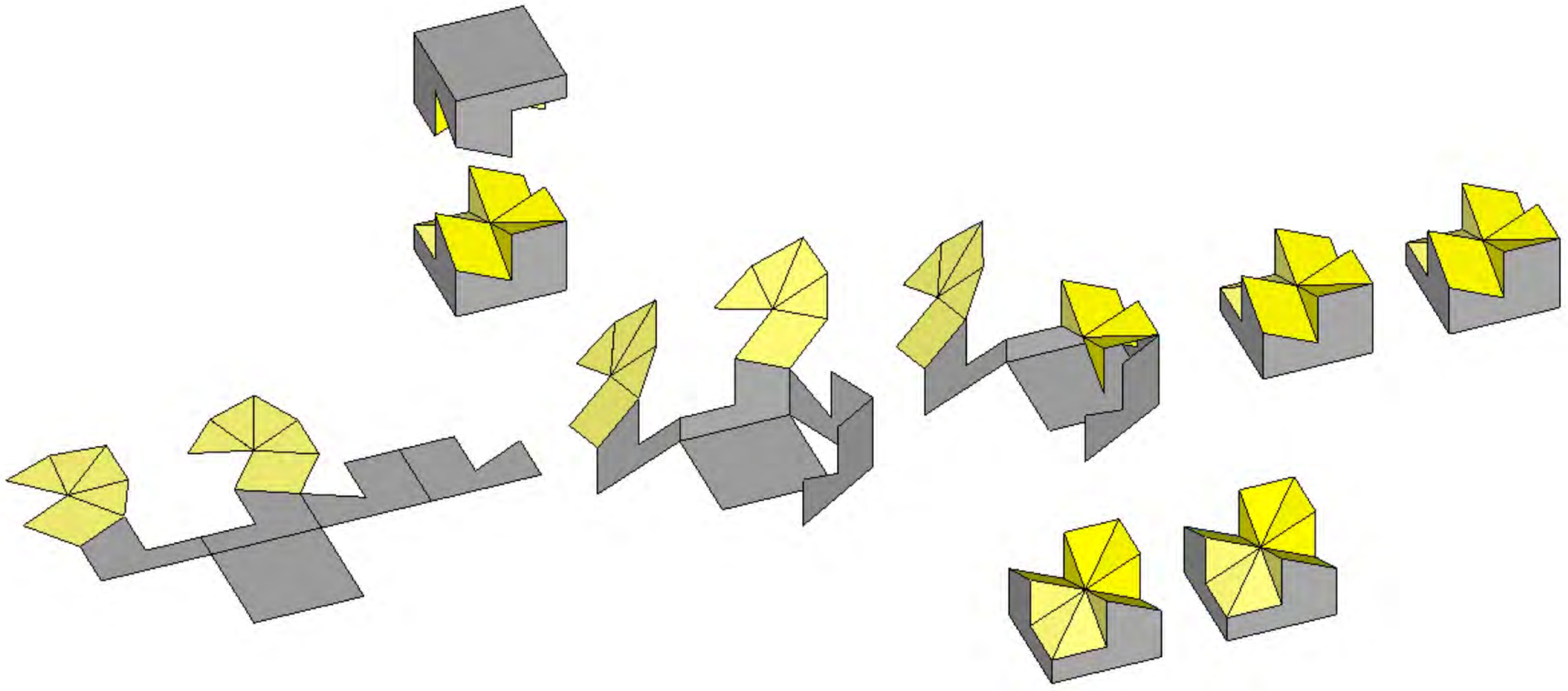
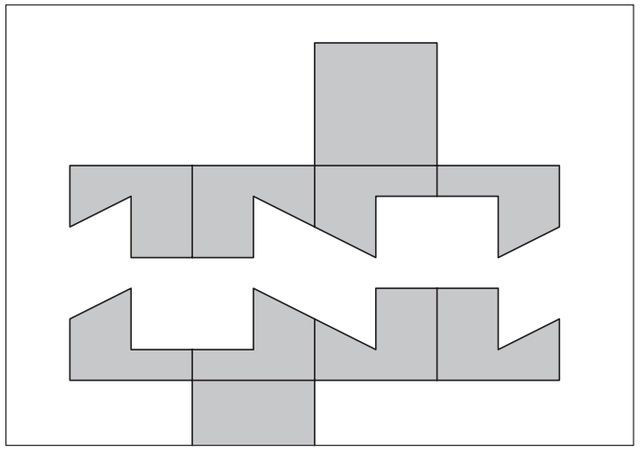
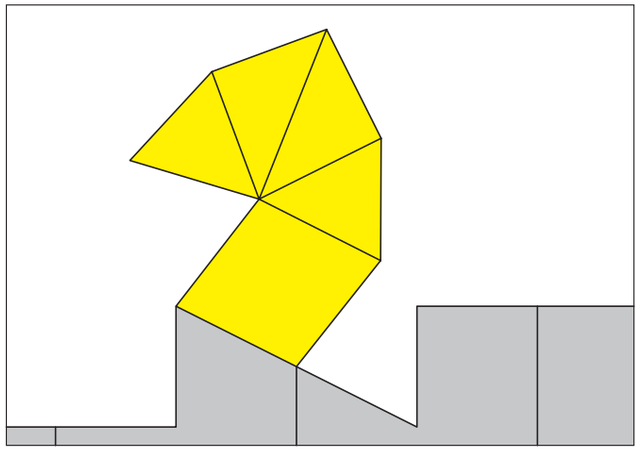
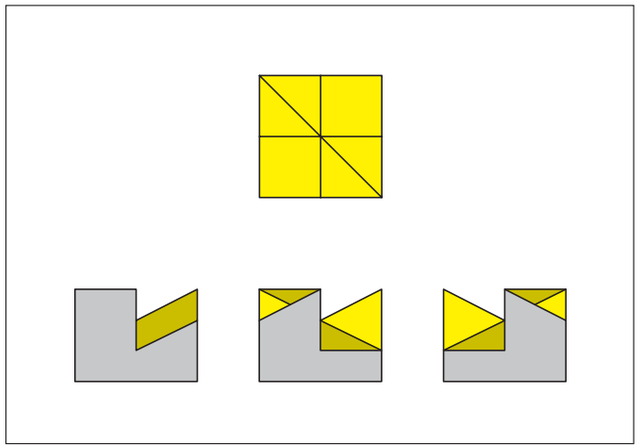
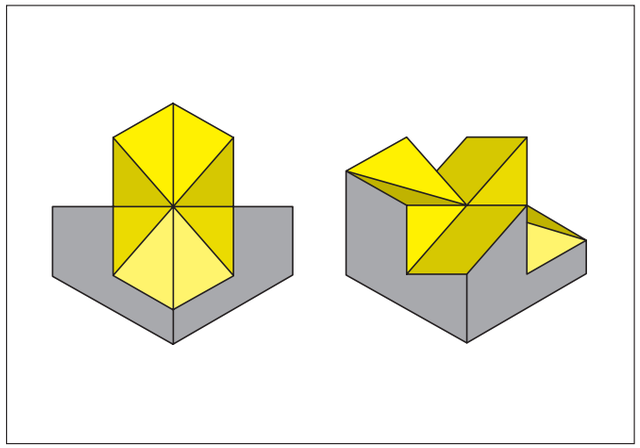
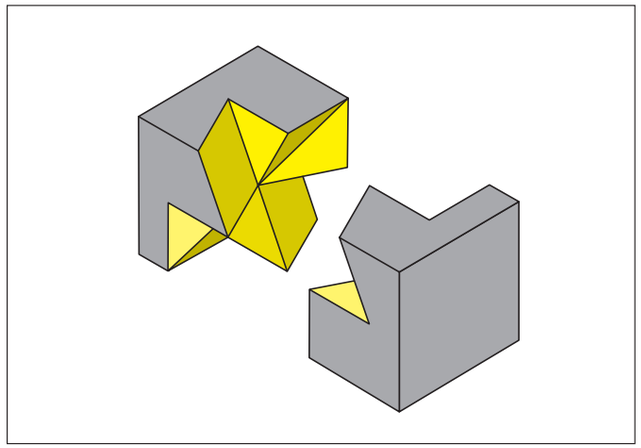




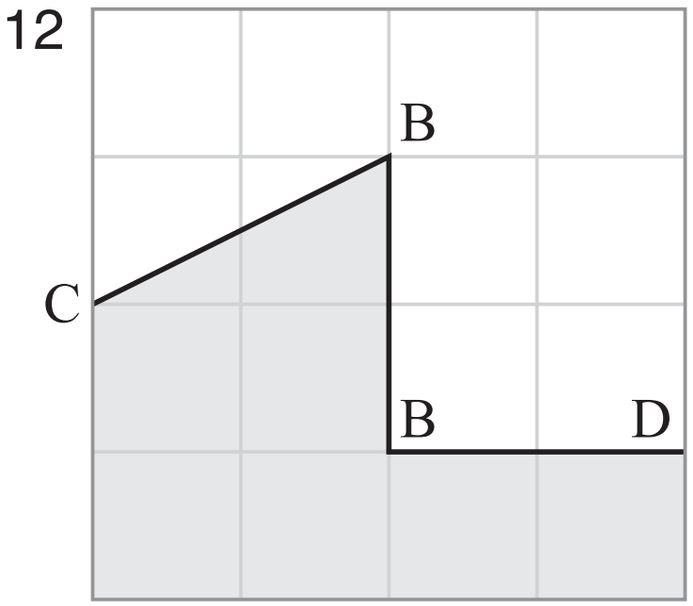


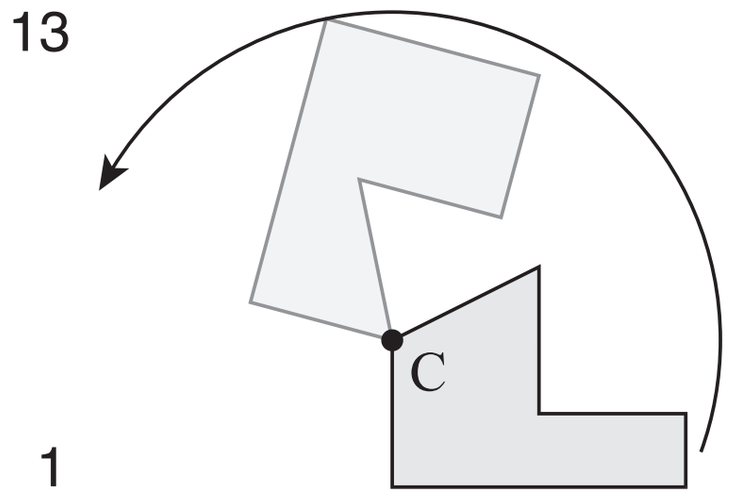


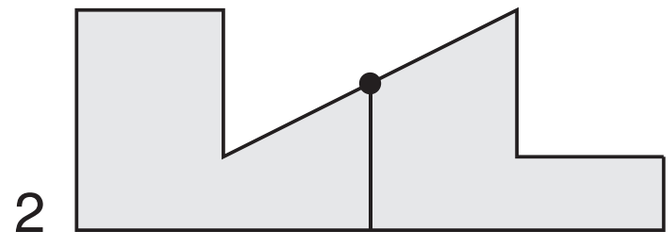




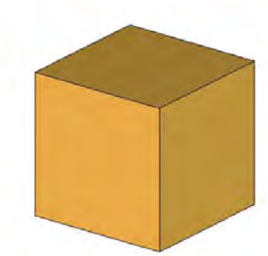
CUBE DIVIDED IN THREE PARTS







ROTATION OF 180°



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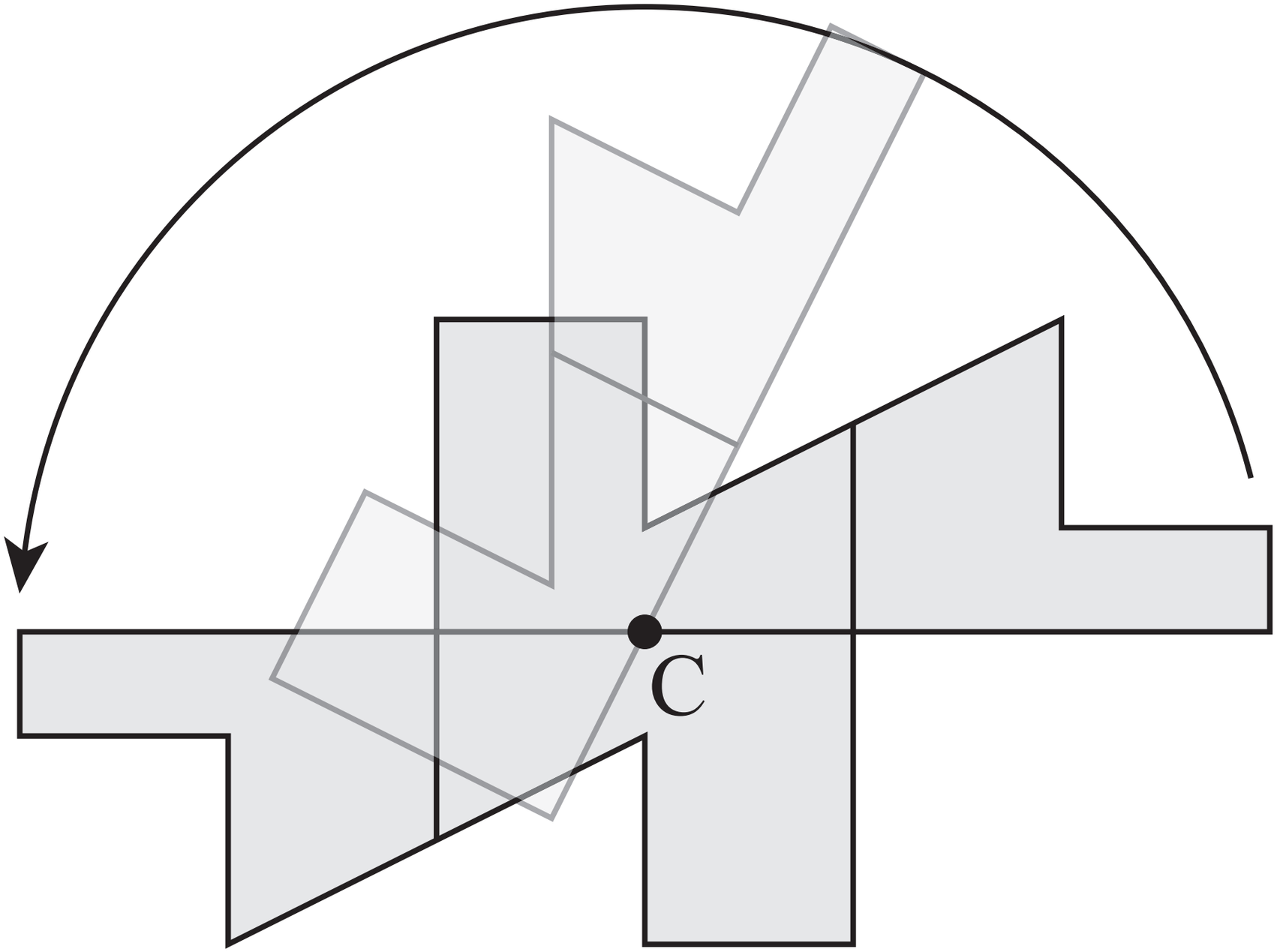
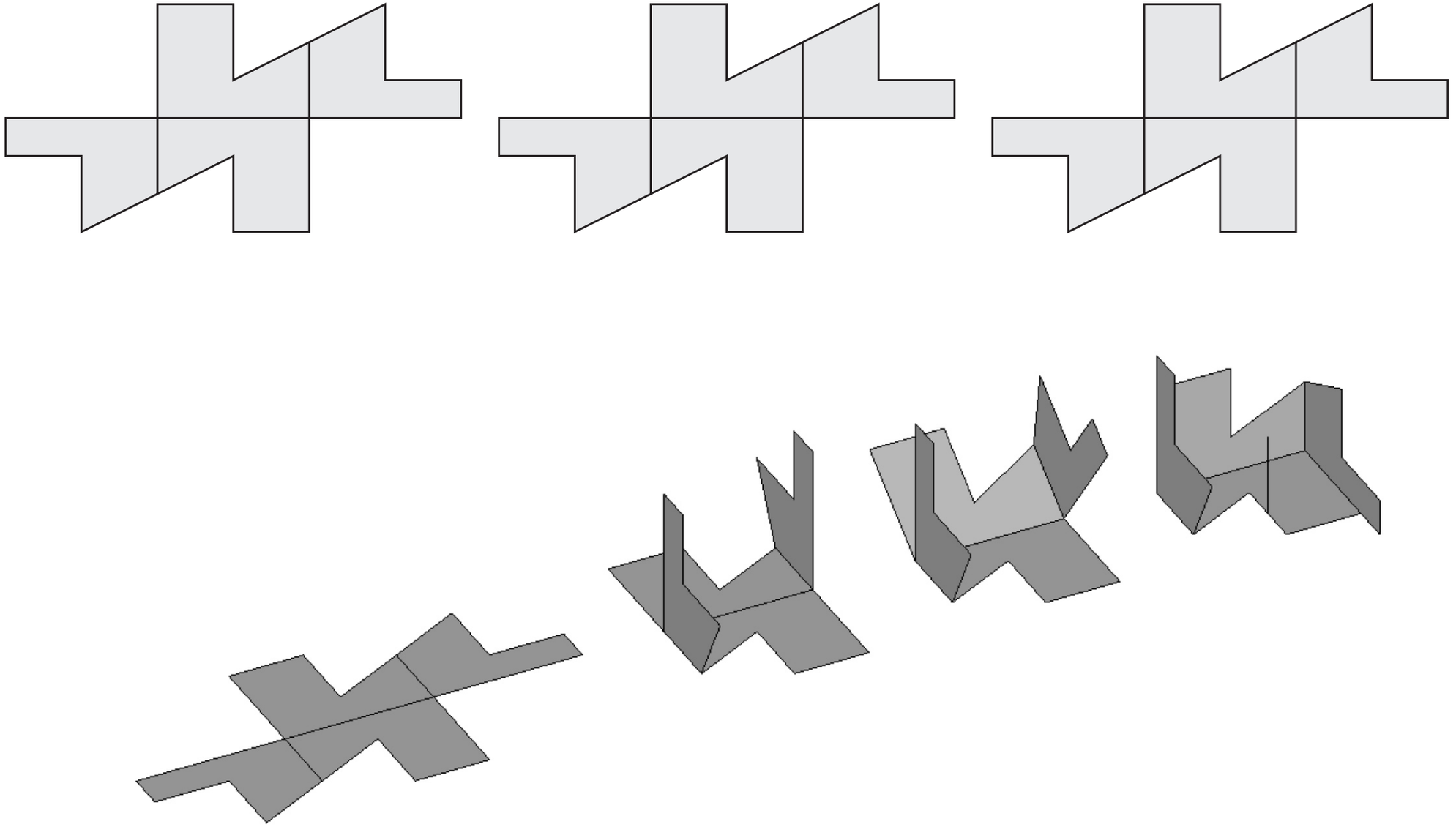
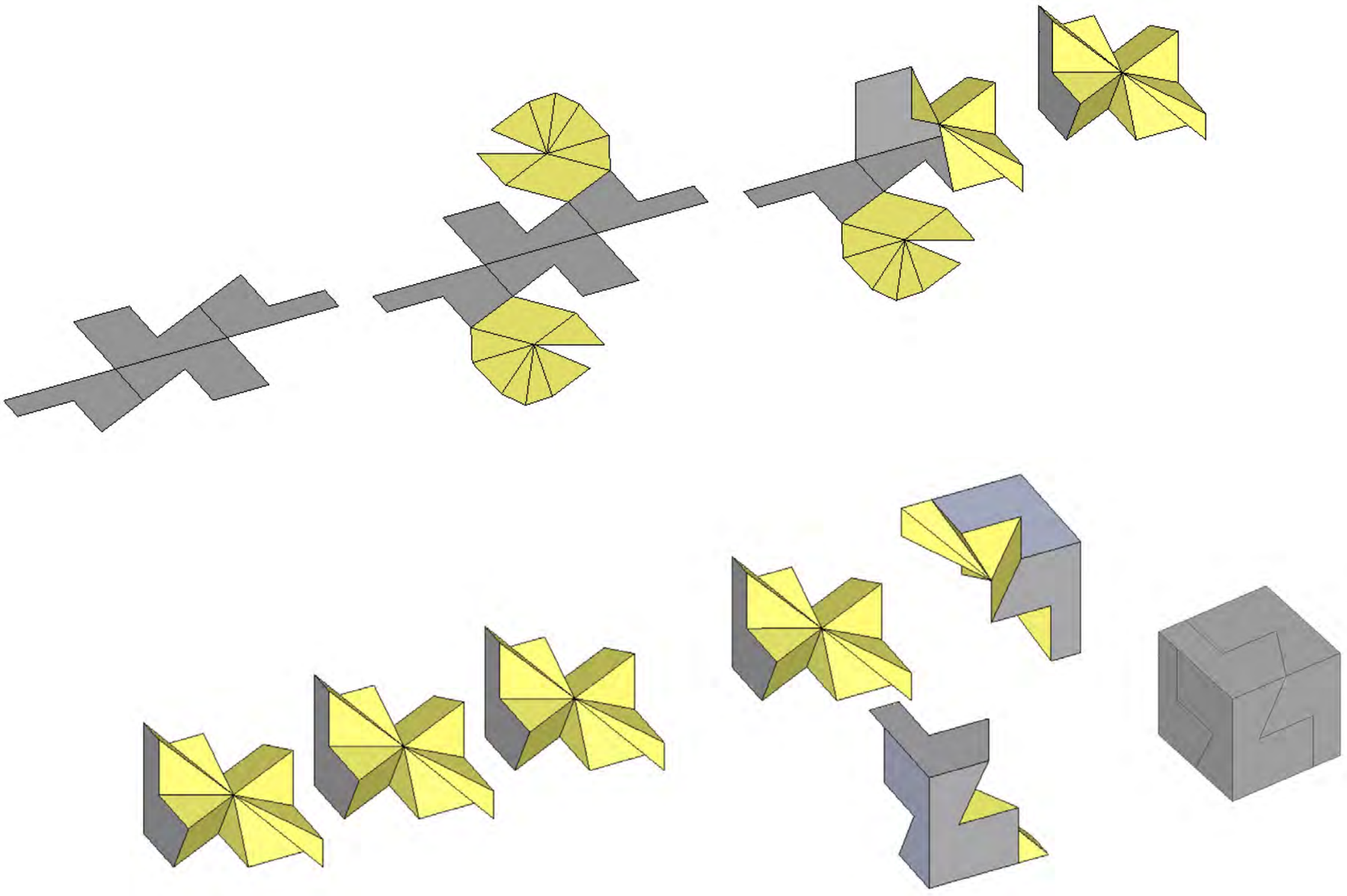
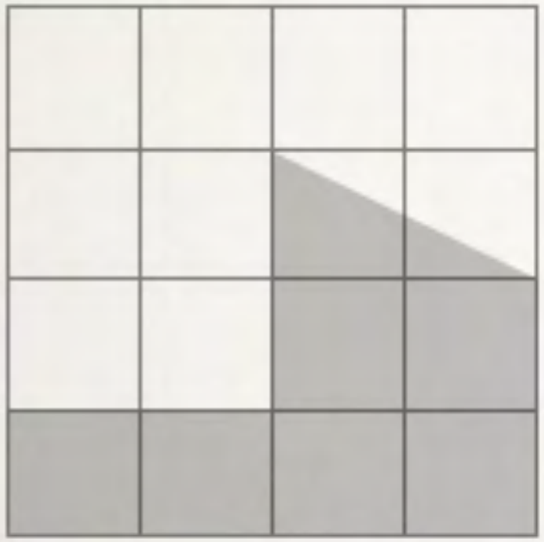
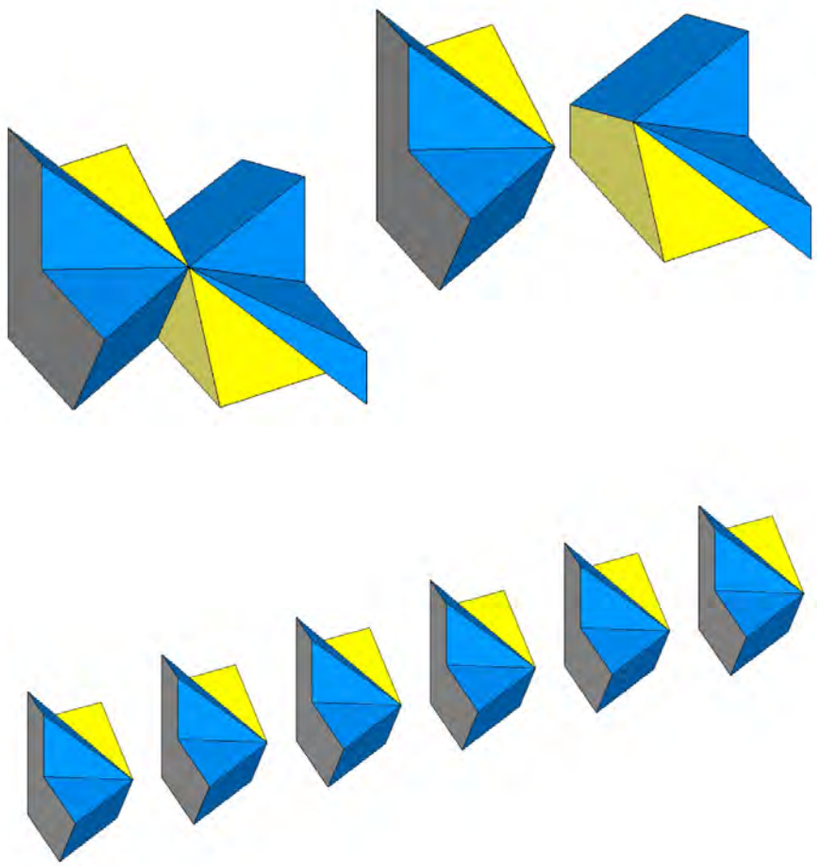








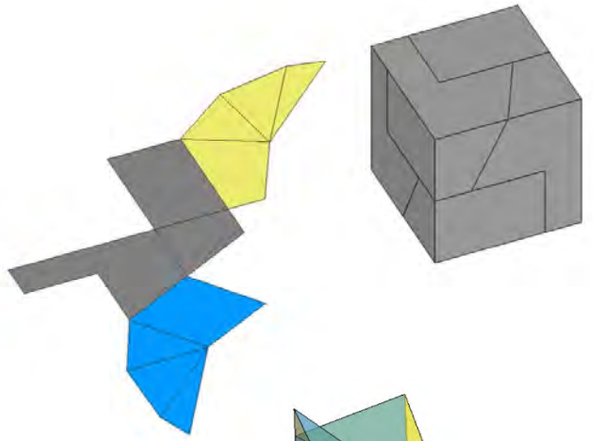
HINGES

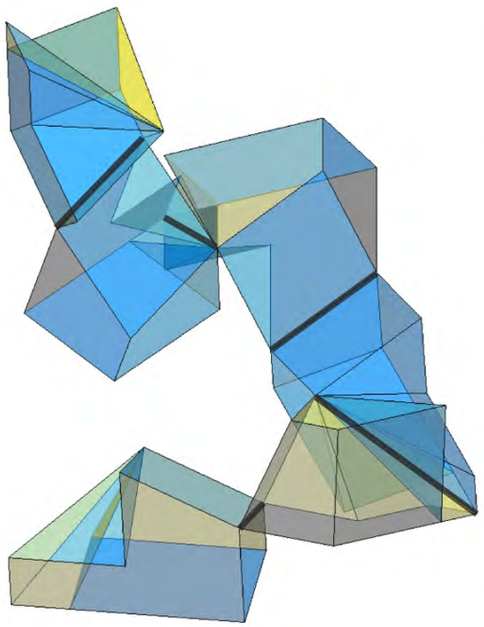


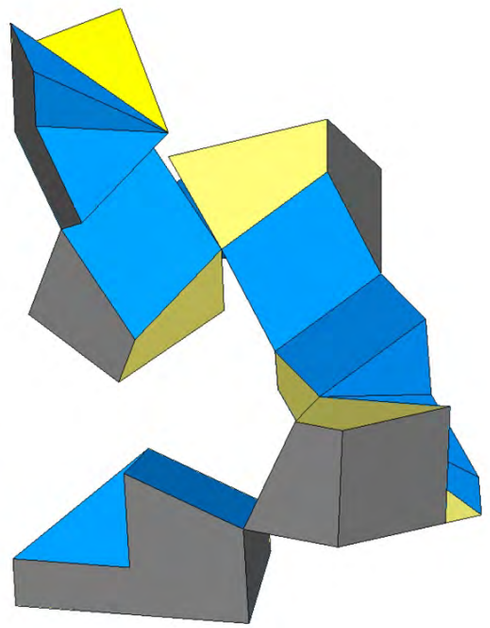
THE CHAINS OF PAIRS OF SPECULAR MODULES

1. The tetrahedron, the cube..., all polyhedra, can be considered as one of the numerous three-dimensional configurations resulting from the folding of flexible chains of modules.

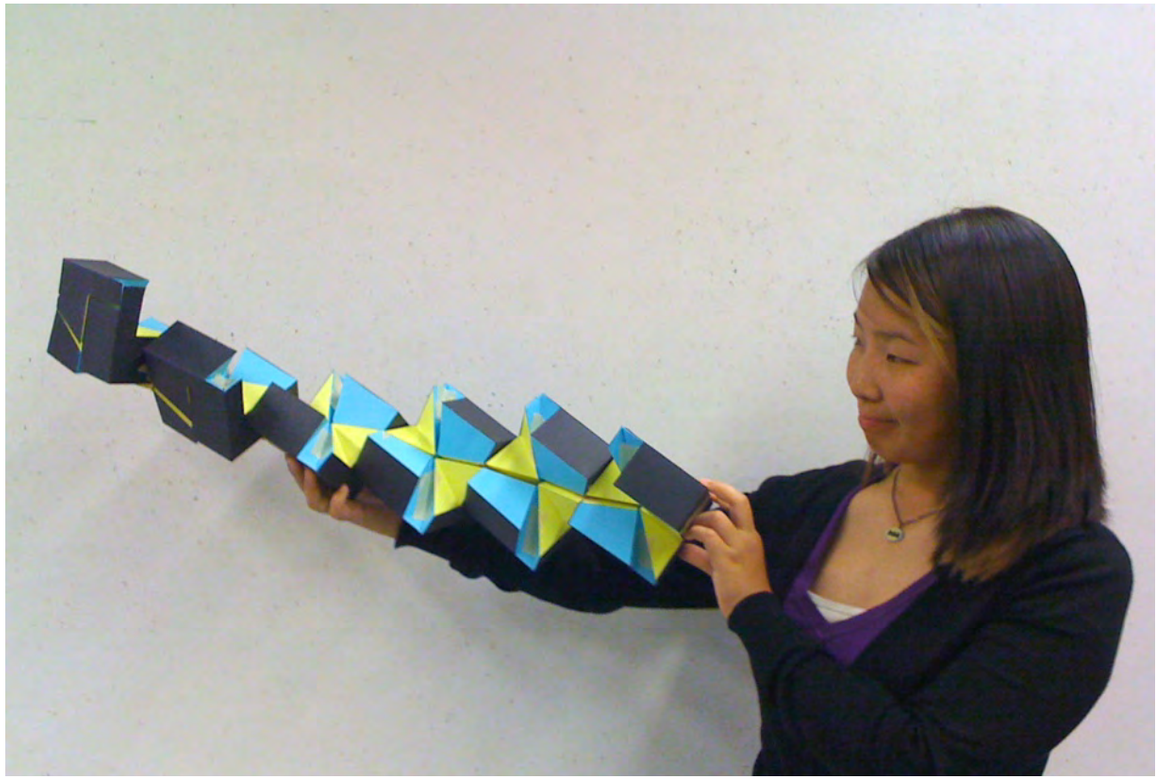
2. The chains are costituted by pairs of modules in which one component is the mirror image of the other.

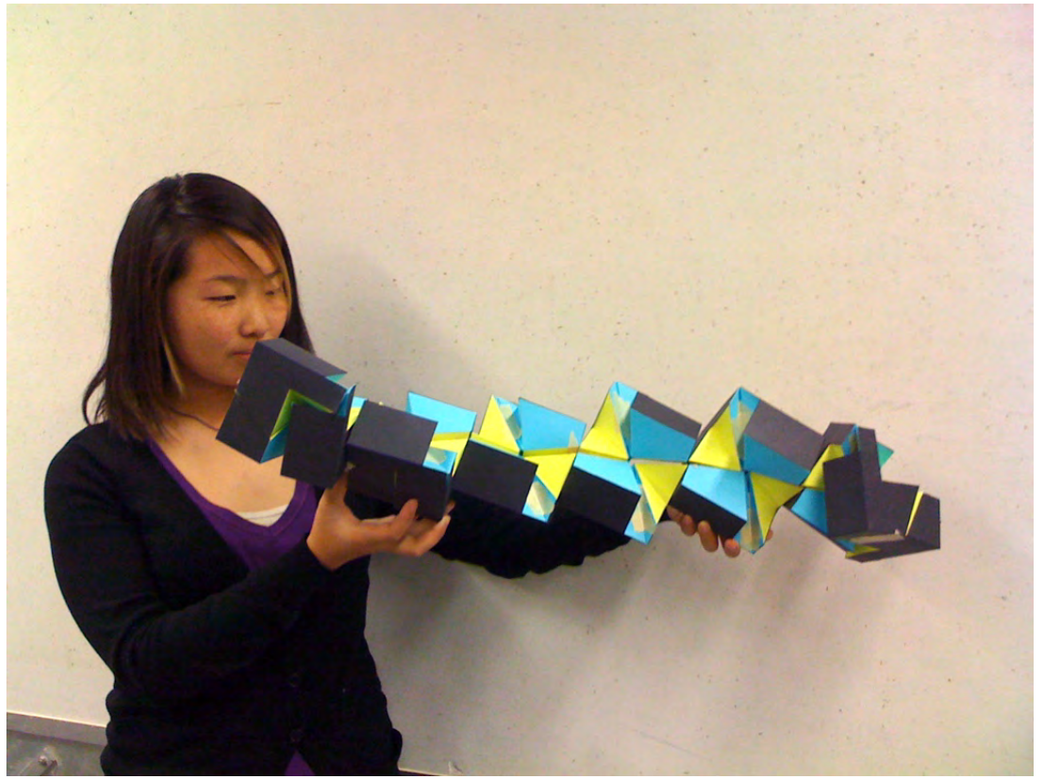


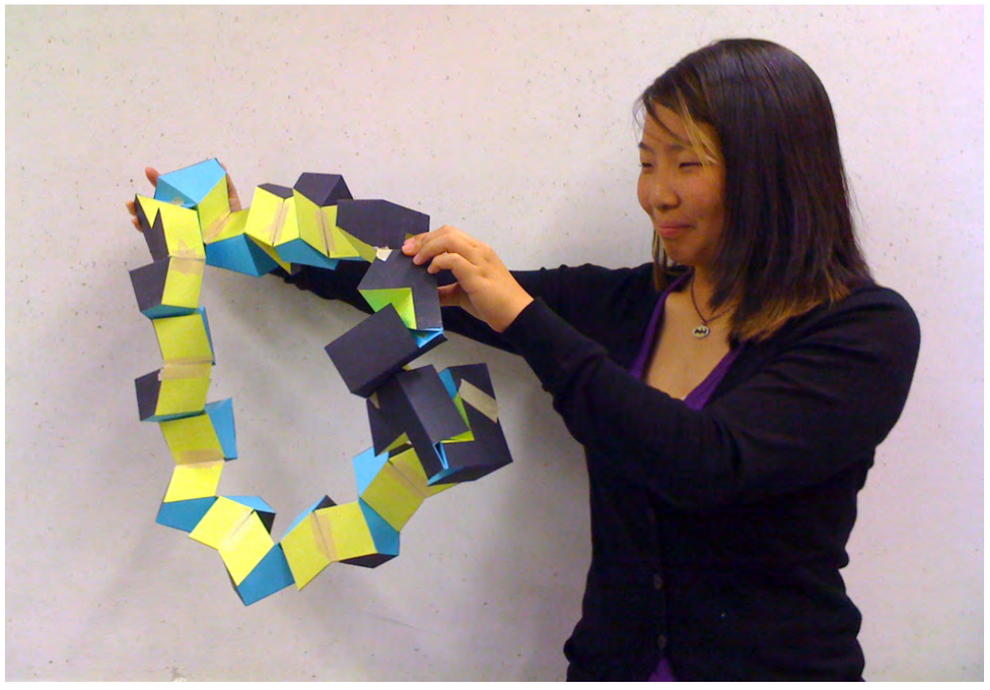




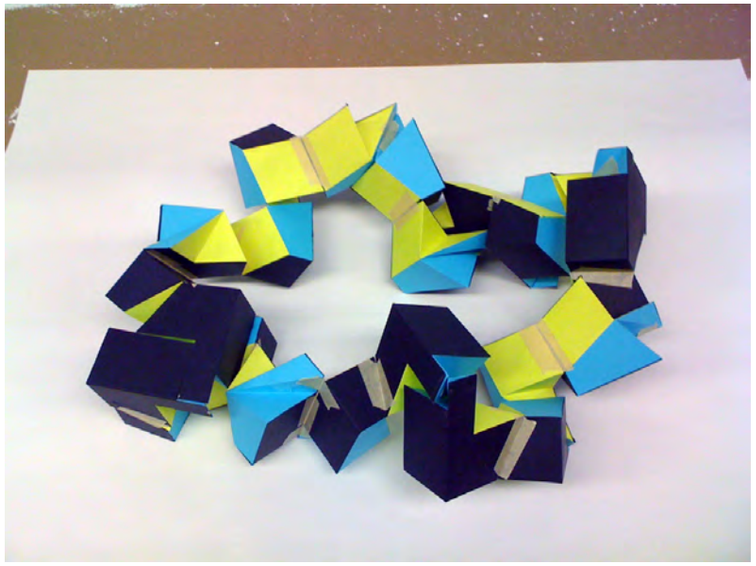
24-MODULE CHAIN

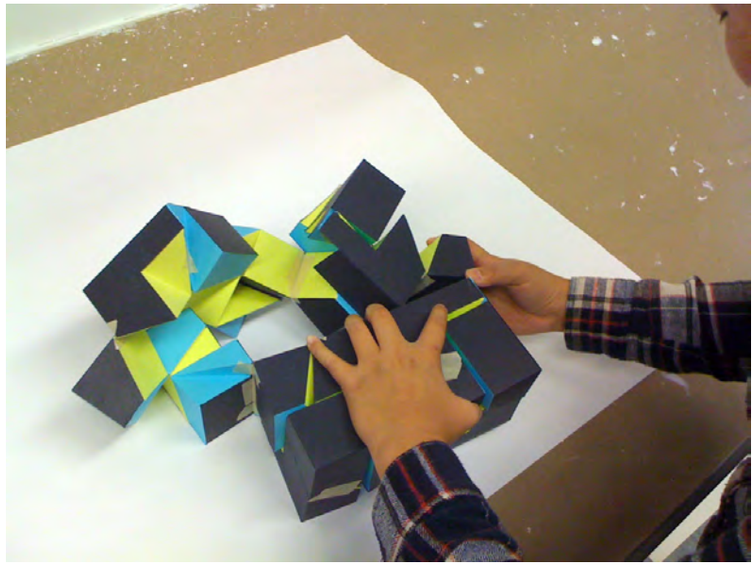


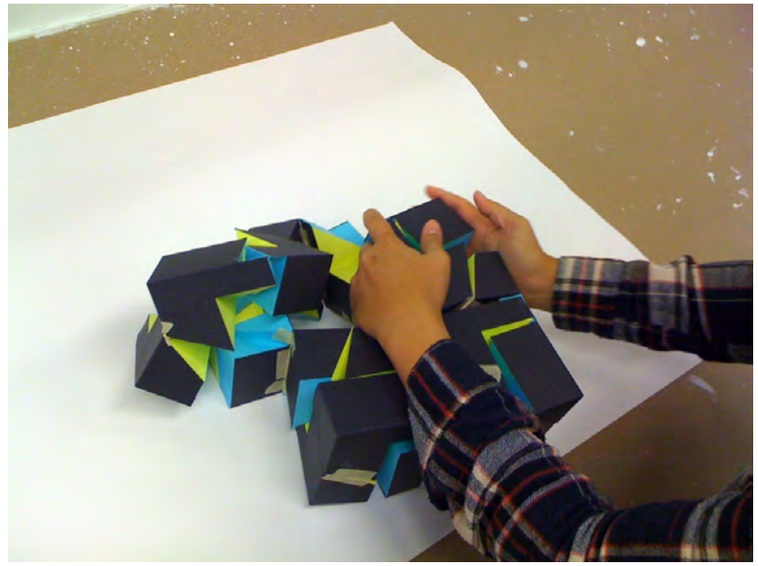


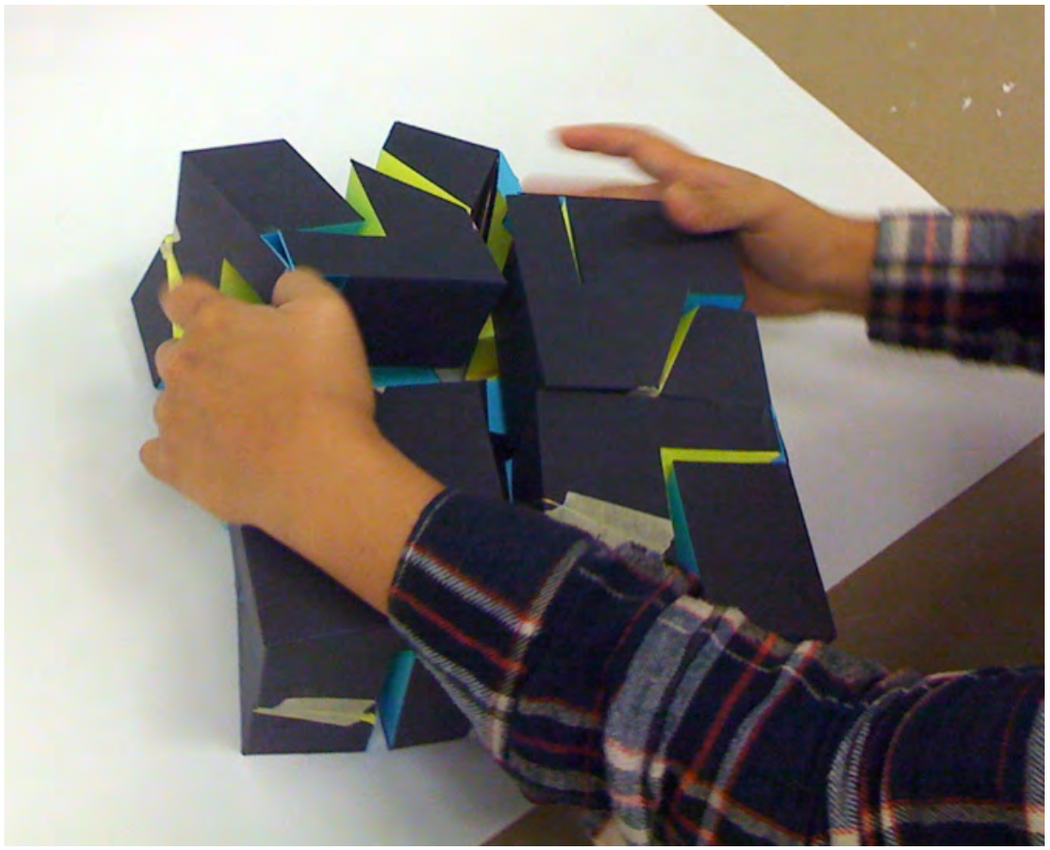


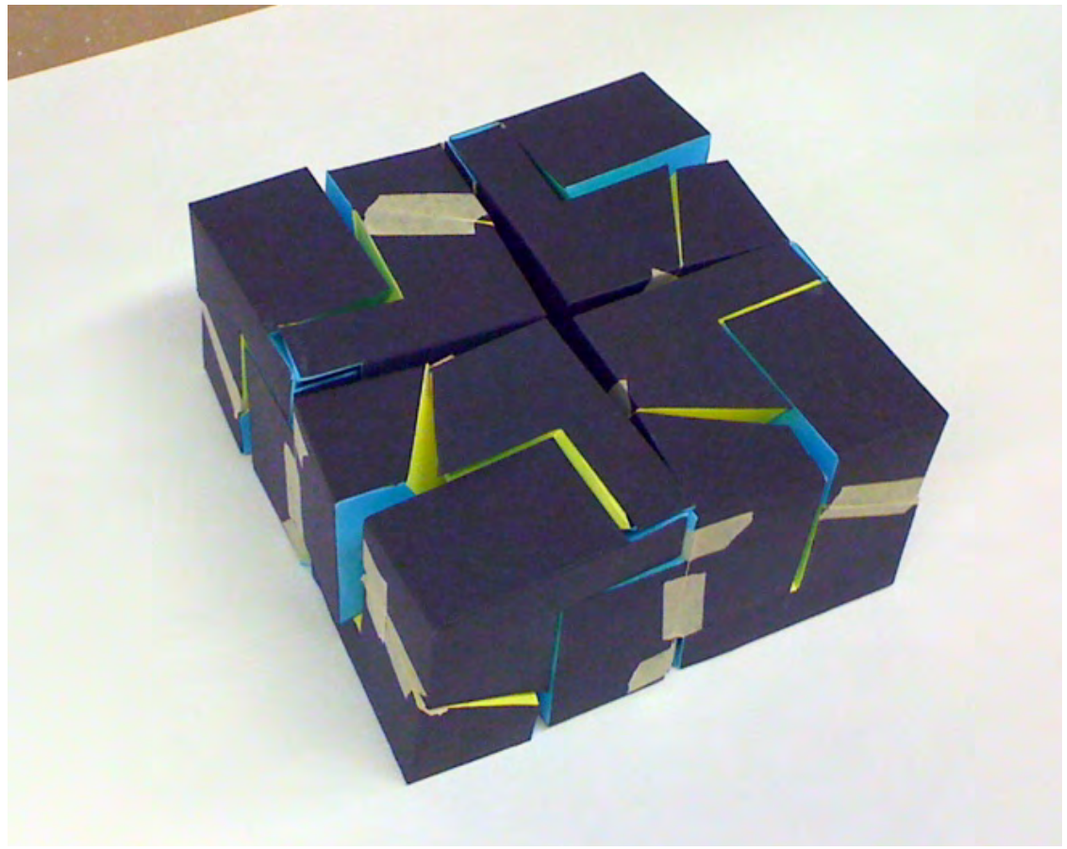
CHAIN DESIGN BY FLORENCE YUEN
SAN FRANCISCO STATE UNIVERSITY

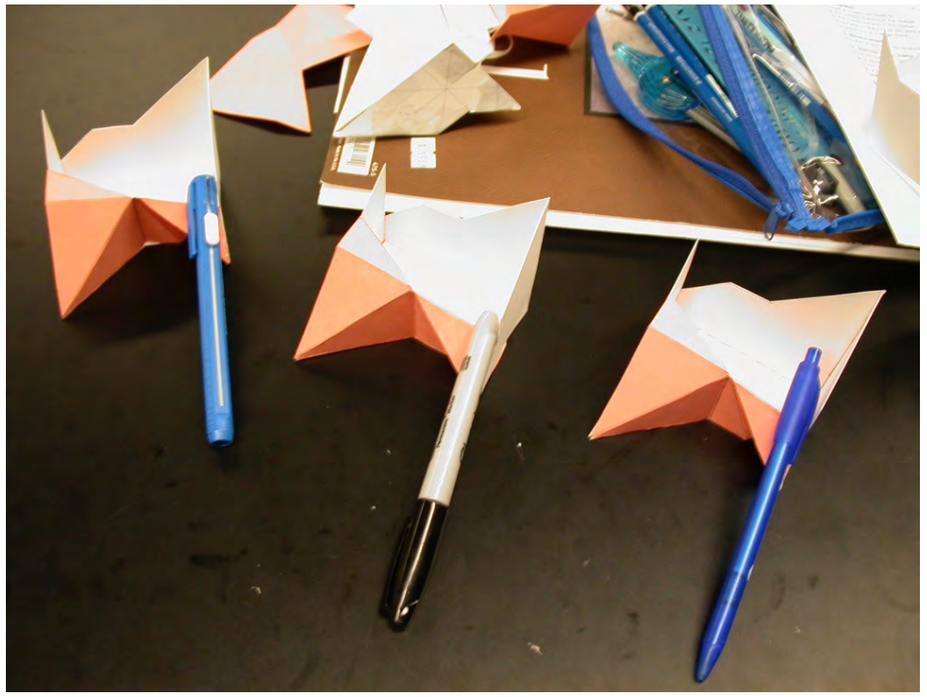


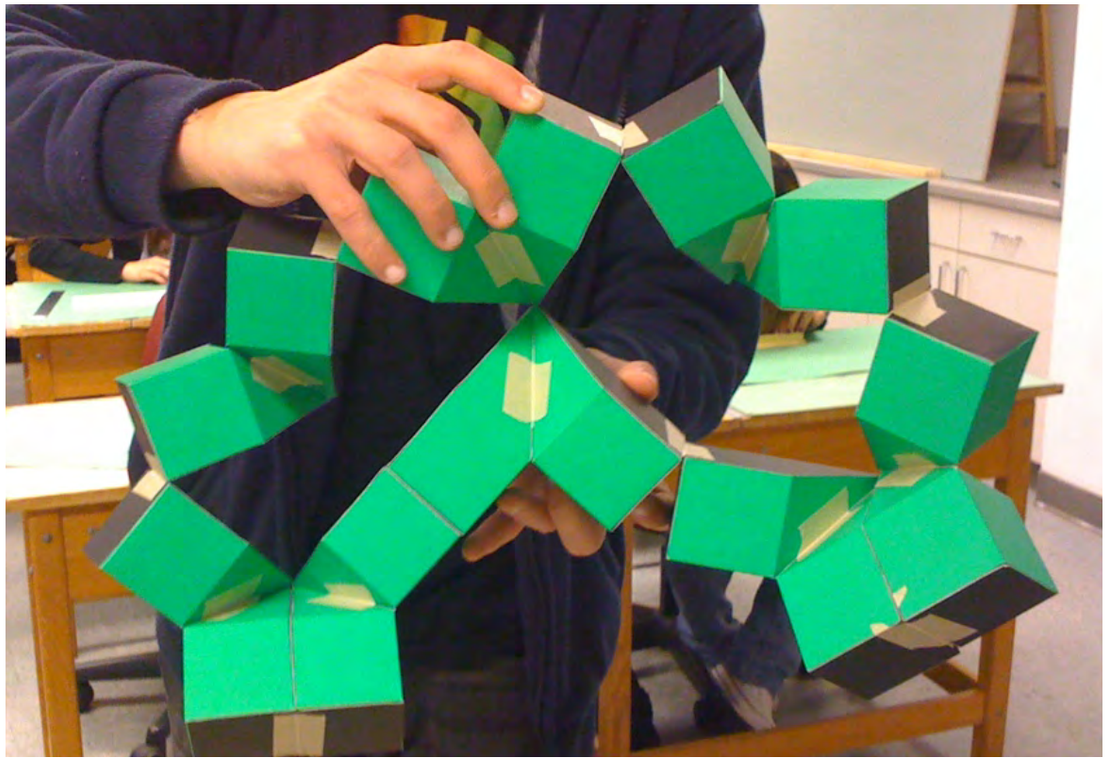








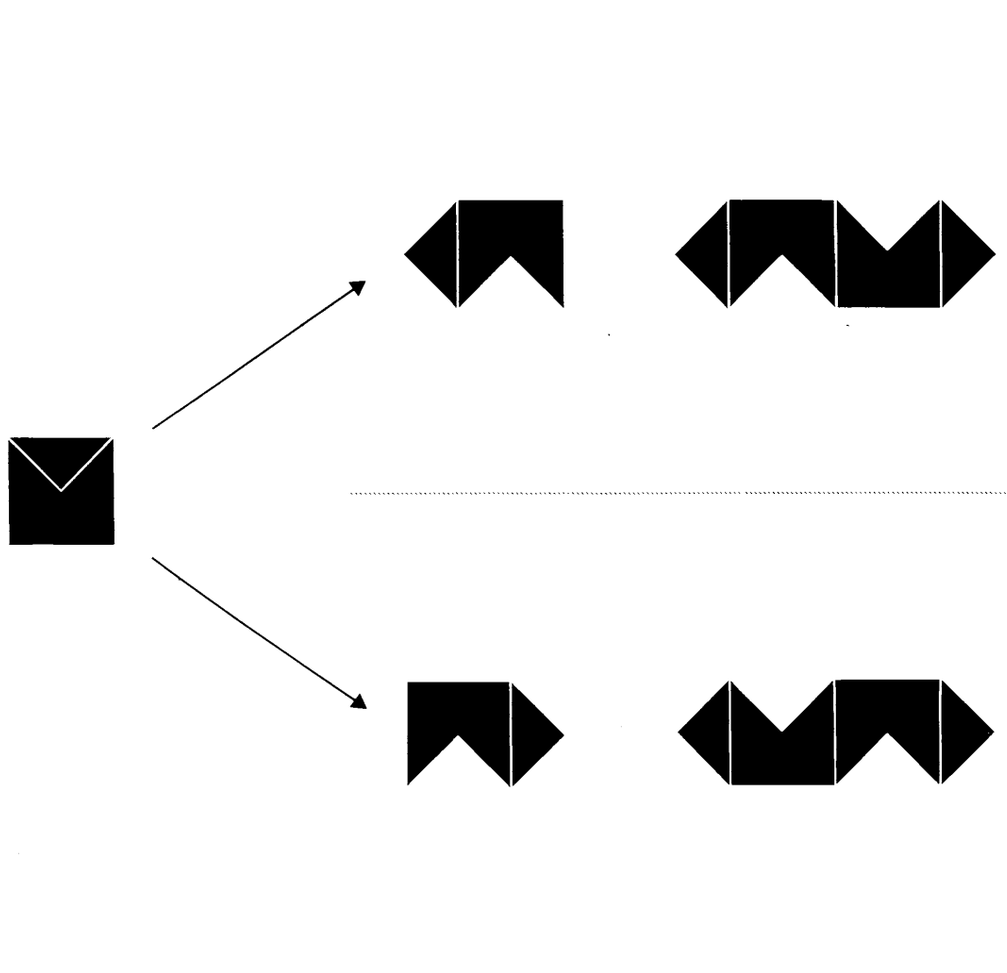




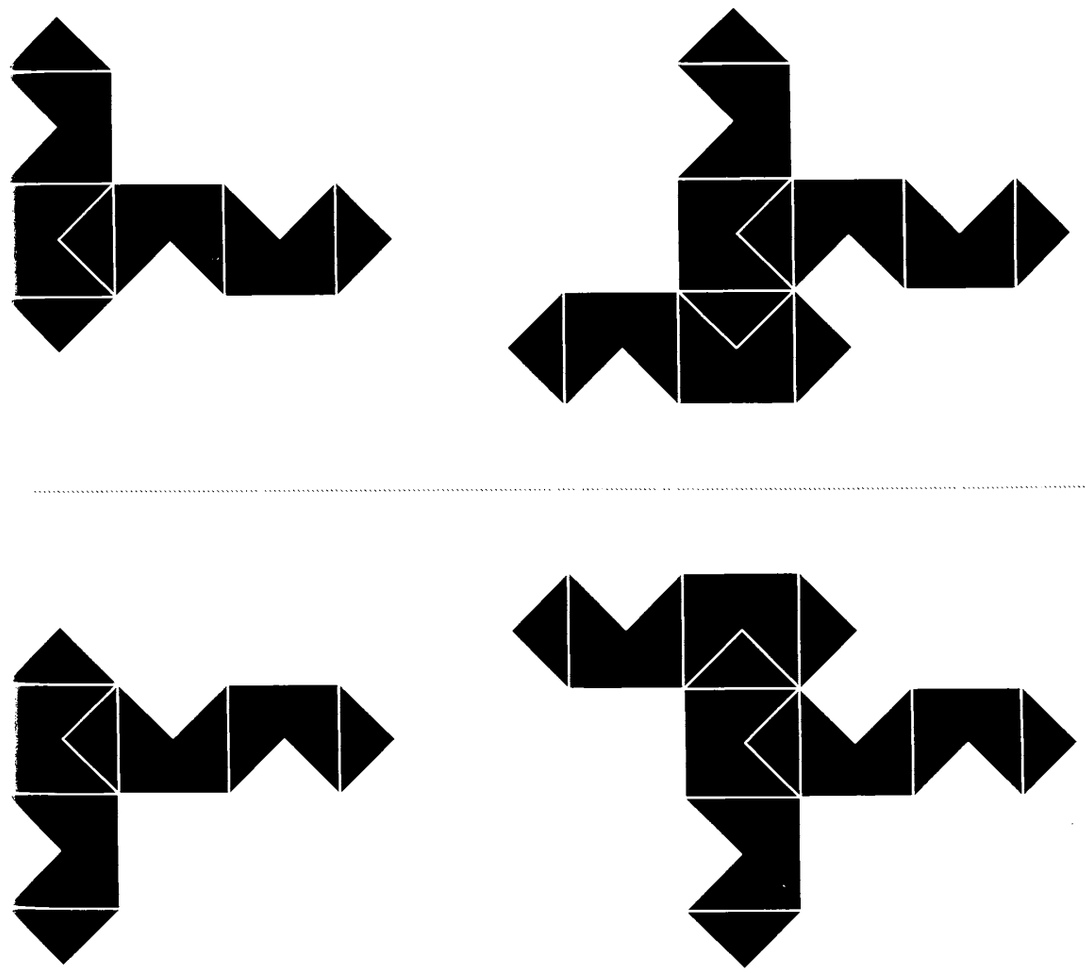
AN INVITATION TO EXPLORE

INITIAL STEPS

Overview example with eight configurations in fold-out progression, laid out in two sequences, one to the right and one to the left.



24

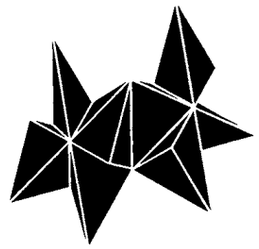


25

CONSTRUCTION OF A CHAIN

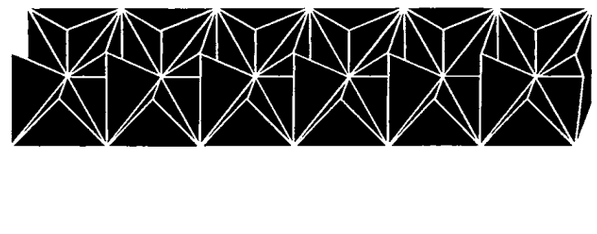
CONSTRUCTION OF A CHAIN

A practical way to realize a hinge consists in joining the modules together with a little piece of scotch tape.

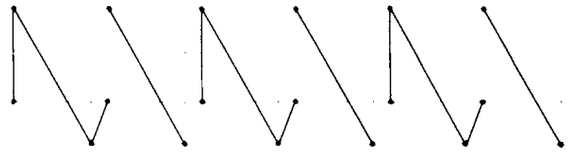


Coupling.

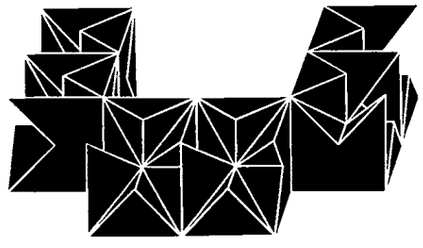
By connecting together six pairs (twelve modules) we contruct a chain.



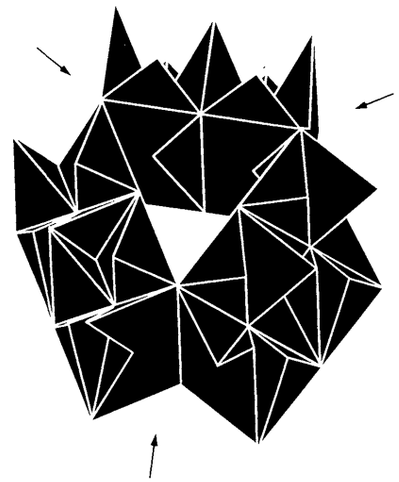
Let's now dispose the modules on a line, following the montage scheme that indicates the spatial position of the hinges.



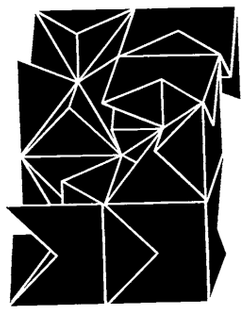
Connecting the first and last of the modules the chain will spontaneously dispose itself in the simplest obtainable form of closed chain: the closed chain with a triangular configuration.

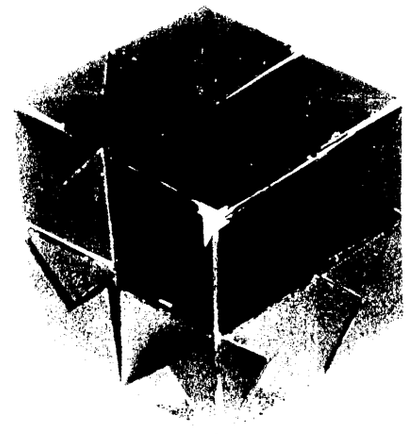


By applying, at the same time, a light pressure on the points indicated by the arrows,



the chain will assume a cubic form.





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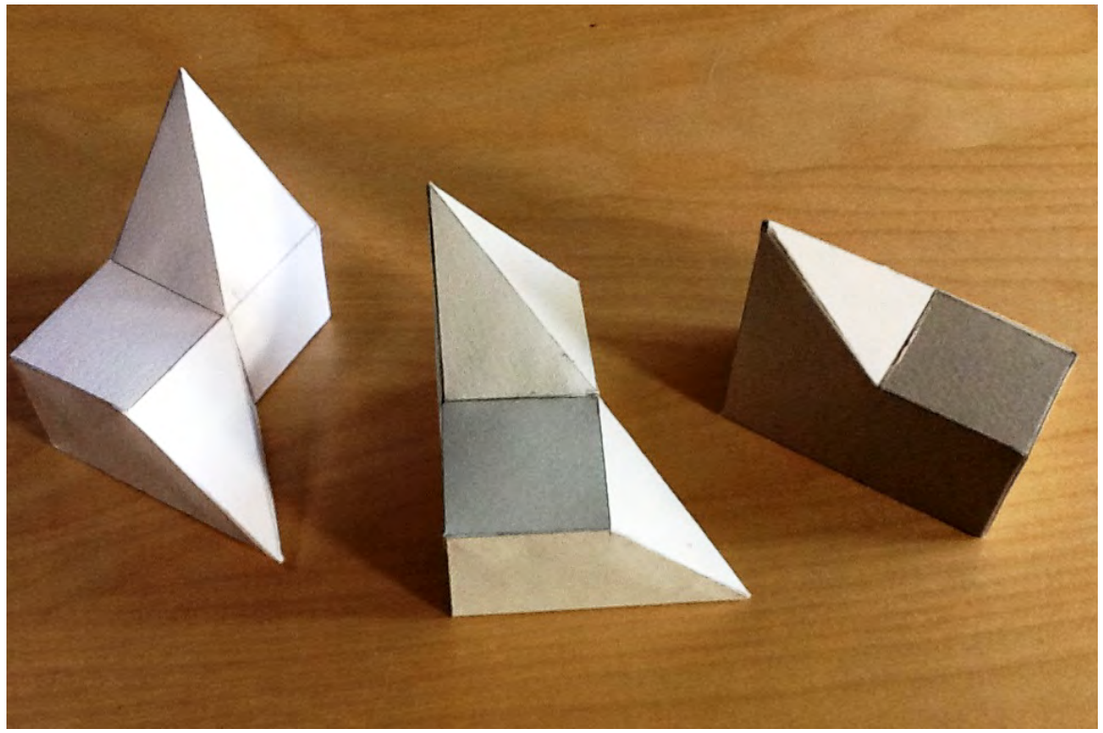
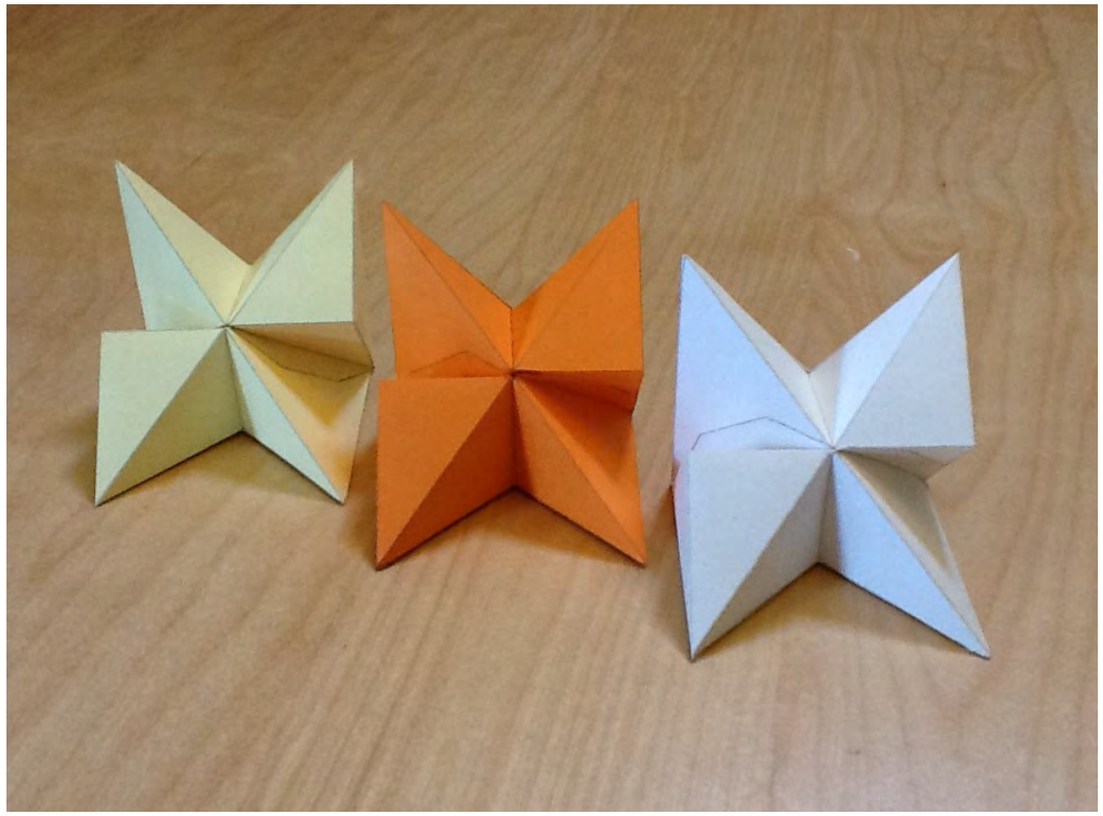
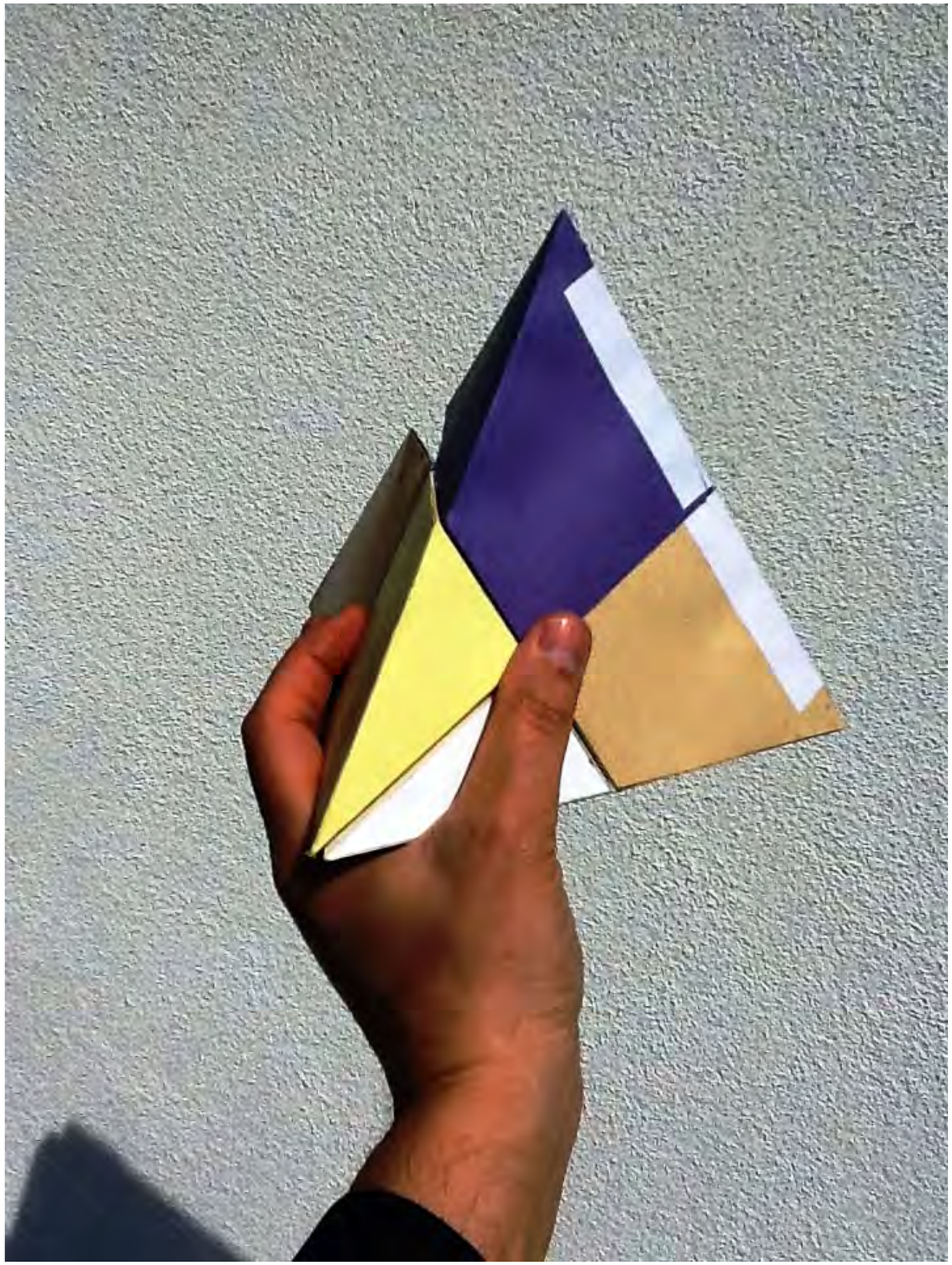
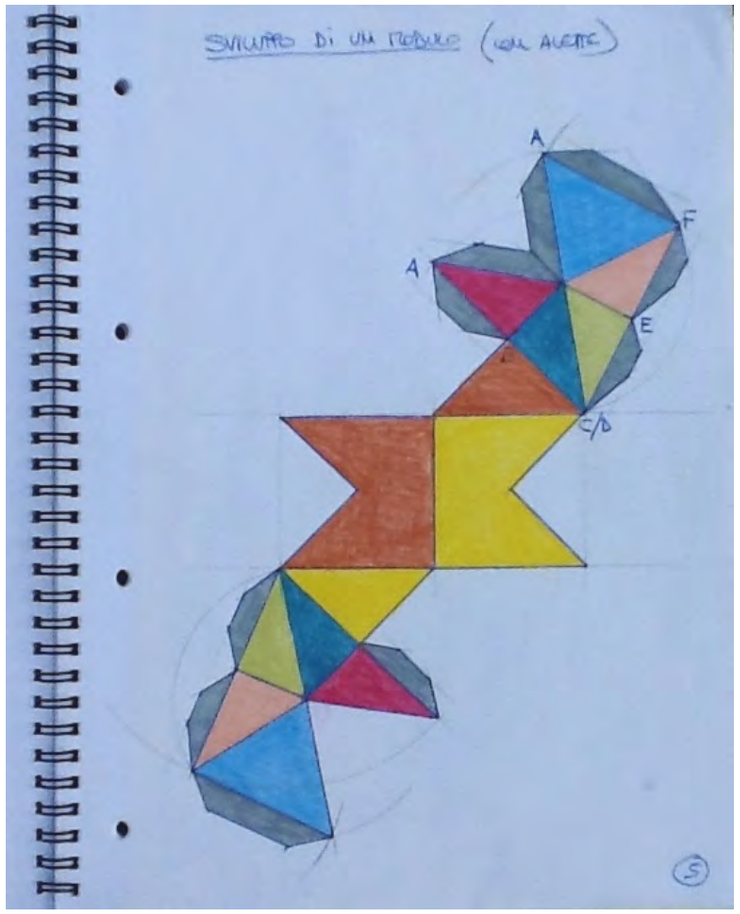
MODELS BUILT BY MIDDLE SCHOOL STUDENTS – OFFANENGO, ITALY

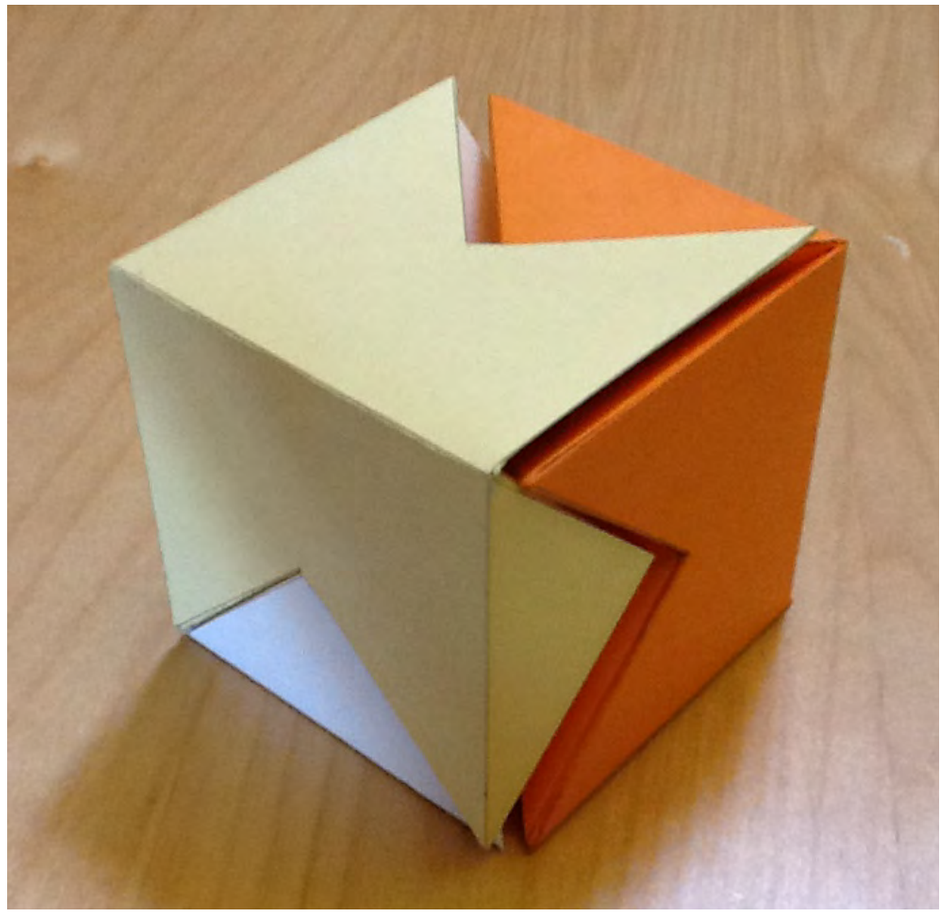


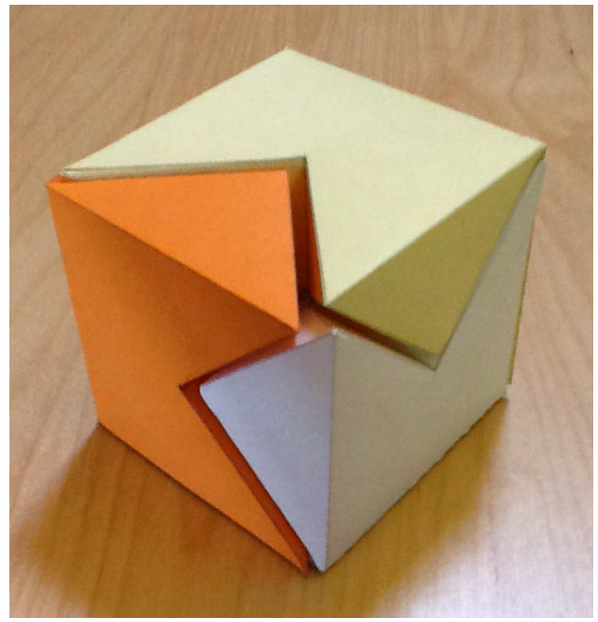


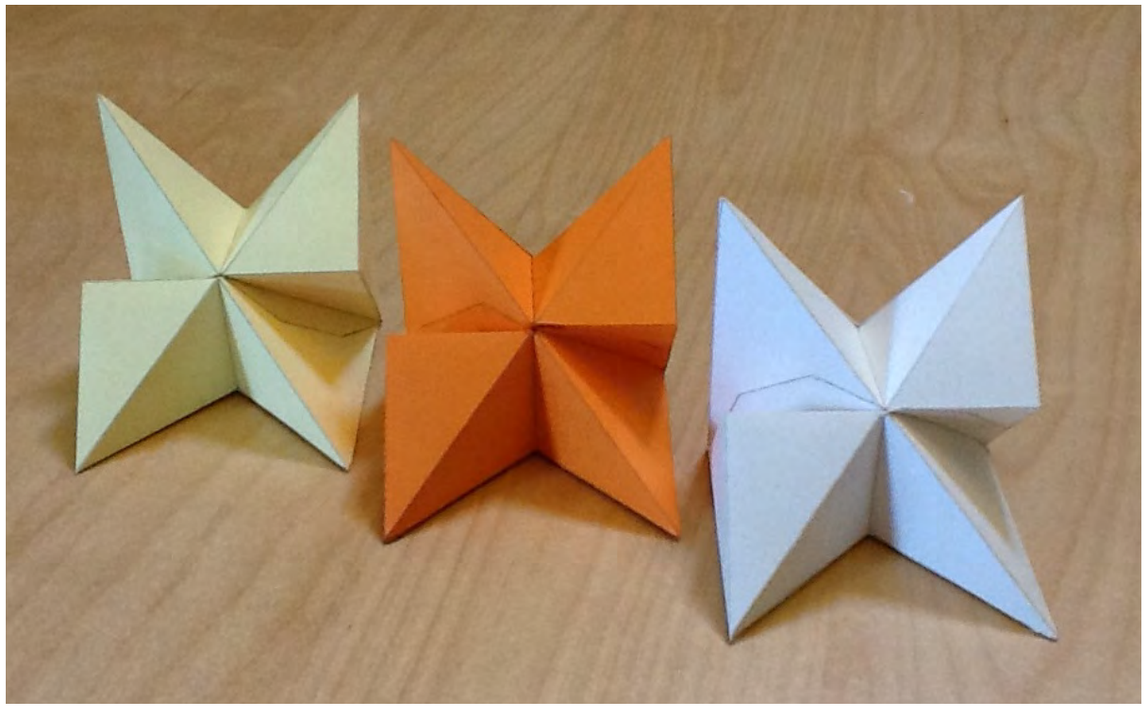


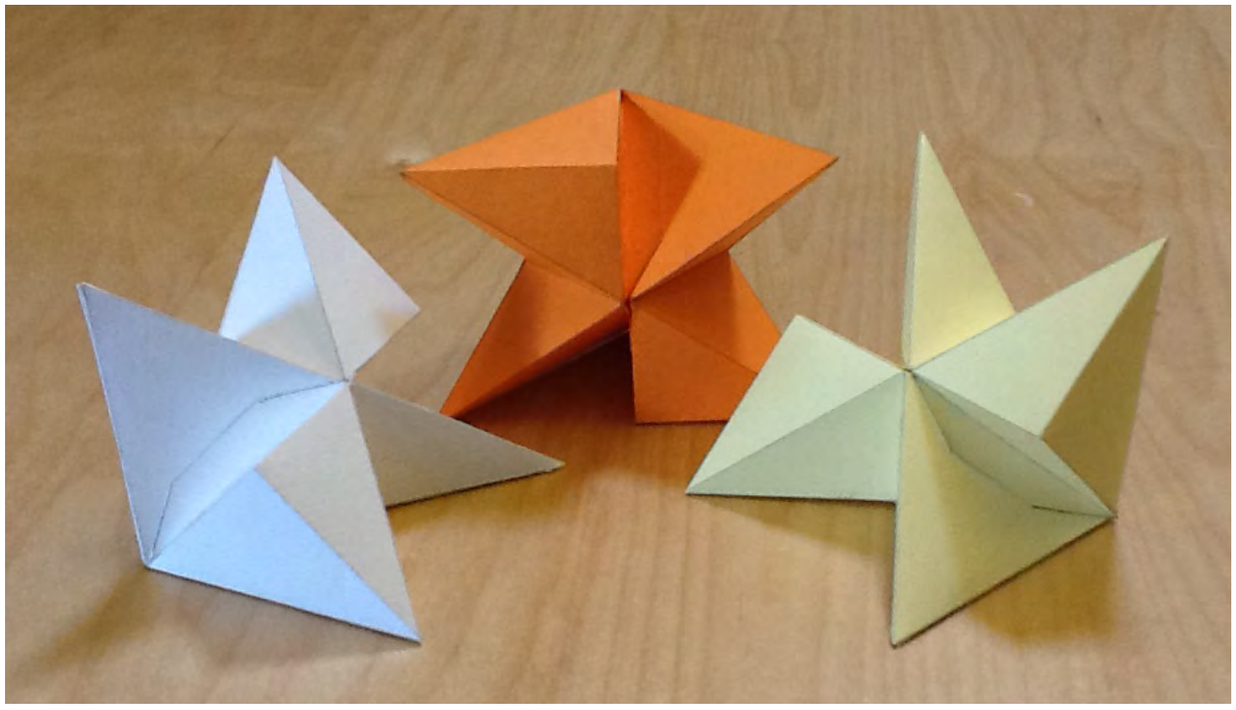
MODELS BUILT BY MIDDLE SCHOOL STUDENTS – OFFANENGO, ITALY





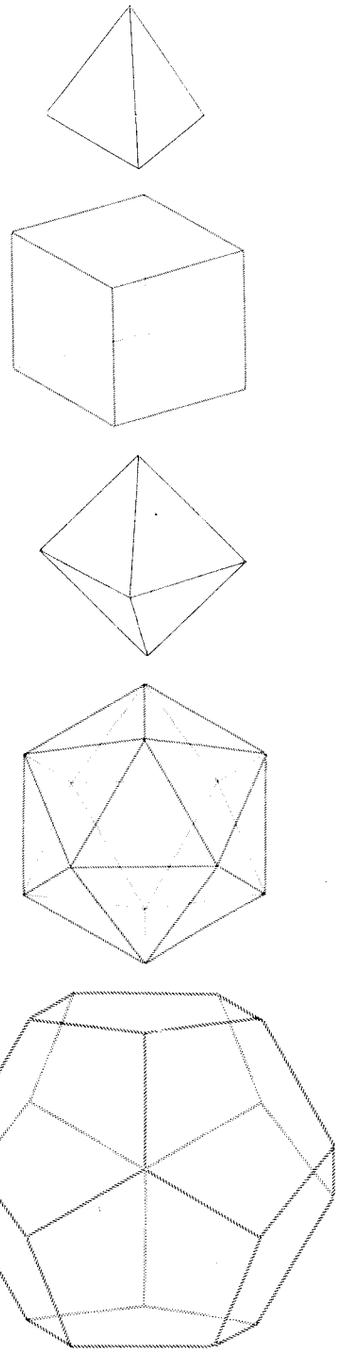




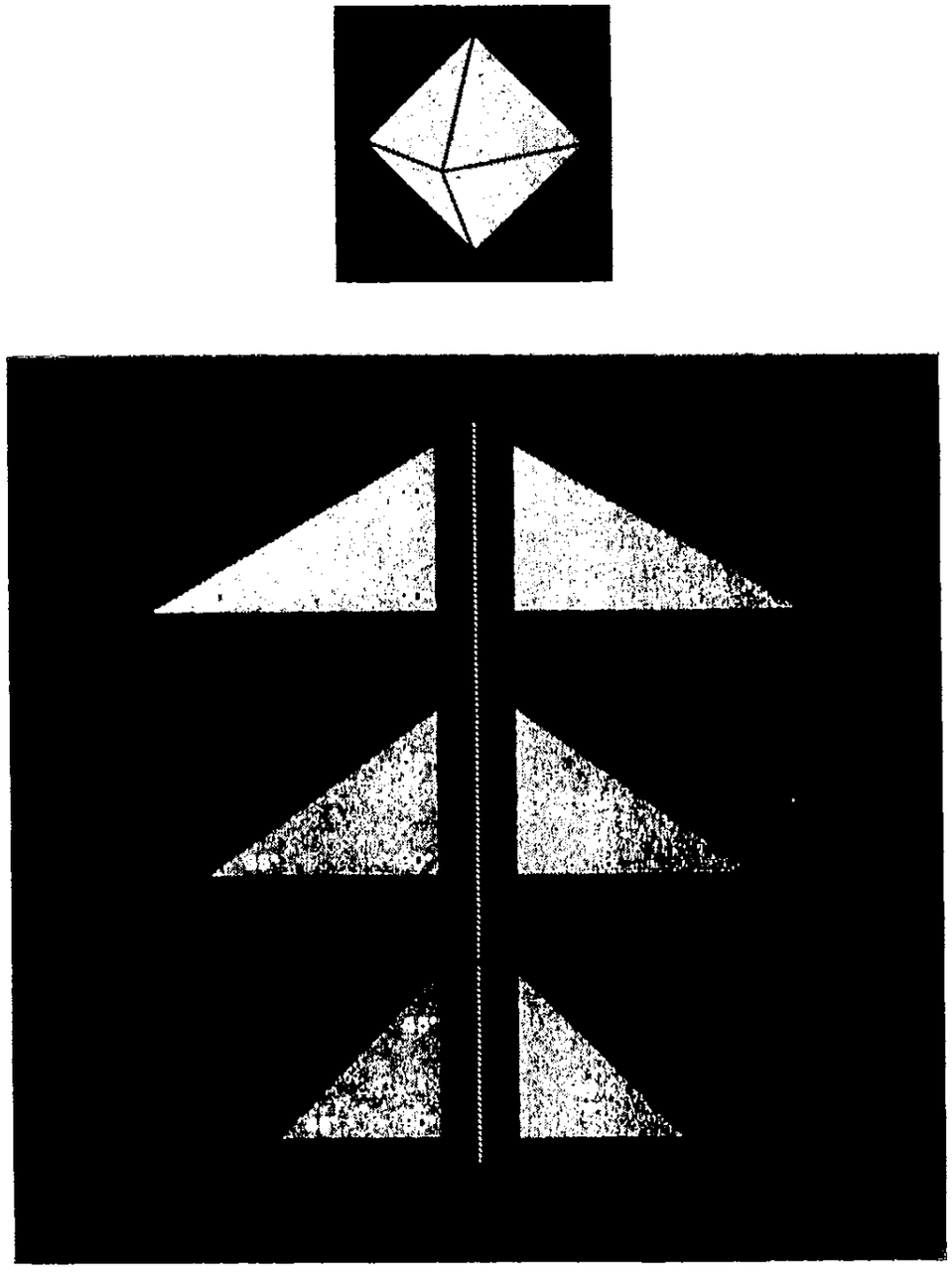


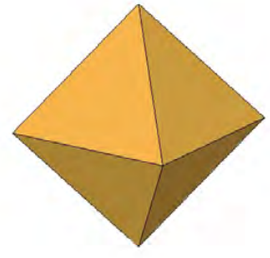
MODEL BUILT BY FEDERICA DESTRI
OFFANENGO MIDDLE SCHOOL, 2016-2017 (ITALY)

INSTRUCTIONS FOR PLATONIC SOLID CHAINS



I cinque poliedri platonici.





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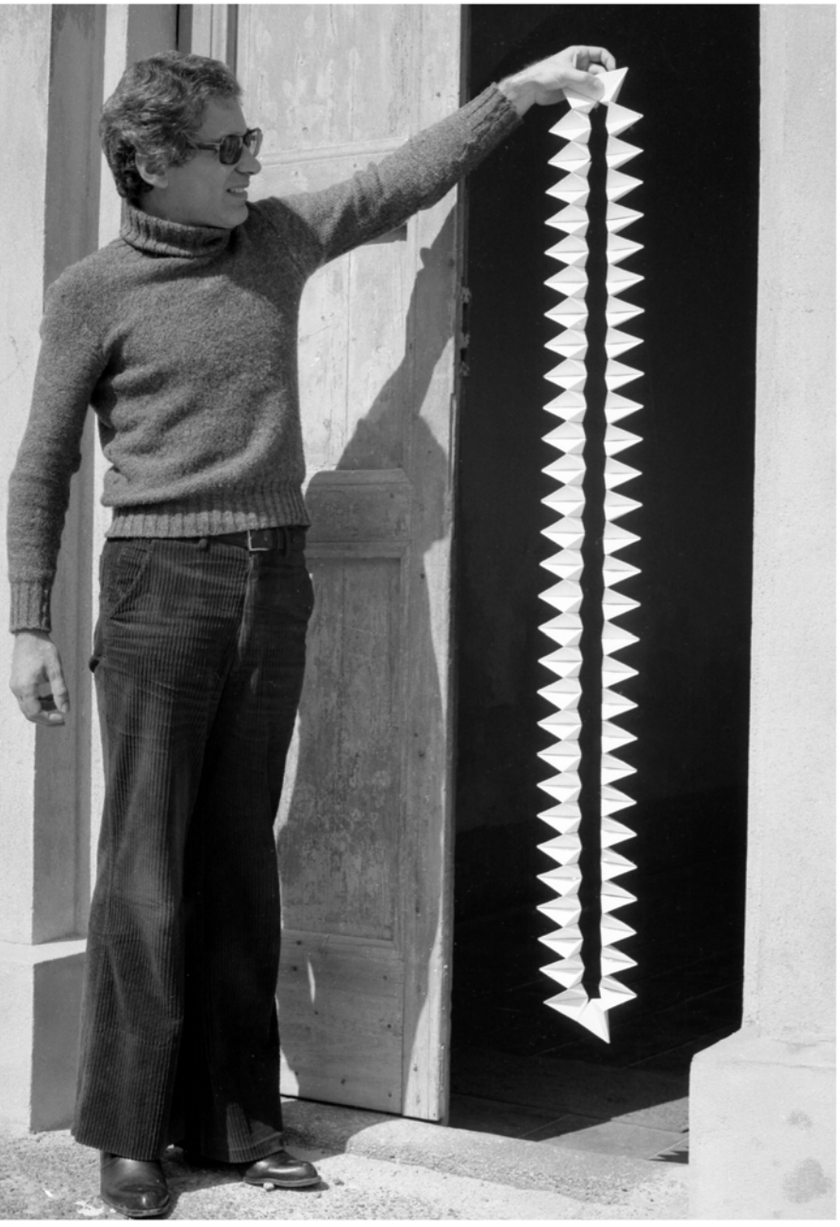
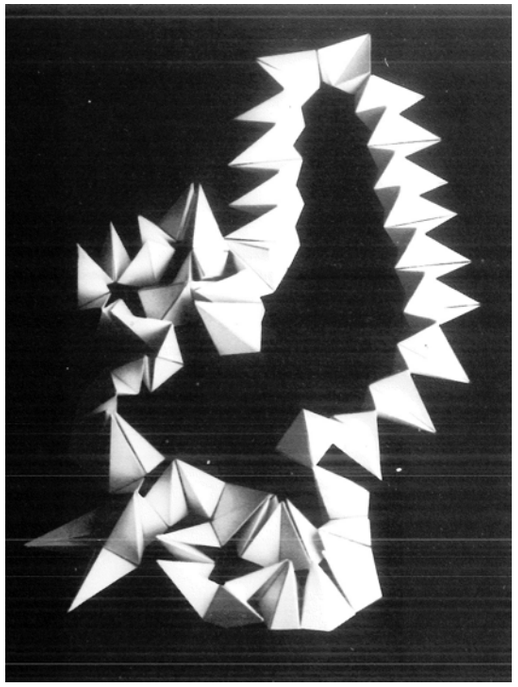
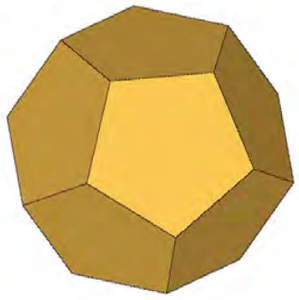
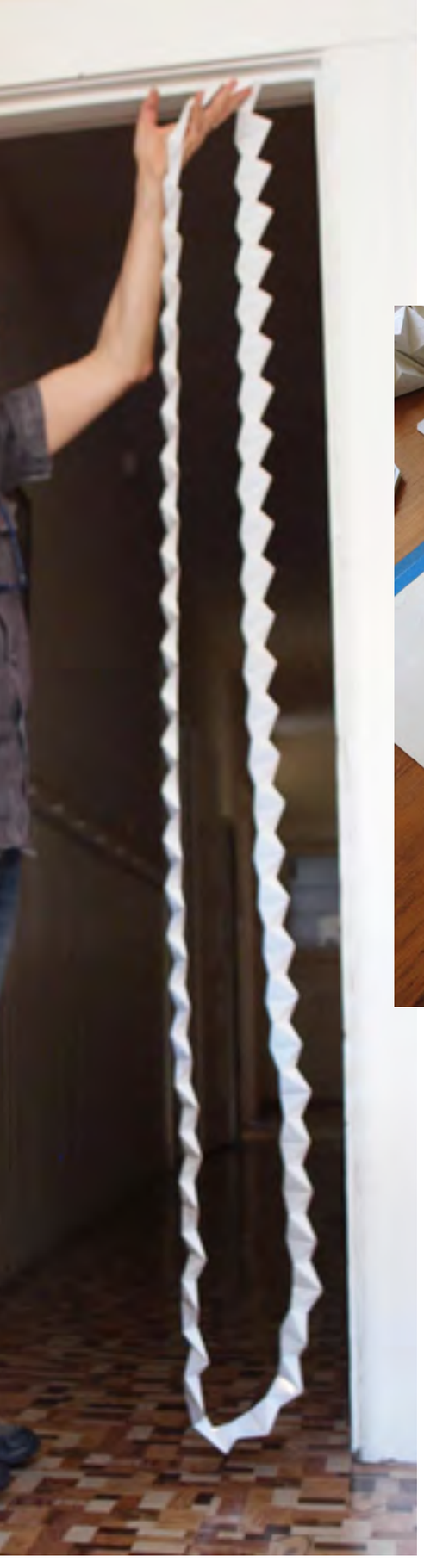
DODECAHEDRON: 120 PYRAMIDS

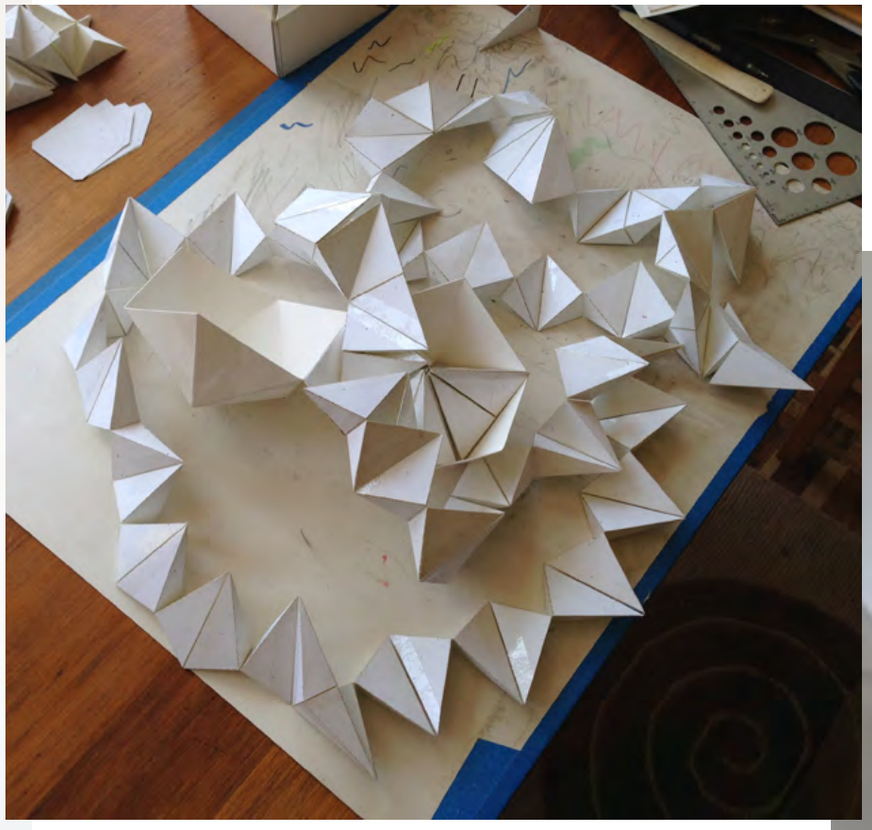


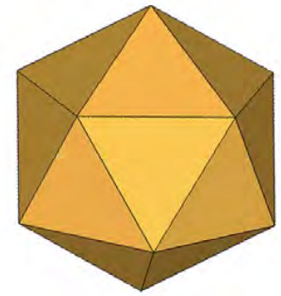




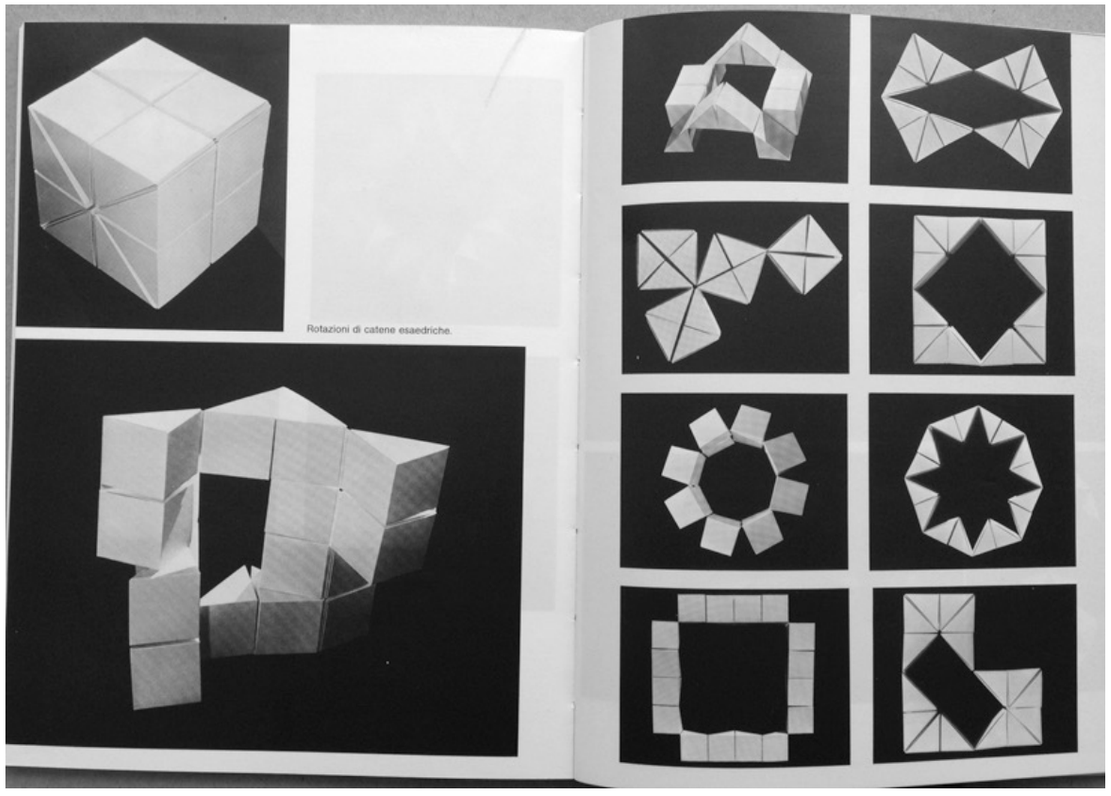
ICOSAHEDRON: 120 PYRAMIDS



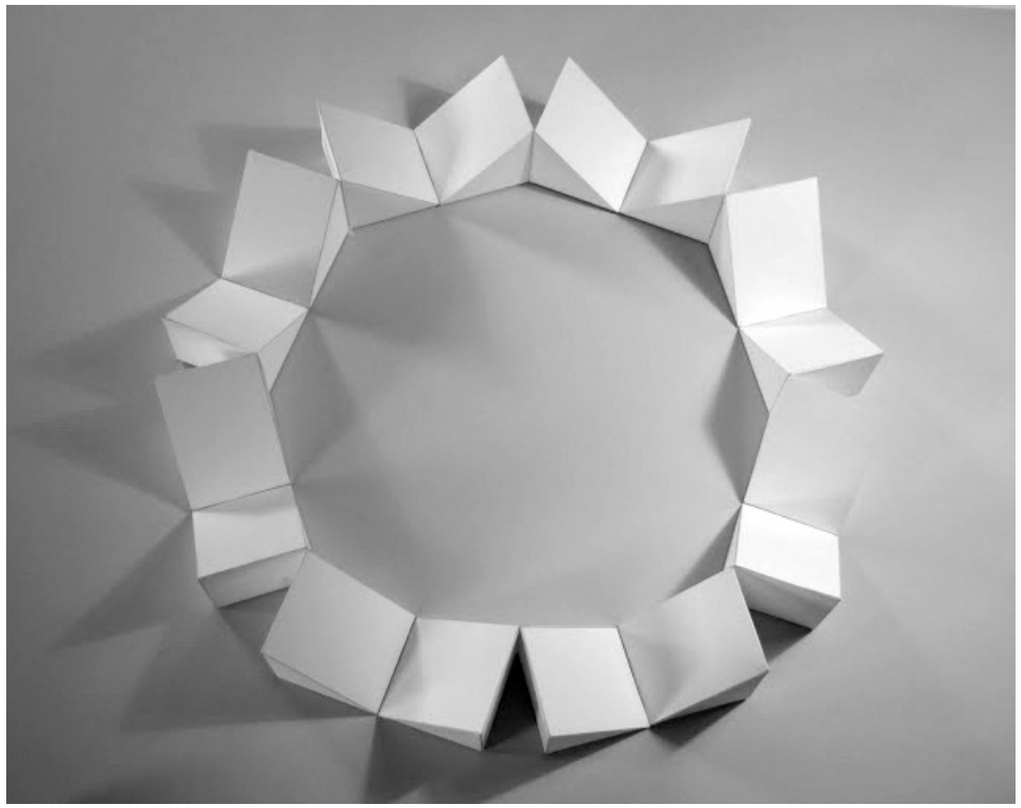




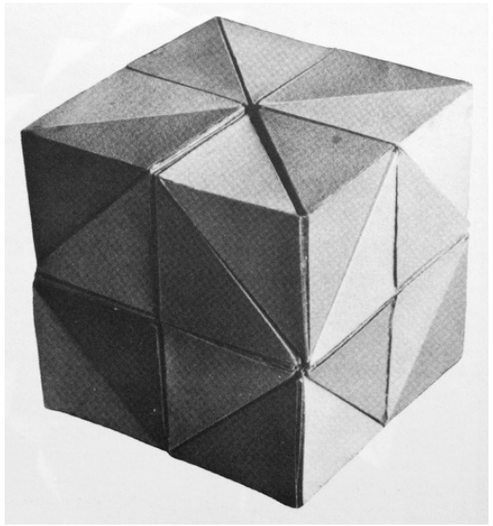
(Trogu & Nies, model based on Scarpa, 2015)



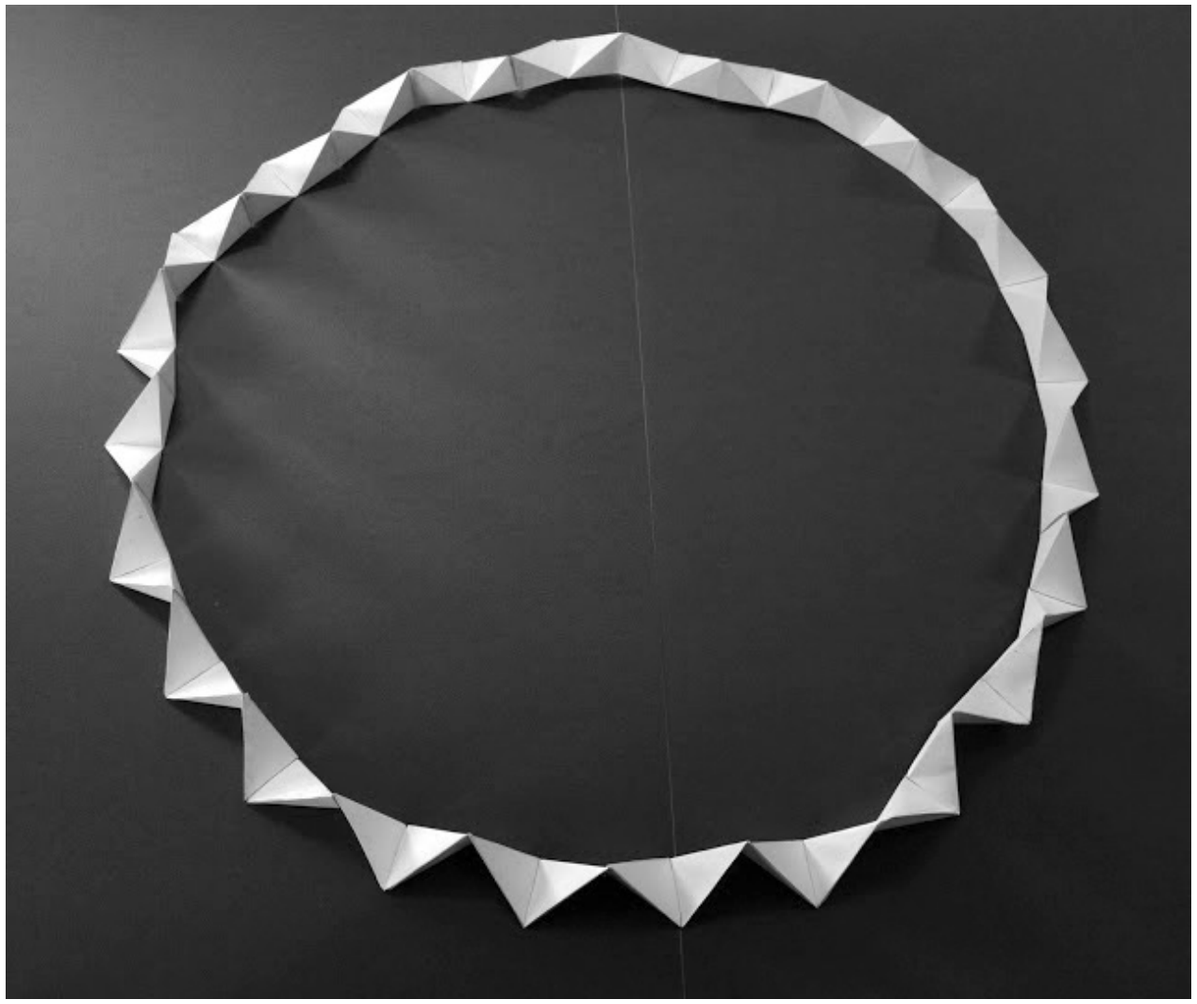
Scarpa, *Models of Rotational Geometry*
pp. 76–77

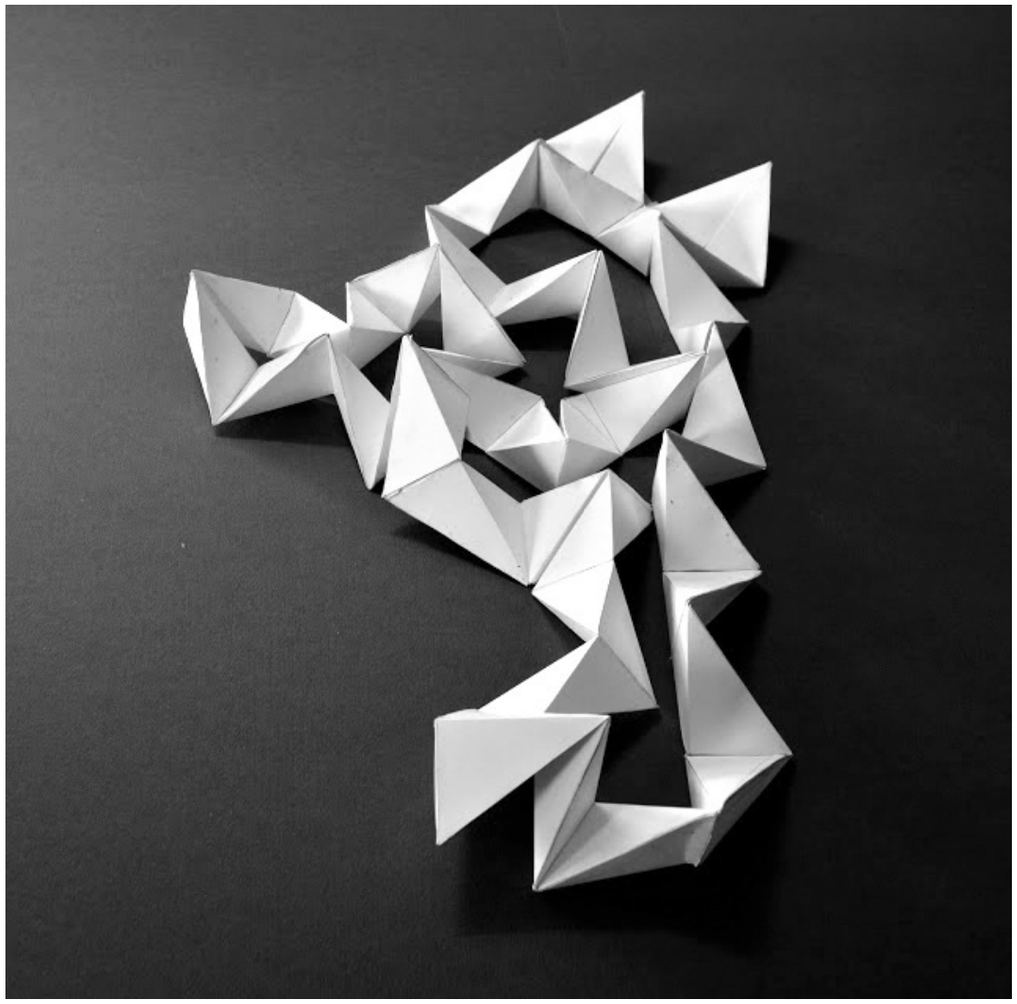


(L. Bocca, model replica, 2014)



(L. Bocca, model replica, 2014)





Scarpa, *Models of Rotational Geometry*, pp. 87–92

RECENT MODELS AND DEVELOPMENTS


Collana diretta da Bruno Munari
Quaderni di design
MODELLI DI BIONICA
Capire la natura attraverso i modelli
a cura di Giorgio Scarpa
13
Zanichelli

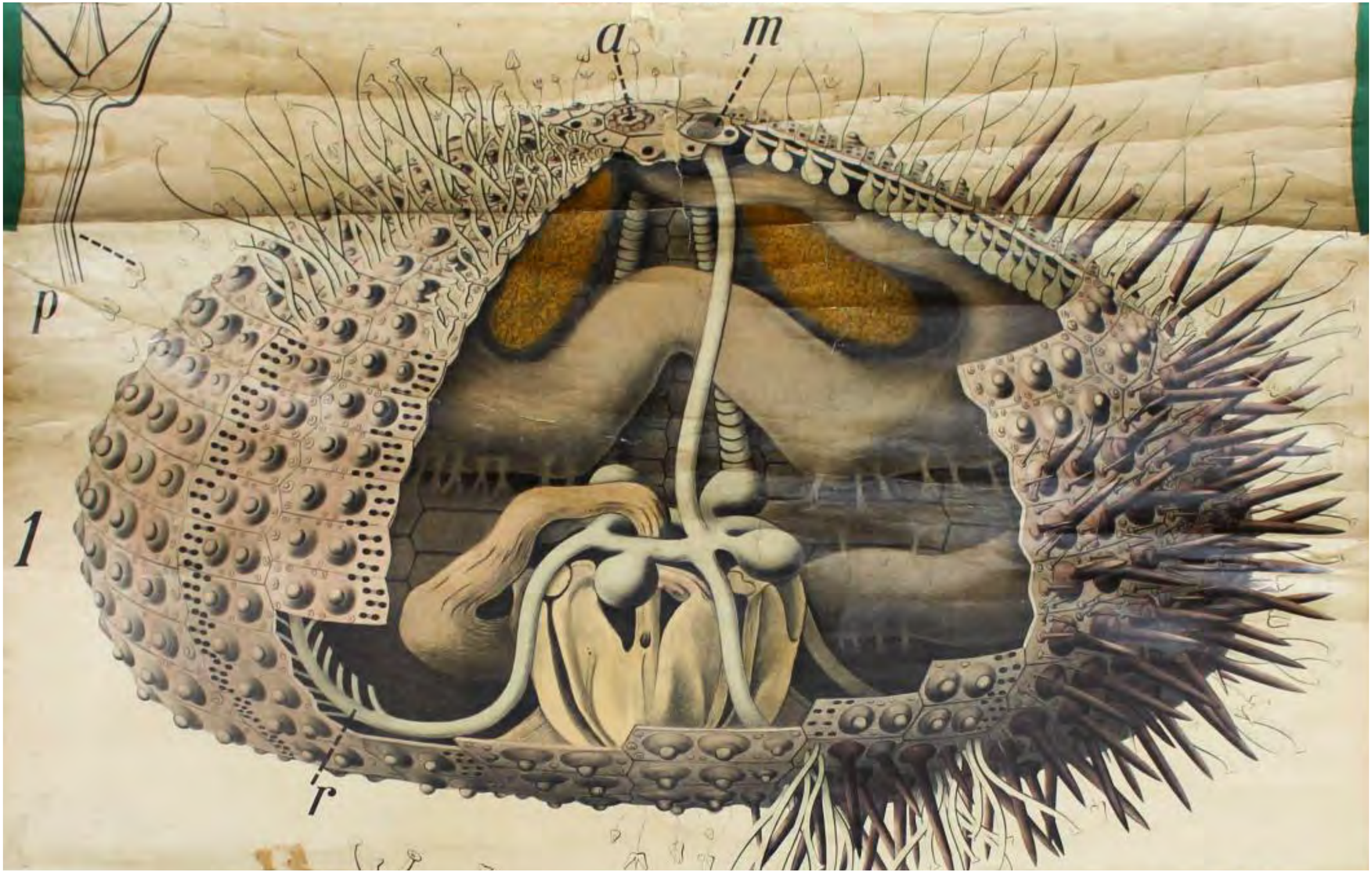
Giorgio Scarpa, presentation of Aristotle's Lantern. Faenza, c. 1980

"To play (to explore) is something that costs nothing and brings the mind closer to its desires by asking about the goals and function of every choice, so that every project, before it even becomes an application in its diversified specificity, every project should mean freedom and spontaneity in making, a non-paralyzing immersion, a contrast to what surrounds us, in a seamless process. (...) The image of destroyed sea urchins, their scattered fragments in the sand, and of the live sea urchins observed in their marine habitat, are the source of this study. (...) Not a single sea urchin was sacrificed in order to study it."

Giorgio Scarpa, c. 1970

Lantern replicant 2. Delft, NL, 19 Oct. 2017

(Replica constructed by Pino Trogu)



[Chart Sea Urchin by Paul Pfurtscheller, 1907: https://www.pamono.com/antique-wall-chart-sea-urchin-by-paul-pfurtscheller-1907-1](https://www.pamono.com/antique-wall-chart-sea-urchin-by-paul-pfurtscheller-1907-1)

Photo: Giorgio Cireddu

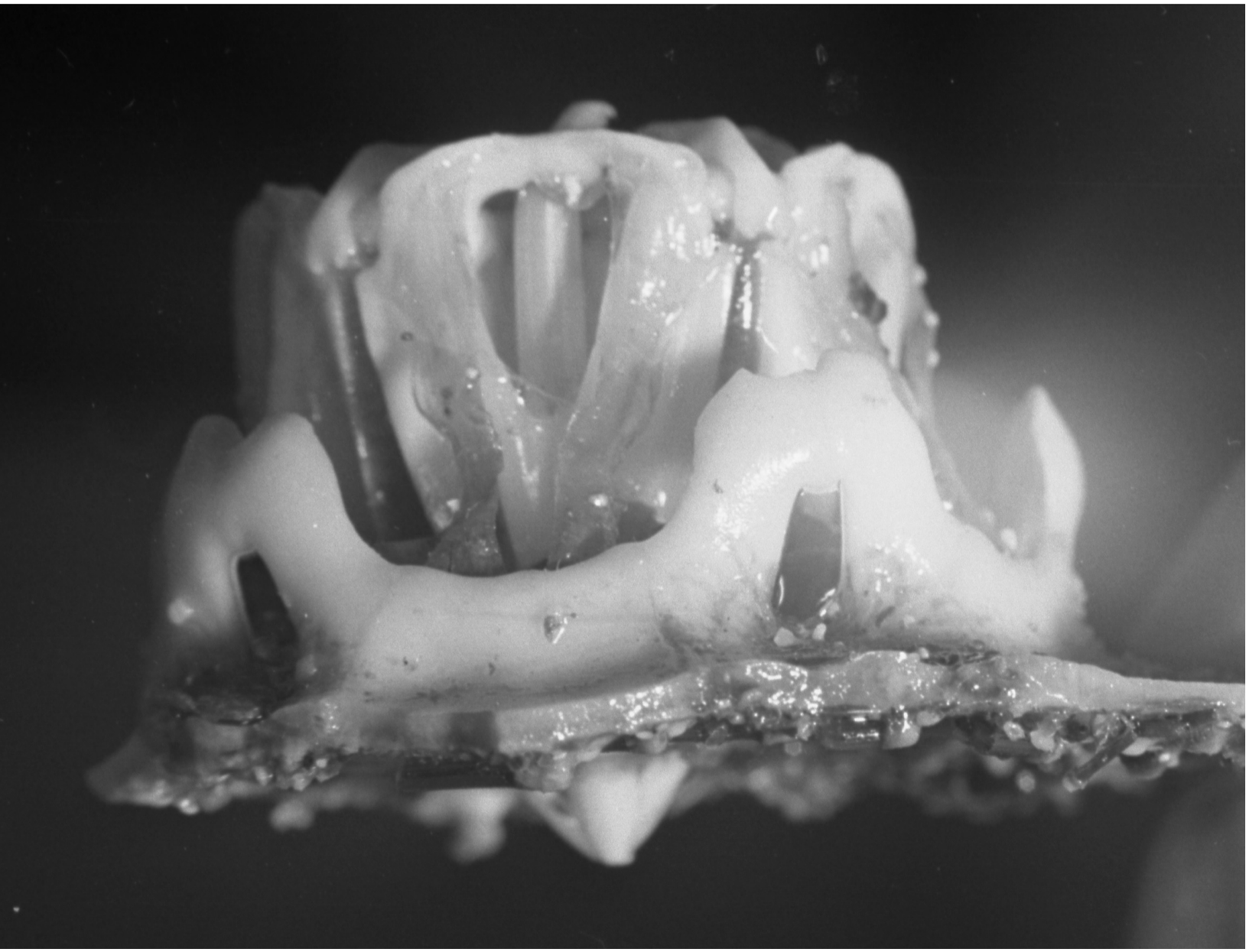
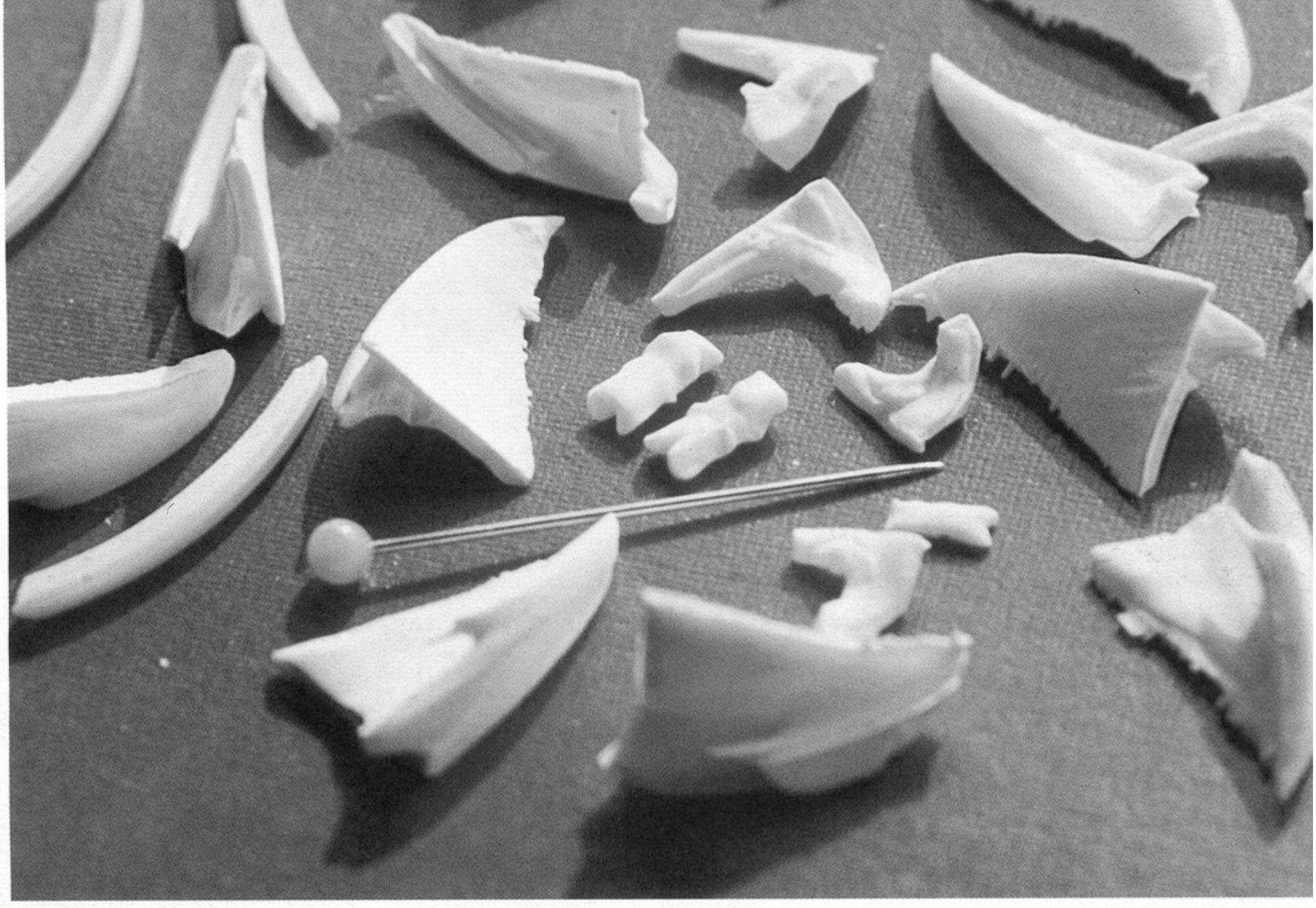


Photo: Giorgio Cireddu

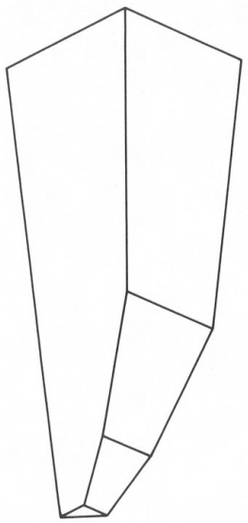
Drawing by Giorgio Scarpa

Photo: Giorgio Cireddu

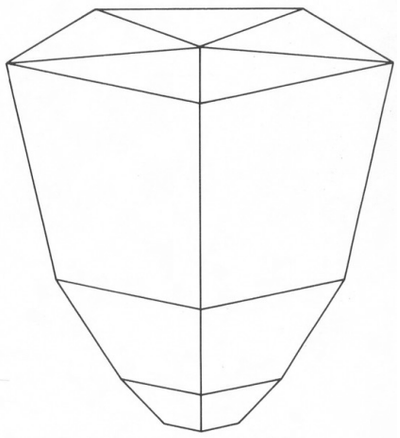


Calcareous pieces which form the skeletal structure. The pin shows the dimensions of the parts.

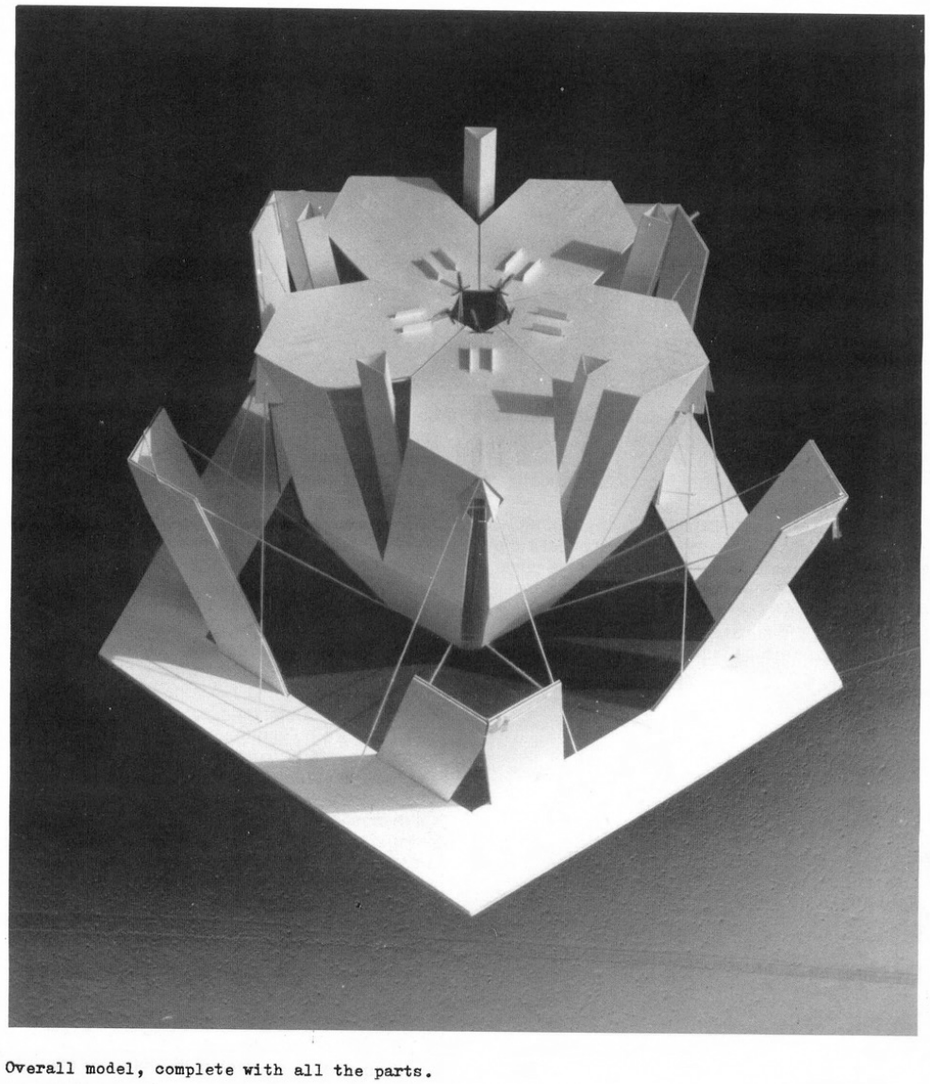
Scarpa, Giorgio, Modelli di bionica: capire la natura attraverso i modelli. Quaderni di design 13, ed. B. Munari (Bologna: Zanichelli, 1985).



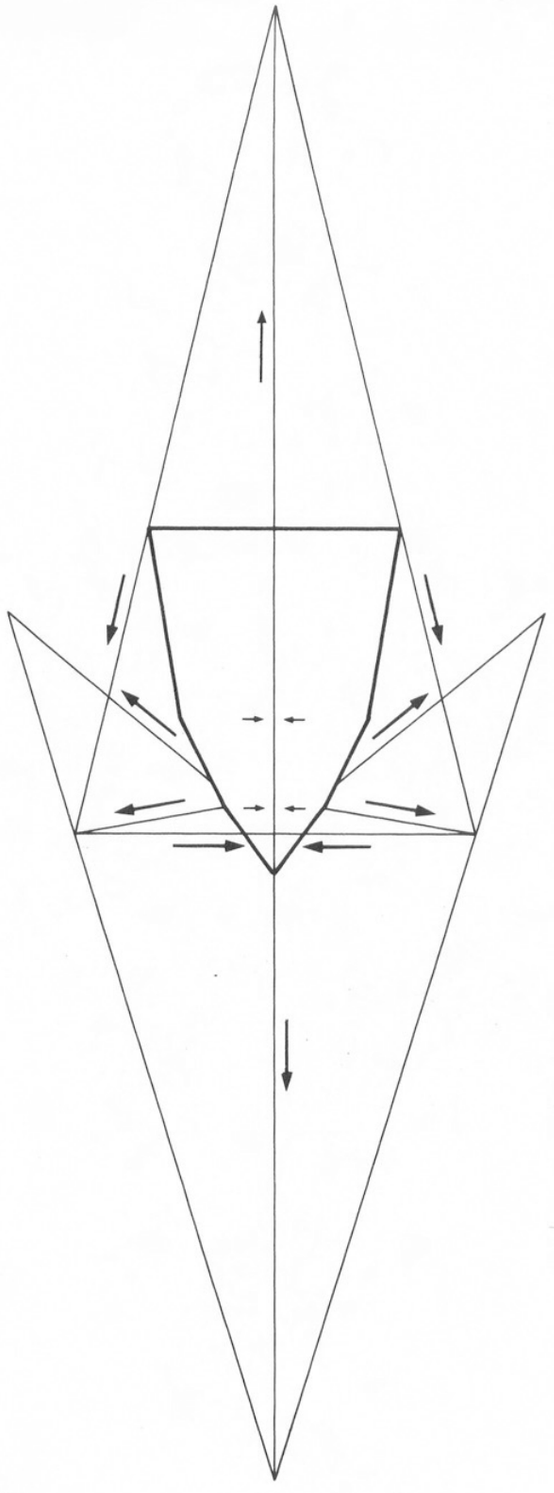
Drawing of a model of jaw.



Five models combined together.



Overall model, complete with all the parts.



Schematic d
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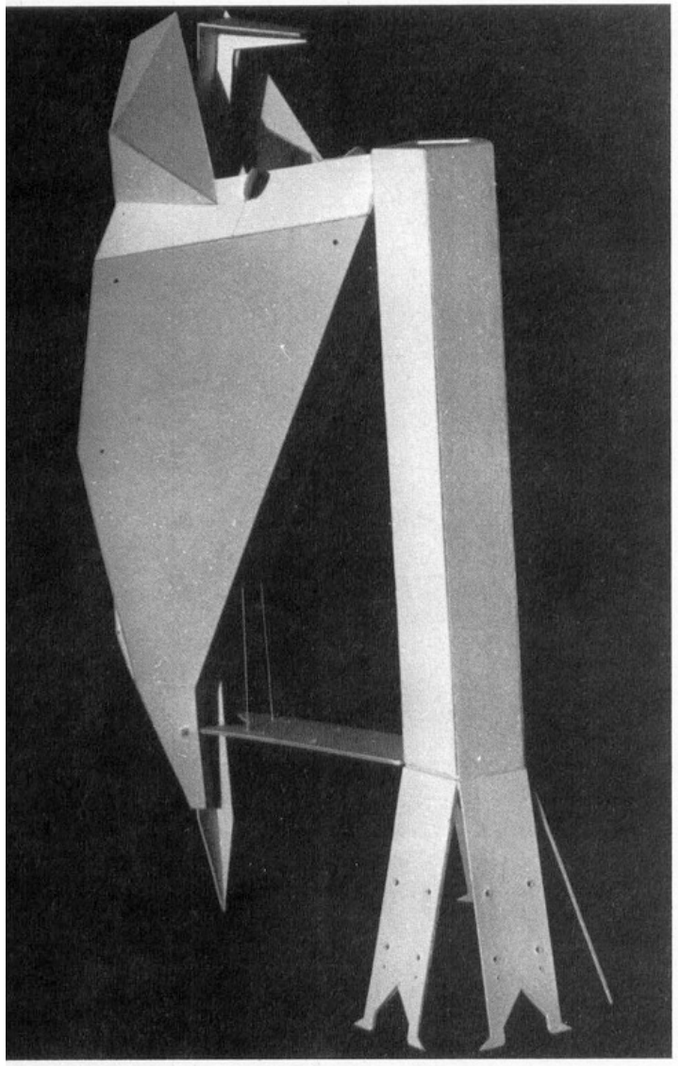
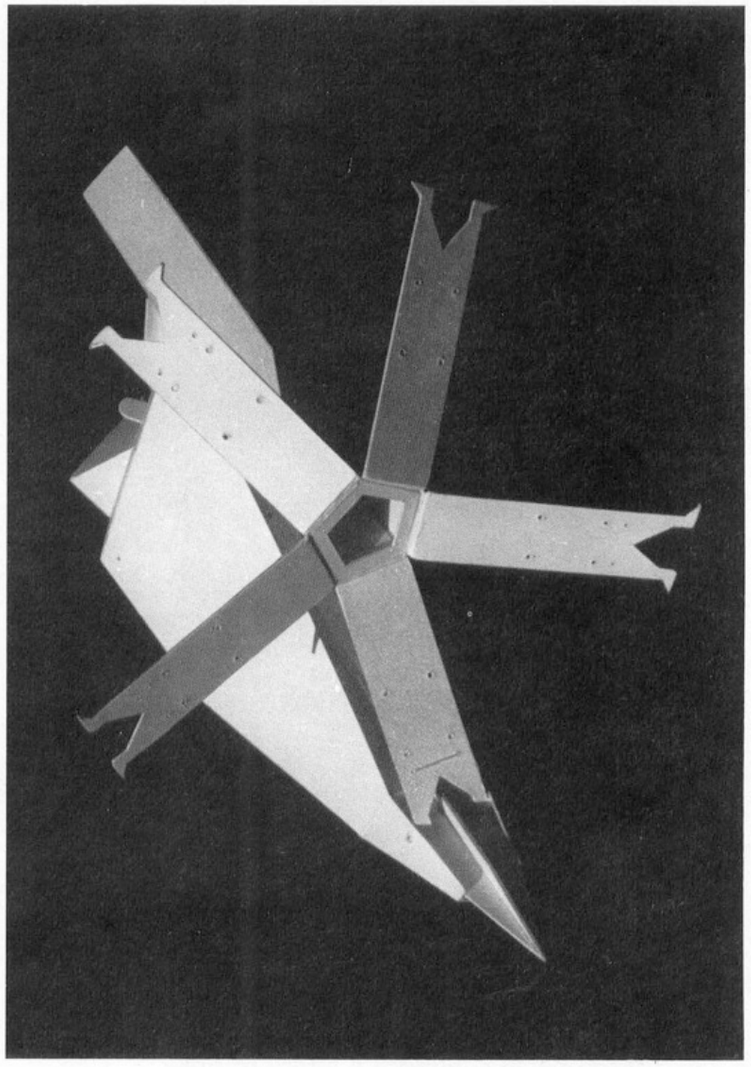
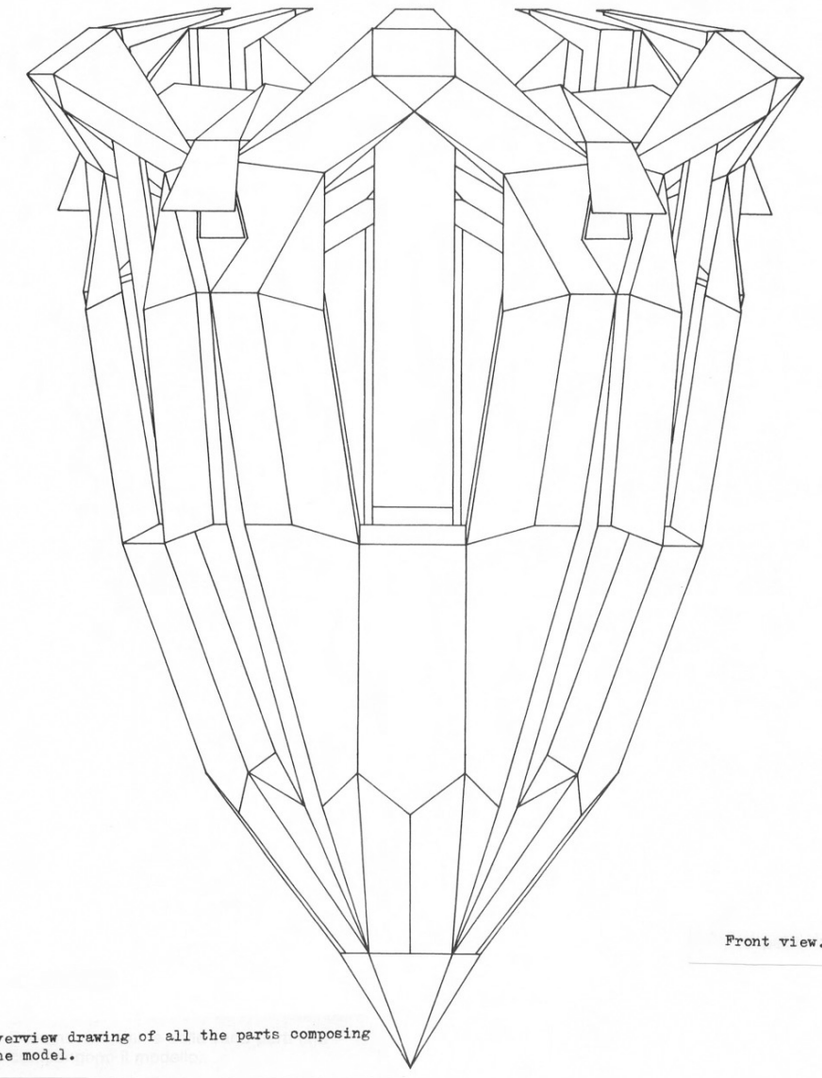
Scarpa, Giorgio, Modelli di bionica,1985.


in ITALY
ARCHIMEDE





Models of the pentagonal prism and the jaw, connected together.

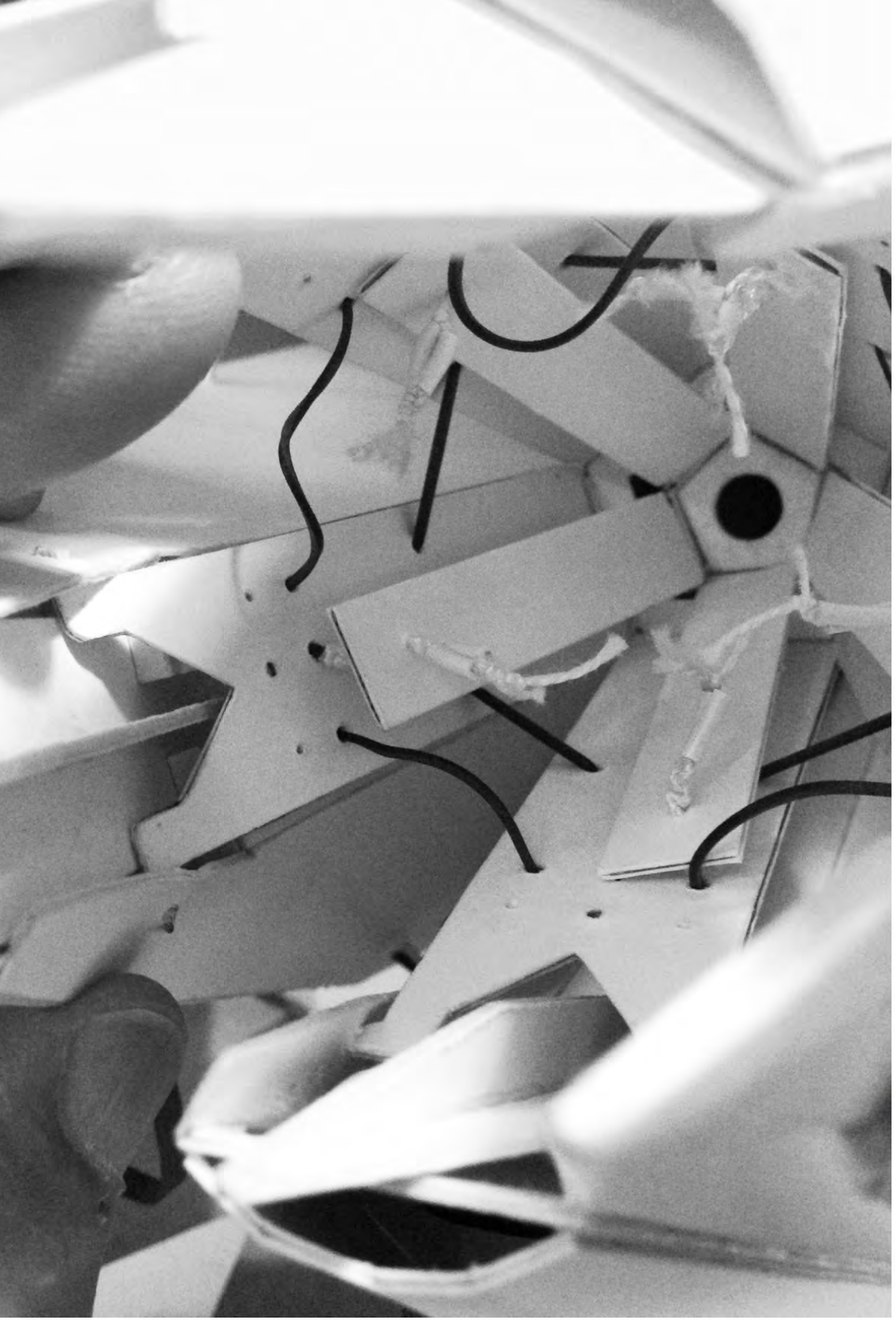


Front view.

Overview drawing of all the parts composing the model.

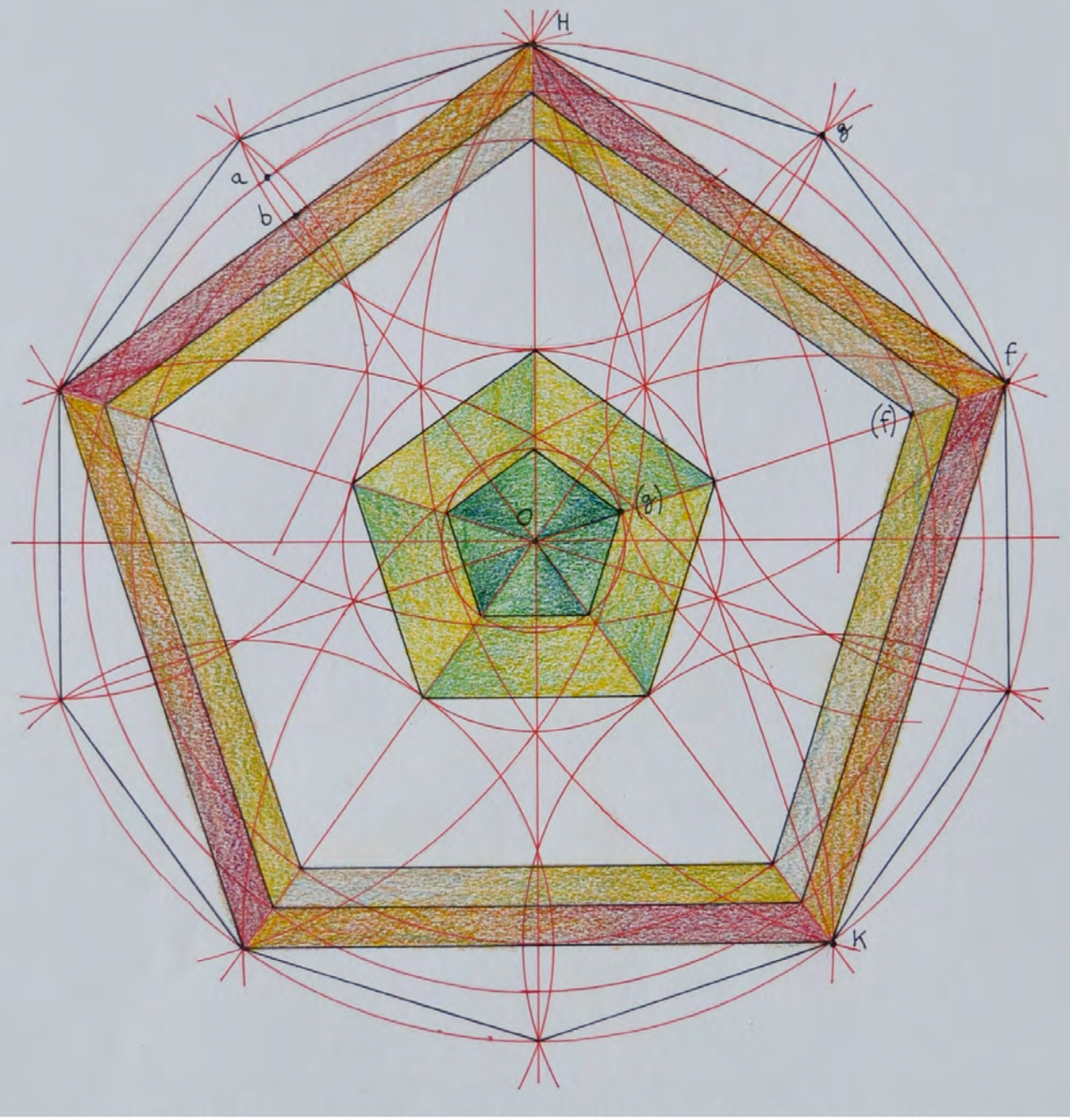
66

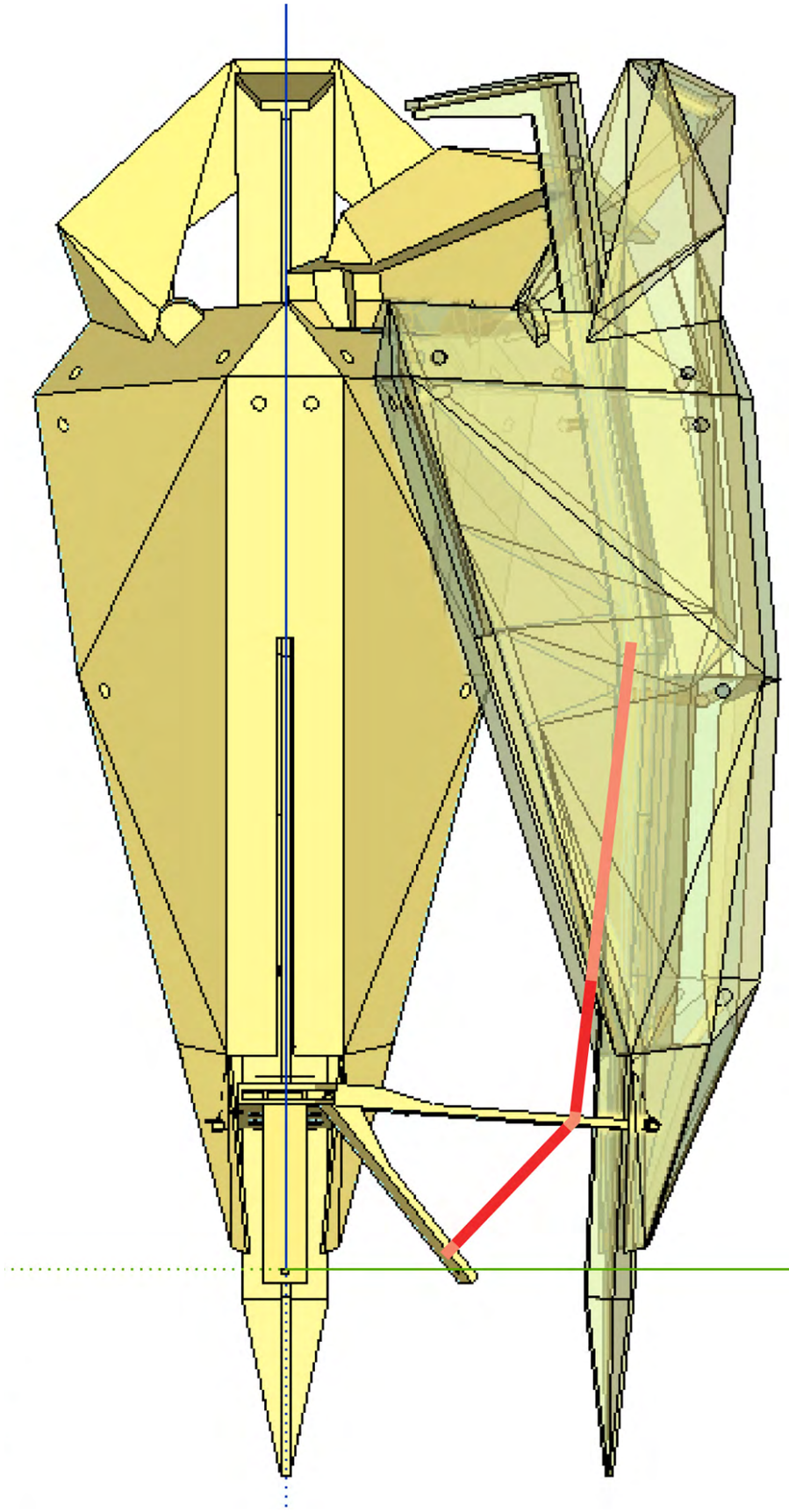
Scarpa, Giorgio, Modelli di bionica,1985.

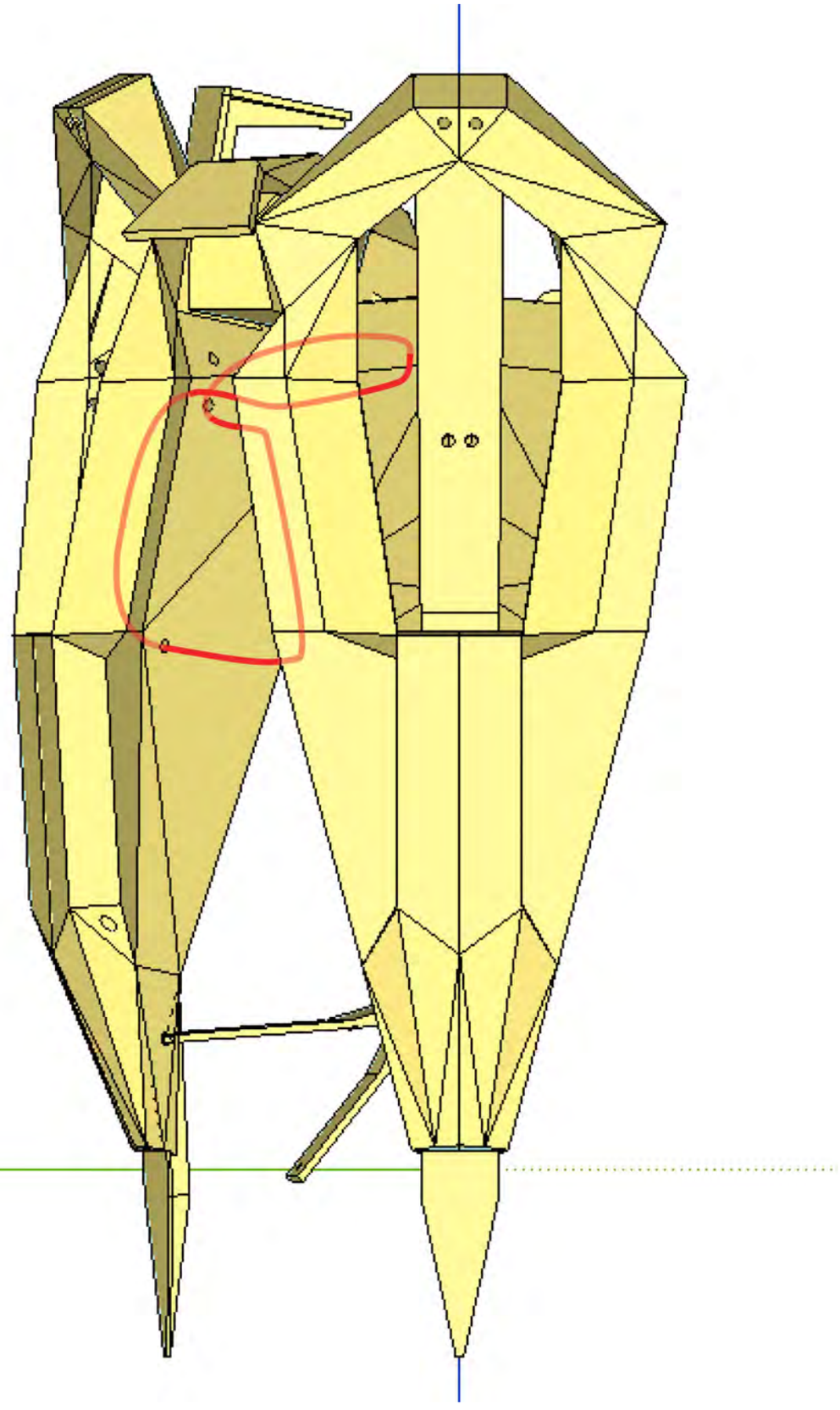


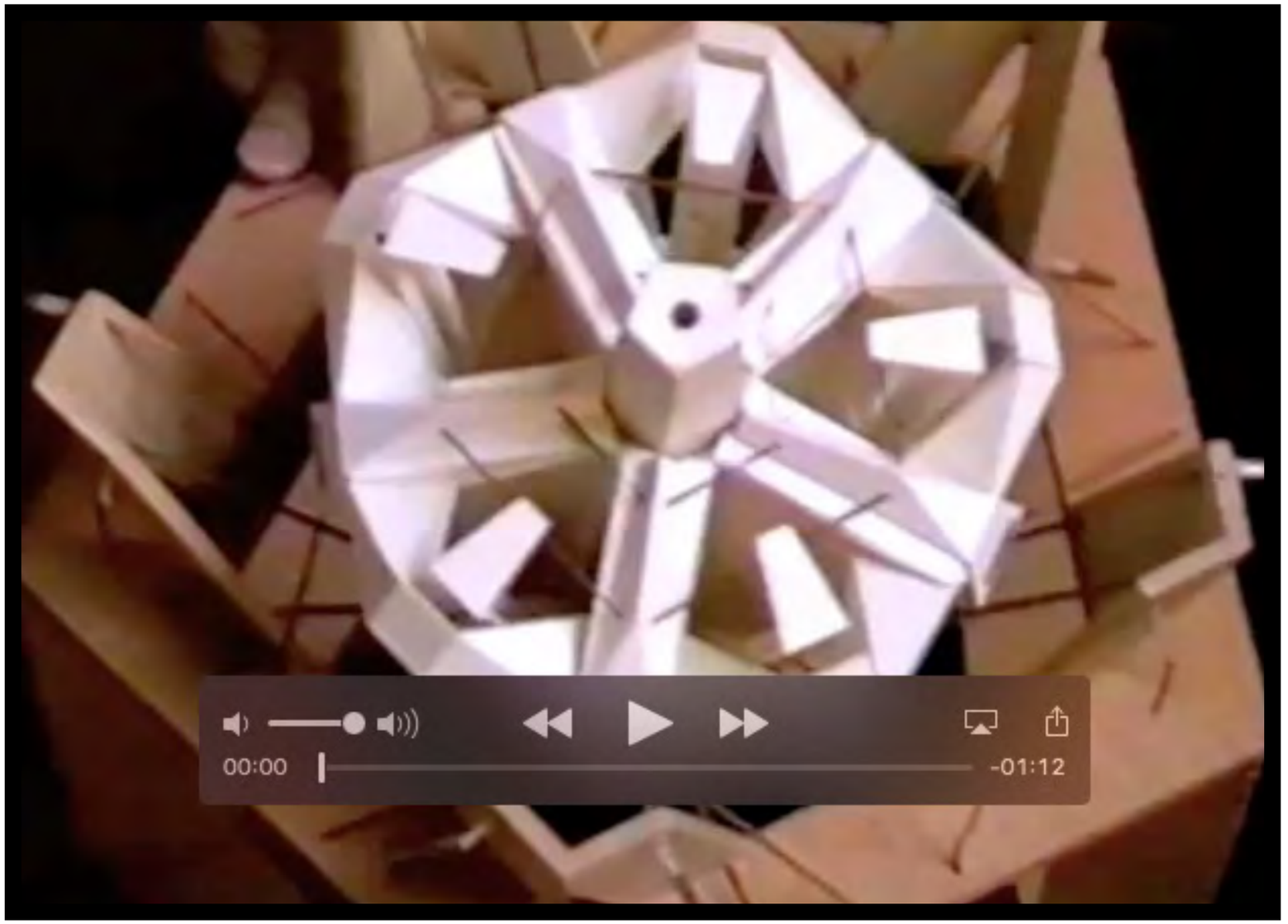
DETERMINAZIONE GEOMETRICA DEI PIANI ORIZZONTALI DEL MODELLO DELLA LANTERNA DI ARISTOTELE DI GIORGIO SCARPA

LORENZO BOCCA









[Bionic Model of Aristotle's Lantern by Giorgio Scarpa -- Youtube video]

Scarpa, Giorgio, Modelli di bionica,1985.

GIORGIO SCARPA'S MODEL OF A SEA URCHIN INSPIRES NEW INSTRUMENTATION

LEONARDO JOURNAL MIT PRESS, 2016

PDF: static.trogu.com/documents/scarpa/leon_a_01384.pdf

Trogu, 2016
Leonardo Just Accepted MS.
doi: 10.1162/LEON_a_01384

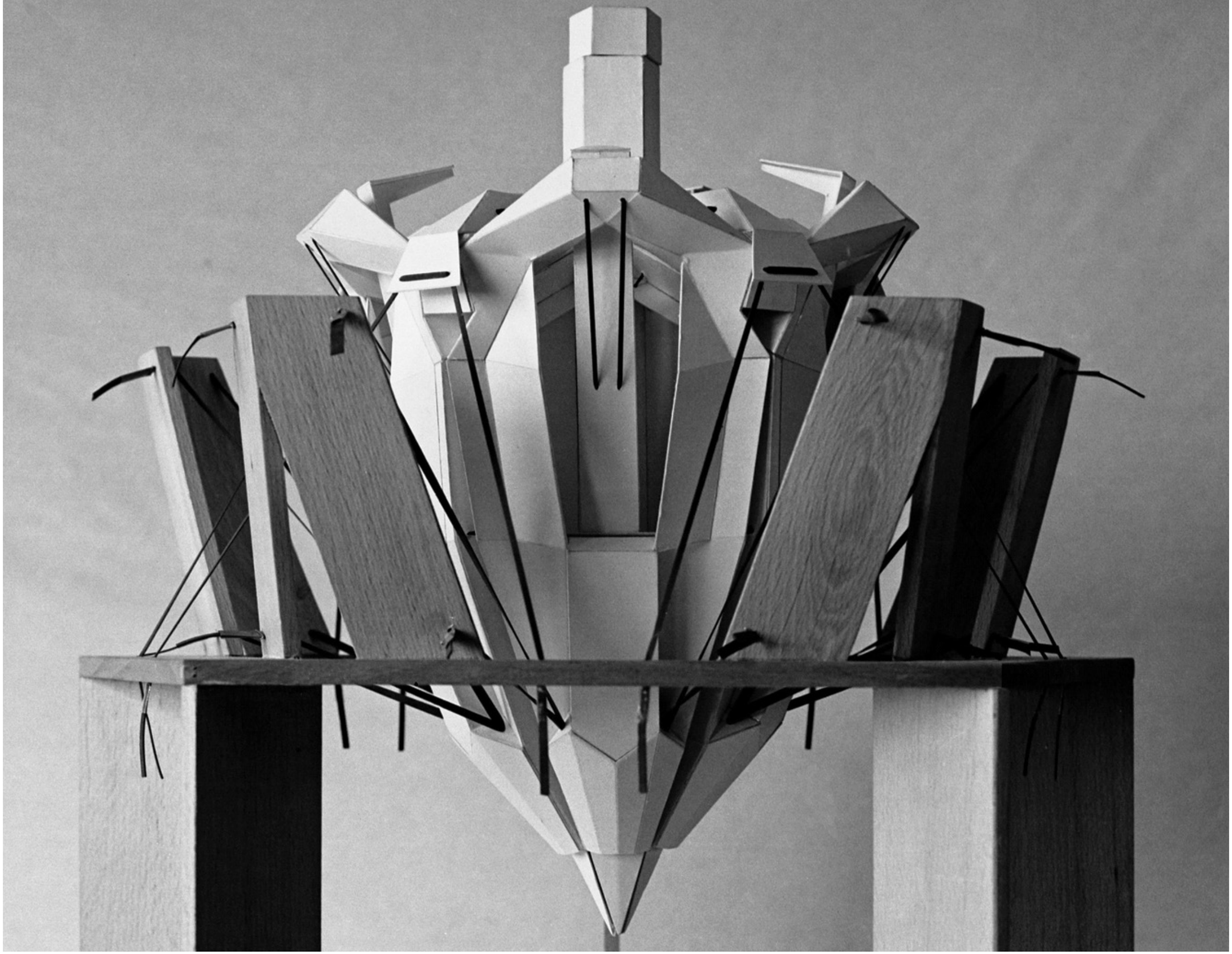


Photo: Giorgio Cireddu

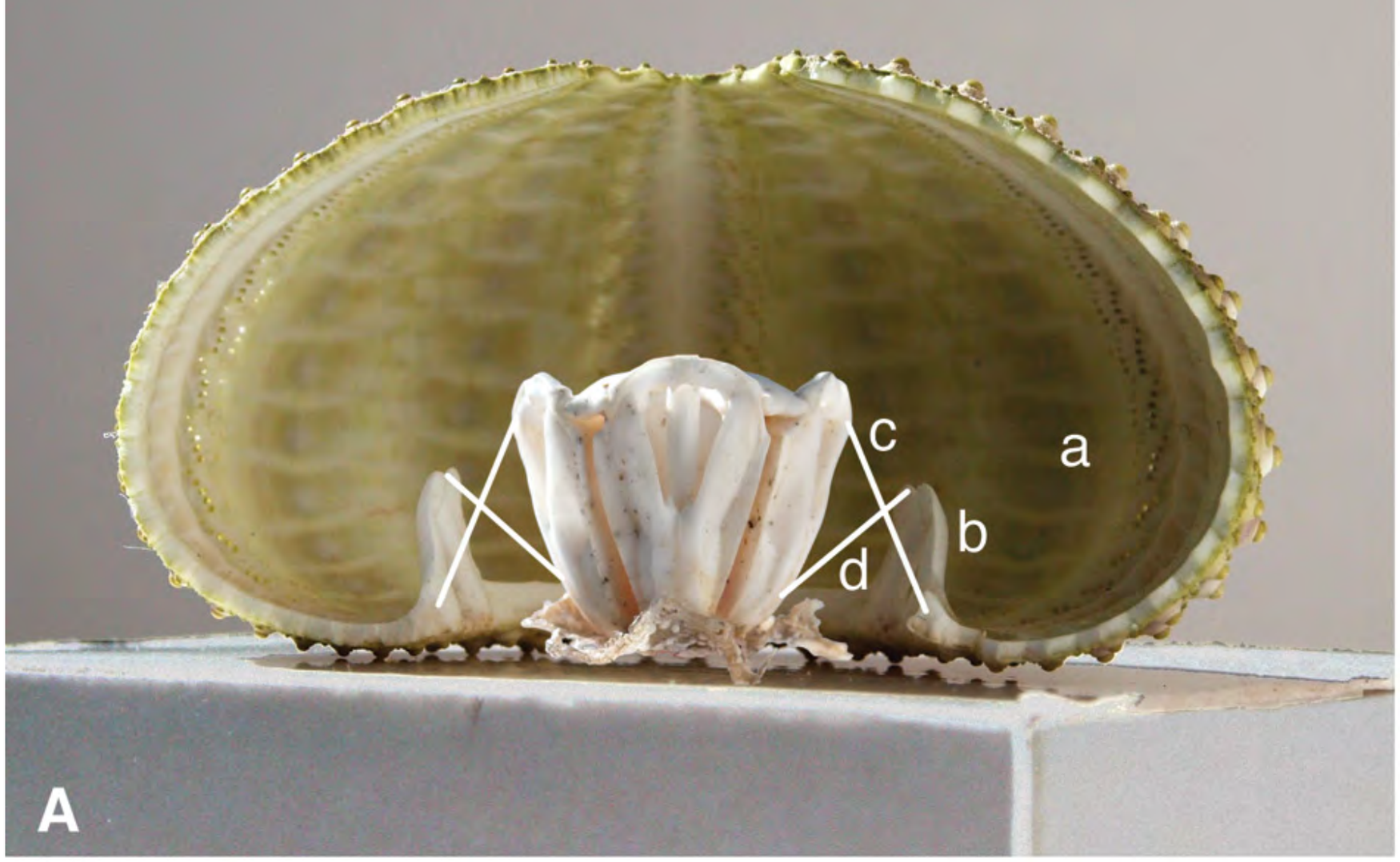
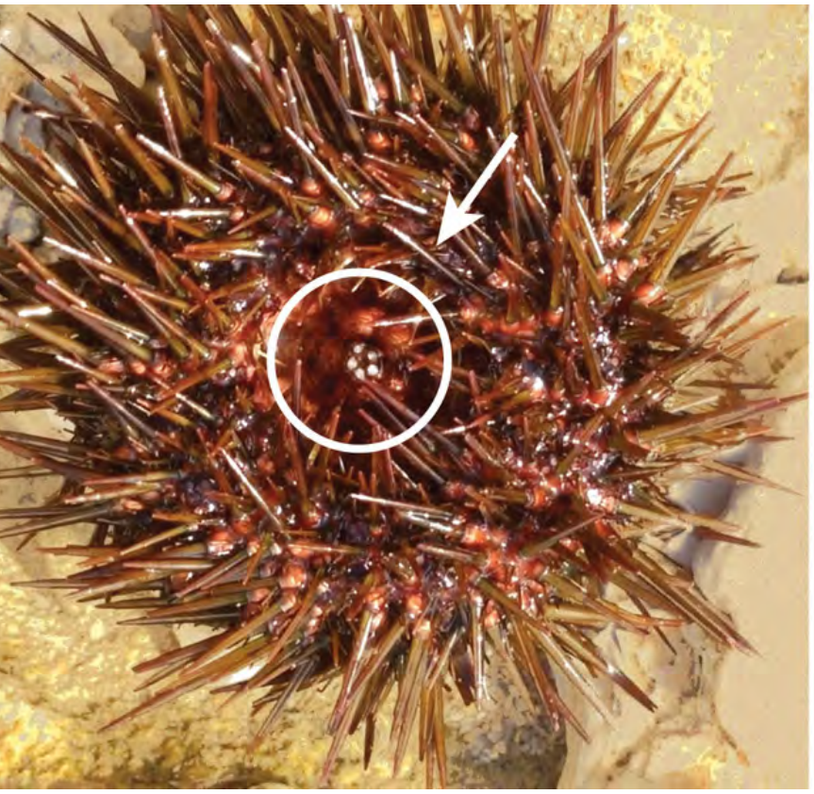
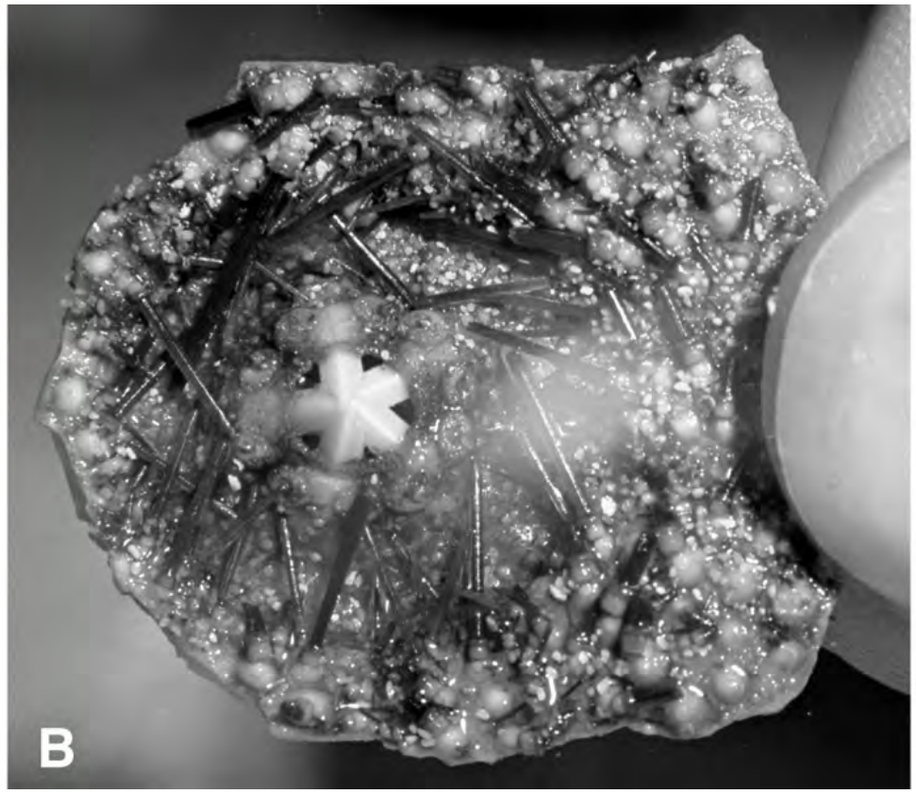


Photo: Giorgio Cireddu





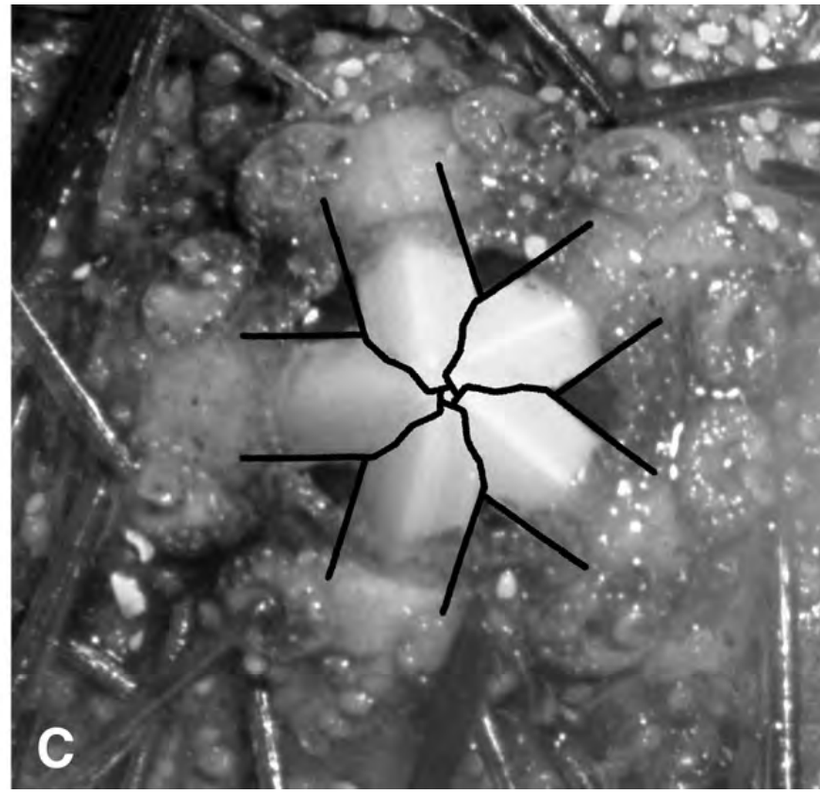
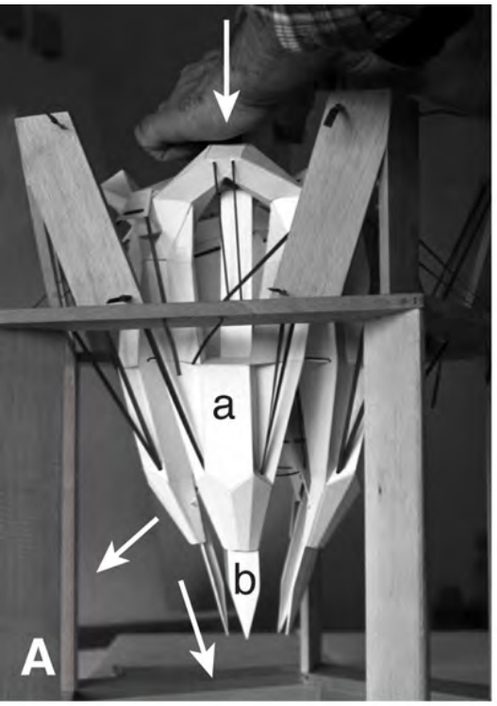


Photo: Giorgio Cireddu


a
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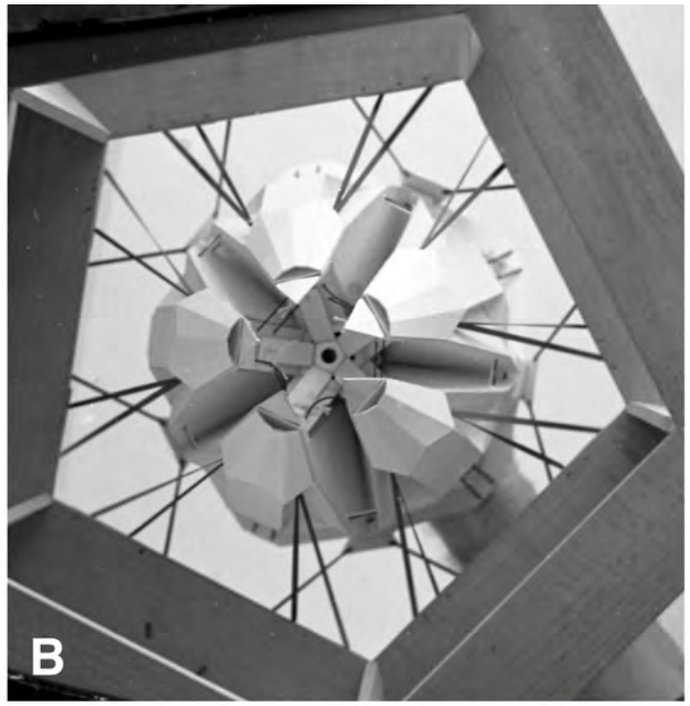
A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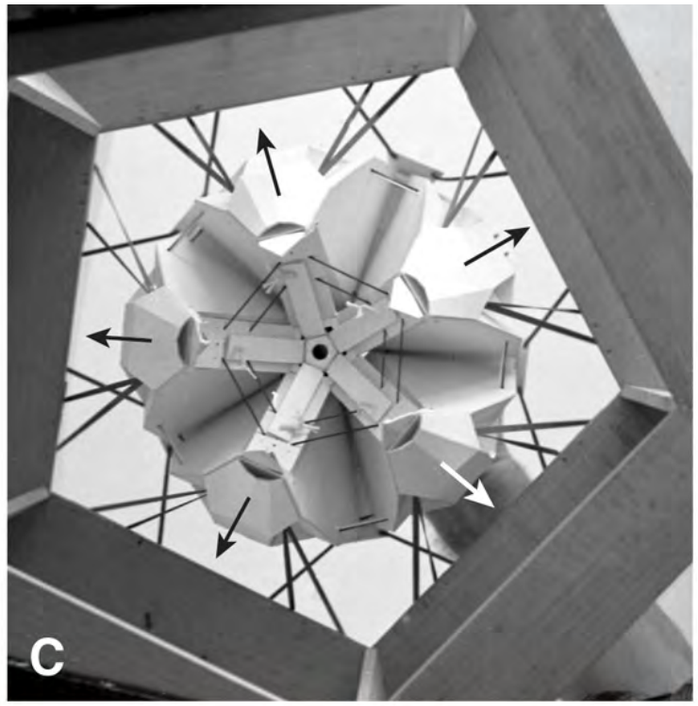
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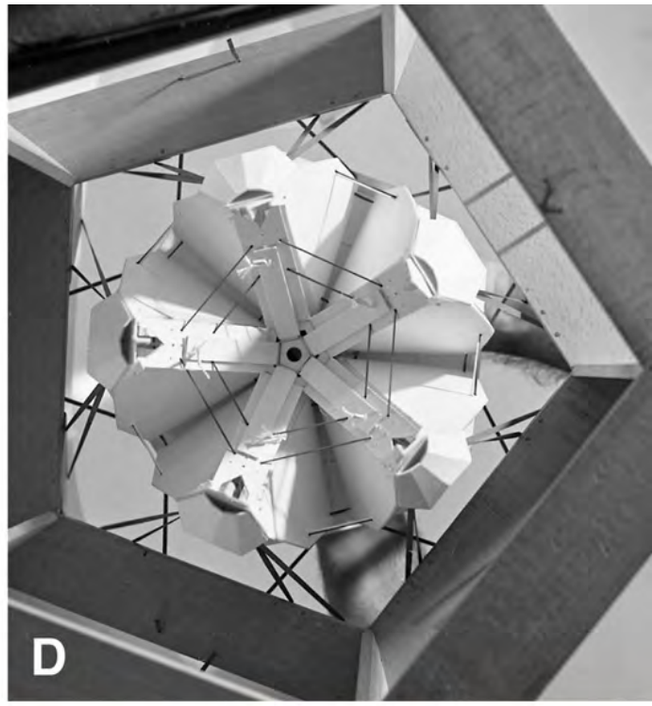
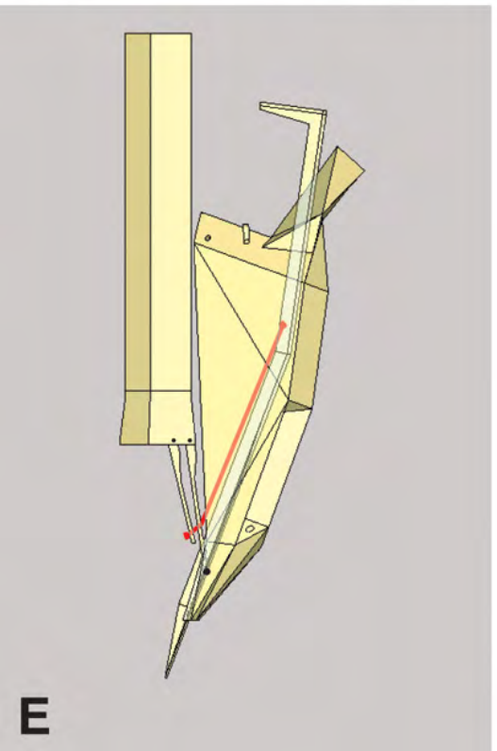

D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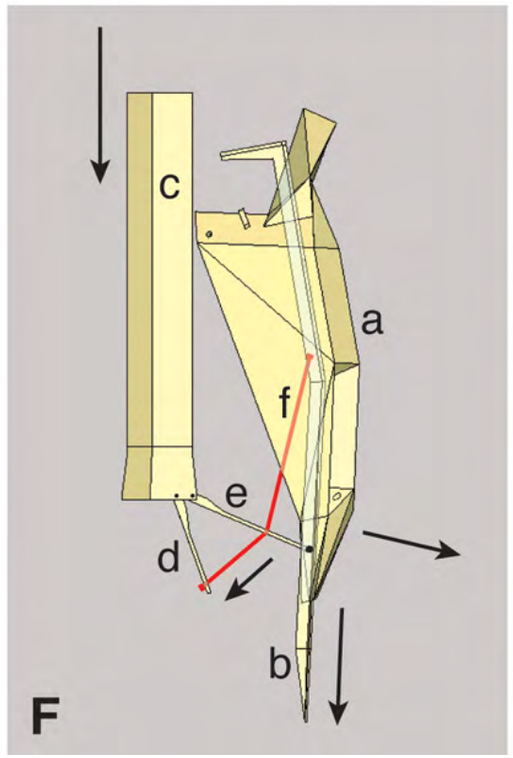
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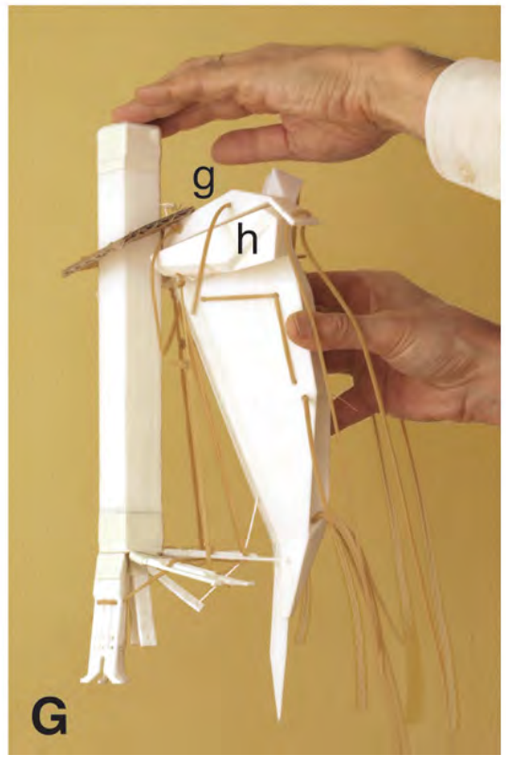
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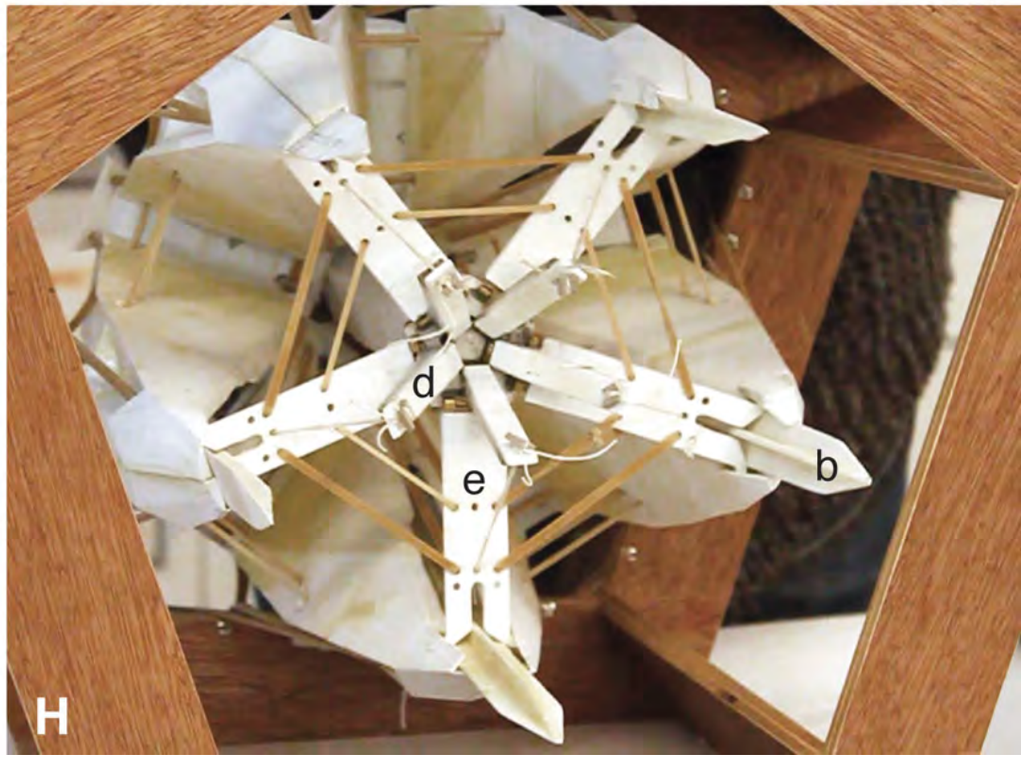
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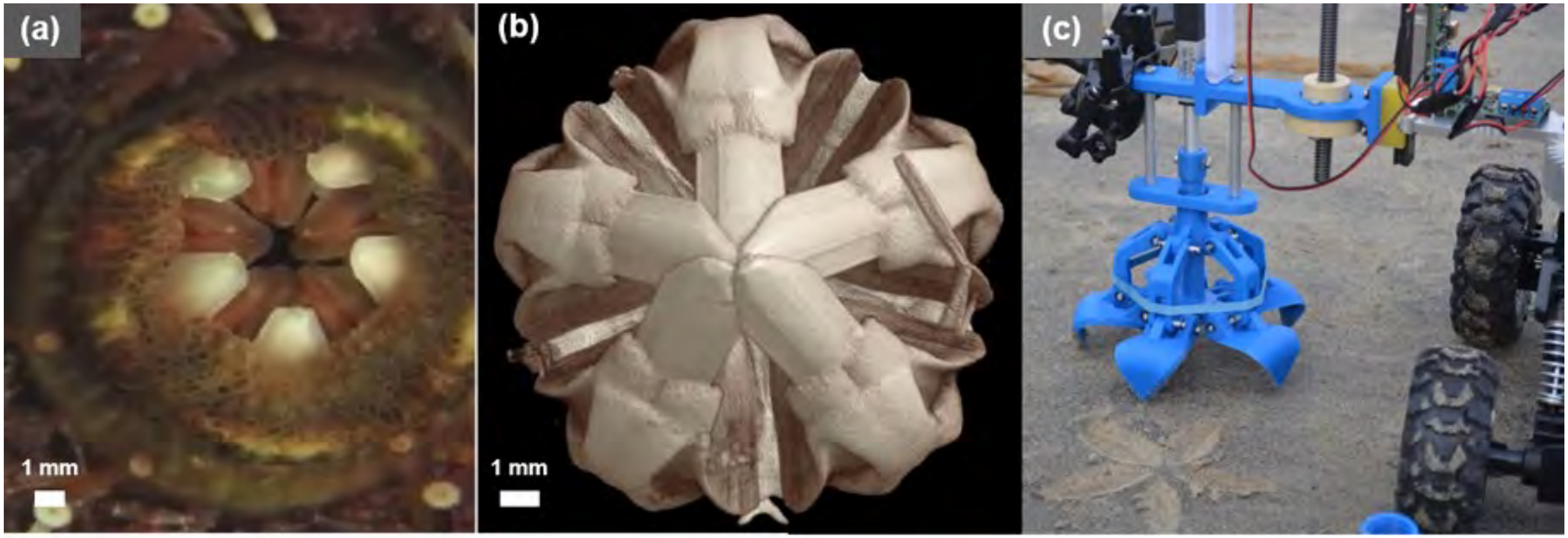
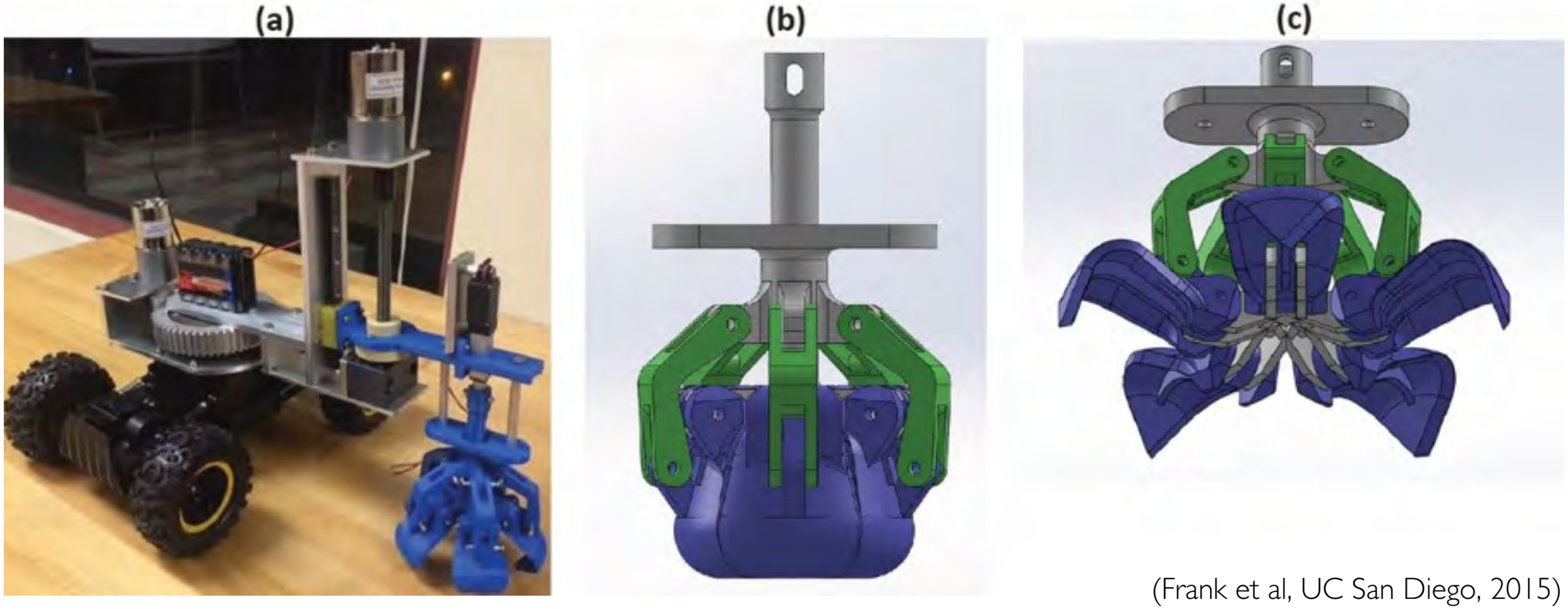
GROUND SAMPLER

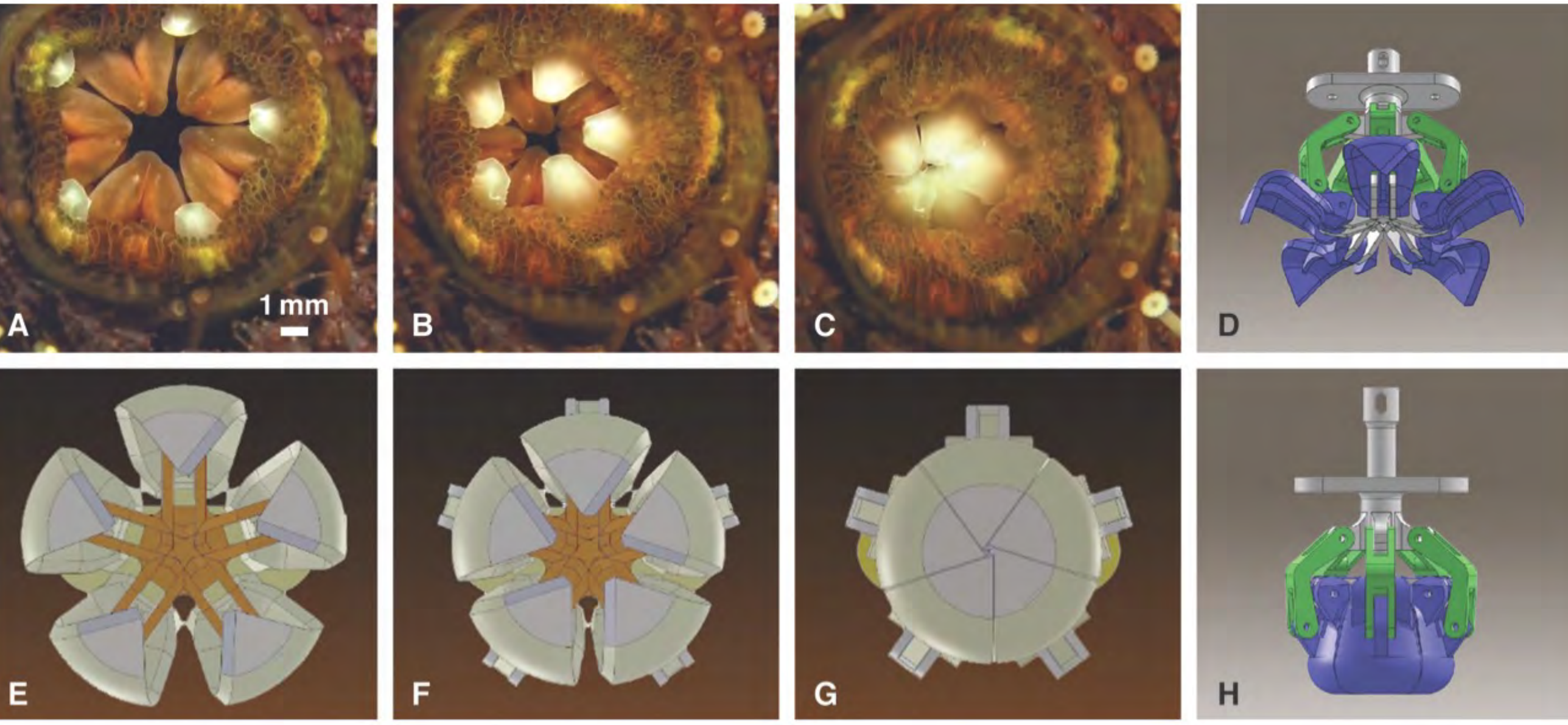
FRANK ET AL.
UNIVERSITY OF CALIFORNIA
SANTA CRUZ (UCSC)

(Frank et al, UC San Diego, 2015)

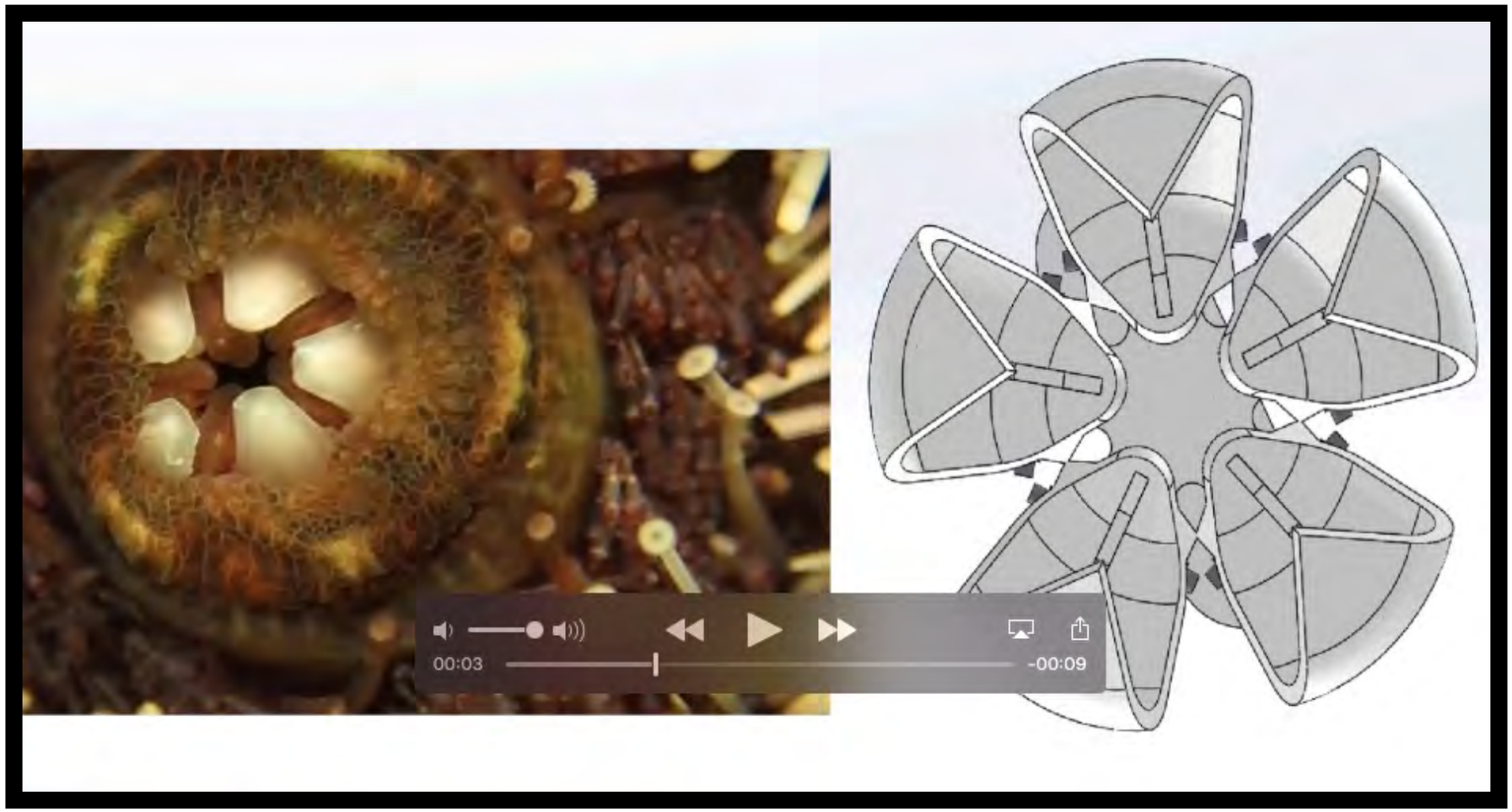




(Frank et al, UC San Diego, 2015)



(Frank et al, UC San Diego, 2015)



[Frank et al., UCSD urchin side-by-side video]

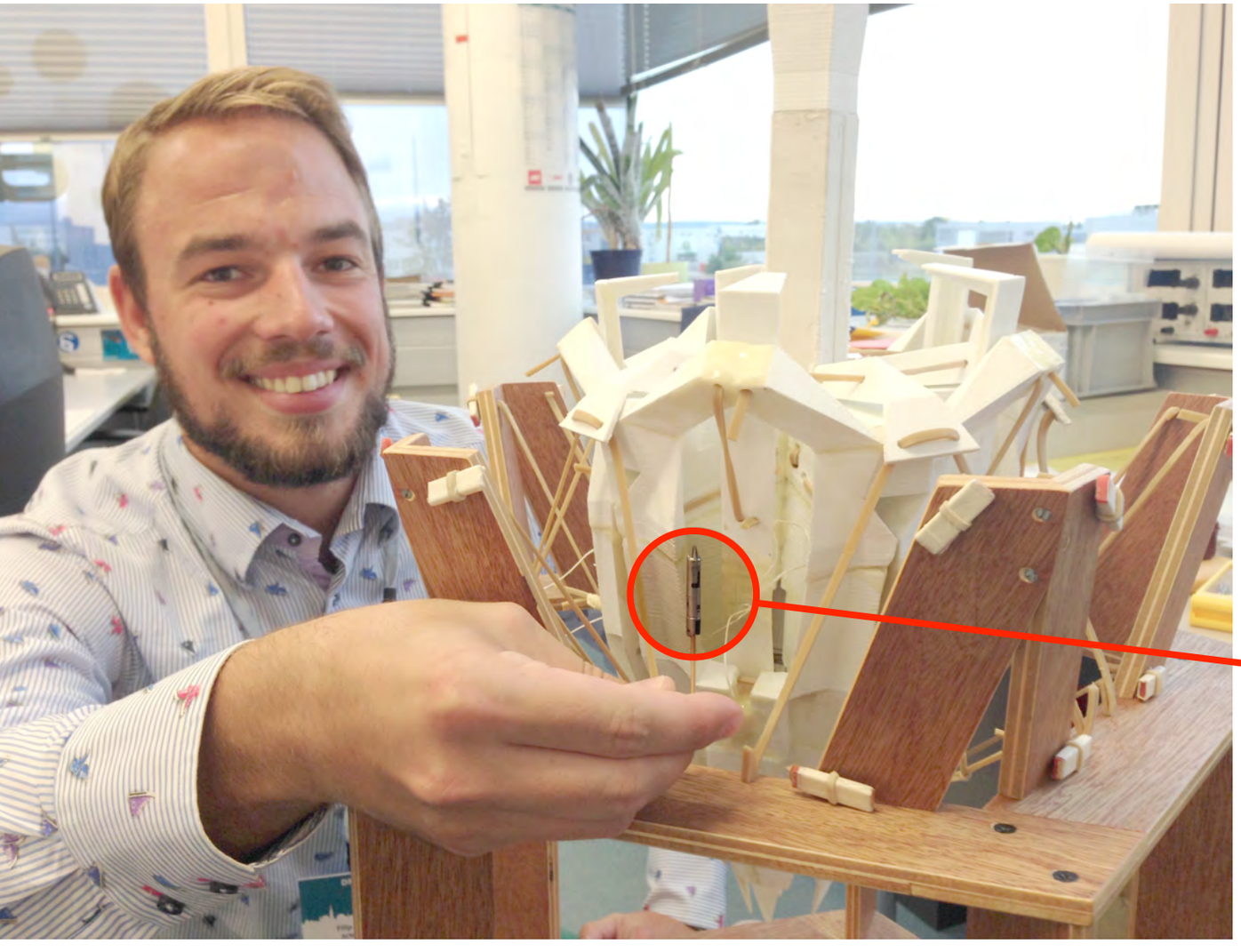
(Frank et al, UC San Diego, 2015)

BIOPSY HARVESTER

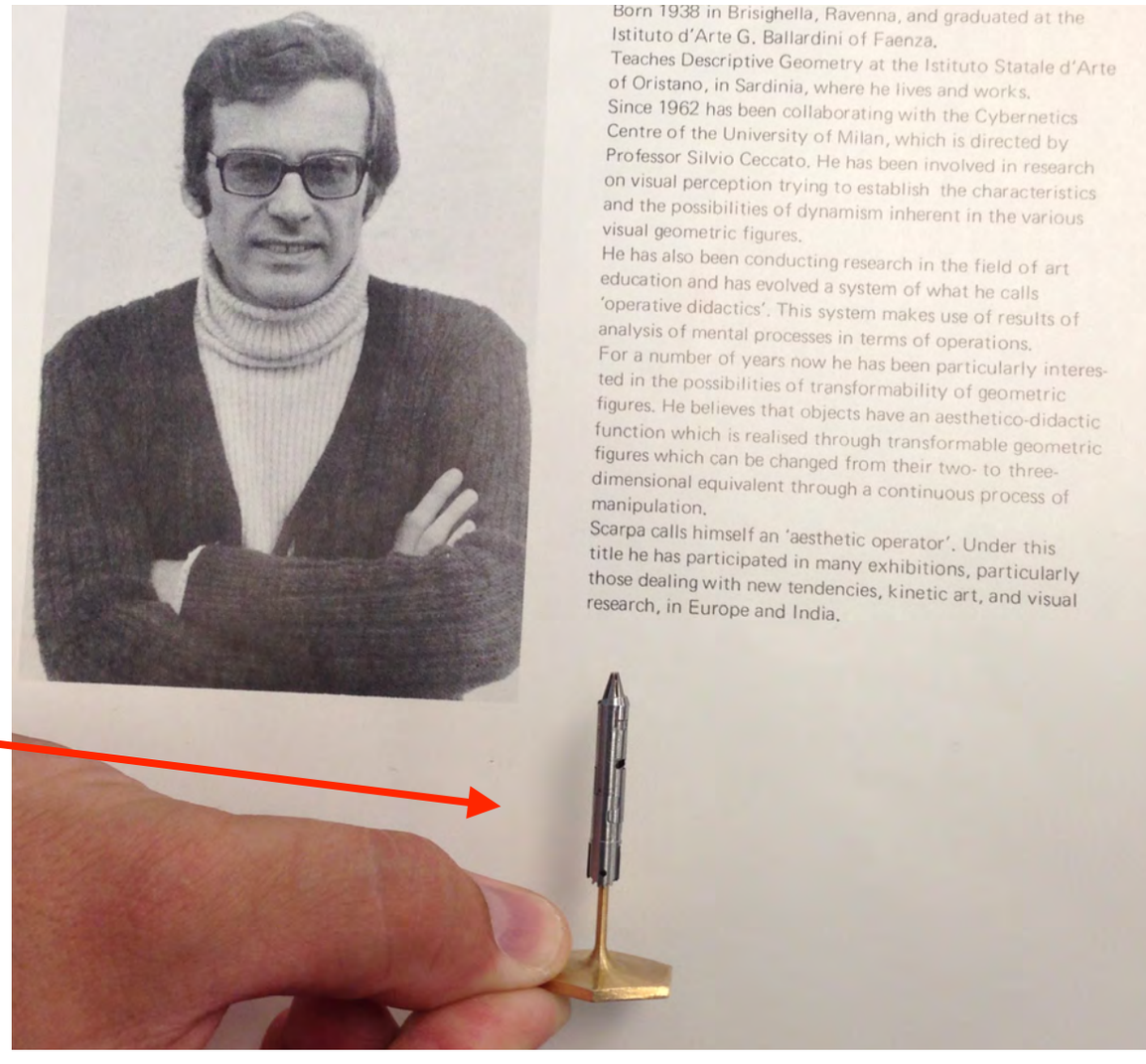
JELÍNEK ET AL.
DELFT UNIVERSITY OF TECHNOLOGY
(TU DELFT)

(Jelínek, Smit, Breedveld, TU Delft; ACMIT, Austria, 2014)

Filip Jelínek

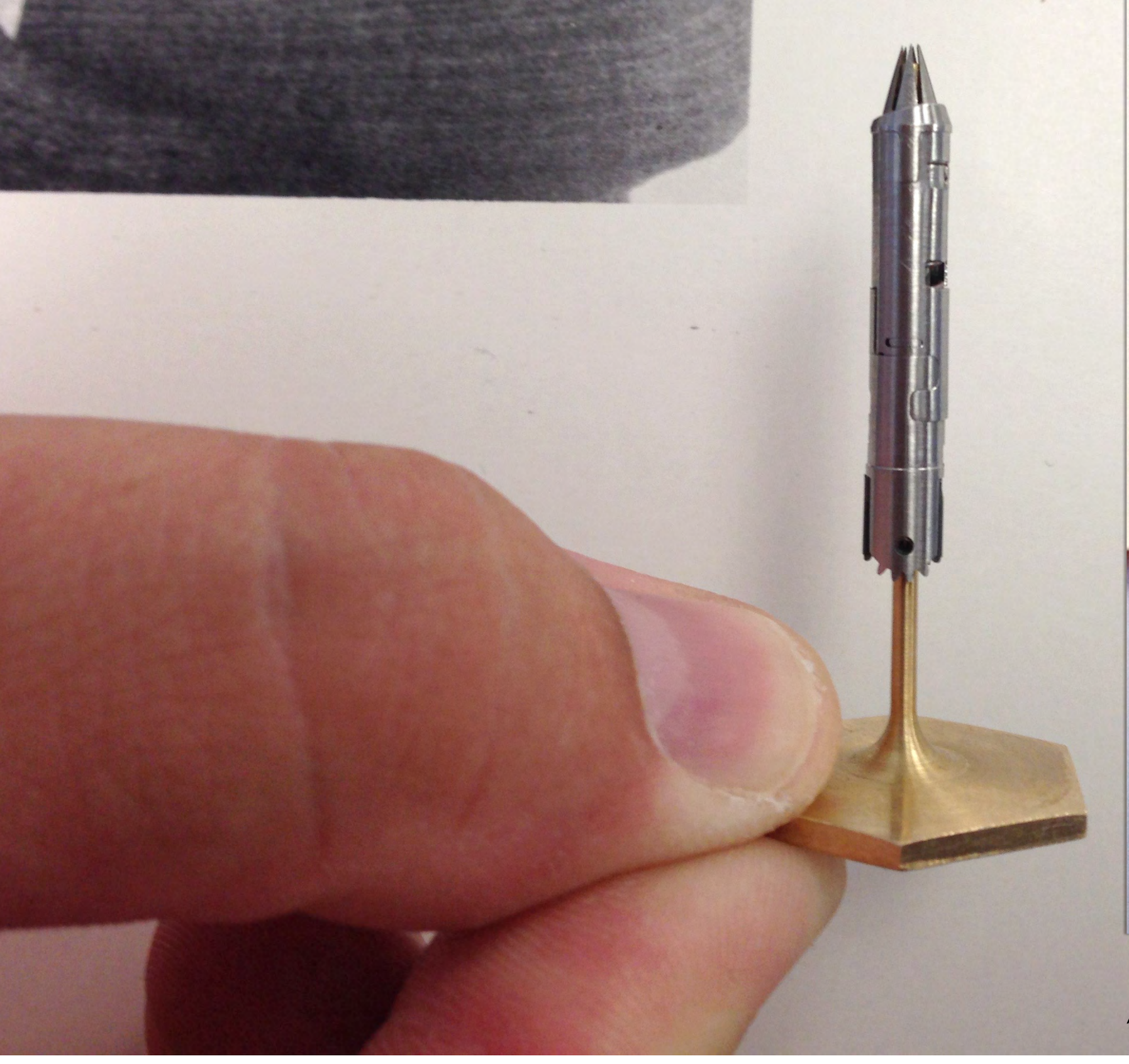


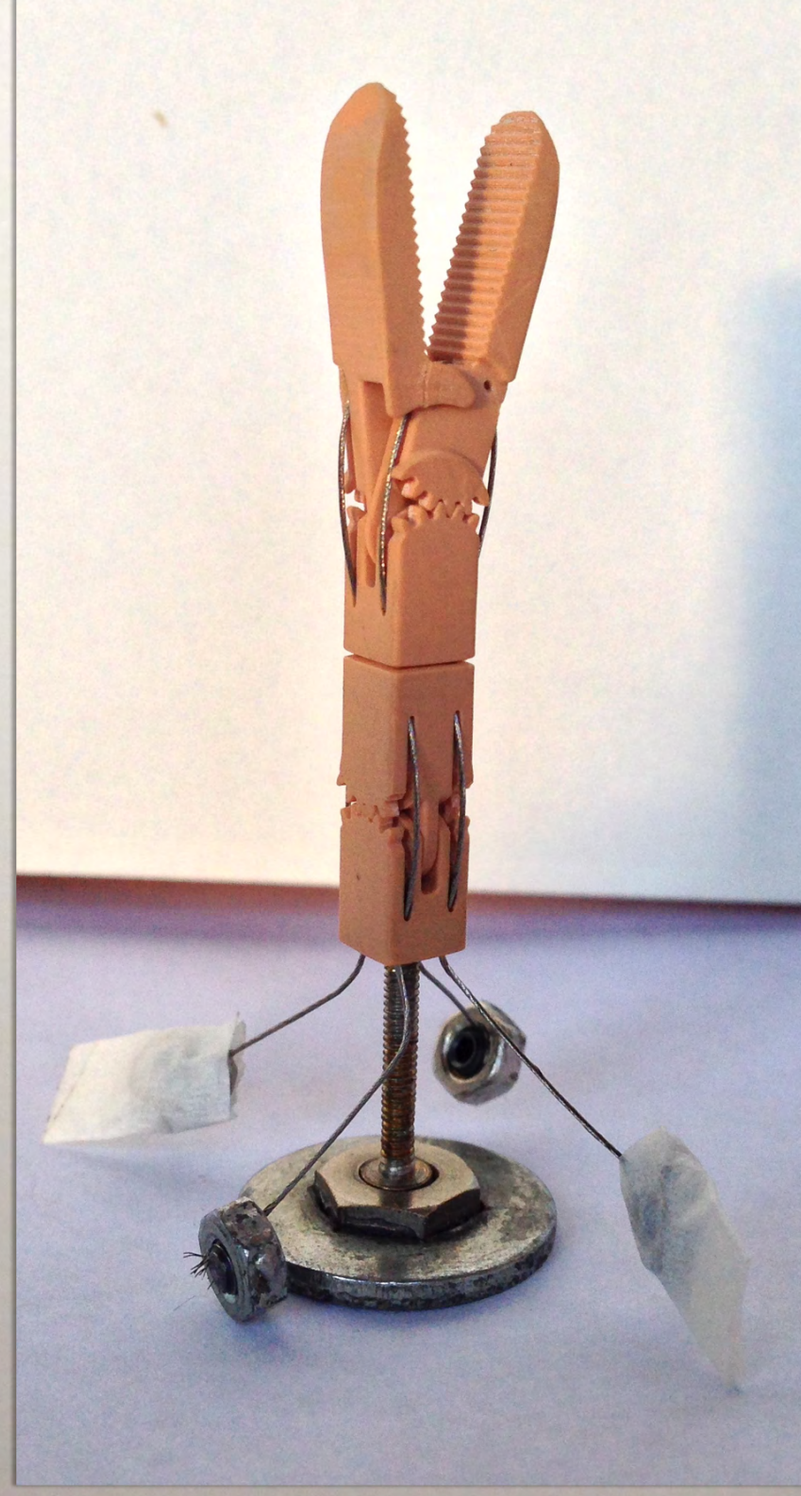
Giorgio Scarpa



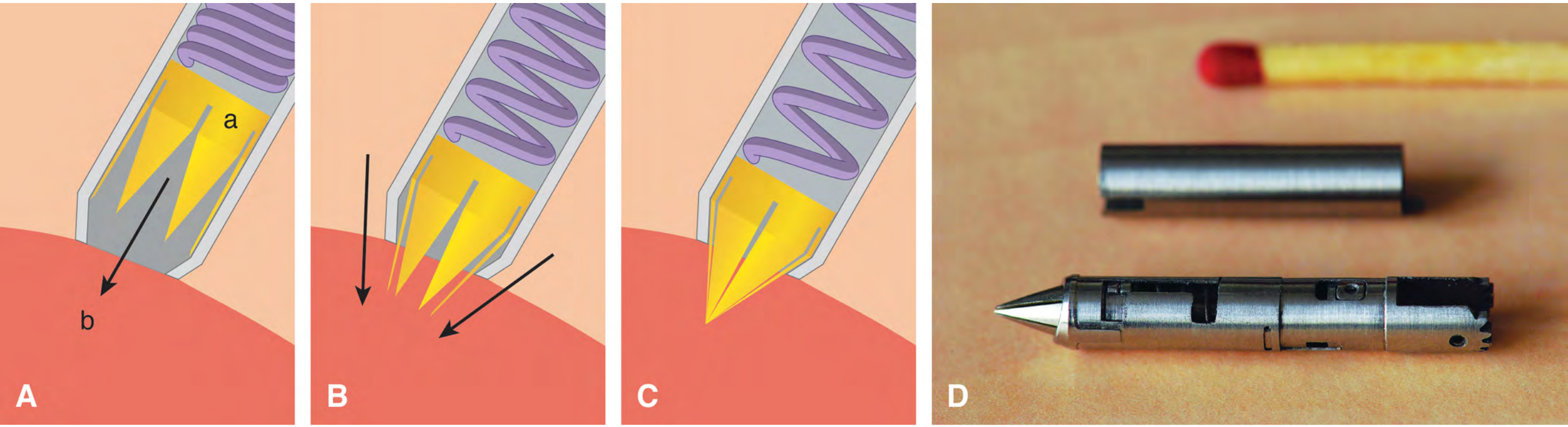
Born 1938 in Brisighella, Ravenna, and graduated at the Istituto d'Arte G. Ballardini of Faenza.
Teaches Descriptive Geometry at the Istituto Statale d'Arte of Oristano, in Sardinia, where he lives and works.
Since 1962 has been collaborating with the Cybernetics Centre of the University of Milan, which is directed by Professor Silvio Ceccato. He has been involved in research on visual perception trying to establish the characteristics and the possibilities of dynamism inherent in the various visual geometric figures.
He has also been conducting research in the field of art education and has evolved a system of what he calls 'operative didactics'. This system makes use of results of analysis of mental processes in terms of operations.
For a number of years now he has been particularly interested in the possibilities of transformability of geometric figures. He believes that objects have an aesthetico-didactic function which is realised through transformable geometric figures which can be changed from their two- to three-dimensional equivalent through a continuous process of manipulation.
Scarpa calls himself an 'aesthetic operator'. Under this title he has participated in many exhibitions, particularly those dealing with new tendencies, kinetic art, and visual research, in Europe and India.

(Jelínek, Smit, Breedveld, TU Delft; ACMIT, Austria, 2014)





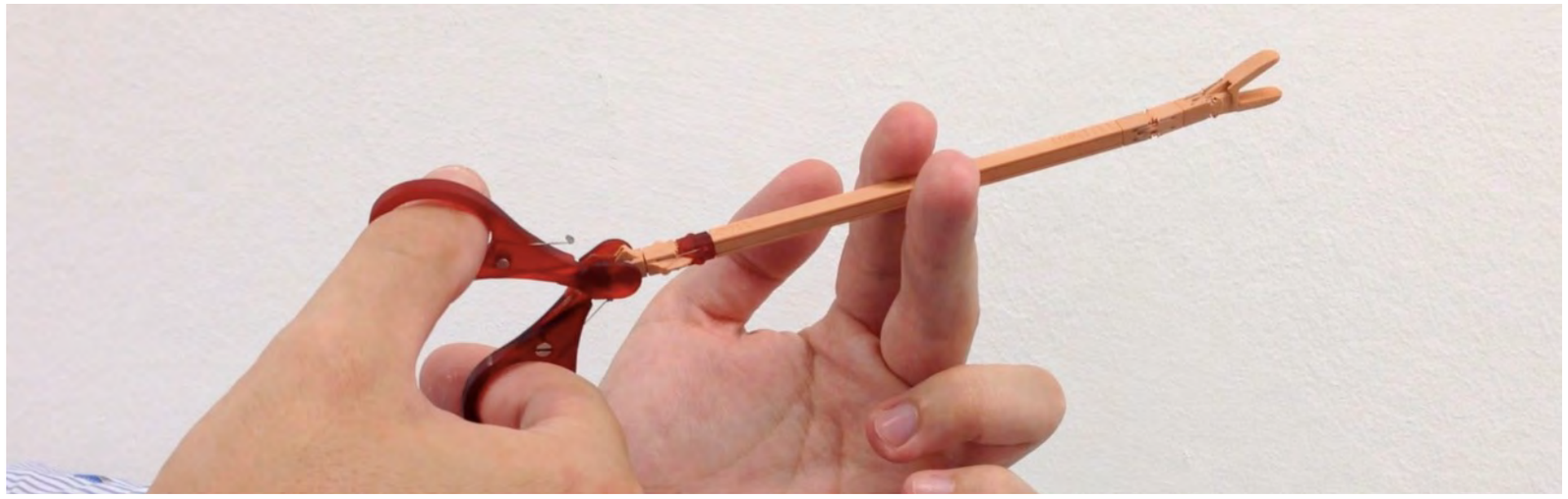
(Jelínek, Smit, Breedveld, TU Delft; ACMIT, Austria, 2014)



(Jelínek, Smit, Breedveld, TU Delft; ACMIT, Austria, 2014)

(Jelínek, Smit, Breedveld, TU Delft; ACMIT, Austria, 2014)

Figure 9.4 *Final manufactured steerable opto-mechanical biopsy harvester prototype.*



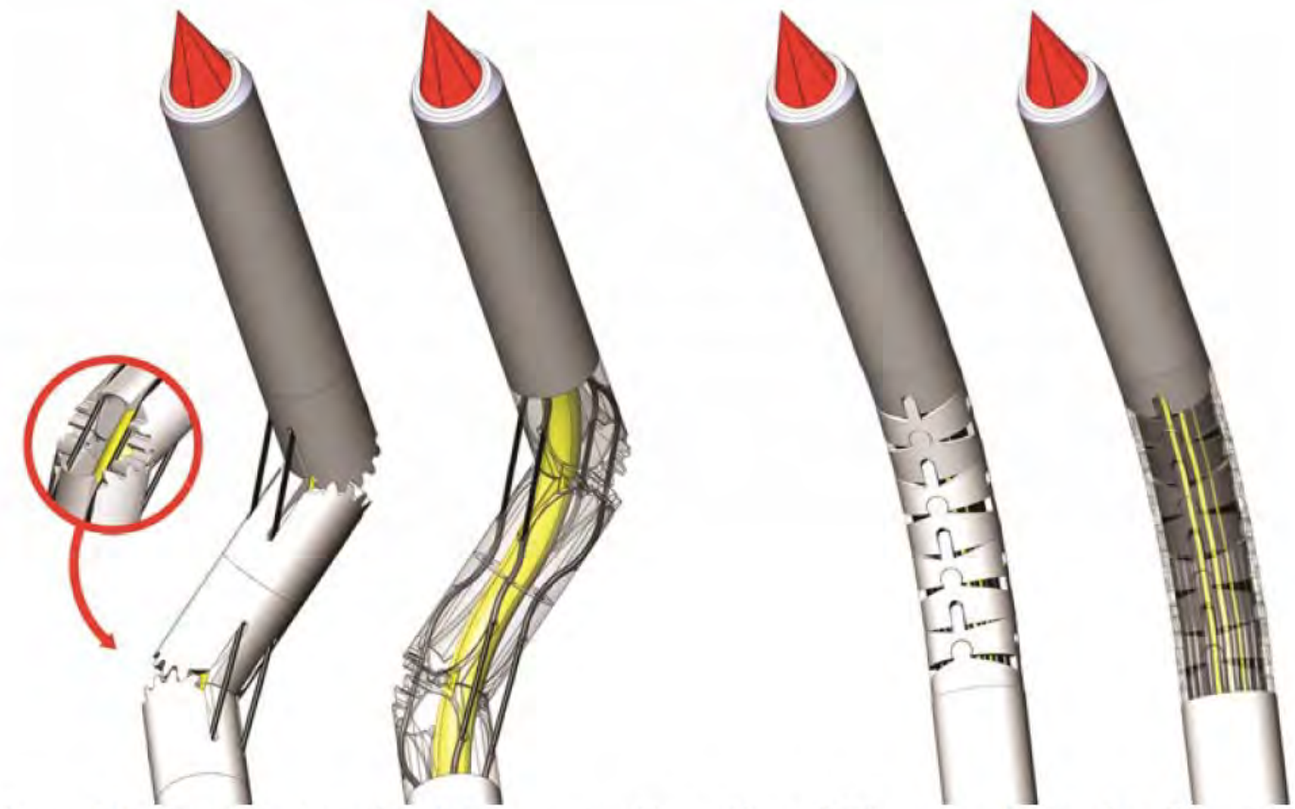


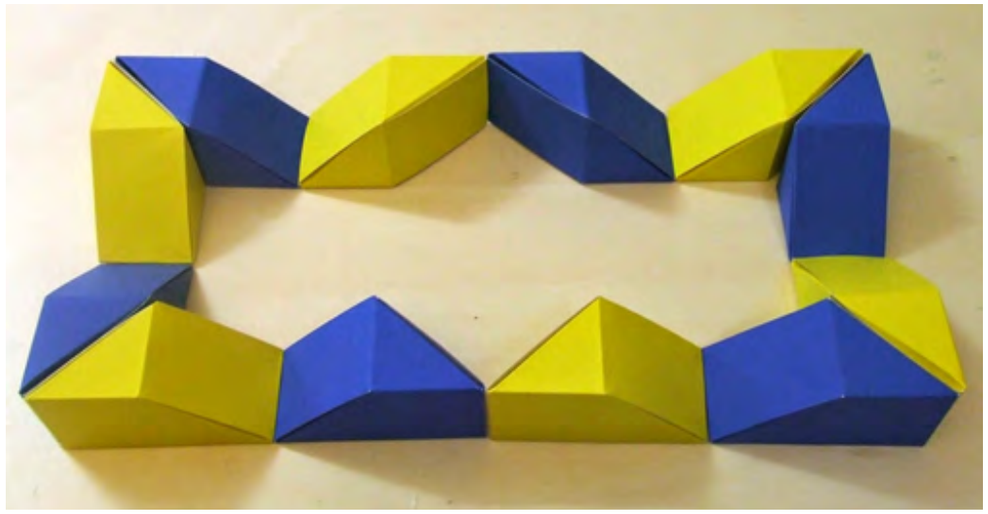
Figure 9.3 *Feasible steerable joint constructions: the additive manufactured rolling joint construction and the laser cut joint construction. Joints are actuated by steering cables (black).*

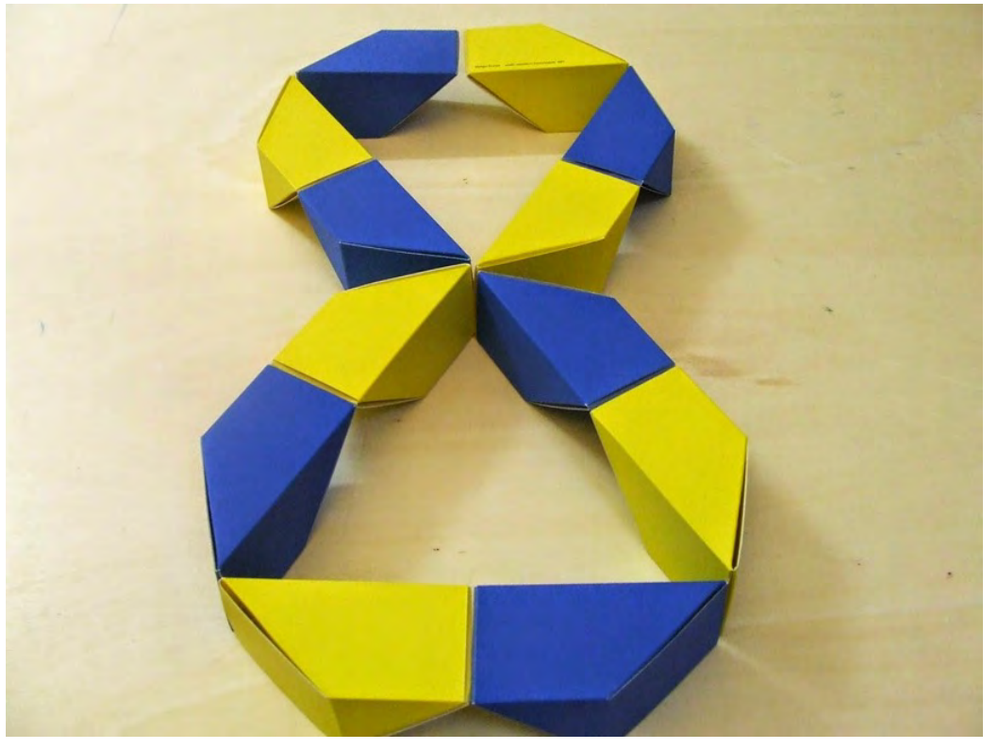
Jelínek, Filip, Steering and Harvesting Technology for Minimally Invasive Biopsy

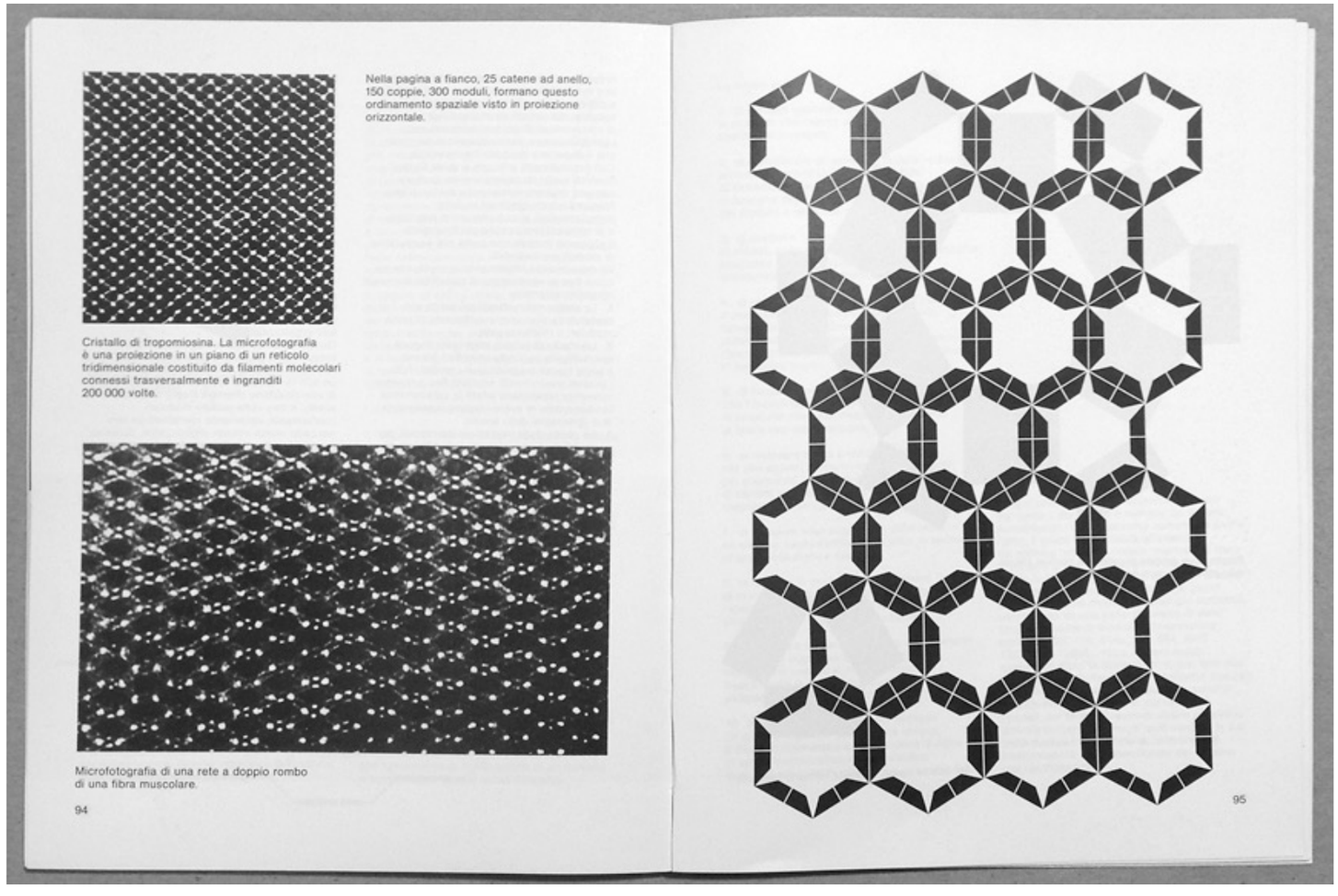
PhD dissertation
doi:10.4233/uuid:18bc7cc6-153b-4ffe-8da1-474f08a212fc
Delft University of Technology, 2015

[Jelínek, Filip, Steering and Harvesting Technology for Minimally Invasive Biopsy]

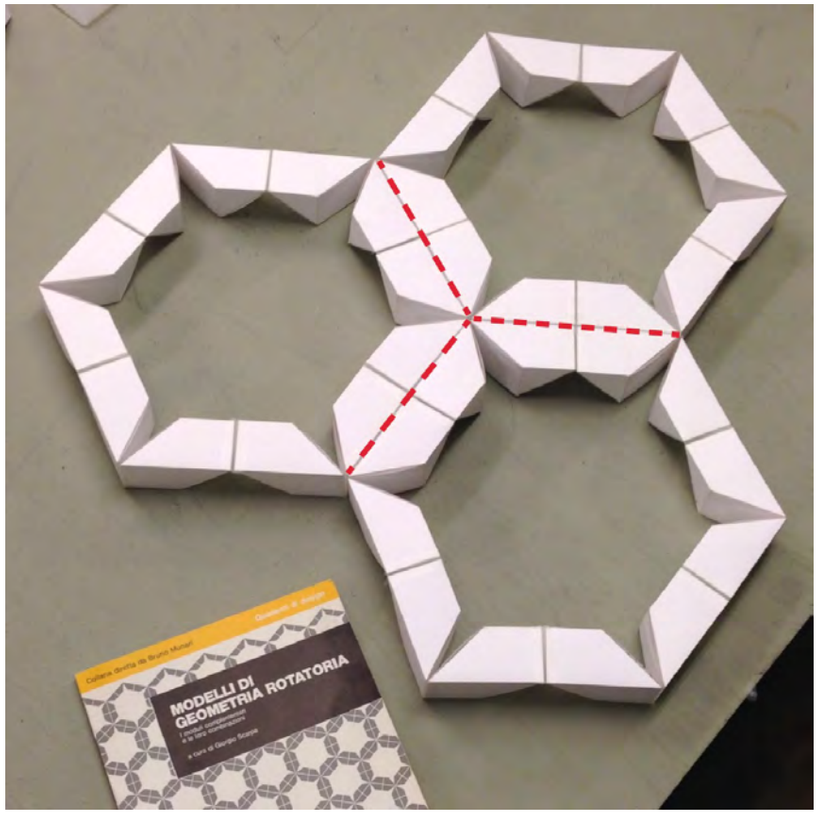
PERIODIC STRUCTURES

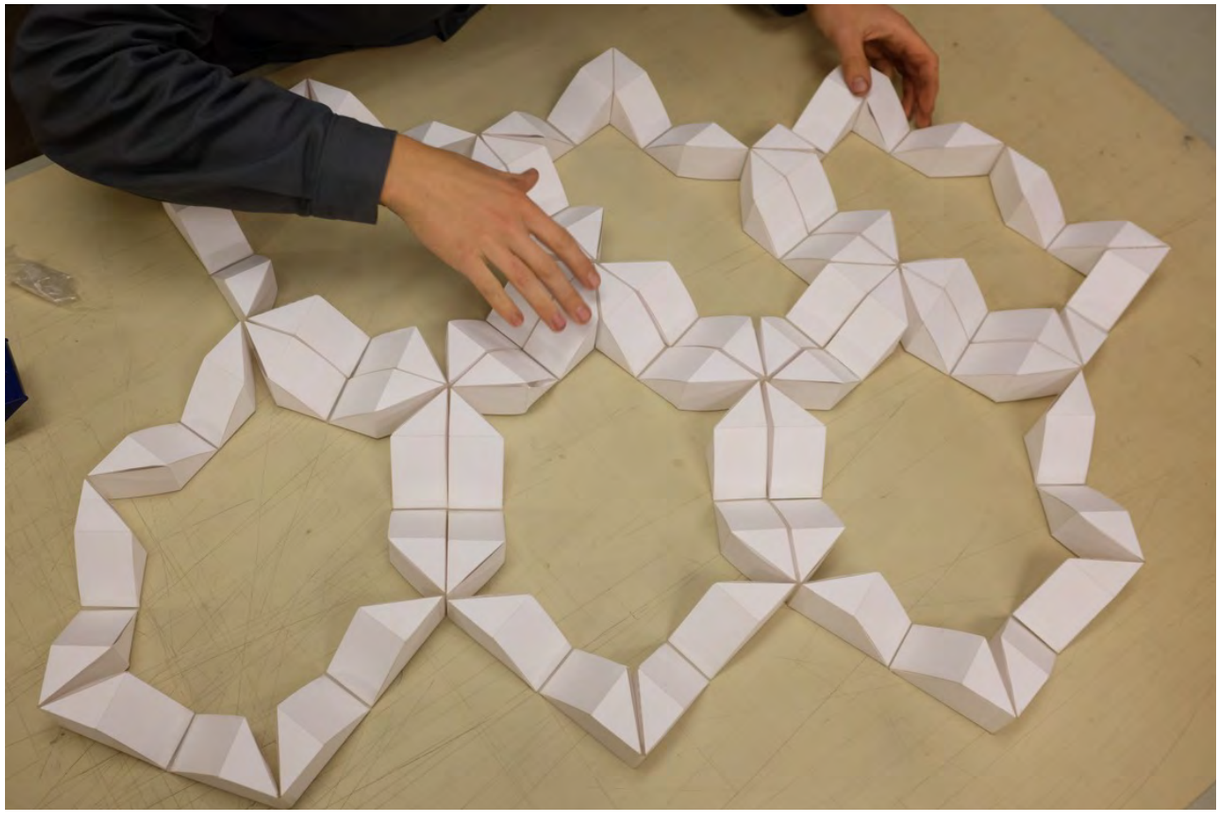


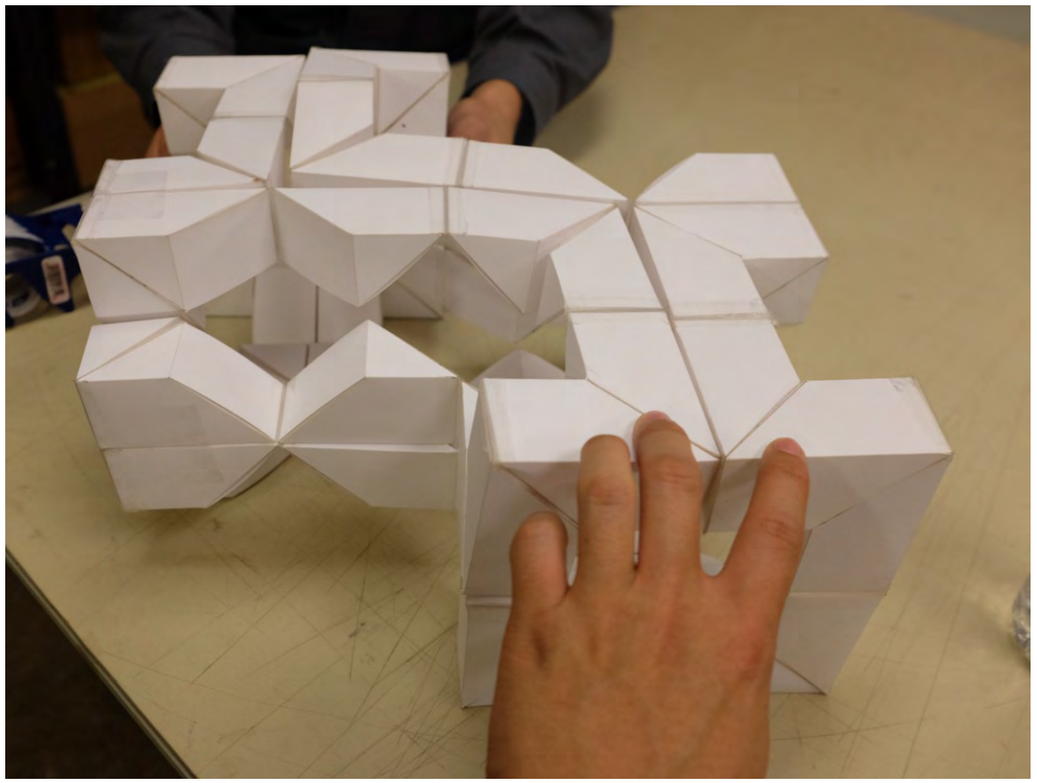


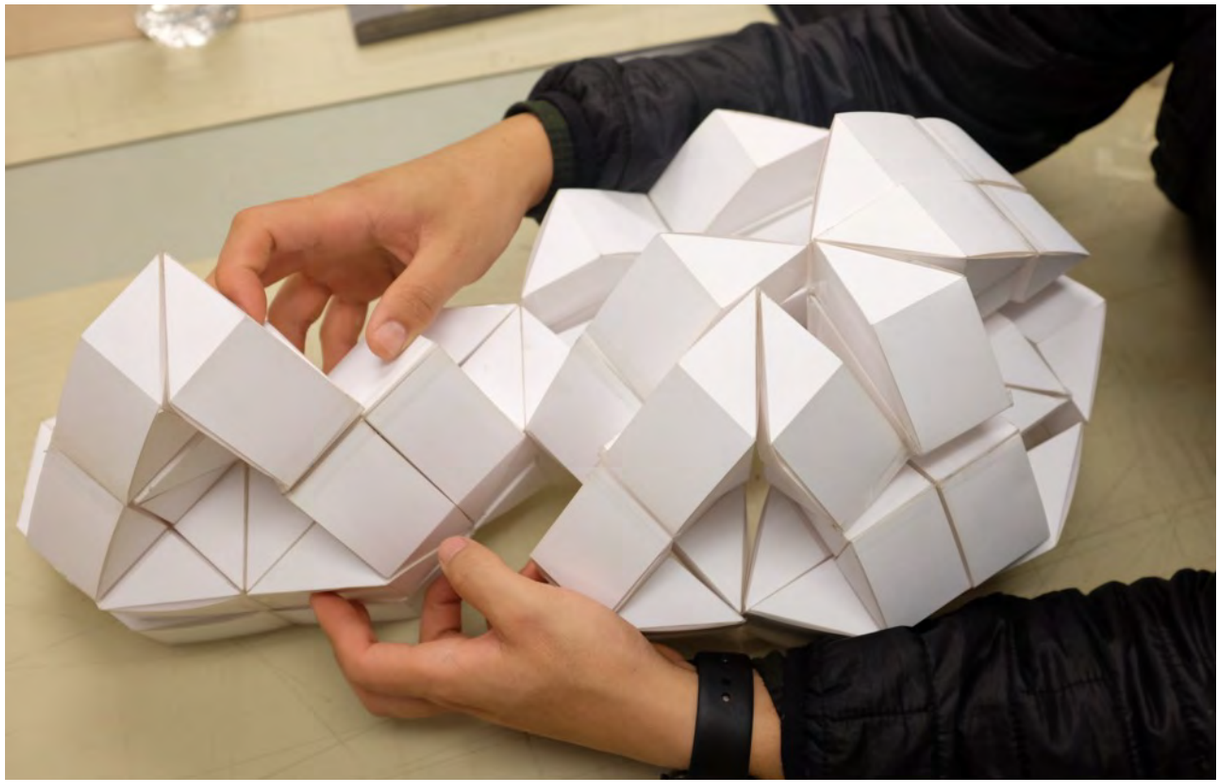

Nella pagina a fianco, 25 catene ad anello, 150 coppie, 300 moduli, formano questo ordinamento spaziale visto in proiezione orizzontale.
Cristallo di tropomiosina. La microfotografia è una proiezione in un piano di un reticolo tridimensionale costituito da filamenti molecolari connessi trasversalmente e ingranditi 200 000 volte.
Microfotografia di una rete a doppio rombo di una fibra muscolare.
94
95

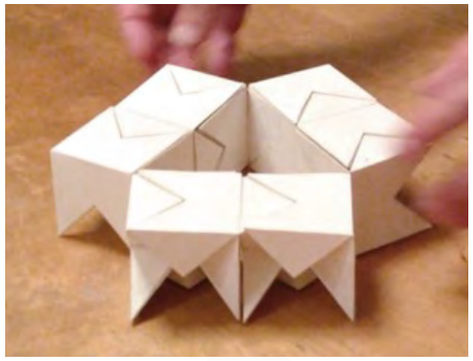
PROTOTYPE OF TRANSFORMABLE CHAIN BY GIORGIO SCARPA.
MODEL CONSTRUCTION: LAMAR PI & JACK LIONS, SAN FRANCISCO STATE UNIVERSITY

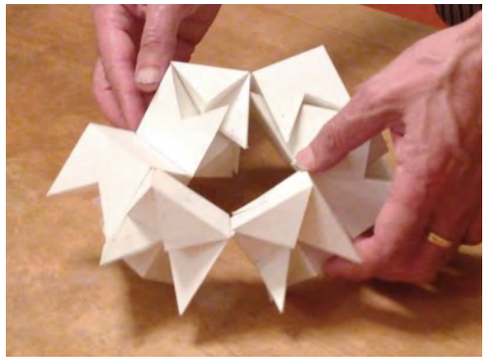


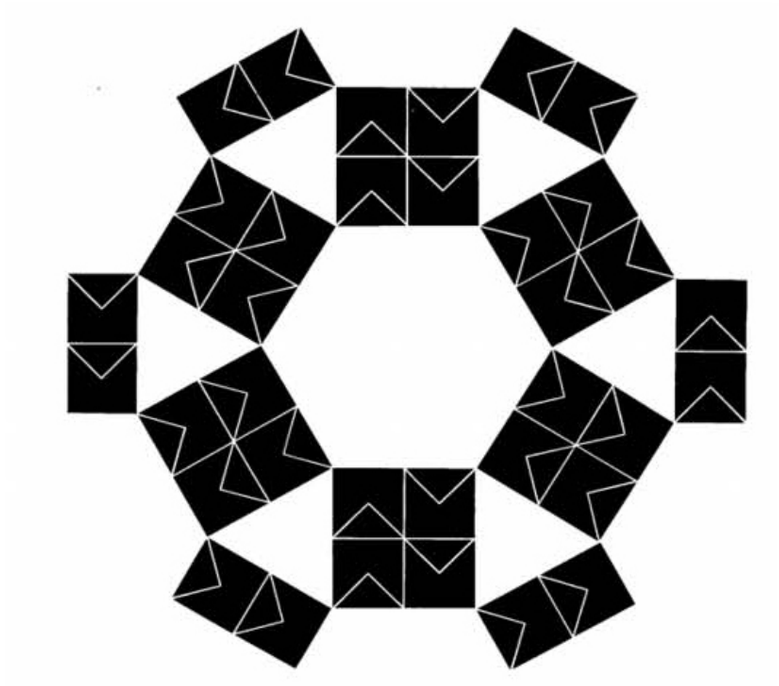


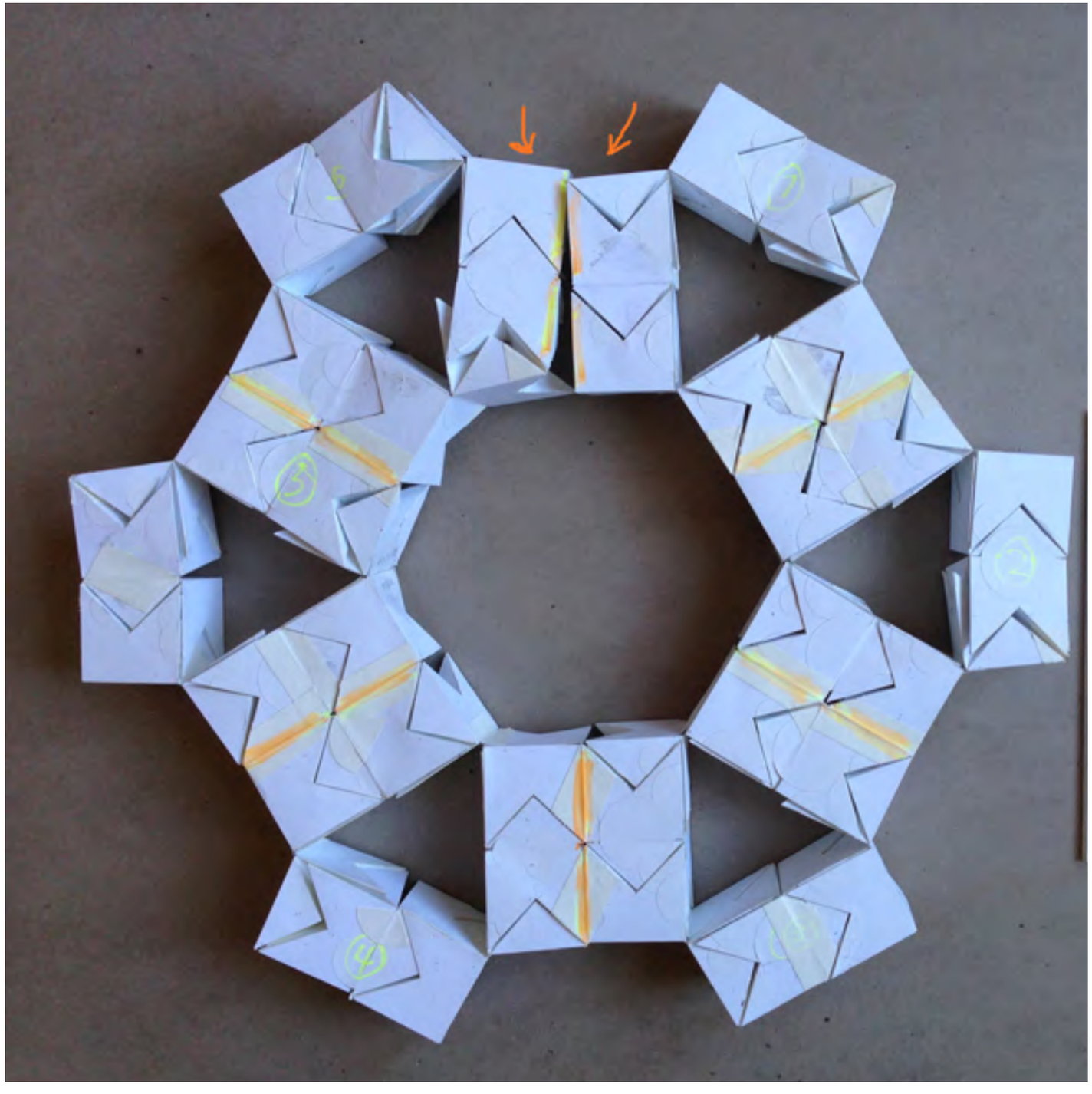






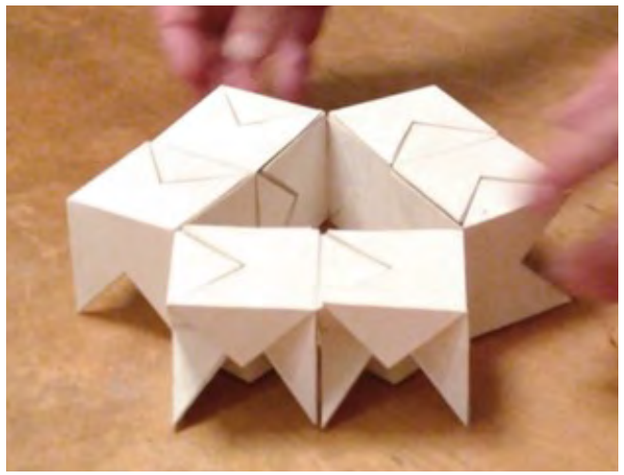


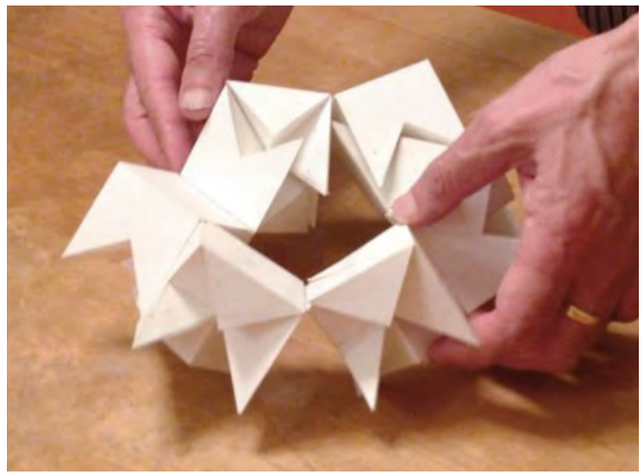


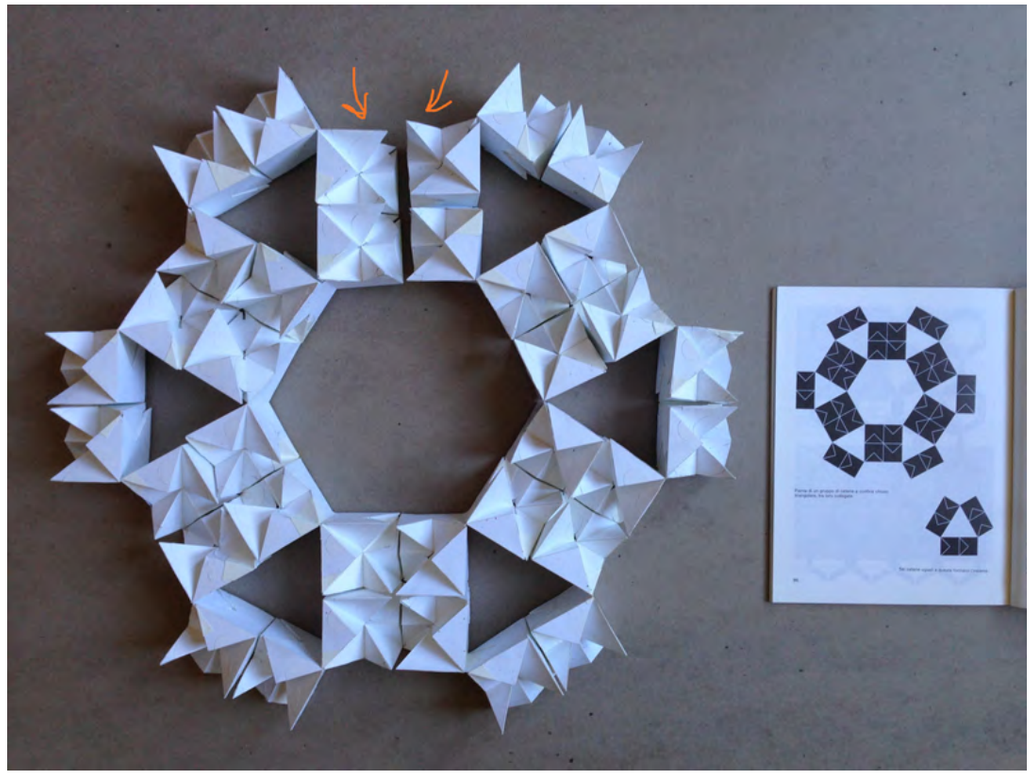


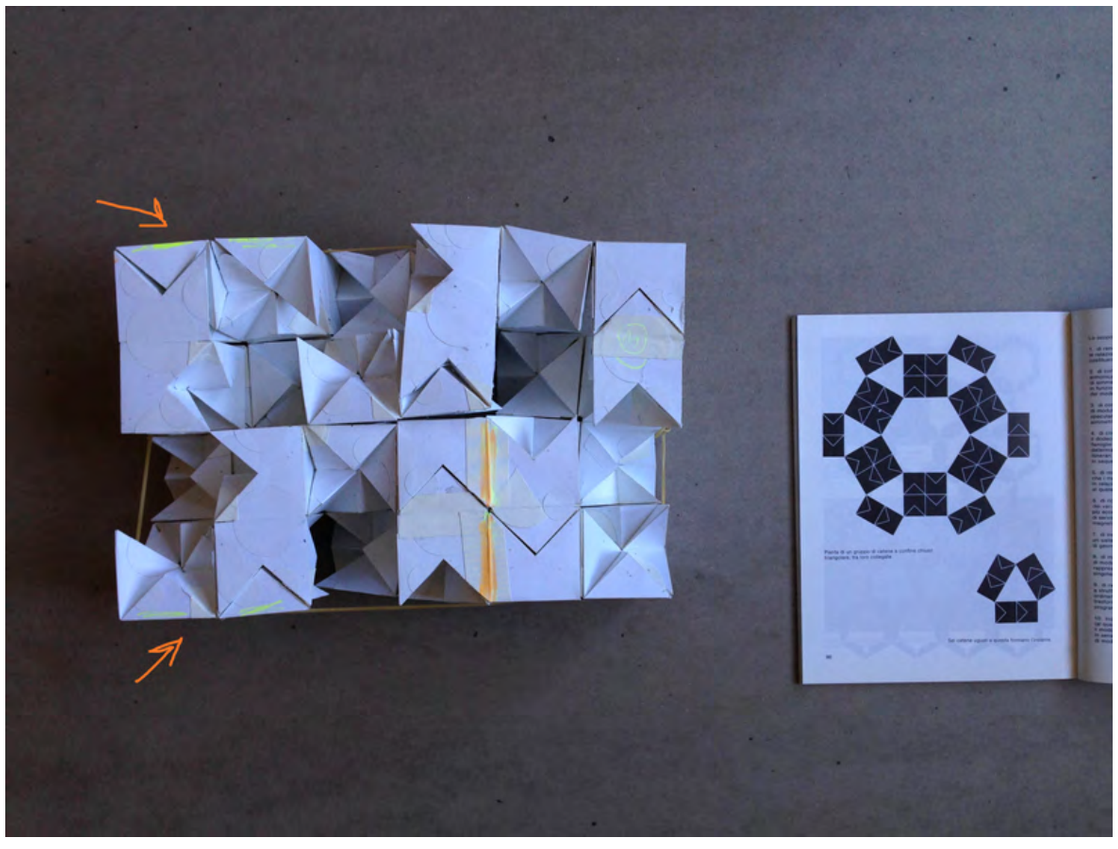
(Trogu & Nies, prototype, 2015)

PROTOTYPE OF TRANSFORMABLE CHAIN BY GIORGIO SCARPA.
MODEL CONSTRUCTION BY PINO TROGU & CLIFF NIES





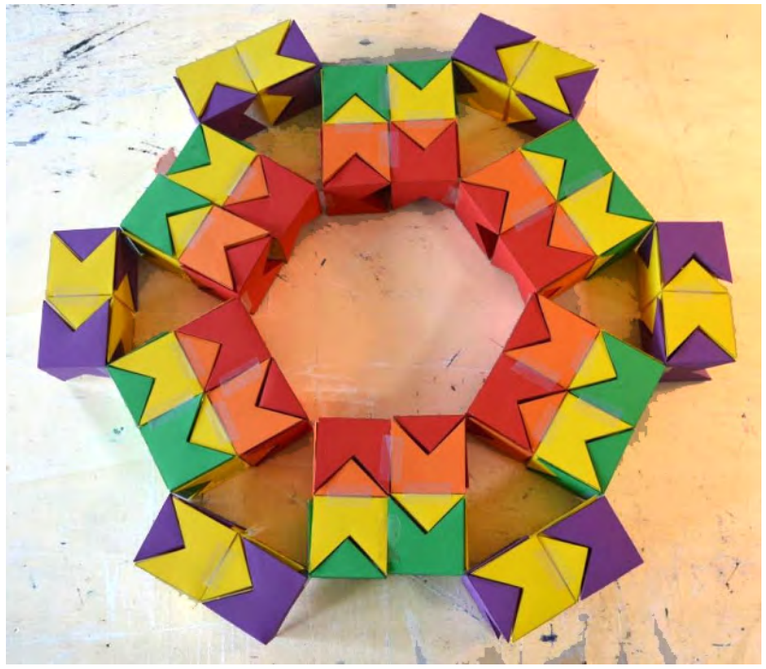




Scarpa, *Models of Rotational Geometry*, pp. 66-68, 96

(Trogu & Nies, prototype, 2015)

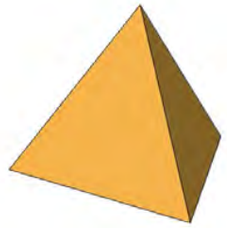




PROTOTYPE OF TRANSFORMABLE CHAIN BY GIORGIO SCARPA.
MODEL CONSTRUCTION BY FEDERICA DESTRI, OFFANENGO (ITALY)

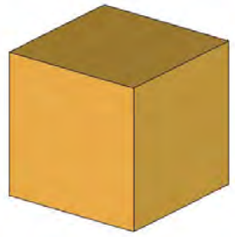
PLATONIC SOLIDS
(REGULAR POLYHEDRA)

TETRAHEDRON



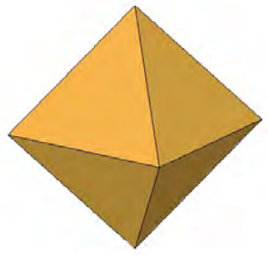
4 TRIANGLES

HEXAHEDRON (CUBE)



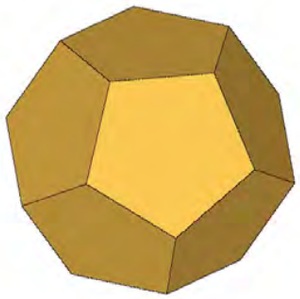
6 SQUARES

OCTAHEDRON



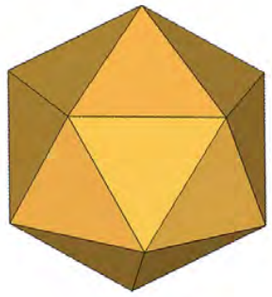
8 TRIANGLES

DODECAHEDRON



12 PENTAGONS

ICOSAHEDRON



20 TRIANGLES

THE THREE REGULAR HONEYCOMBS

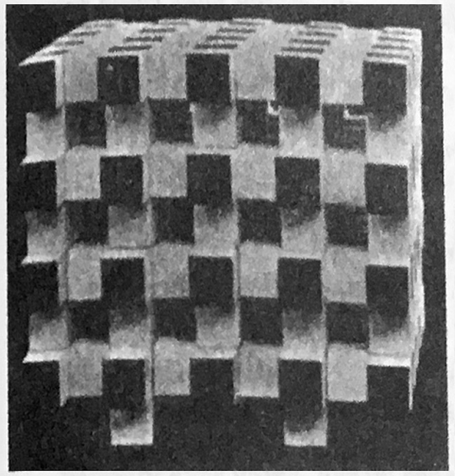


Fig. i: {4, 6|4}.

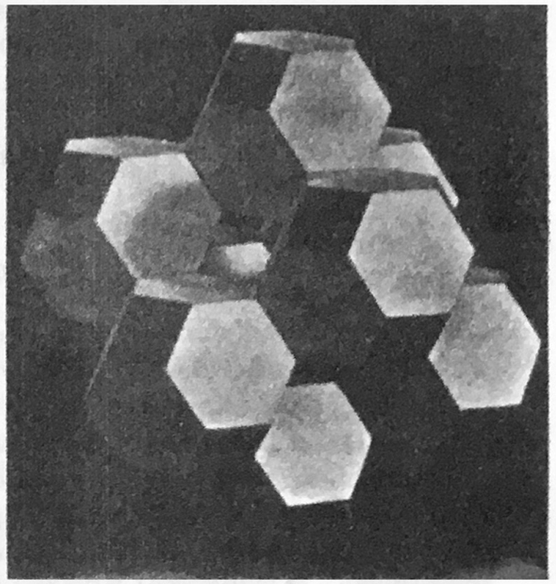


Fig. ii: {6, 4|4}.

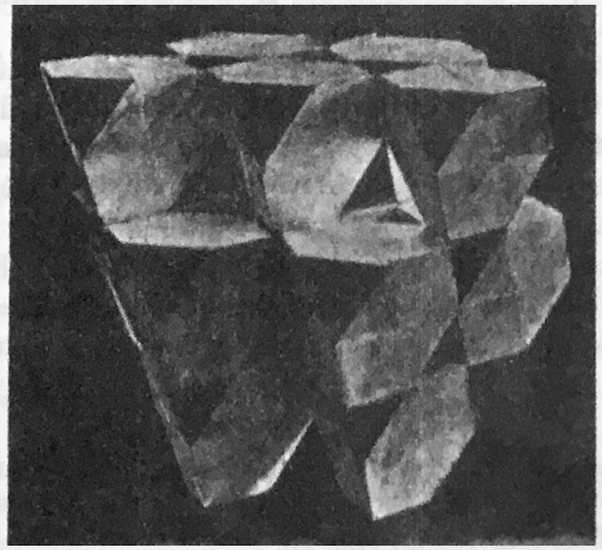
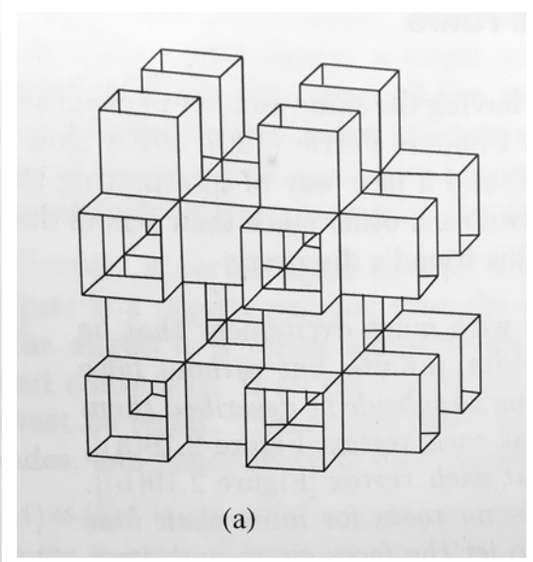
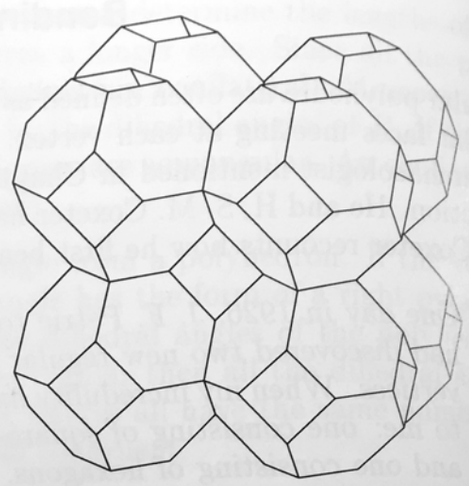


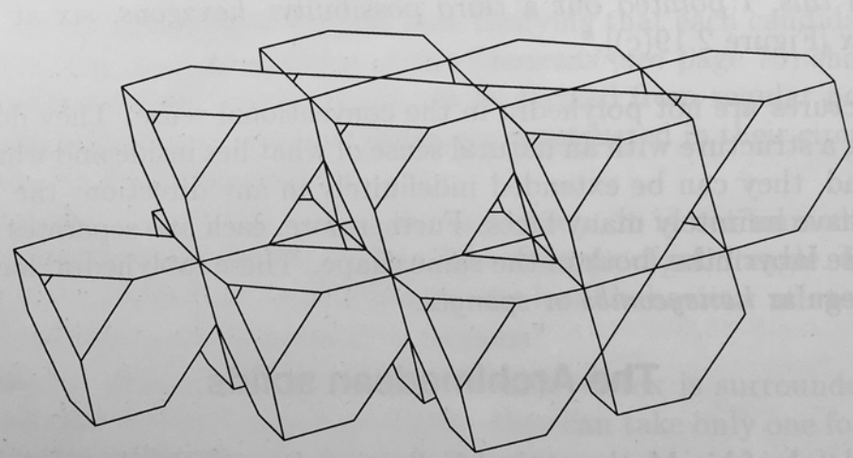
Fig. iii: {6, 6|3}.



(a)



(b)

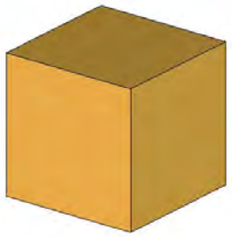


(c)

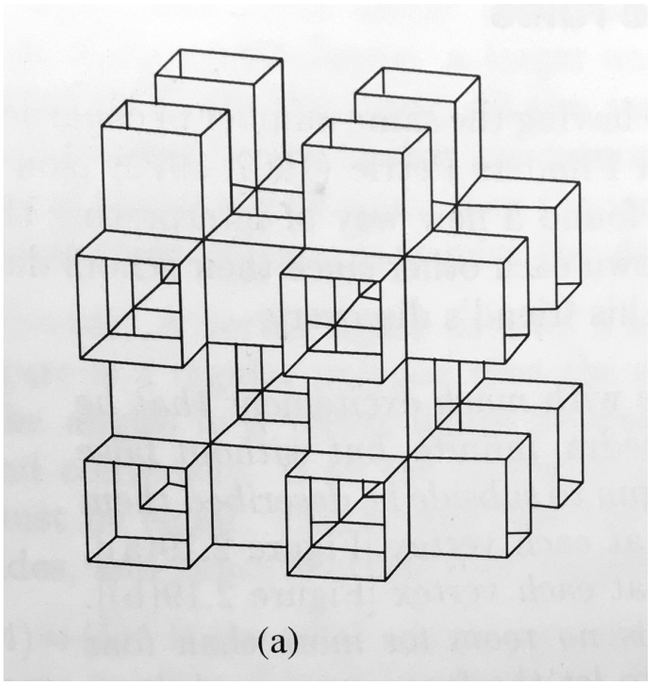
Figure 2.19. The three regular honeycombs.

J. F. PETRIE & H.S.M. COXETER, 1926

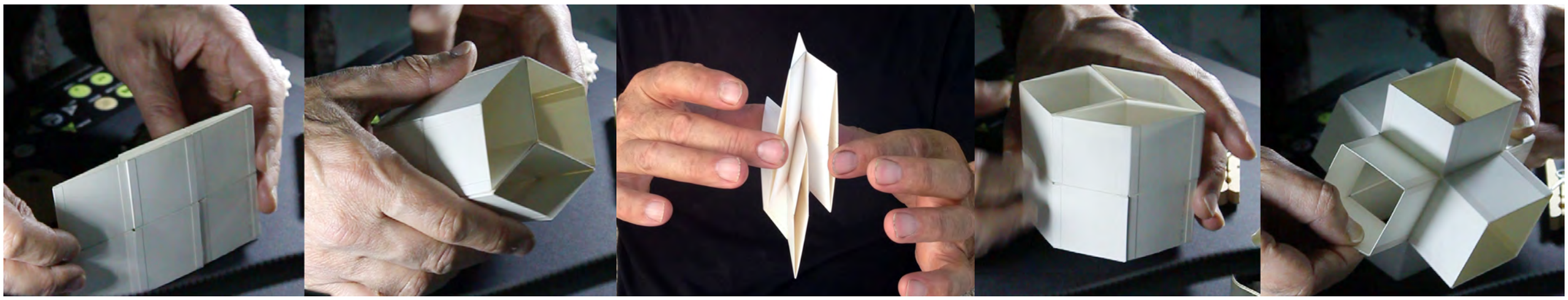
P. CROMWELL, 1997



J. F. PETRIE, 1926



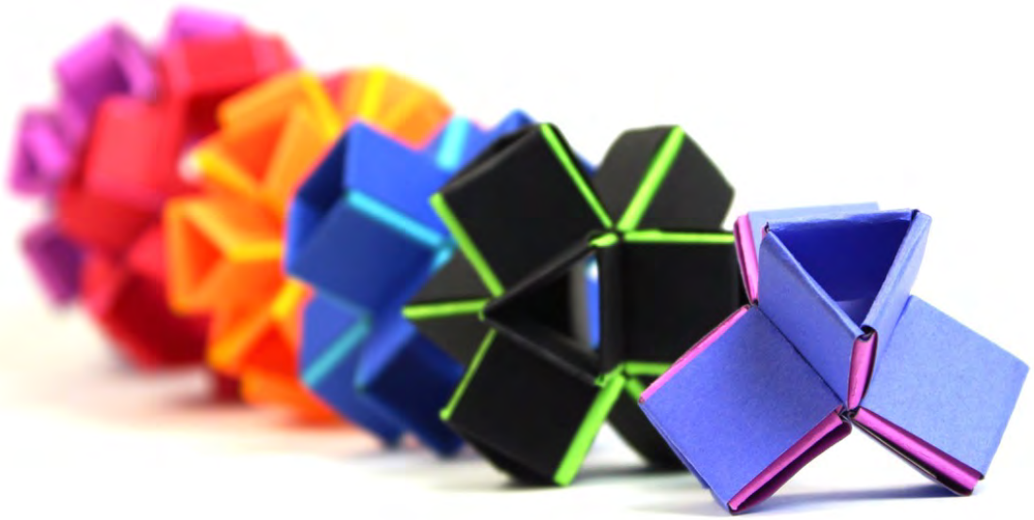
G. SCARPA, 1996



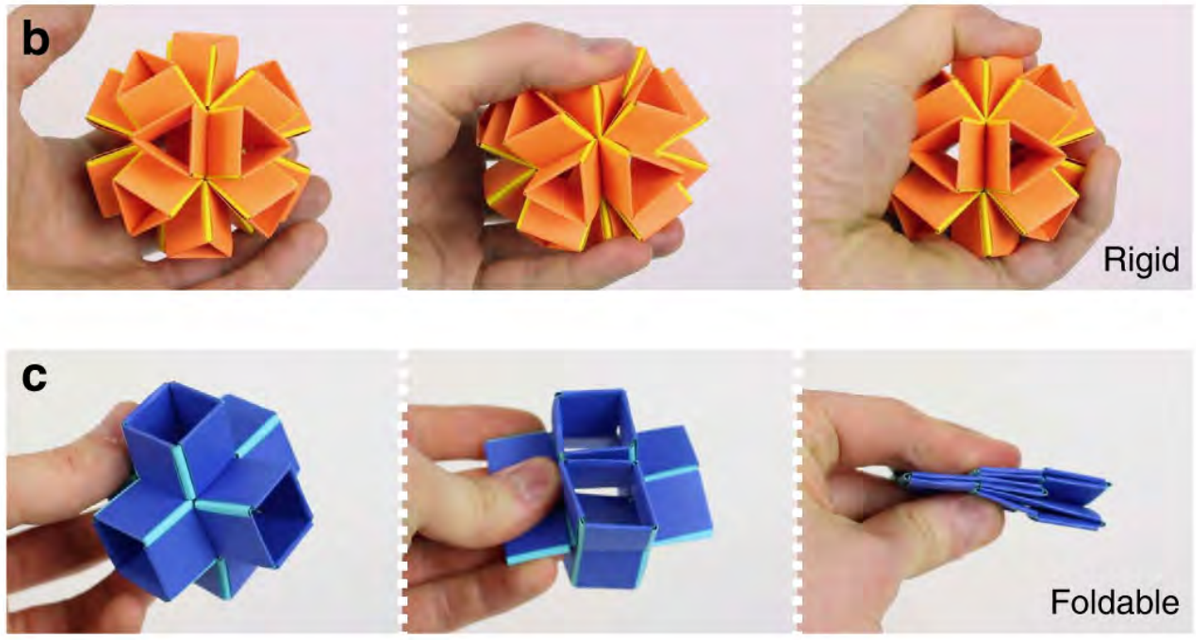
B. OVERVELDE, 2016

“METAMATERIALS”, B. OVERVELDE, 2016

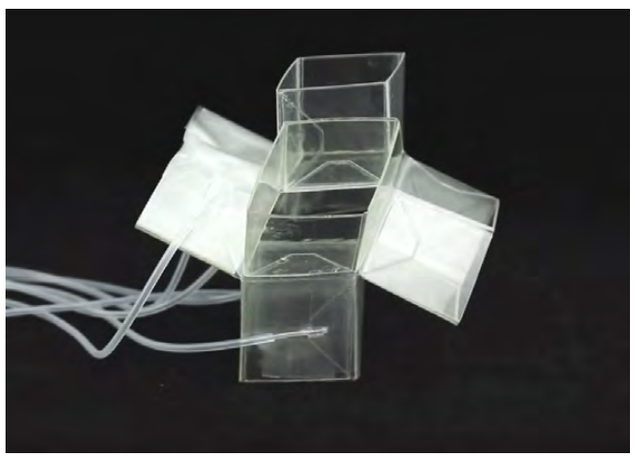
SNAP ORIGAMI POLYHEDRA



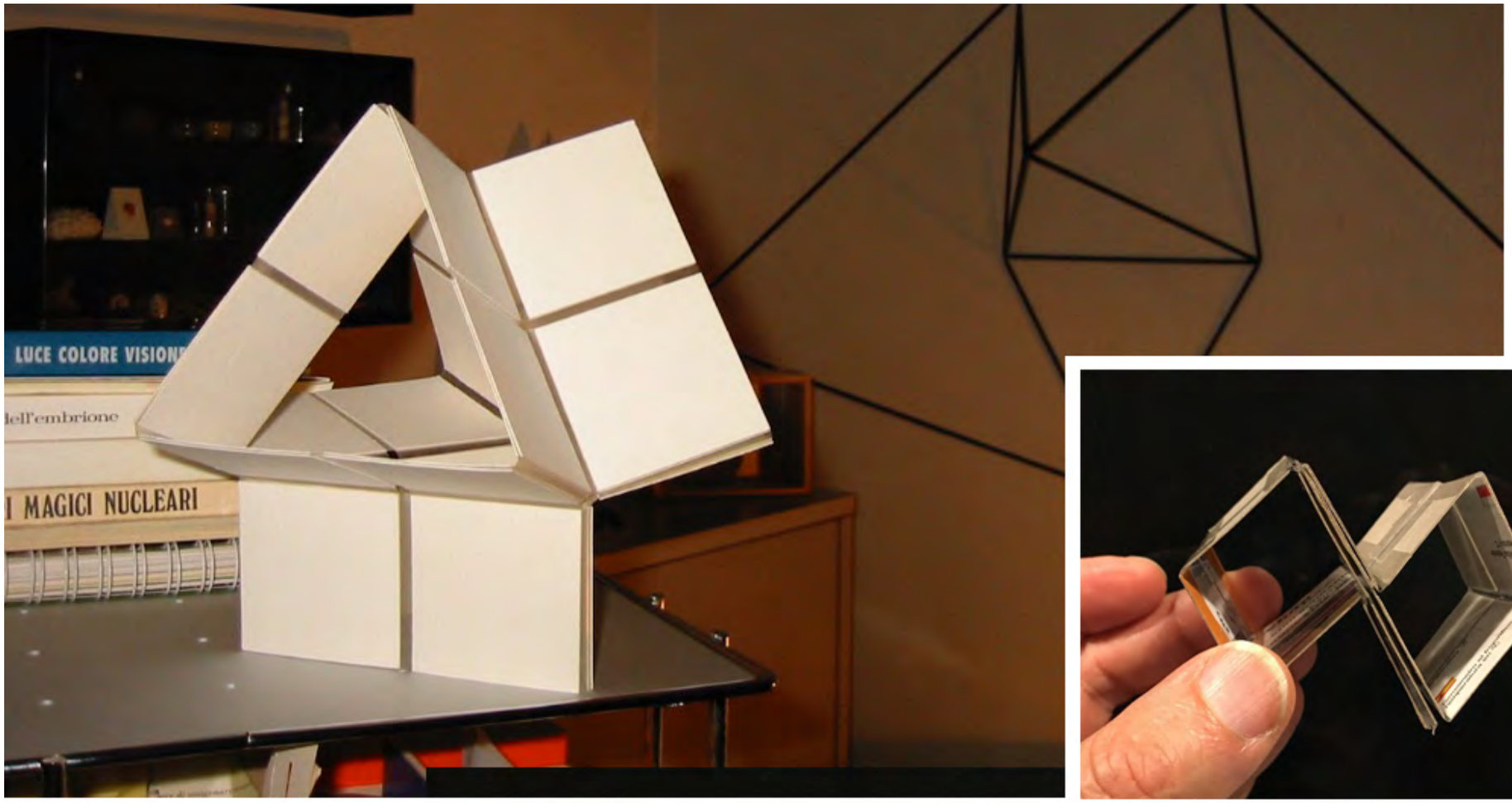
ICOSAHEDRON: RIGID

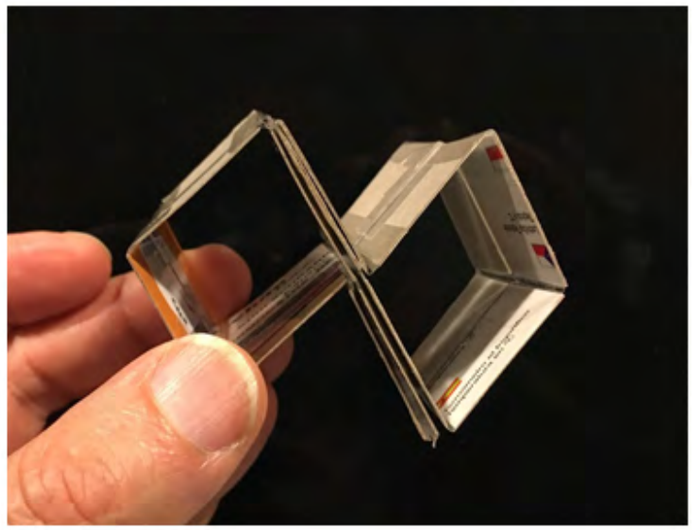


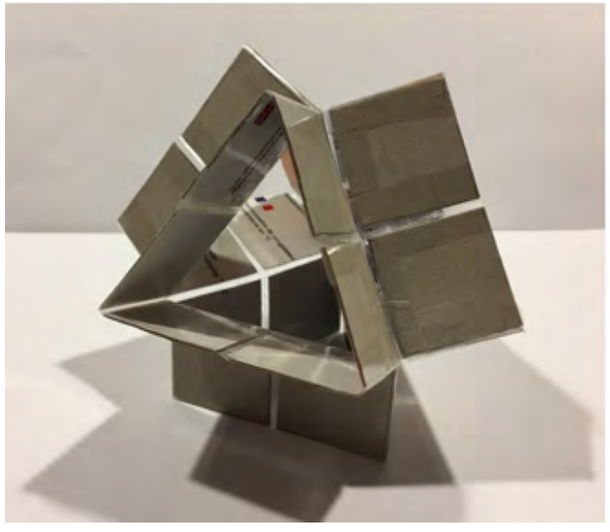
CUBE: FLEXIBLE

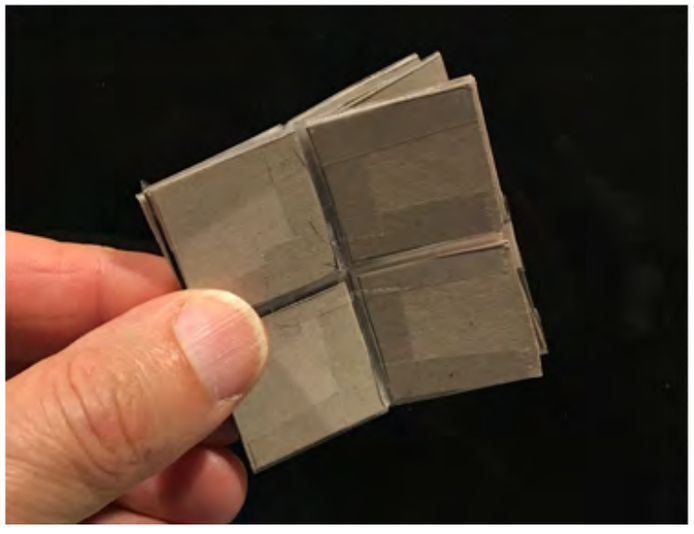


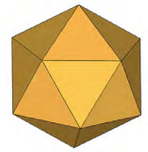
SPLIT EXTRUSION TETRAHEDRON BY G. SCARPA

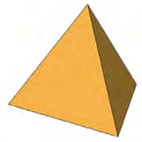






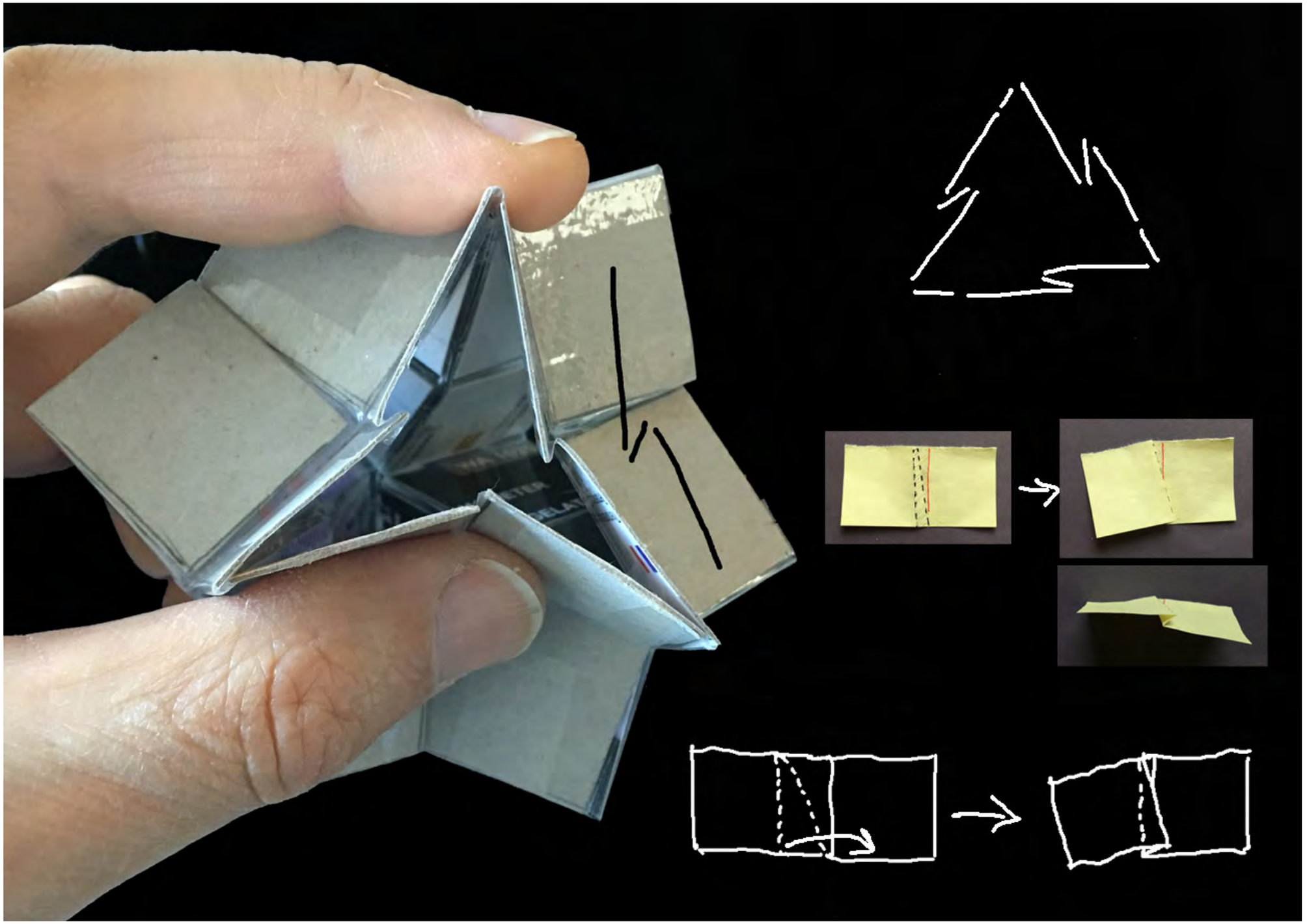






SPLIT EXTRUSION TETRAHEDRON (REPLICA) PINO TROGU, 2017

SPLIT EXTRUSION TETRAHEDRON BY G. SCARPA

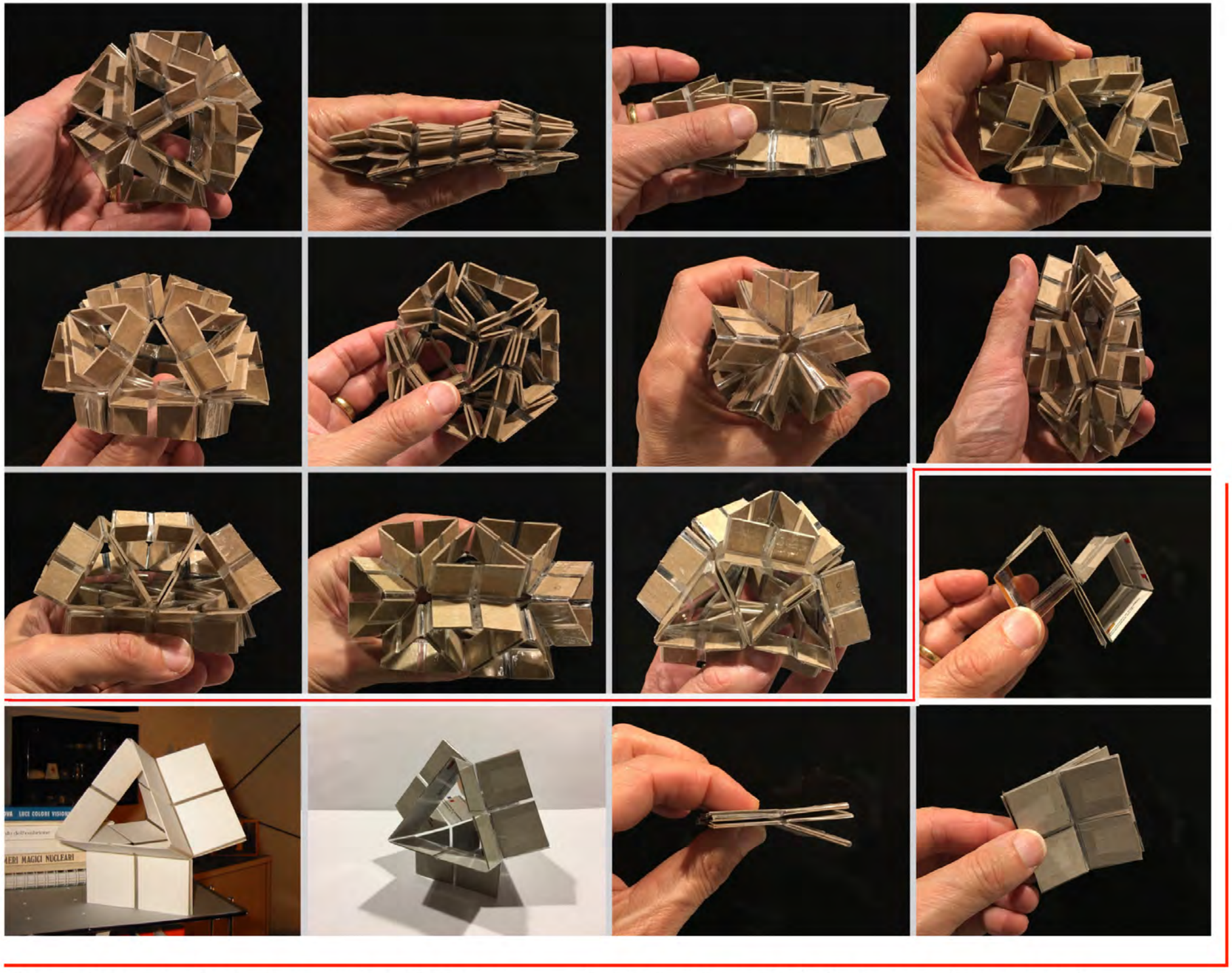


SPLIT EXTRUSION TETRAHEDRON (REPLICA) PINO TROGU, 2017

Segmented extrusion snap origami icosahedron constructed by P. Trogu.
Based on G. Scarpa's tetrahedron. Delft, NL, October 2017.

FLEXIBLE ICOSAHEDRON, 2017

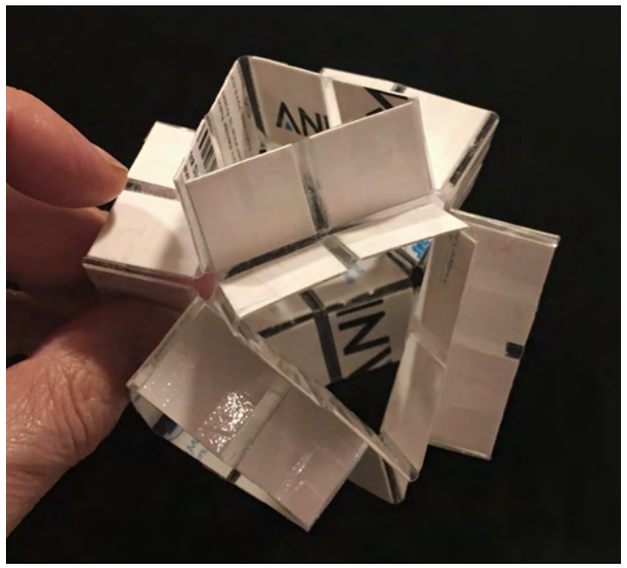
SPLIT EXTRUSION ICOSAHEDRON – FLEXIBLE TROGU, 2017



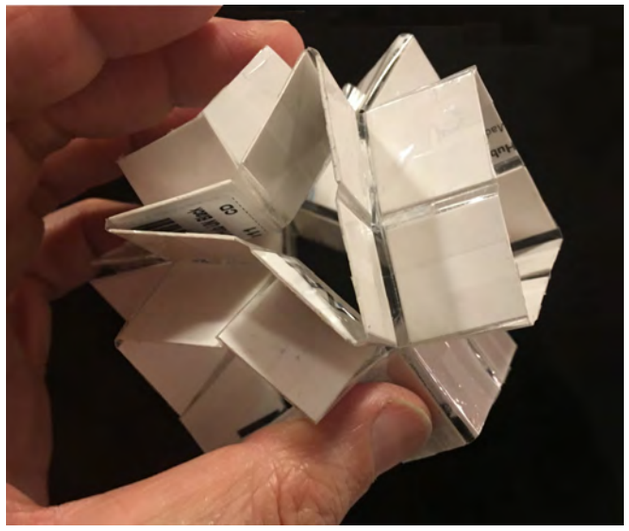
Segmented extrusion snap origami tetrahedron by Giorgio Scarpa. Circa 1996.

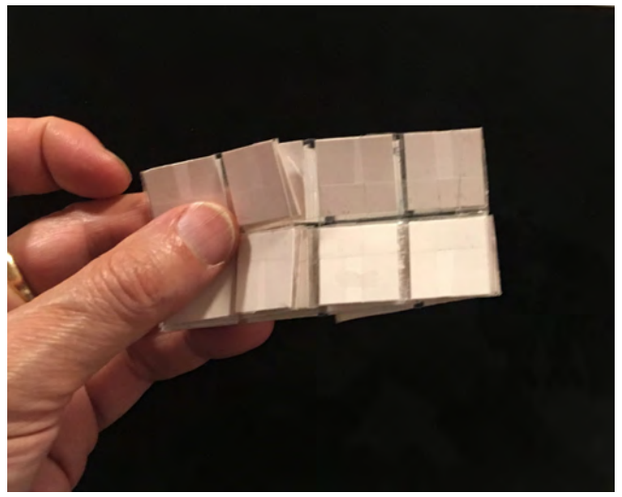
Original white model (left) photographed in Castel Bolognese, 2002. Small chip board model constructed by P. Trogu. Delft, NL, October 2017.

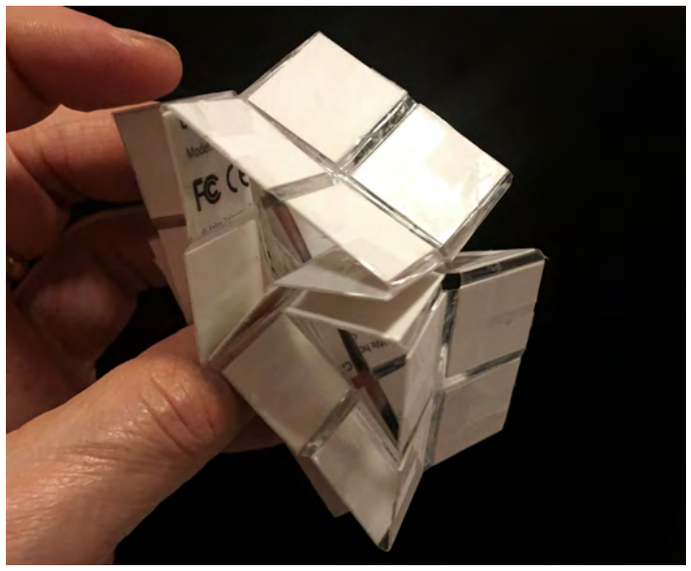
FLEXIBLE OCTAHEDRON

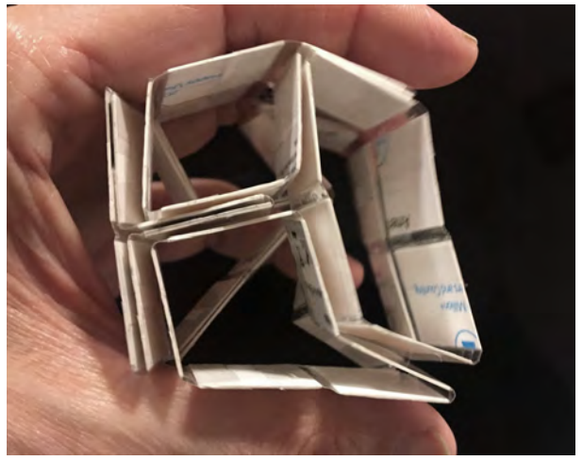


FLEXIBLE OCTAHEDRON
TROGU, 2017

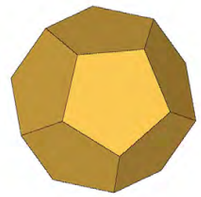


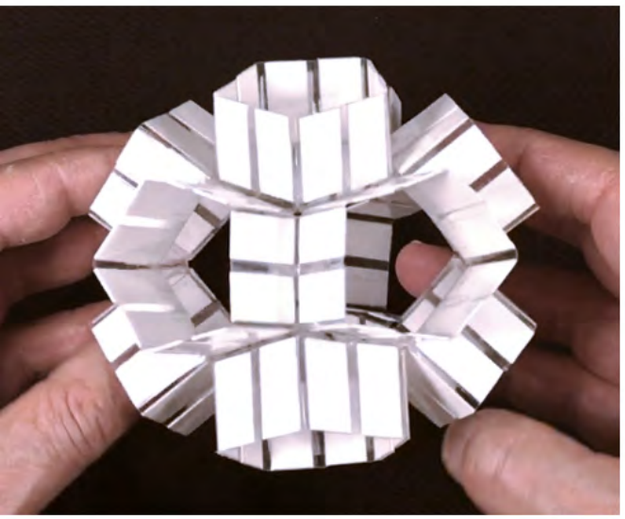
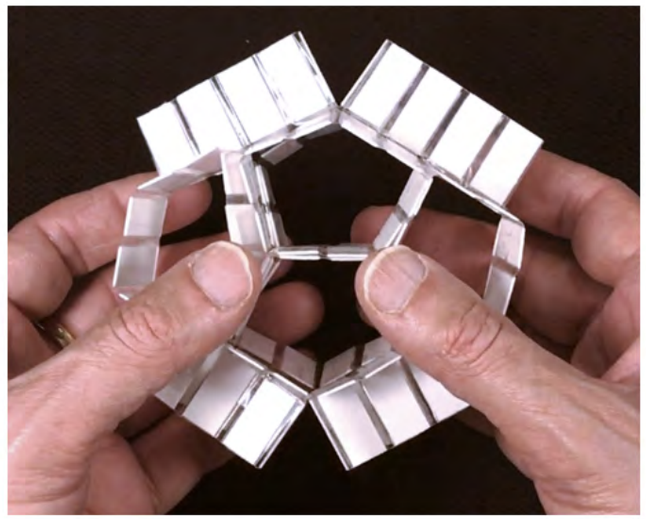
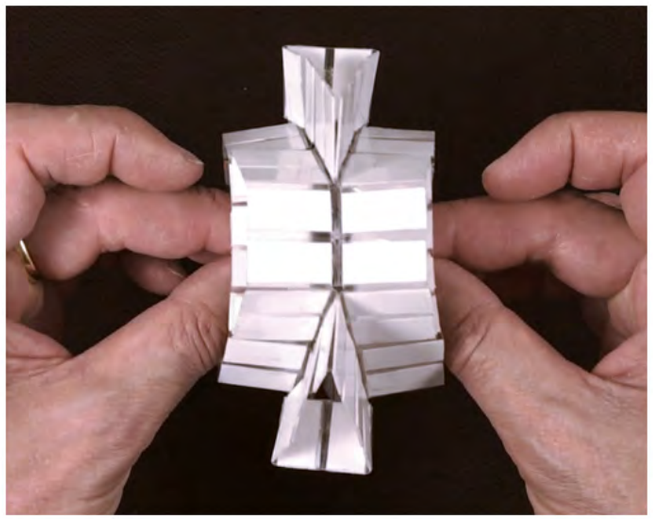
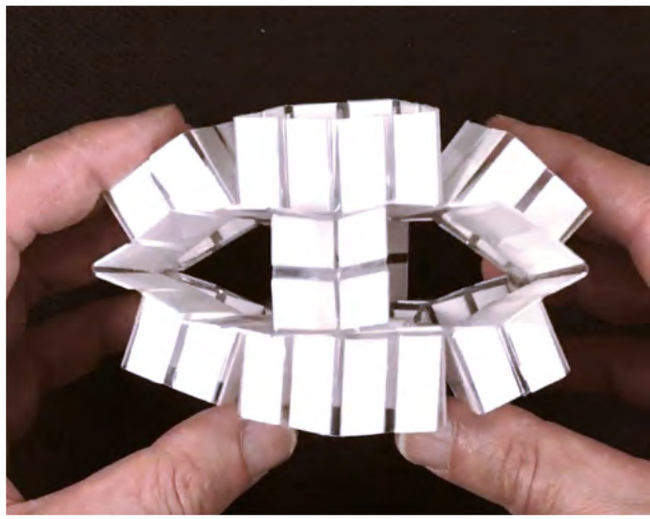
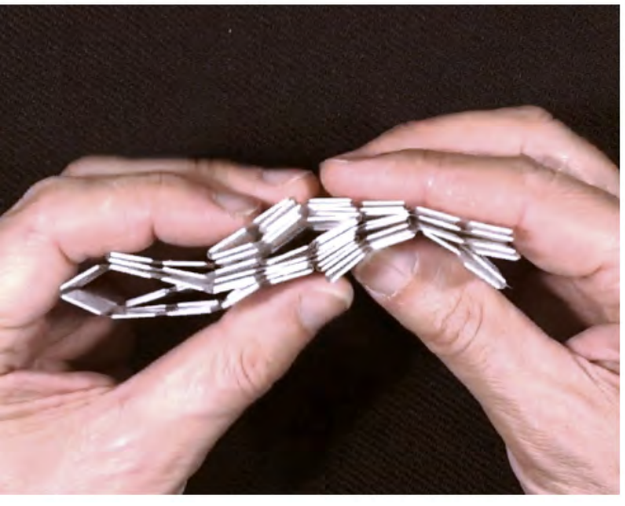
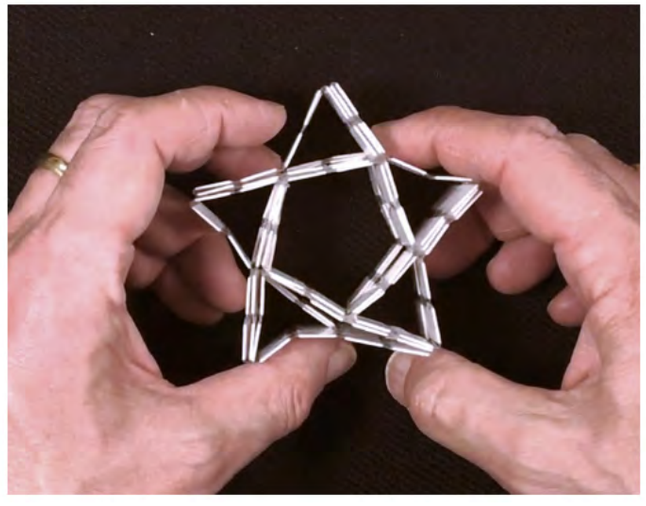
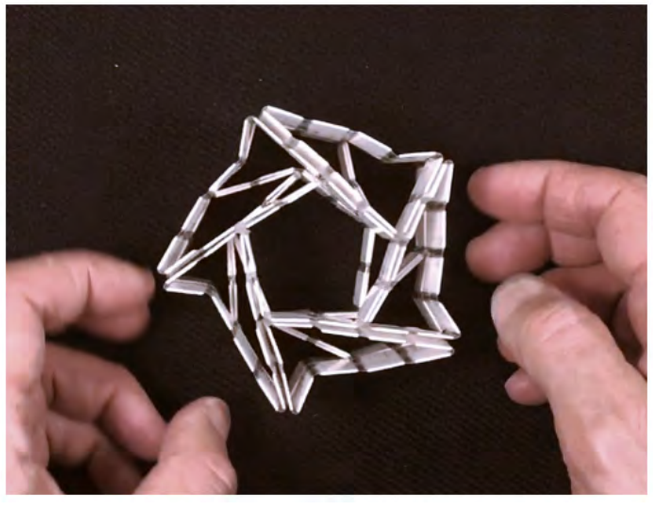
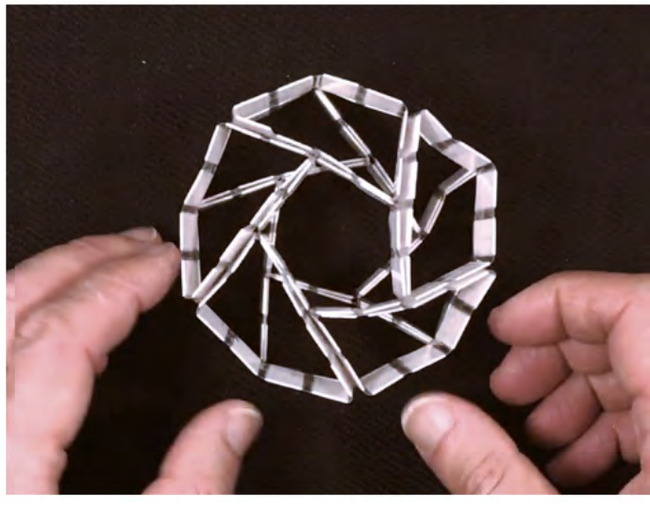






SPLIT EXTRUSION DODECAHEDRON – FLEXIBLE

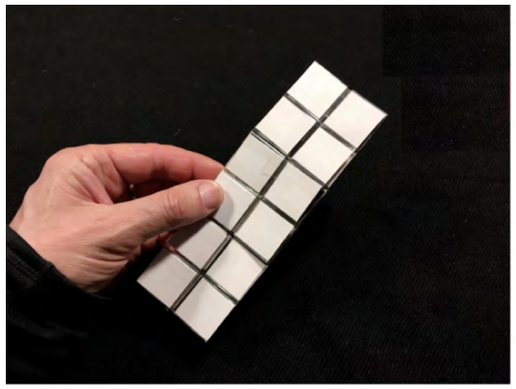
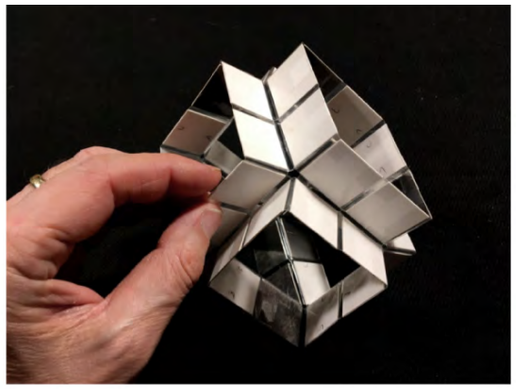
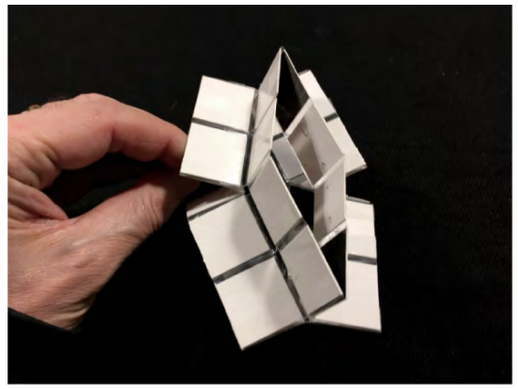
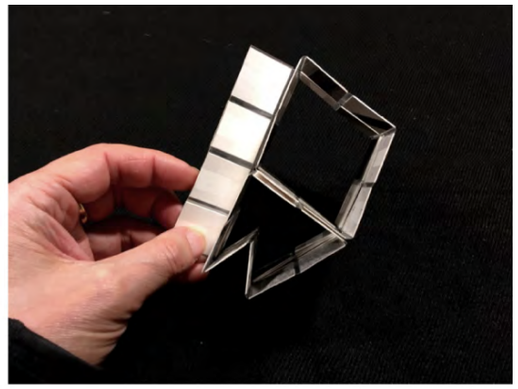
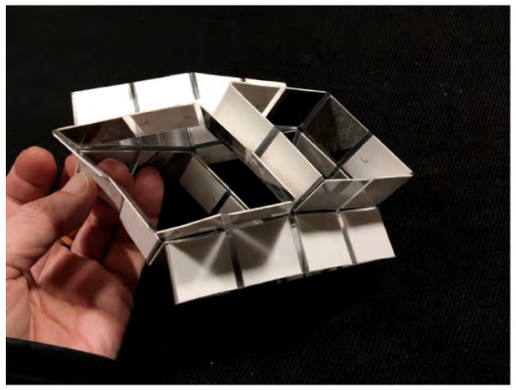
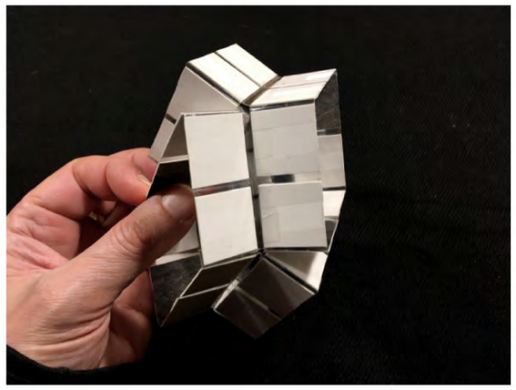
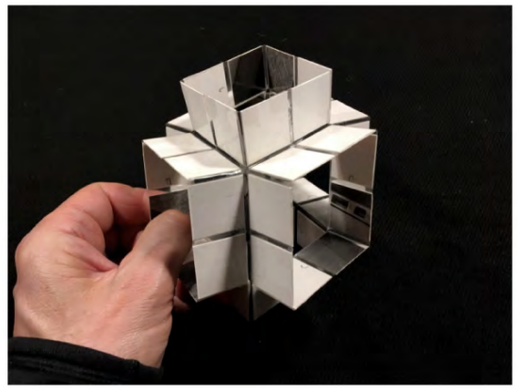
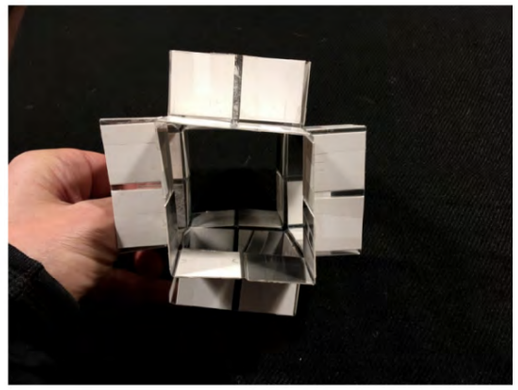
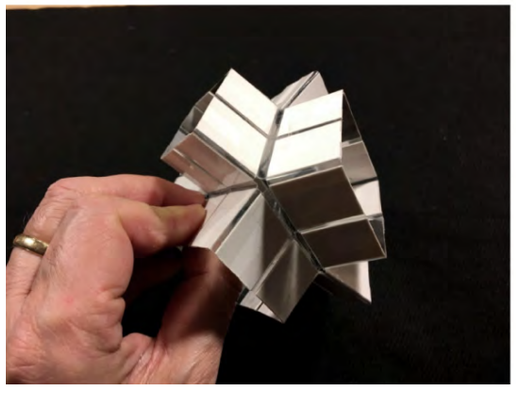
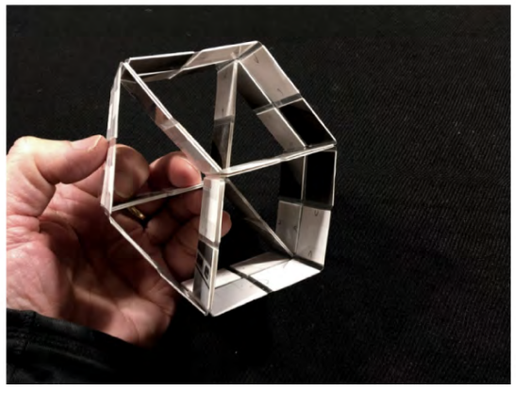
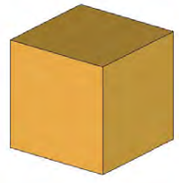


SPLIT EXTRUSION DODECAHEDRON
TROGU, 2017

120 RECTANGLES OF RATIO 2:1

SPLIT EXTRUSION CUBE (HEXAHEDRON)

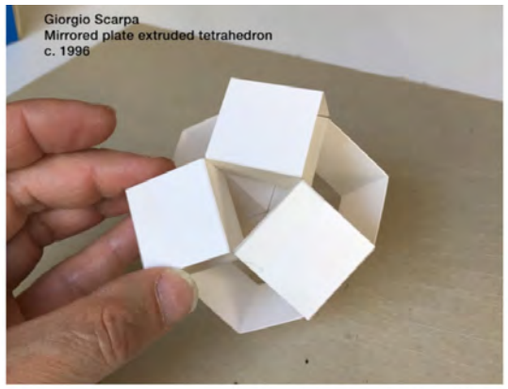












SPLIT EXTRUSION CUBE
TROGU, 2017

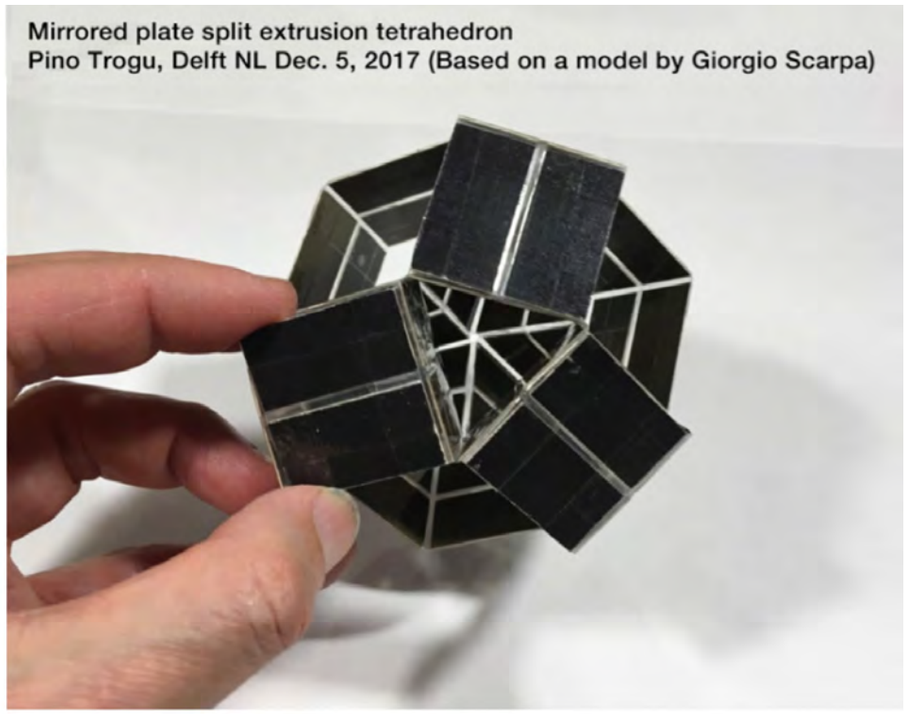
48 SQUARES

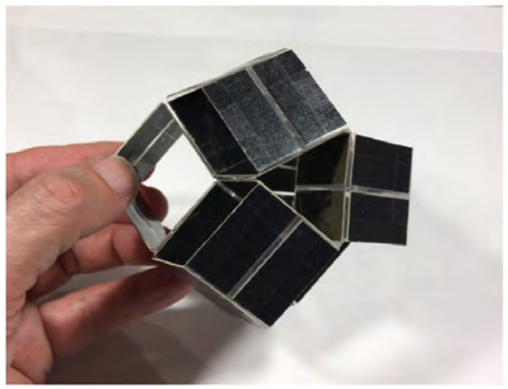
MIRRORED PLATE SPLIT EXTRUSION TETRAHEDRON

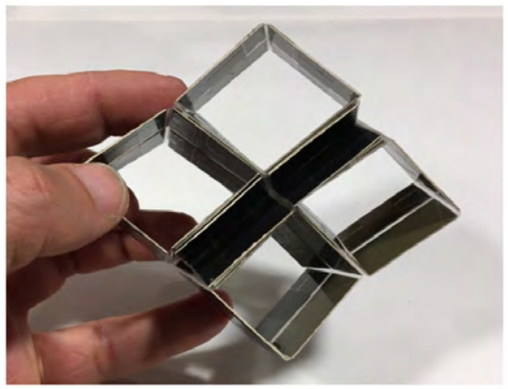
24 SQUARES

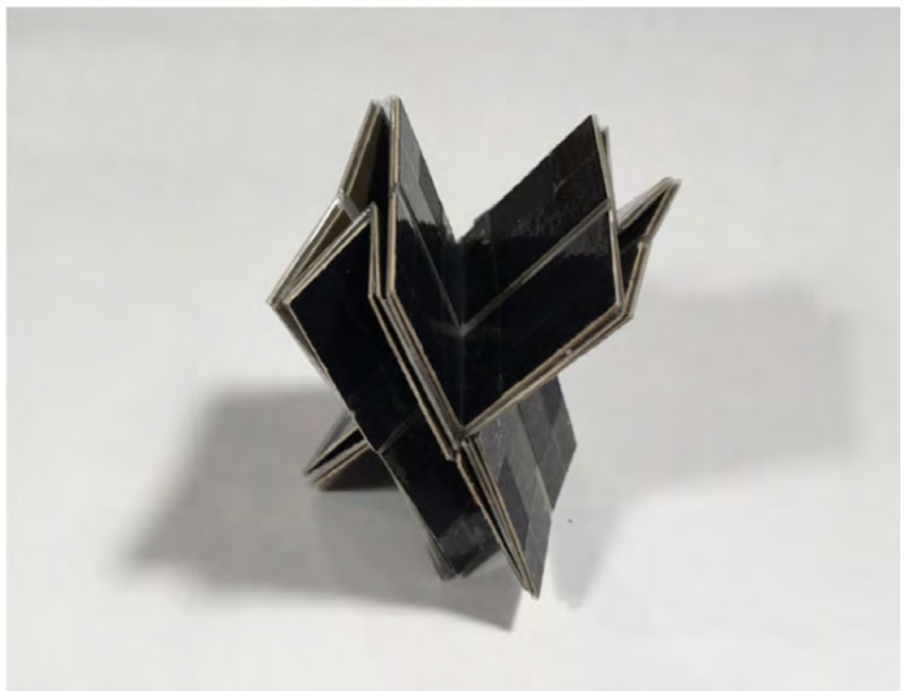


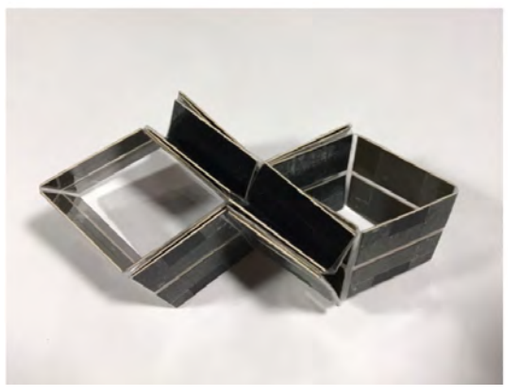
24 SQUARES

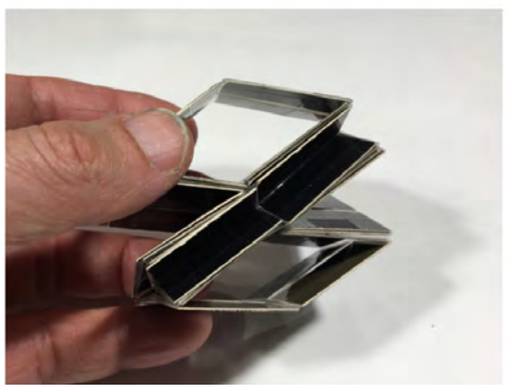






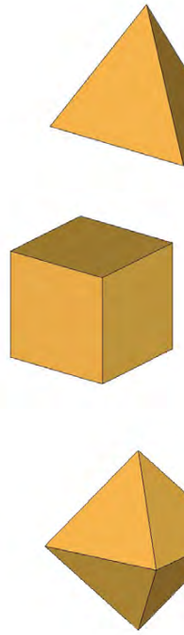




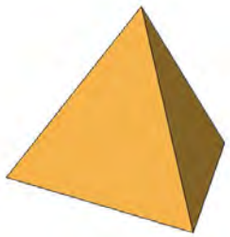


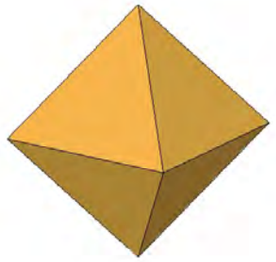
MIRRORED PLATE SPLIT EXTRUSION TETRAHEDRON – 48 RECTANGLES OF RATIO 2:1 – TROGU, 2017

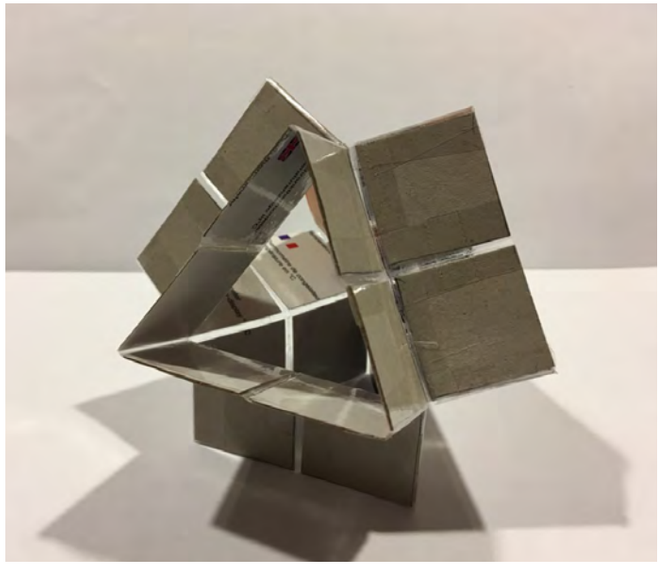
CUBE:
SPACE FILLING



TETRAHEDRON
WITH OCTAHEDRON:
SPACE FILLING







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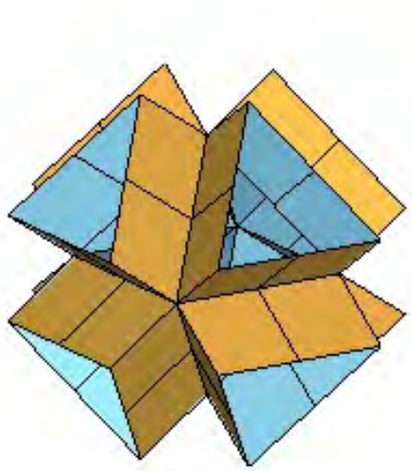
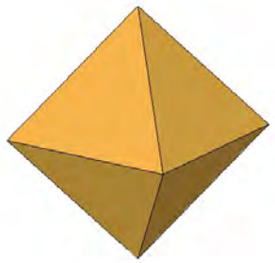
= ?

8 EXTRUDED TETRAHEDRONS
AROUND ONE EXTRUDED OCTAHEDRON





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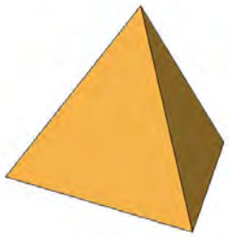
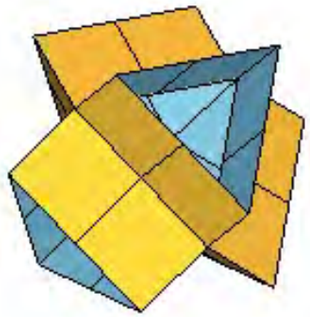
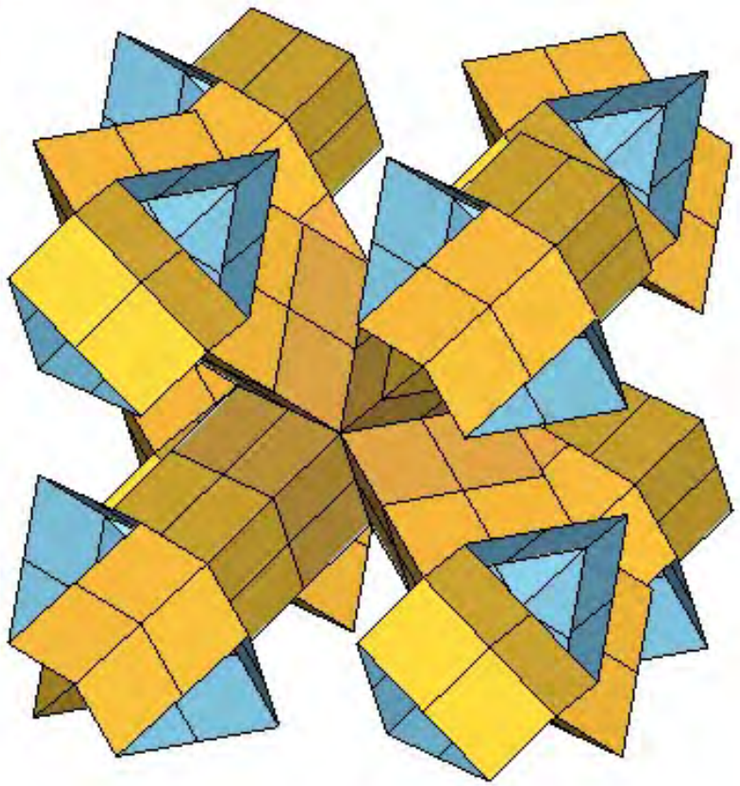
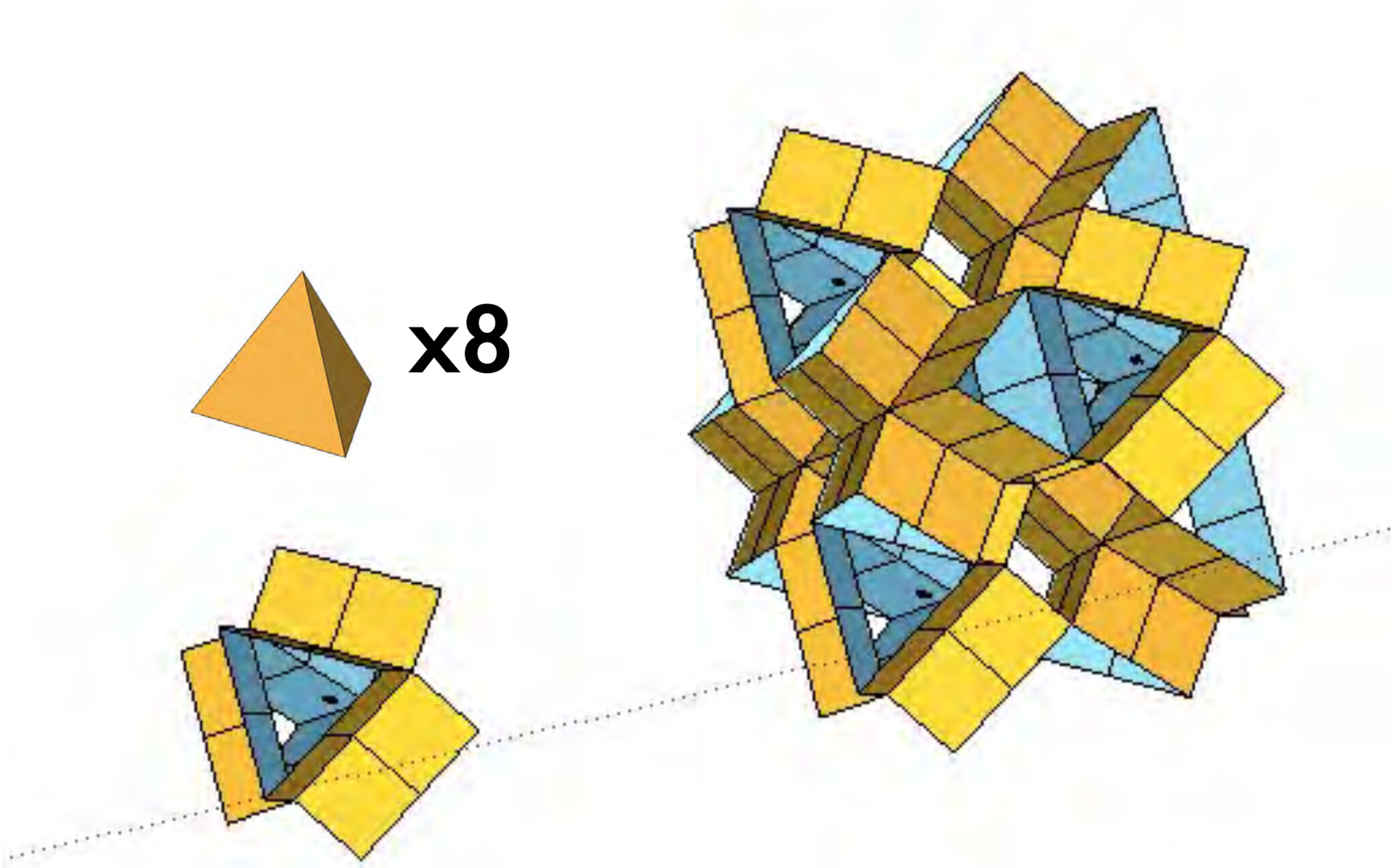


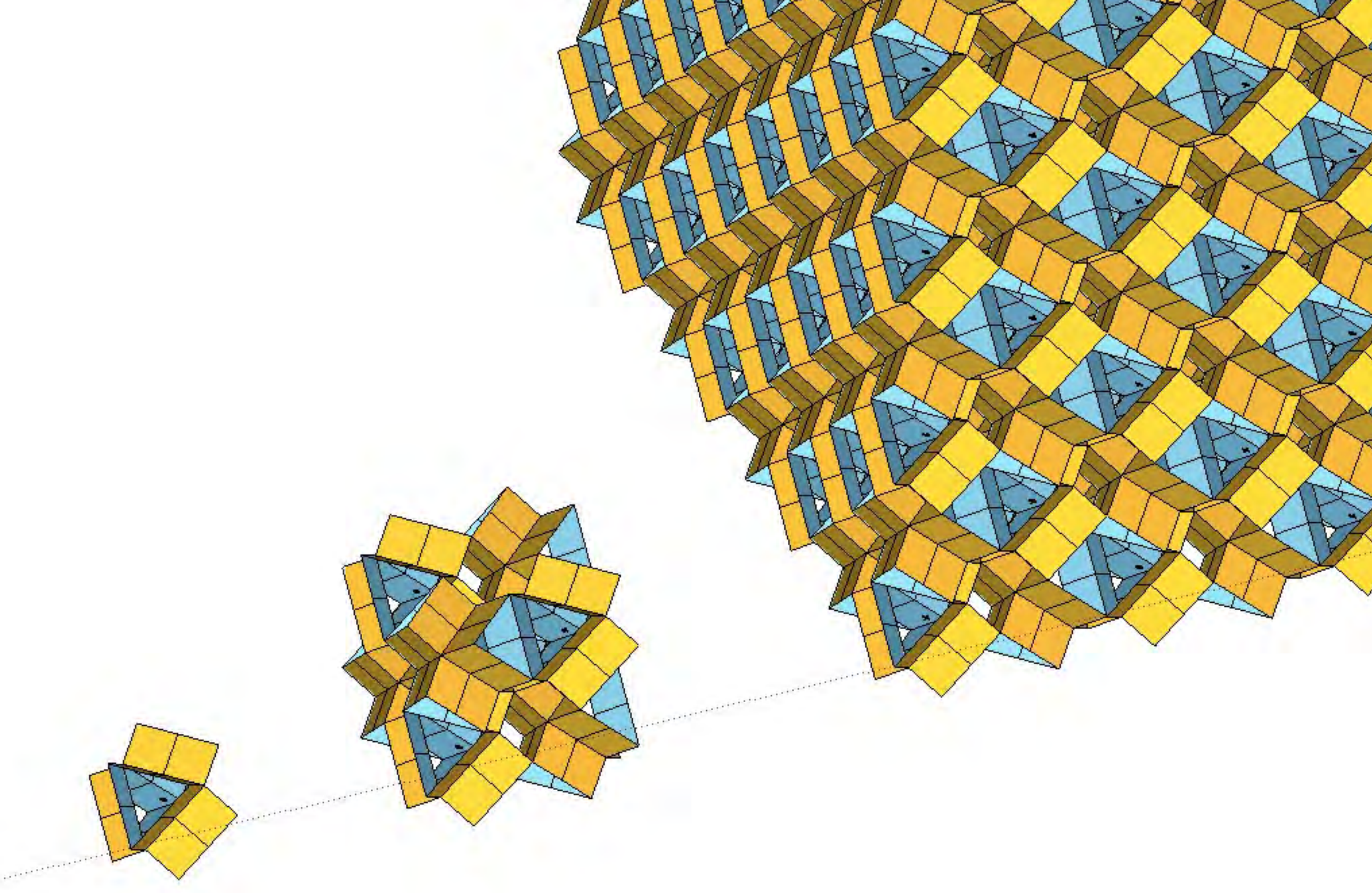
x8

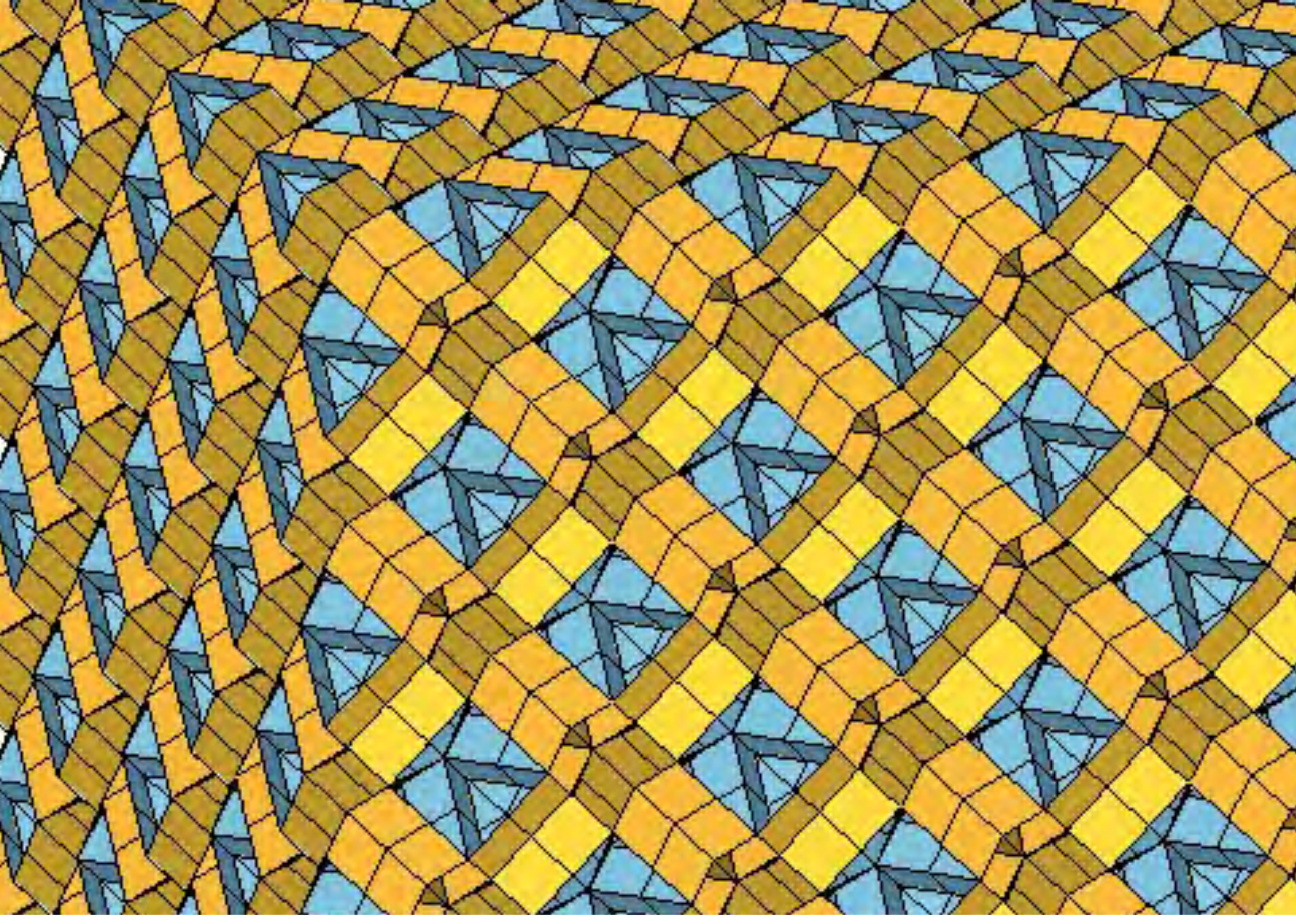




8 EXTRUDED TETRAHEDRONS – ALL SQUARES ARE CONNECTED

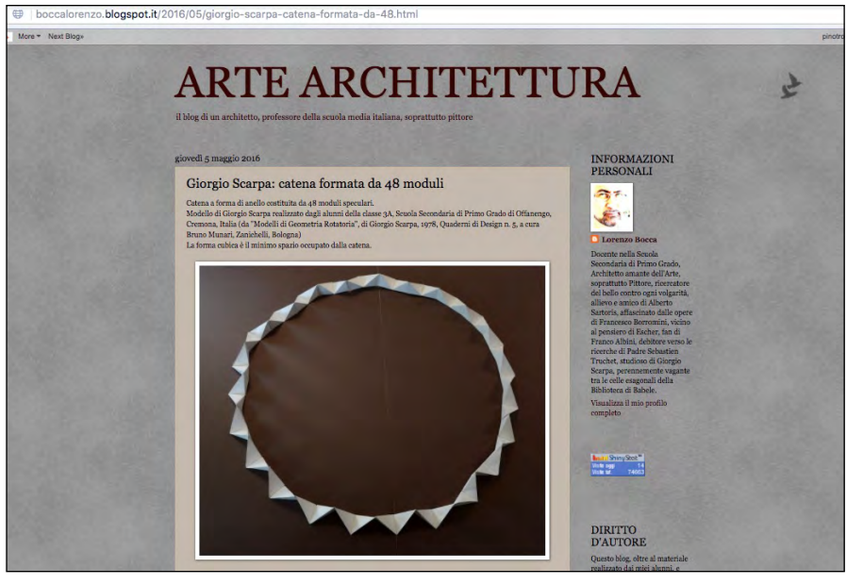






WEB LINKS

online.sfsu.edu/trogu/scarpa/



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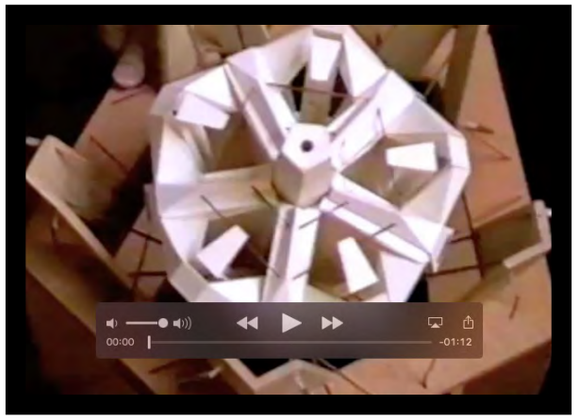
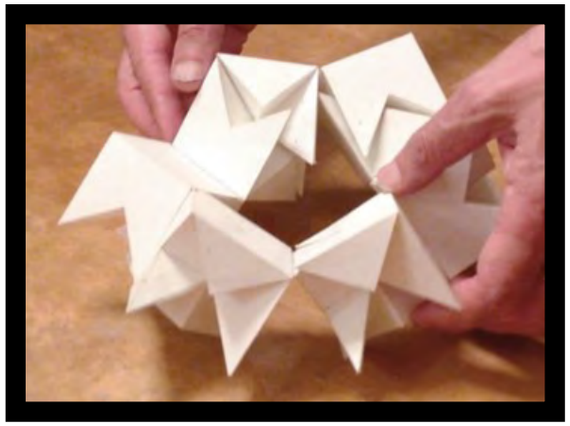
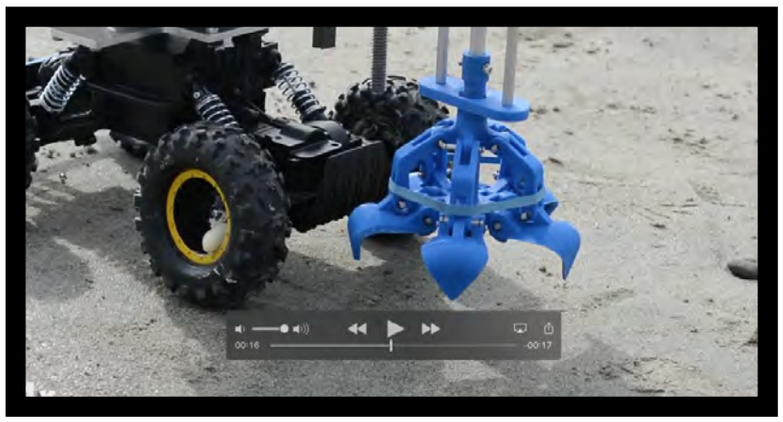
VIDEO



Scarpa-- Aristotle's lantern video

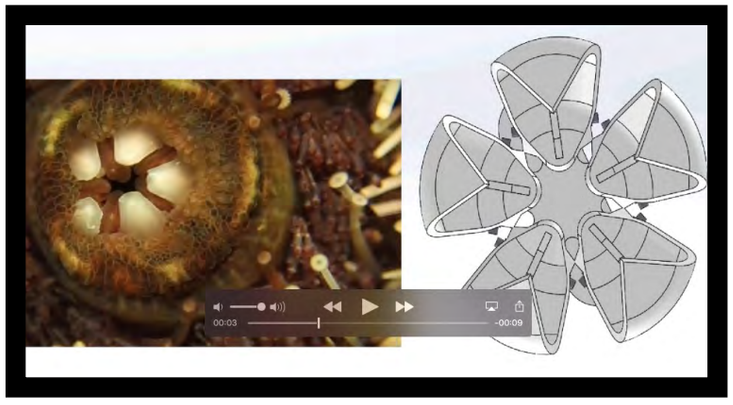


Trasformable hexahedral chain

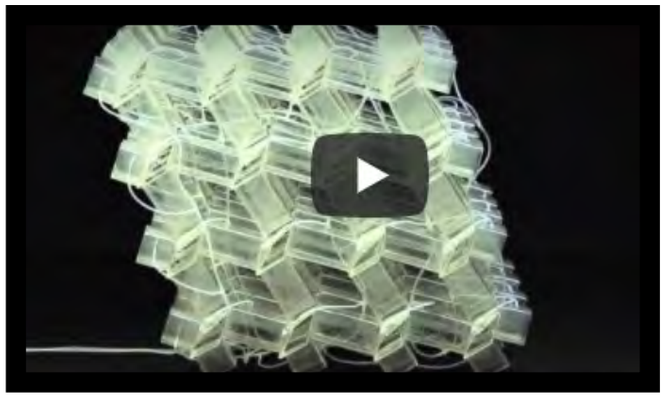


Frank UCSD -- mars rover video

Scarpa -- "I forget" video



Frank UCSD -- urchin side-by-side video



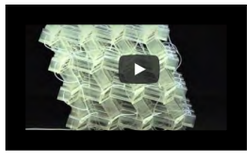
B. Overvelde -- Metamaterials

CONF. (LOCAL)

Scarpa -- "I forget" video

Scarpa -- Aristotle's lantern video

Frank, UCSD -- Urchin side-by-side video



B. Overvelde -- Metamaterials video

THANK YOU

PINO TROGU

BIO-INSPIRED MODELS OF ROTATIONAL GEOMETRY

Giorgio Scarpa & Pino Trogu, 1988

MODELS BASED ON GIORGIO SCARPA'S WORK
IN TOPOLOGY, BIO-INSPIRED DESIGN, AND ROTATIONAL GEOMETRY

TU DELFT – FACULTY ROOM (LAGERHUYSCH) AT 3ME
THURSDAY, 21 DECEMBER 2017 – 12:45 PM

Contact: trogu@sfsu.edu g.m.trogu@tudelft.nl

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