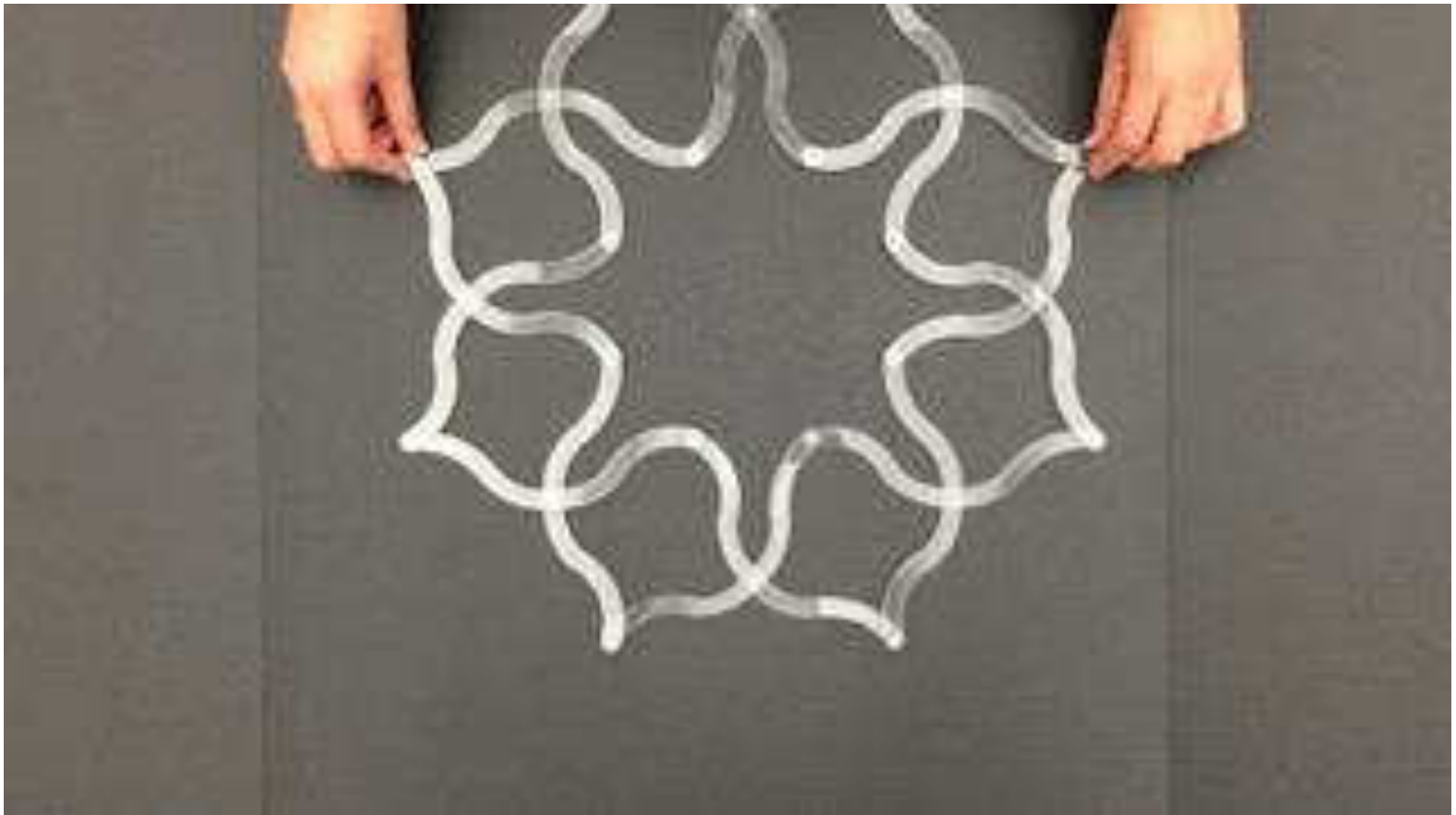


KONNICHI WA! HELLO!

ORIGAMI FOR FUN, SCIENCE USES, AND
SPACECRAFT APPLICATIONS



COMPILED BY HOWIE BAUM

ORIGAMI

- Origami, (pronounced **or-i-GA-me**) is the Japanese art of paper folding.
- "**Ori**" is the Japanese word for folding and "**kami**" is the Japanese word for paper.



The Origins of Origami. . .

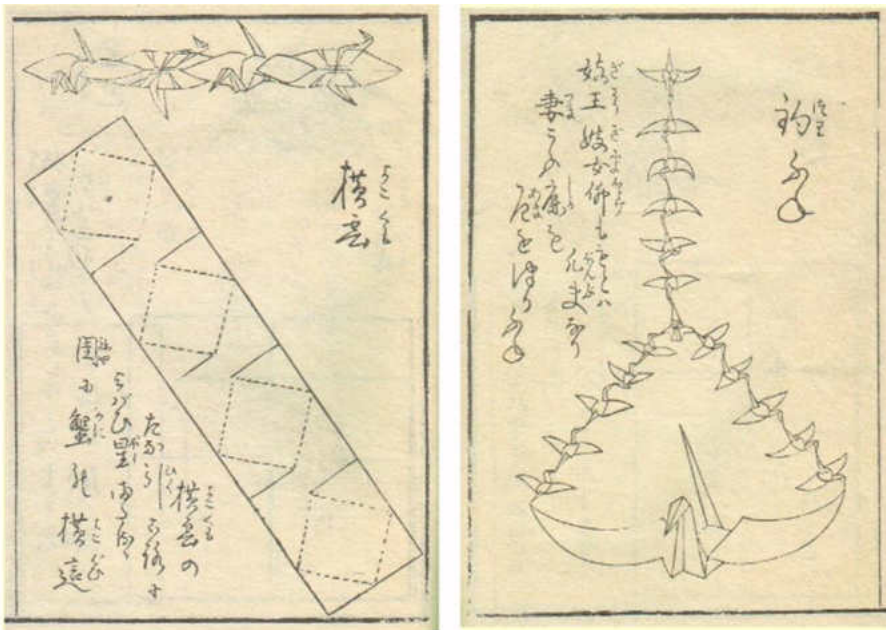


Although Origami is known as a Japanese Art, it actually began in China.

The Chinese invented paper around 100 A.D., and when the invention spread to Japan around 600 A.D., so did the art of paper folding.

FIRST BOOK ON ORIGAMI

The first known book on how to make an origami object was written in 1797 and is called *The Secret of One Thousand Cranes Origami* (Hiden Senbazuru Orikata)



Pictured to the left are pages from "*The Secret of One Thousand Cranes Origami*"..

THE HISTORY OF ORIGAMI

- The art of paper folding was not called Origami until the end of the nineteenth century.
- By the 1950's origami gained popularity from world famous origami artist [Akira Yoshizawa](#) (1911-2005).
- He created more than 50,000 models.
- He wrote 18 books about the art of origami.
- In 1983, he was named into the "Order of the Rising Sun", one of the highest honors that can be given to a Japanese citizen, by Japanese emperor Hirohito.



BASES

- When you are making origami **models**, you will be doing the same set of folds in the beginning stage even though the **final outcome** is different.
- The sets of folds in the beginning stages are called origami **bases**. You can click on each of these links to see how to make them.

Common Origami Bases

- [Kite Base](#)

- [Fish Base](#)

- [Waterbomb Base](#)

- [Preliminary Base](#)

- [Windmill Base](#)






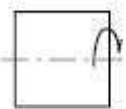





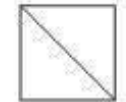



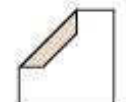



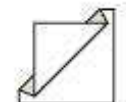





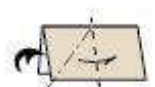













- [Bird Base](#)

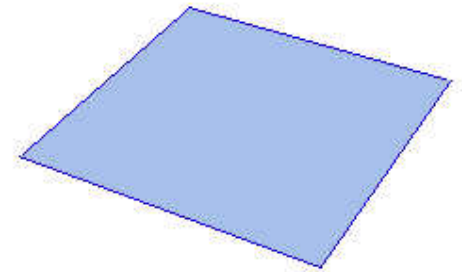
- [Frog Base](#)

The preliminary and waterbomb bases are the bread-and-butter of the origami world.

There are many origami models which start with these two bases. In fact, the two bases are interconvertible: if you invert the preliminary, it will become a waterbomb base. The opposite is also true, a waterbomb base can be inverted to form the preliminary. The only issue being that the colors (color or white) would be inverted too.

EXAMPLES OF ORIGAMI FOLDS

	mountain fold			
	valley fold			
	crease (fold then unfold)			
	roll in fold			
	pleat (zig zag) fold			
	turn over			
	squash fold			
	push in			
	inside reverse fold			
	outside reverse fold			



MAIN FOLDING LINES

- A crease is a line segment, or even a curve, on a piece of paper.
- Creases may be folded in one of two ways: as a mountain fold, forming a protruding ridge, or a valley fold, forming (not altogether surprisingly) a valley.
- A crease pattern is a collection of creases.
- A mountain-valley assignment is a specification of which creases should be folded as mountains, and the low parts become valleys.

Origami Symbols



[Lines, Arrow & Symbols](#)

ORIGAMI BASICS FOLDS

[Valley Fold](#)

[Mountain Fold](#)

[Pleat Fold](#)

[Blintz Fold](#)

[Squash Fold](#)

[Petal Fold](#)

[Inside Reverse Fold](#)

[Outside Reverse Fold](#)

[Sink Fold](#)

[Rabbit Ear Fold](#)

[Crimp Fold](#)

Note: The blue, underlined items to the left and on the next page, are all active links so if you want to learn more about any of them, just click on them in presentation mode.

The info on this and the next slide is from an excellent site:

<https://www.origami-resource-center.com/origami-basics.html>

Shapes of Paper

Make a Square:

[from a Rectangle](#)

Make a Triangle:

[from a Square](#) (easy)

[from a Square](#) (efficient)

[from a Rectangle](#)

Make a Pentagon:

[from a square, A5](#)

Make a Hexagon:

[from a Square](#)

[from a Rectangle](#)

Make a Heptagon:

[from a square](#) (easy)

[from a square or circle](#) (easy)

[from a circle](#) (not easy)

[from a square](#) (with proofs)

[from a square](#) (exact?)

Make an Octagon:

[from a Square](#)

Make a A4, A5, or A6 Paper:

[from a Square](#)

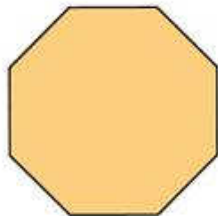
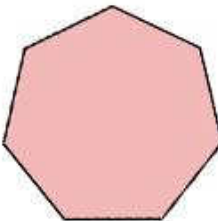
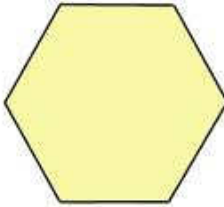
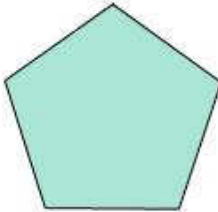
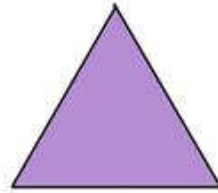
[from 8.5" x 11"](#)

Make a Dollar Bill proportion:

[from 8.5" x 11"](#)

Make the Largest Square:

[from a Dollar Bill](#) (S Chen)



Dividing Paper

Divide into Thirds:

[Method 1](#)

[Method 2](#)

[Method 3](#)

[Estimation Method](#)

[More Methods](#) (diagrams by H Koshiro)

Divide into Fifths:

[Method 1](#)

[Method 2](#)

[Method 3](#)

[Fujimoto's Approximation Method](#)

Divide into Sevenths:

[Method 1](#)

[Method 2](#)

[Method 3](#)

Divide into Any number of Segments:

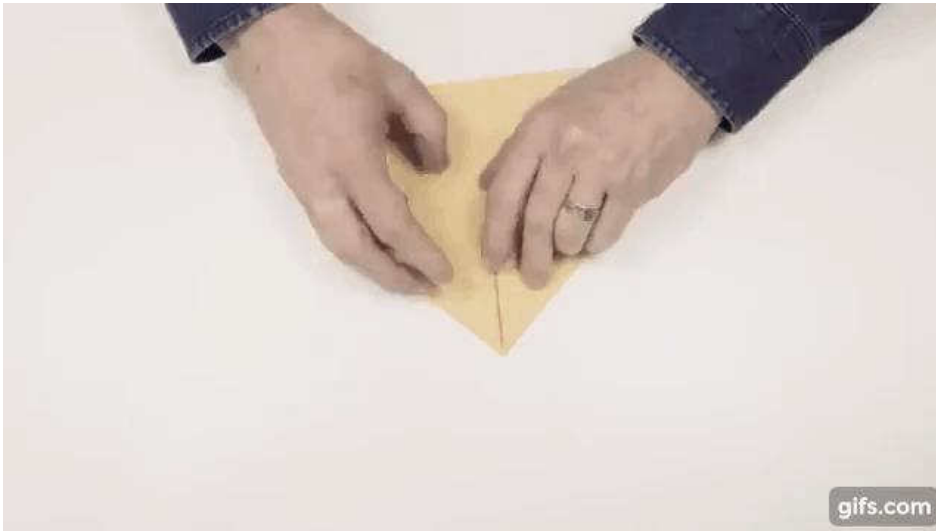
[Intersecting Diagonals Method](#)

[Using a Template](#)

[Using Scissors](#)

GOLDEN RULES FOR PAPER FOLDING ORIGAMI

- Always work on a smooth flat surface.
- Make your folds carefully.
- Run your bone folder or thumbnail along the crease each time you make a fold to make it crisp.
- Begin by folding the basic shape required.
- The instruction steps should be followed in sequence. They won't make sense if read alone.



John Collins holds the Guinness World Record for designing the farthest flying paper airplane.

The plane, folded from a single piece of paper, **Flew 227 feet (76 yards)**, in 2012.

https://www.youtube.com/watch?time_continue=2&v=qmCTdCLxJRM

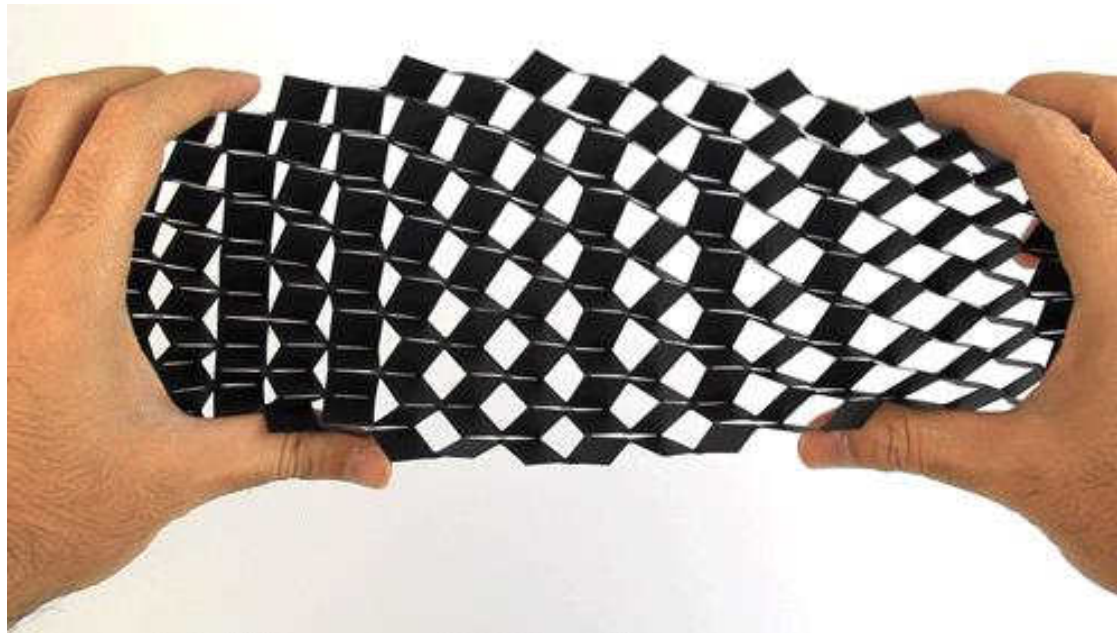


THE ANCIENT ART OF KIRIGAMI IS INSPIRING A NEW CLASS OF MATERIALS

Origami-inspired materials use folds in materials to embed powerful functionality. However, all that folding can be pretty labor intensive.

Now, researchers at the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS) are drawing material inspiration from another ancient Japanese paper craft—kirigami.

It relies on cuts, rather than folds, to change the structure and function of materials, by just stretching it.



https://www.youtube.com/watch?time_continue=9&v=1vG40thRJUQ

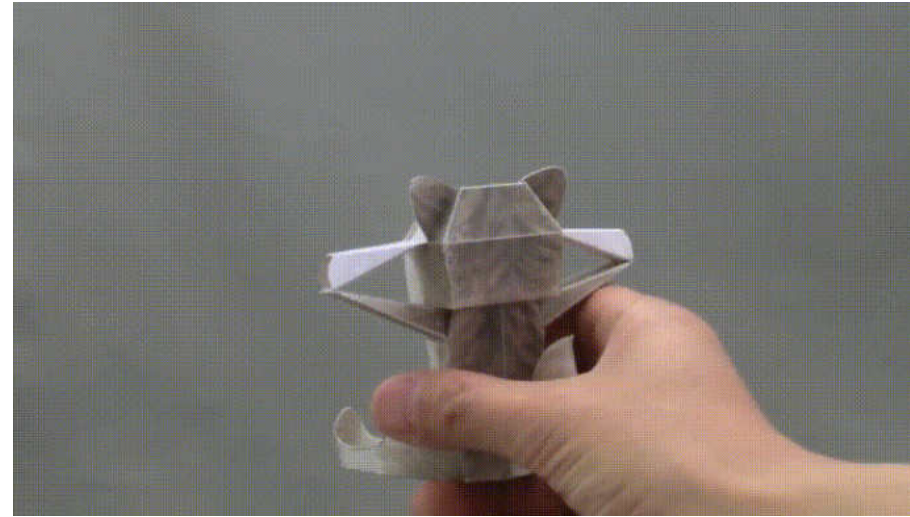
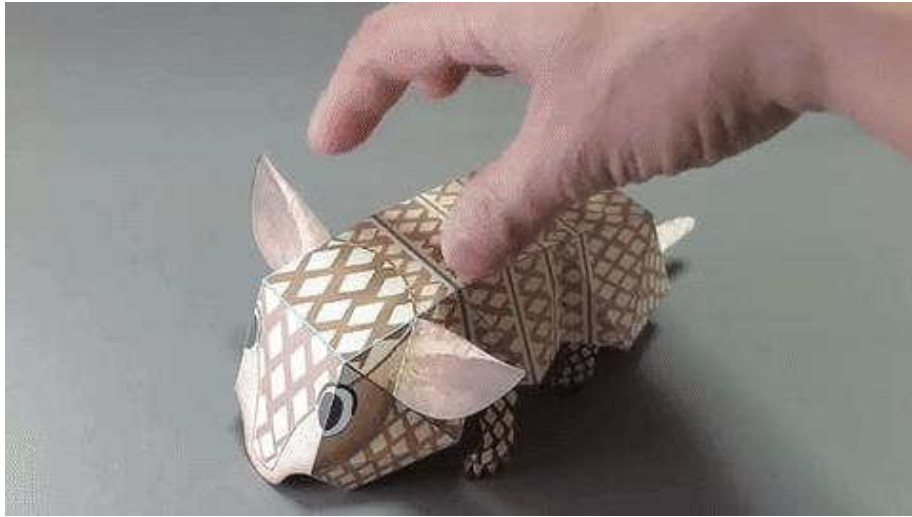
Scraped up knees and elbows are tricky places to securely apply a bandage. More often than not, the adhesive will peel away from the skin with just a few bends of the affected joint.

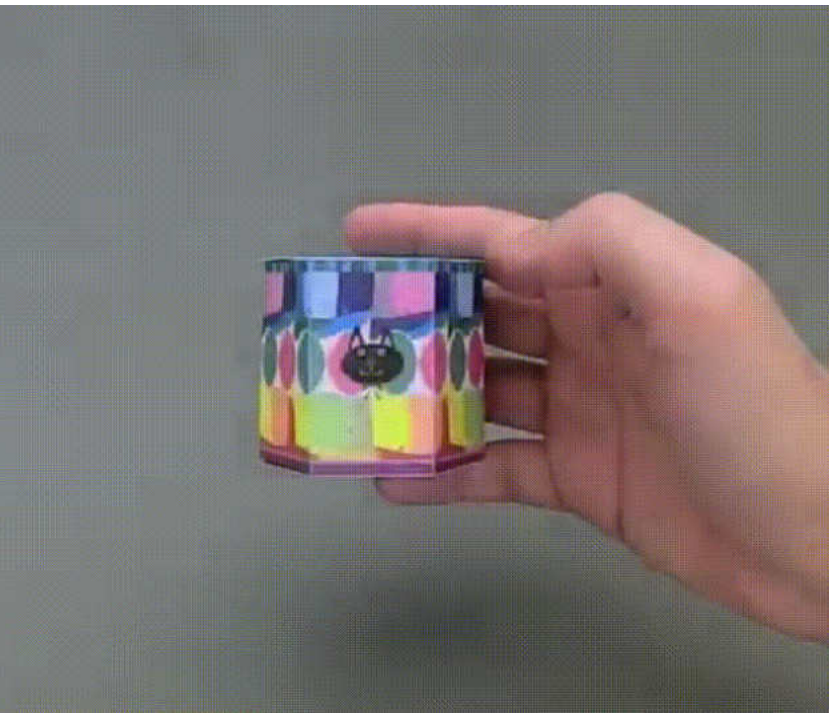
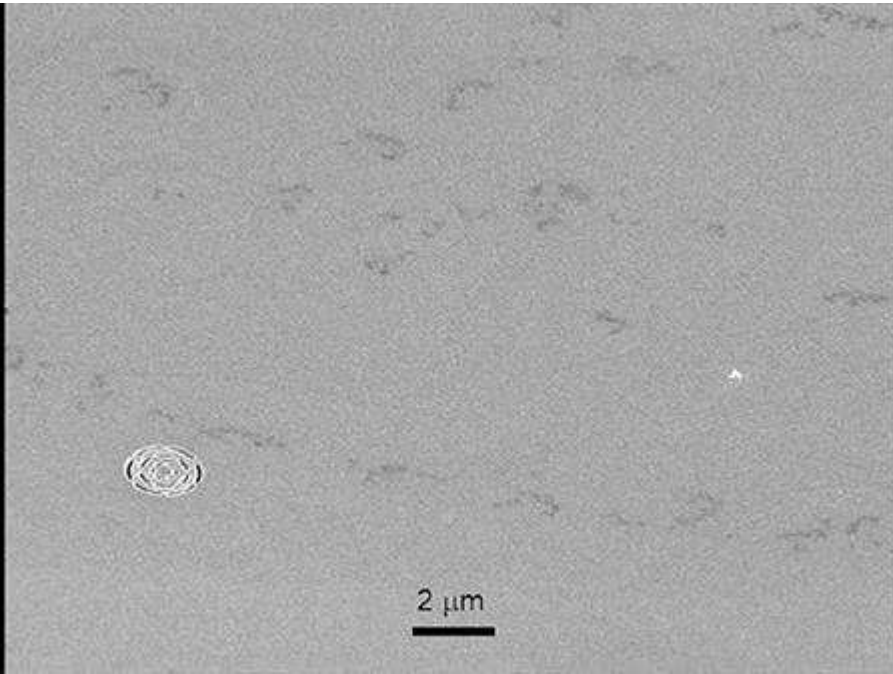
Now MIT engineers have come up with a stickier solution, in the form of a thin, lightweight, rubber-like film. The adhesive film can stick to highly deformable regions of the body and maintain its hold even after 100 bending cycles.

The key to the film's clinginess is a pattern of slits that the researchers have cut into the film, similar to the cuts made in a paper-folding art form known as **Kirigami**.



THESE KIRIGAMI FORMED PAPER PUPPETS ARE A FUN USE OF THE ART FORM





JAPAN - NEW DISCOVERIES IN PAPER FOLDING



<https://www.youtube.com/watch?v=Fz4Ioi1jFHY>

BULLET-PROOF ORIGAMI: FOLDING KEVLAR SHIELD, USING THE YOSHIMURA BENDING METHOD

An origami-inspired, lightweight bulletproof shield stopped bullets from 9 mm, .357 Magnum and .44 Magnum pistols.

It is made of 12 layers of bulletproof Kevlar and weighs only 55 pounds (many of the steel-based barriers in current use approach 100 pounds).

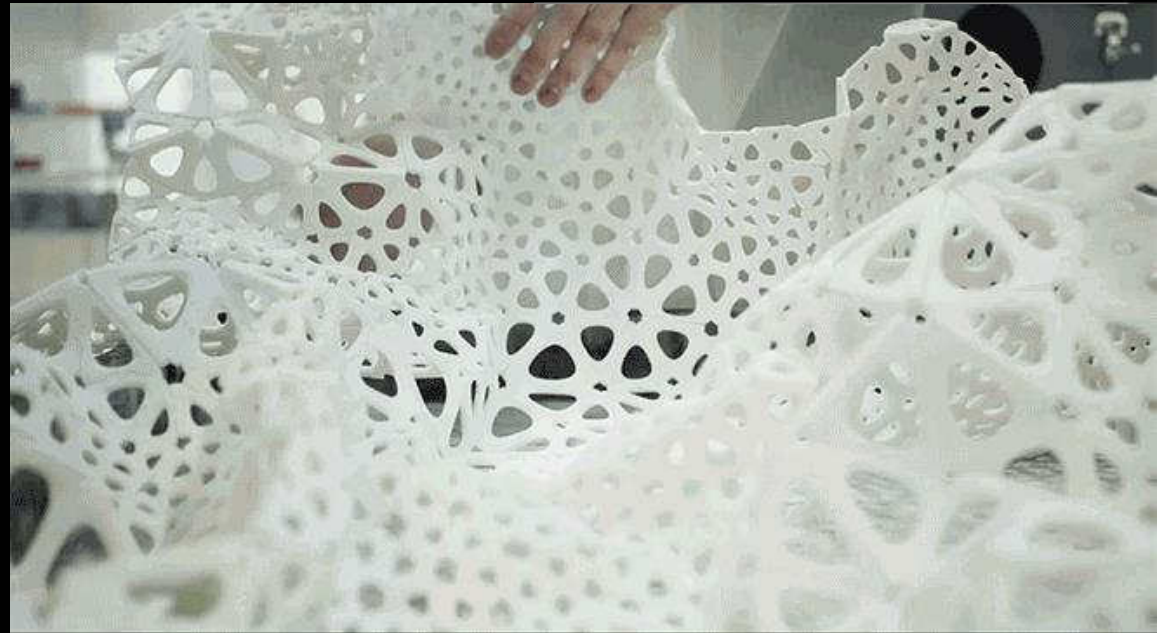
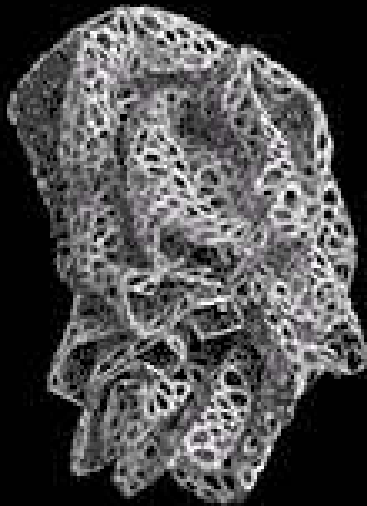
It uses a Yoshimura origami crease pattern to expand around an officer, providing protection on the side in addition to protecting them in the front.

It can be folded compactly when not in use, making it easier to transport and deploy. When expanded — which takes only five seconds

https://www.youtube.com/watch?v=P_ezsOeX5mQ



3D PRINTED DRESS USING ORIGAMI LINKS TO FORM IT



ORIGAMI-BASED FOLDING KAYAK



4m7



ORIGAMI -BASED FURNITURE



<https://www.youtube.com/watch?v=ECTy1jq7qI&list=PL9Eu8Y50RKENFMArtHB32iWrGfuTEuXx&index=4>

AN ORIGAMI SHELL FOR A DRONE FOR SAFE DELIVERIES

A new drone uses cutting-edge technology to deliver parcels weighing up to 500 grams (a little over 1 pound).

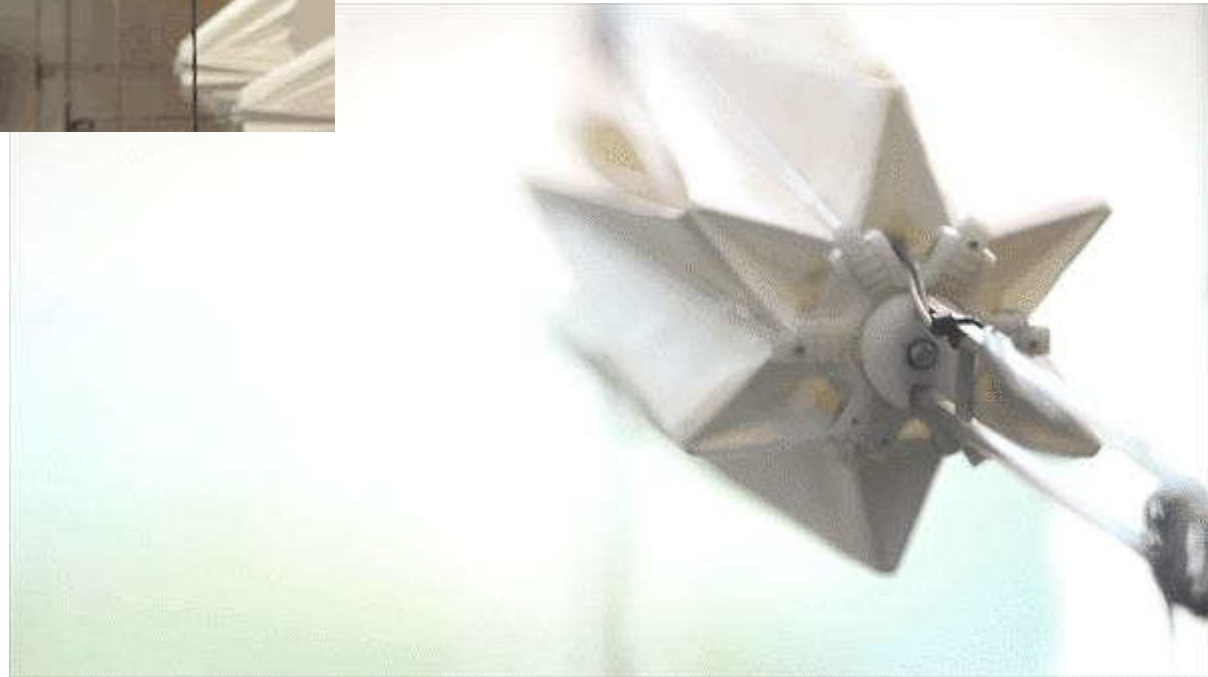
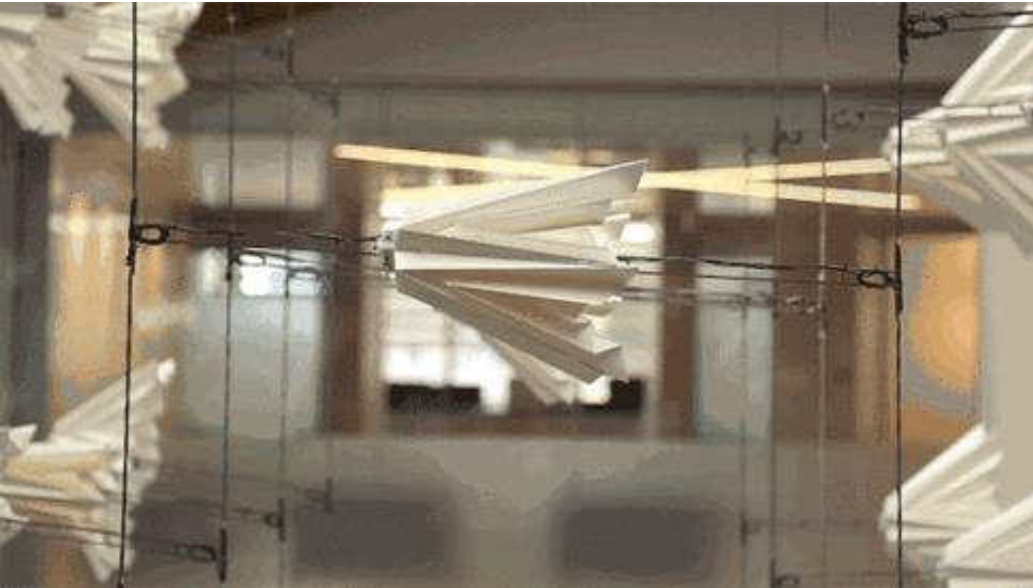
The device will never get stuck in traffic, it's programmed to avoid obstacles, and it can reach destinations on steep or uneven terrain.

Its protective cage and foldable design mean that it can be carried around in a backpack and used in total safety.



https://www.youtube.com/watch?time_continue=1&v=rvijnNm2Djw

Diffusion Choir is a kinetic sculpture that uses 400 folding elements to reveal the movements of an invisible flock of birds.



3D PRINTED ORIGAMI INSPIRED FORCEPS



https://www.youtube.com/watch?time_continue=6&v=8Pjdk0lcOM8

MIT'S SELF-FOLDING ORIGAMI TECHNOLOGY



<https://www.youtube.com/watch?v=C0afucjq9ew>

AN ORIGAMI DESIGNED PURSE



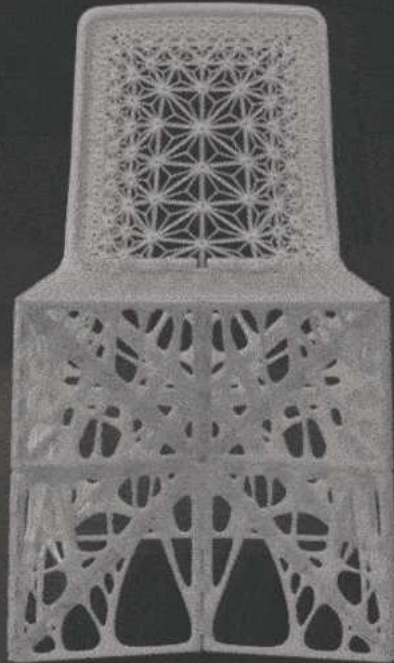
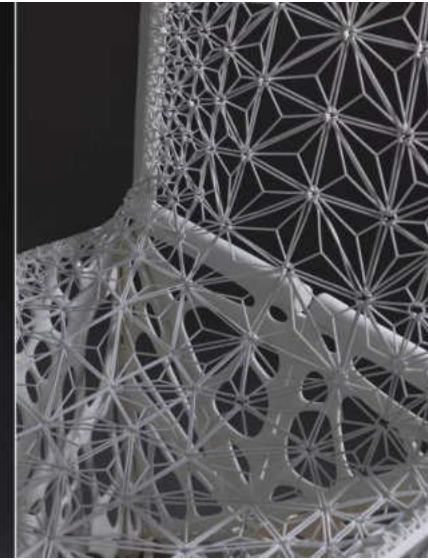
SmartFlower



SUNFLOWER – THE HOME SOLAR CELL DEVICE



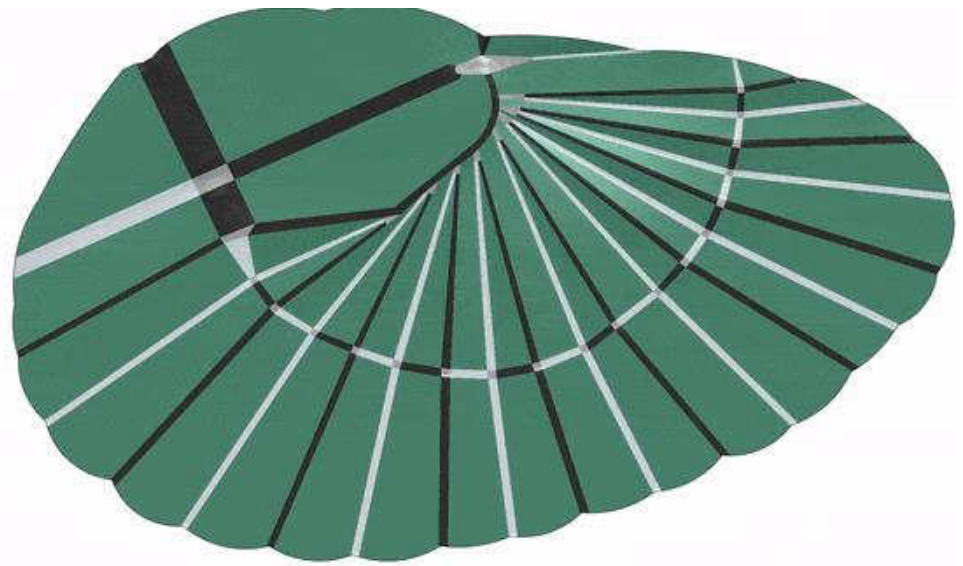
Patrick Jouin unveils a foldable 3D printed chair



BIO-INSPIRED ORIGAMI

Using simulations and creating 4D replicas, researchers from ETH Zürich in Switzerland and Purdue University have been able to study the structure and properties of the Earwig insect's wings.

Like conventional origami, the earwig folds its wings along creases. However, the design of the insect's wing is far more complex, incorporating stretching and tension that would cause paper origami to tear. That stretching and tension is essential to the wing's ability to fold and lock itself into two different shapes: outstretched for when the earwig flies, and collapsed for when the insect needs to navigate its underground home.

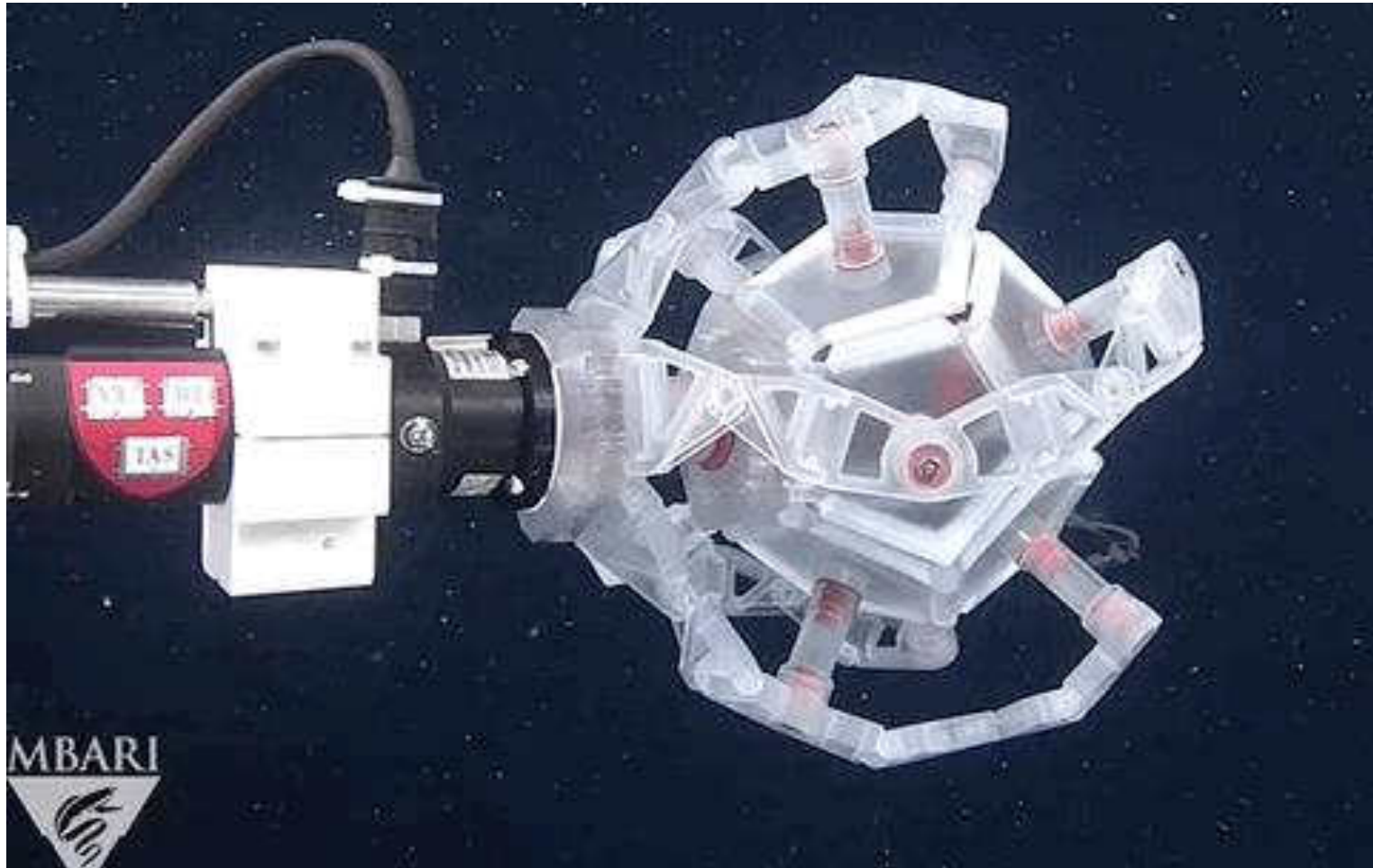


San Francisco-based paper artist [Ekaterina Lukasheva](#) makes dazzling tessellations (the multiple repeat of a shape) seem like child's play, effortlessly folding complex designs from matte and iridescent paper.

The beautiful works have a double presentation, as they each work as expanded and contracted forms.



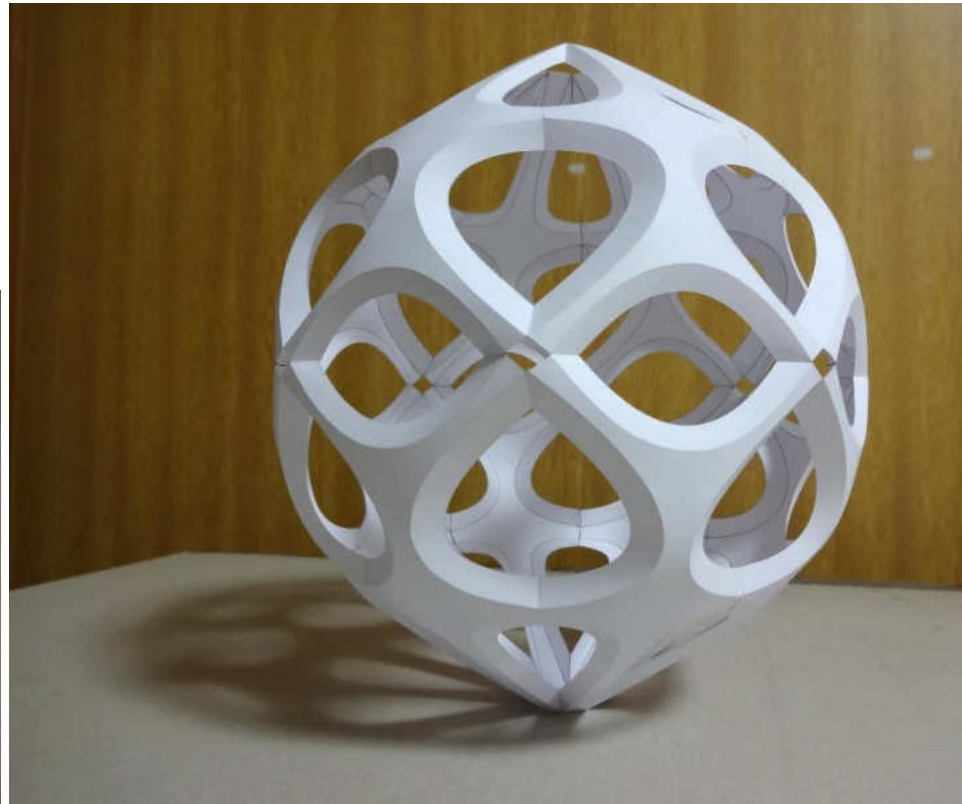
THIS ORIGAMI POKÉBALL SAFELY CAPTURES DELICATE SEA CREATURES



<https://www.youtube.com/watch?v=CqLStpRFdWY>

CURVED PAPER FOLDING

On the left is a "self-forming" origami made from folding concentric circles - it would also happen if we folded concentric rectangles. It is interesting that it can be formed into a saddle shape.



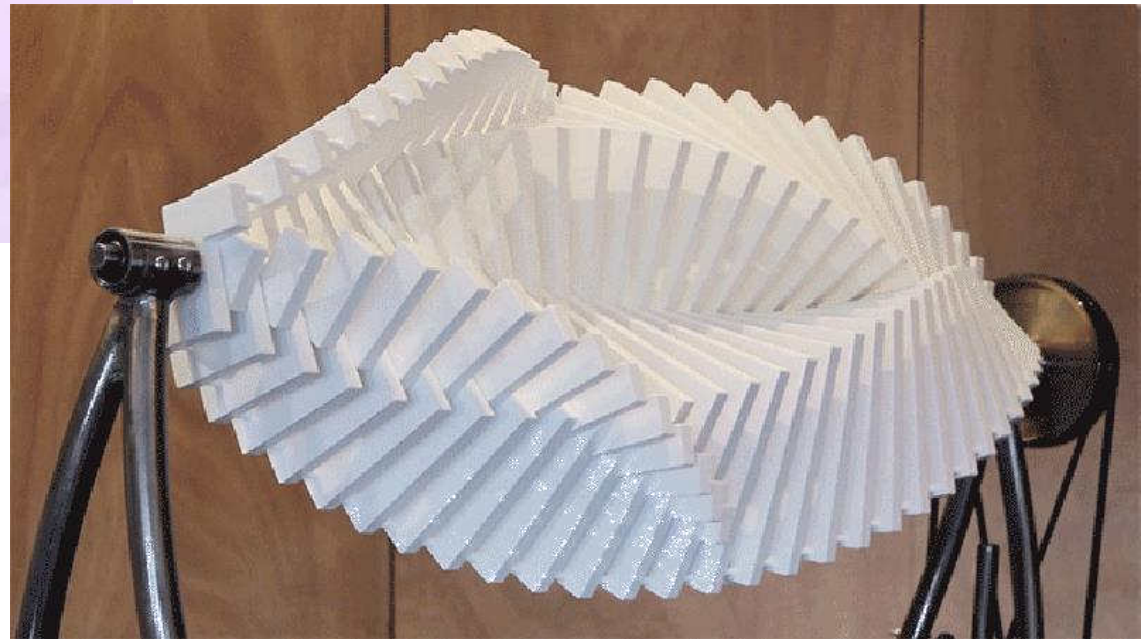
We can explore what shapes are possible with using curves for self-folding origami, with applications to deployable structures, manufacturing, and self-assembly.

This transformation of flat paper into swirling surfaces creates sculptures that feel alive.





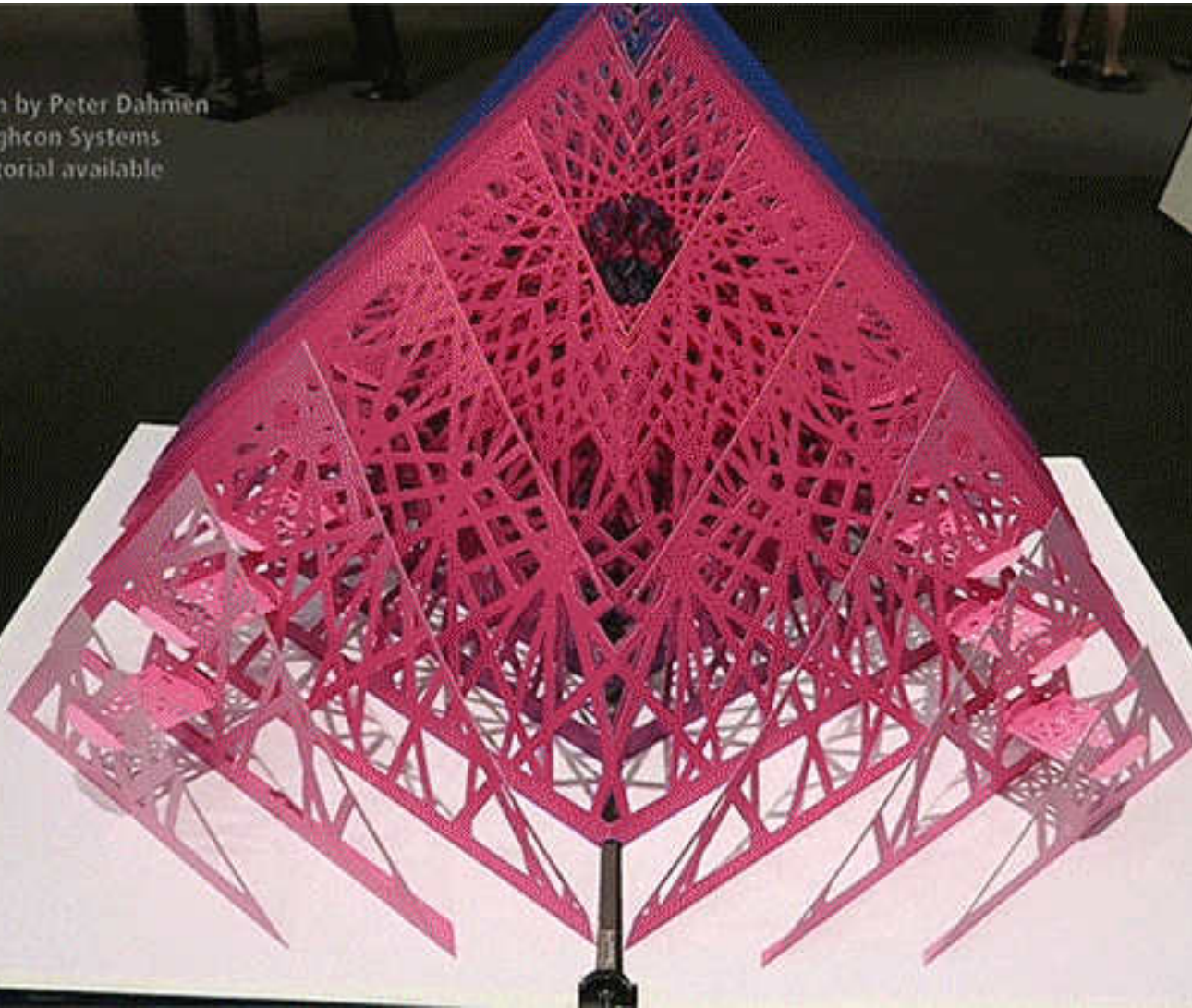
This is what paper rings do when you impose concentric mountain and valley folds onto them.



<https://www.youtube.com/watch?v=8K7LoxP61Mw>

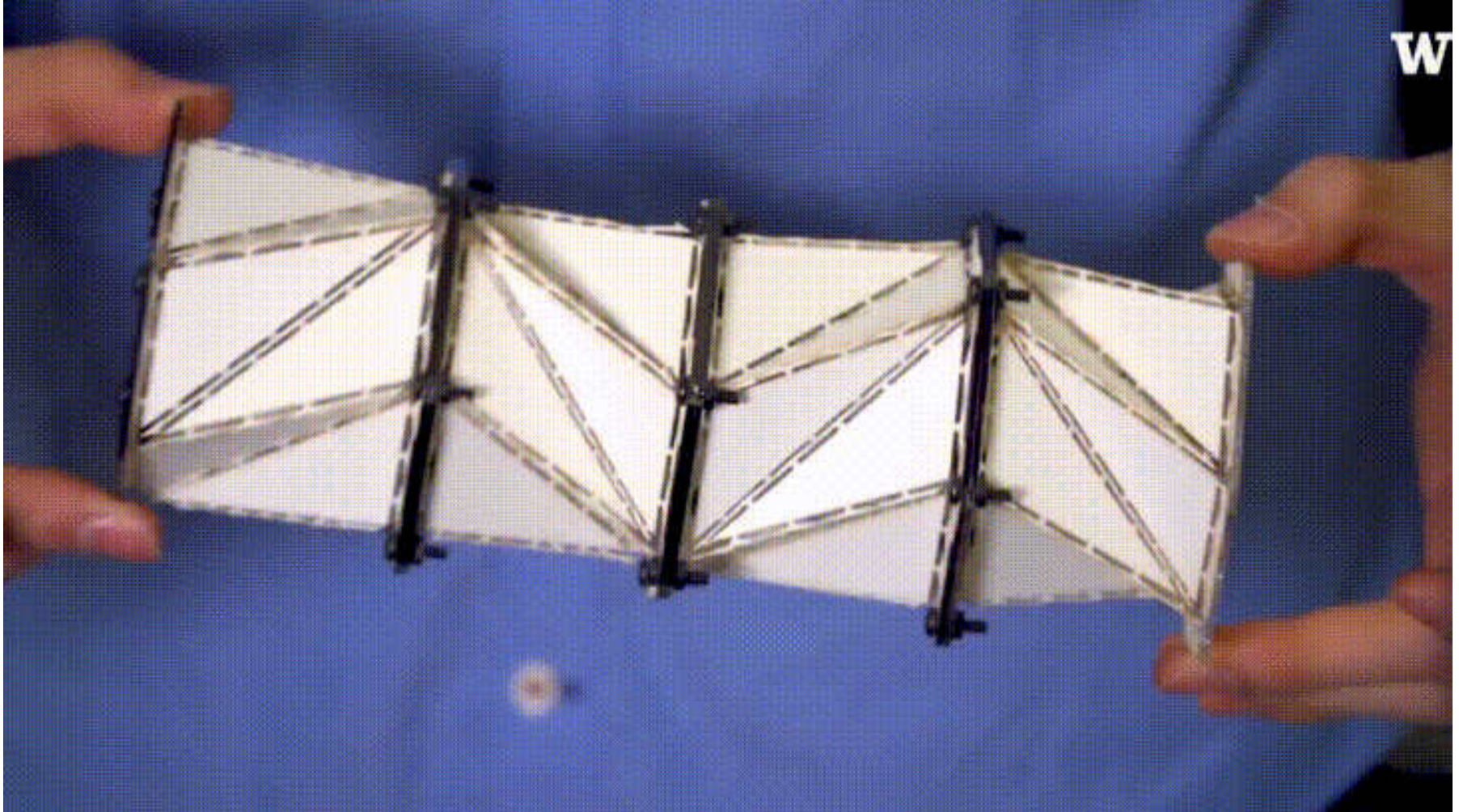
AWESOME POP-UP PAPER SCULPTURES

Design by Peter Dahmen
for Highcon Systems
No tutorial available



https://www.youtube.com/watch?time_continue=2&v=NdXvEXwOEHU

ORIGAMI USES FOR SPACECRAFT SAILS AND SOLAR PANELS



https://www.youtube.com/watch?time_continue=2&v=jjt2lOjMdJ0

MIURA FOLDING

Once in orbit, a spacecraft will be powered by an array of rigid solar panels that fan outward. But to launch the satellite, those panels have to be folded up and compact. How would you design them?

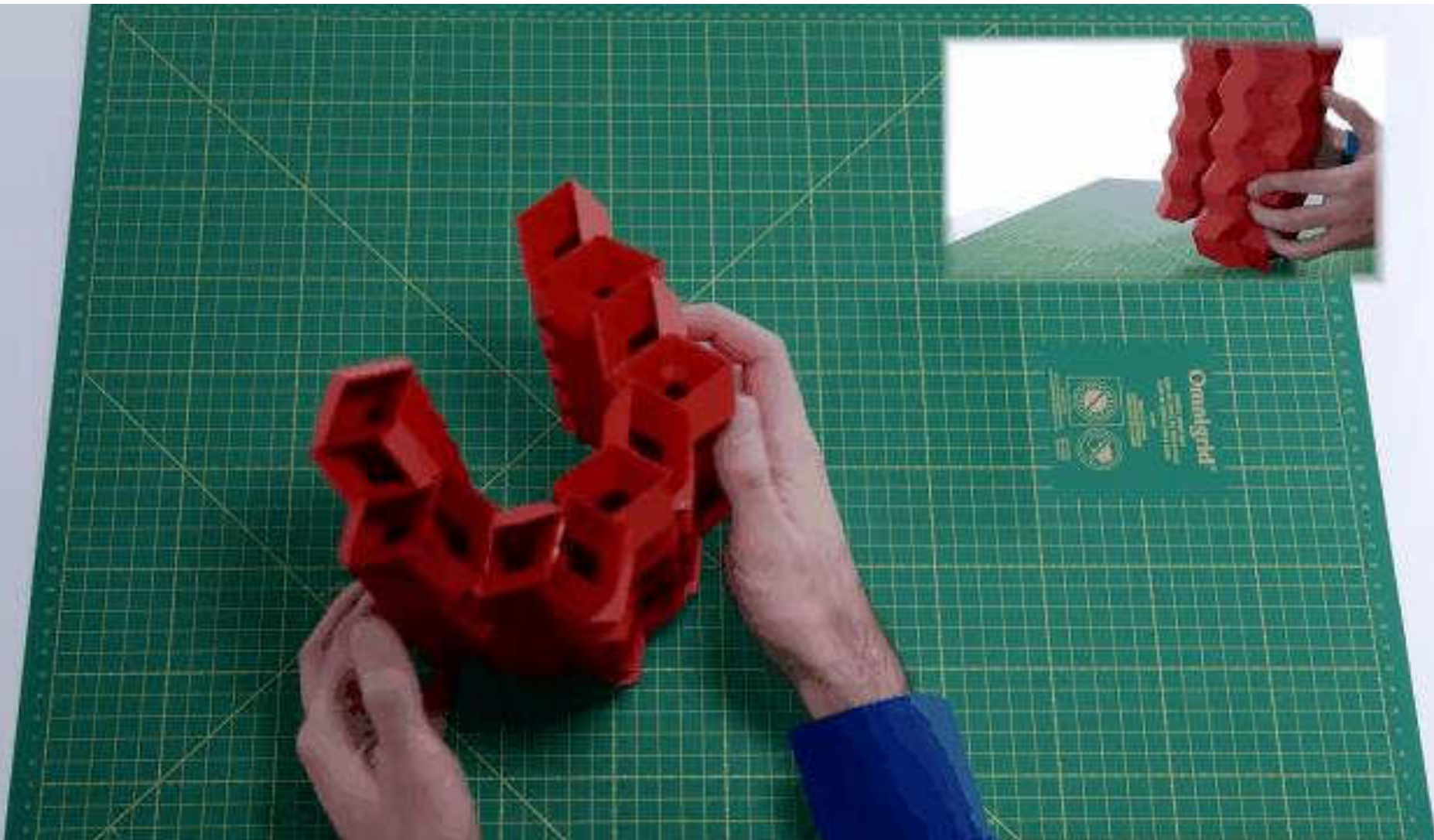
In 1985, Japanese astrophysicist Koryo Miura proposed a form of **rigid origami**, a style of folding paper (or other materials) that allows each section to remain flat—a necessary condition for stiff materials, like some solar panels.

The **Miura fold**, or *Miura-ori*, was used in Japan's Space Flyer Unit (a satellite launched in 1995), and has influenced the development of other folds that allow materials to be packed into a compact shape and then unfold in one continuous motion.



<https://www.youtube.com/watch?v=fYhaDbuksNw>

PAPER TUBES MAKE STIFF ORIGAMI STRUCTURES



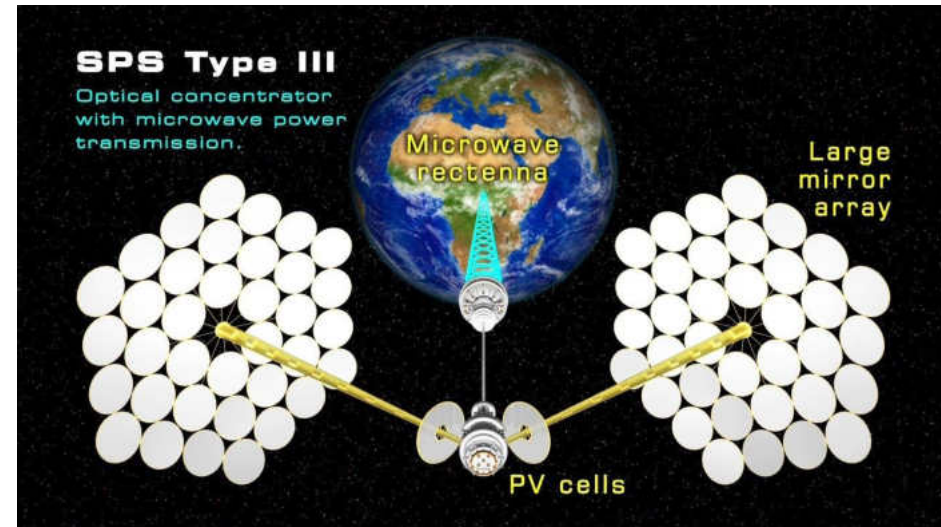
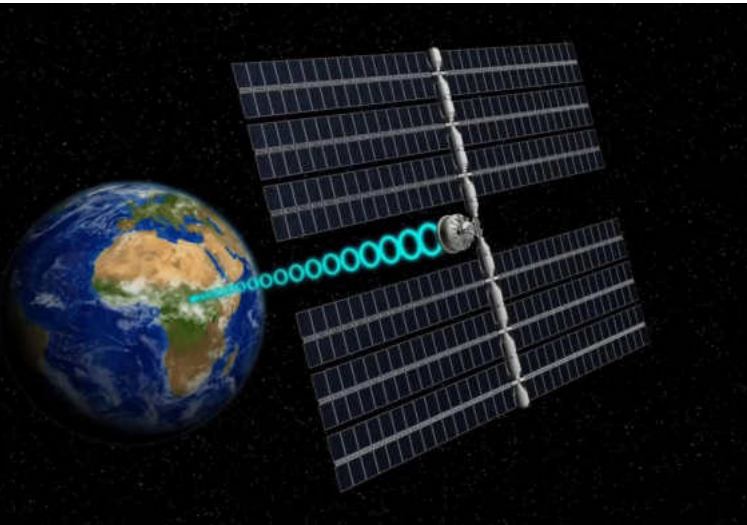
<https://www.youtube.com/watch?v=pzhvqMfYY50>

SPACE-BASED SOLAR POWER

First patented in 1973, Geostationary Earth Orbit (GEO) space-based solar power, or simply space solar power (SSP), provides the scalable sustainable energy solution to replace fossil fuels.

SSP platforms in GEO will operate almost continuously throughout the year collecting sunlight, converting this to electrical power, and transmitting this power to ground receiving stations to supply electric utilities and produce hydrogen fuel.

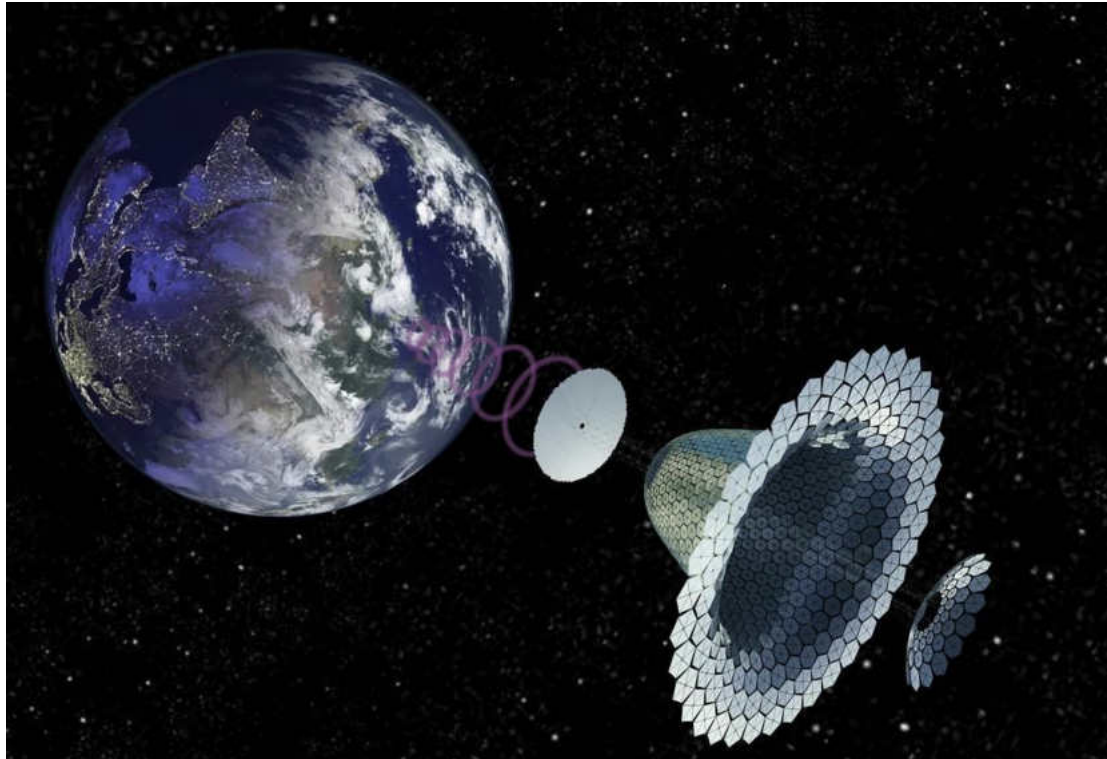
A typical GEO platform, with a sunlight capture area about the size of Manhattan Island, would provide five gigawatts of baseload electrical power to the utilities



<https://www.youtube.com/watch?v=BoxXIF9mepU>

As shown below, the SPS-ALPHA concept involves three major functional elements:

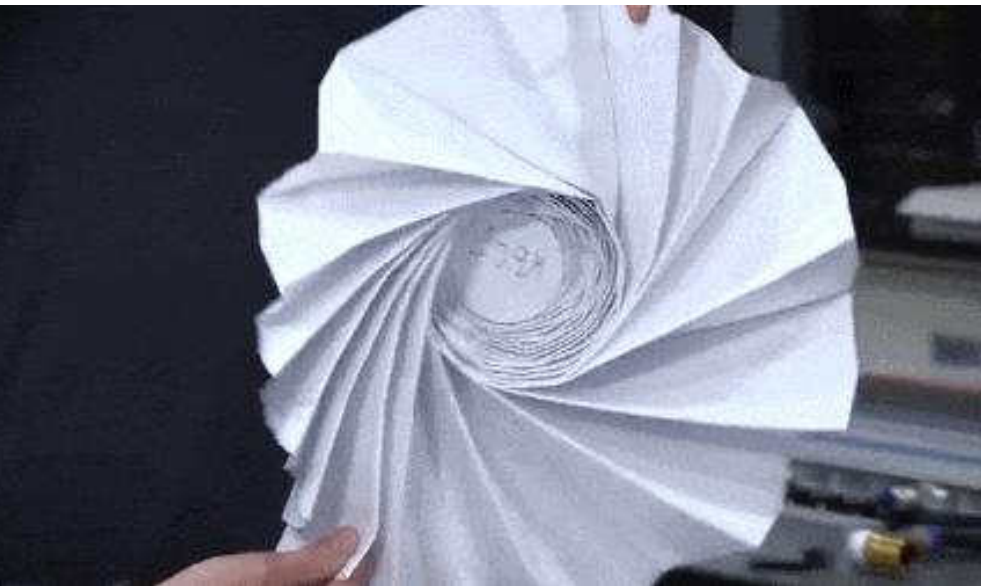
- (1) A large primary array that is pointing (toward Earth).
- (2) A very large sunlight-intercepting reflector system (involving a large number of reflectors that act as individually pointing "heliostats", mounted on a non-moving structure
- (3) A truss structure that connects those two.





<https://www.youtube.com/watch?v=3E12uju1vgQ>

HOW NASA ENGINEERS USE ORIGAMI TO DESIGN FUTURE SPACECRAFT



<https://www.youtube.com/watch?v=Ly3hMBD4h5E&t=65s>

4.3 MINUTES

NASA HAS DESIGNED AN ORIGAMI-INSPIRED ROBOT
– THE PUFFER, BUILT TO REACH TERRAINS AND FIT
INTO PLACES LARGER ROVERS CANNOT ACCESS.



<https://www.youtube.com/watch?v=fhR4PQEEedg>



THE END

29F_