Origami Design
Tree Theory for Uniaxial Bases

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Context

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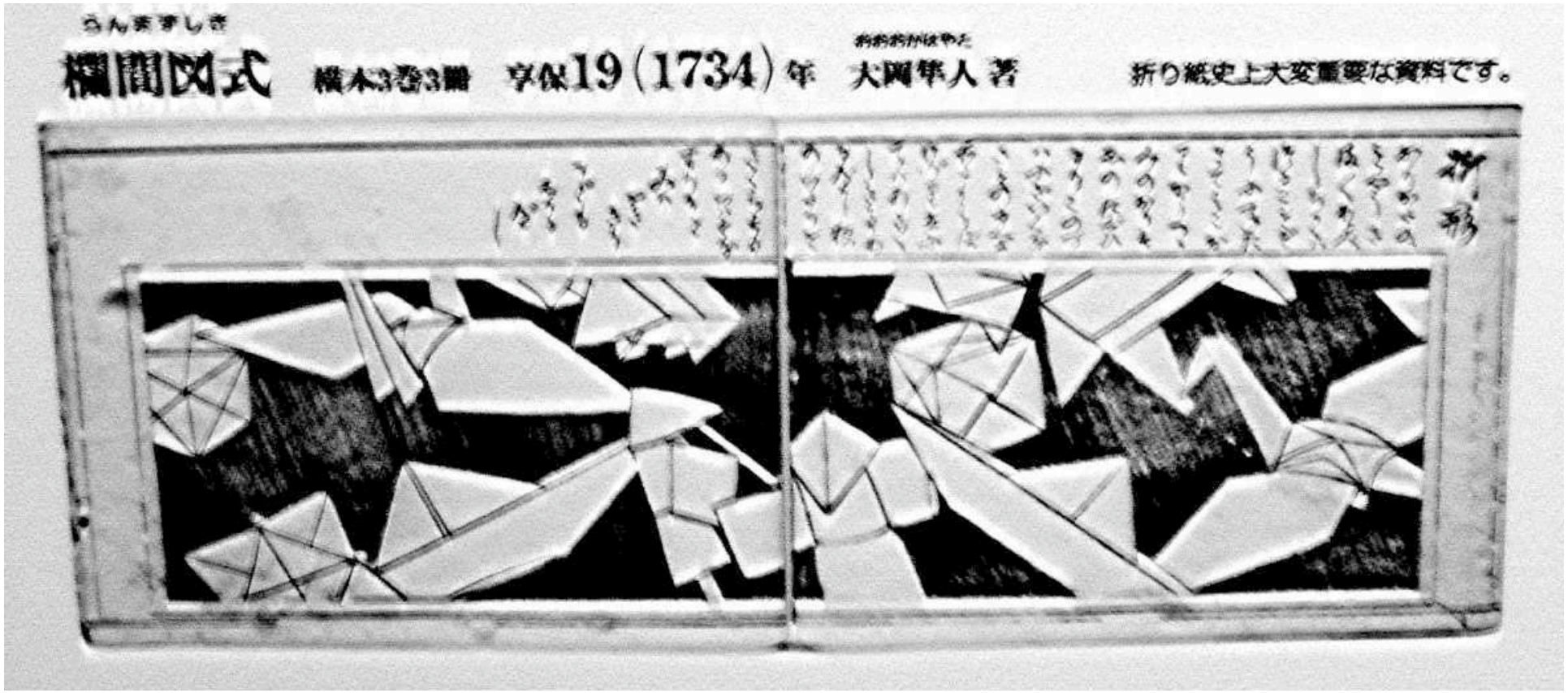
Background

- Origami: Japanese paper-folding.
- Traditional form: Decorative abstract shapes & child's craft
- Modern extension: a form of sculpture in which the primary means of creating the form consists of folding
- Most common version: a figure folded from one sheet of paper, usually a square, with no cuts.

Traditional Origami

- Japanese newspaper from 1734: Crane, boat, table, "yakko-san"
- By 1734, it is already well-developed



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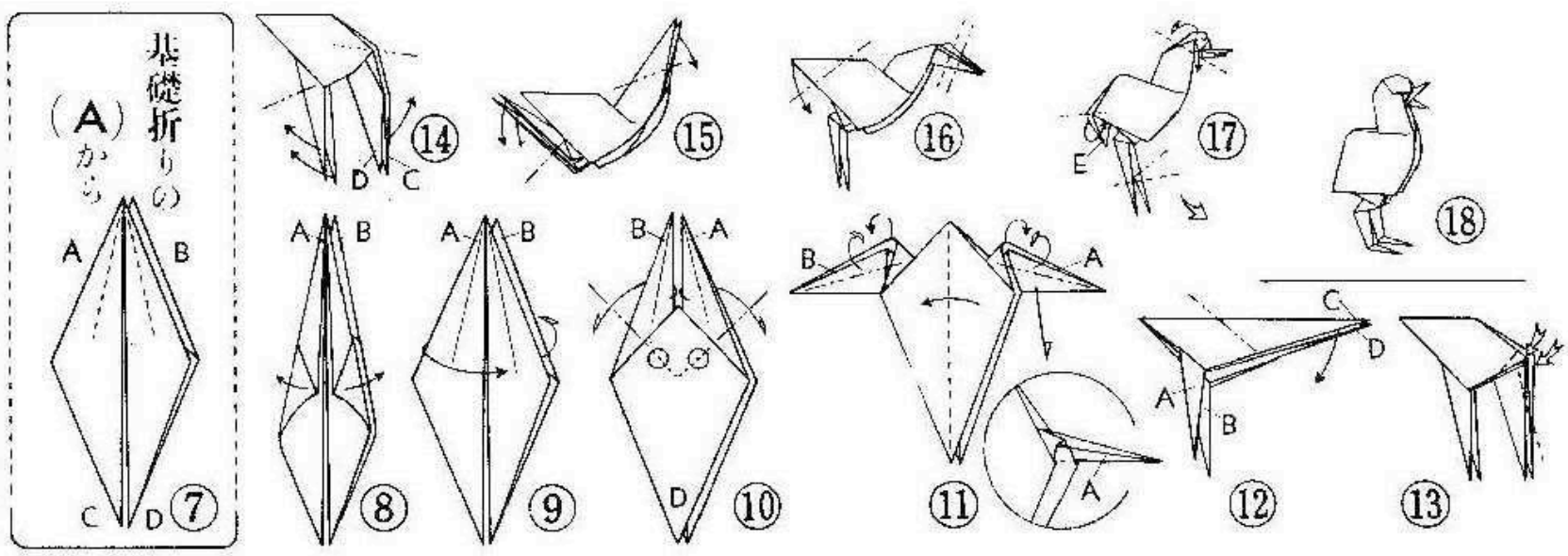
Modern Origami

- The modern art form was reborn in the early 20th century through the efforts of a Japanese artist, Akira Yoshizawa, who created new figures of artistic beauty and developed a written instructional language.



A. Yoshizawa, *Origami Dokuhon I*

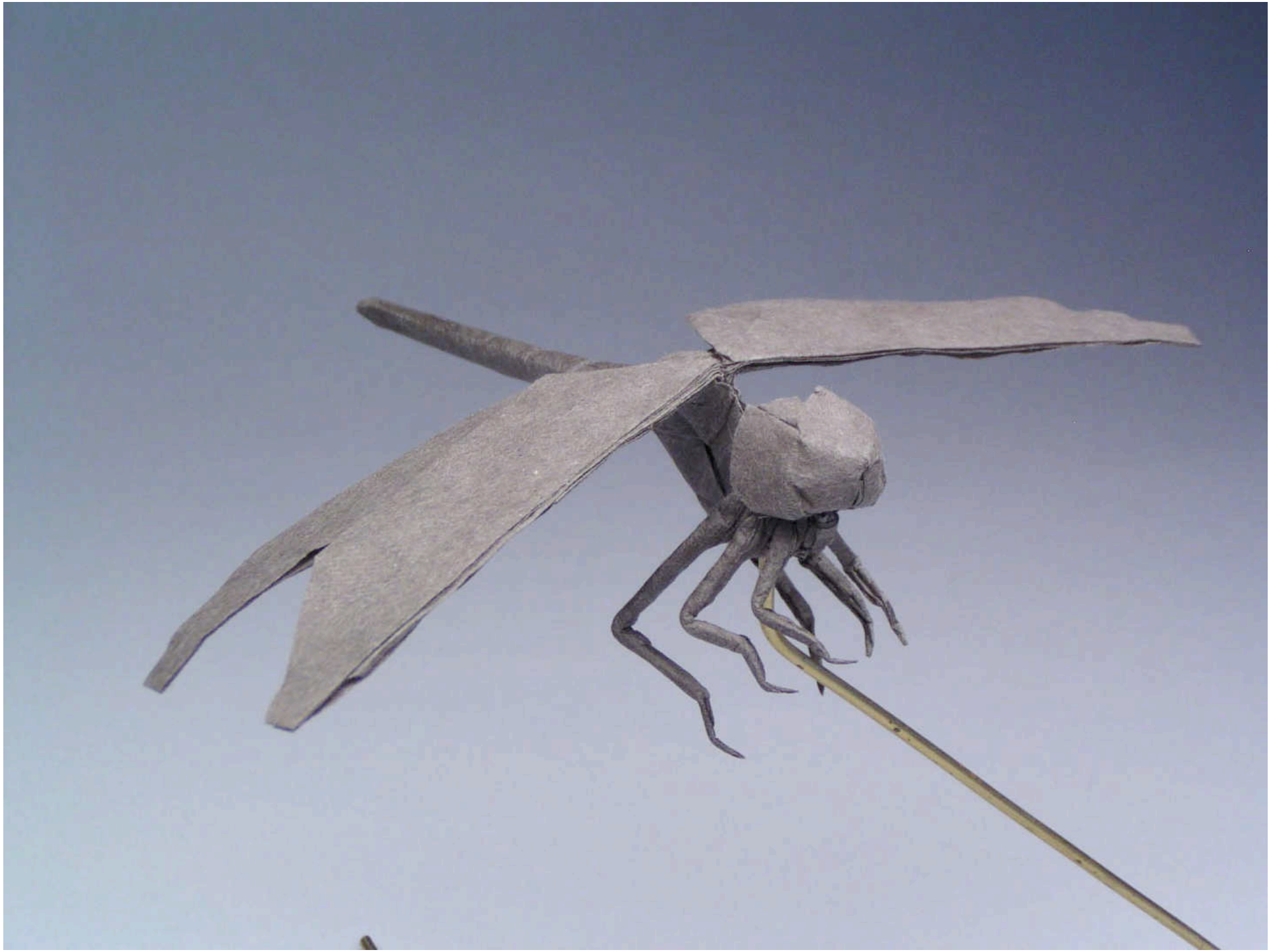
The Design Revolution

- "Creative" origami caught on worldwide in the 1950s and 1960s.
- Beginning in the 1970s, many geometric design techniques were developed that enabled the creation of figures of undreamed-of complexity.
- The mathematical theory of origami was greatly expanded in the 1990s, leading to computer-aided origami design.

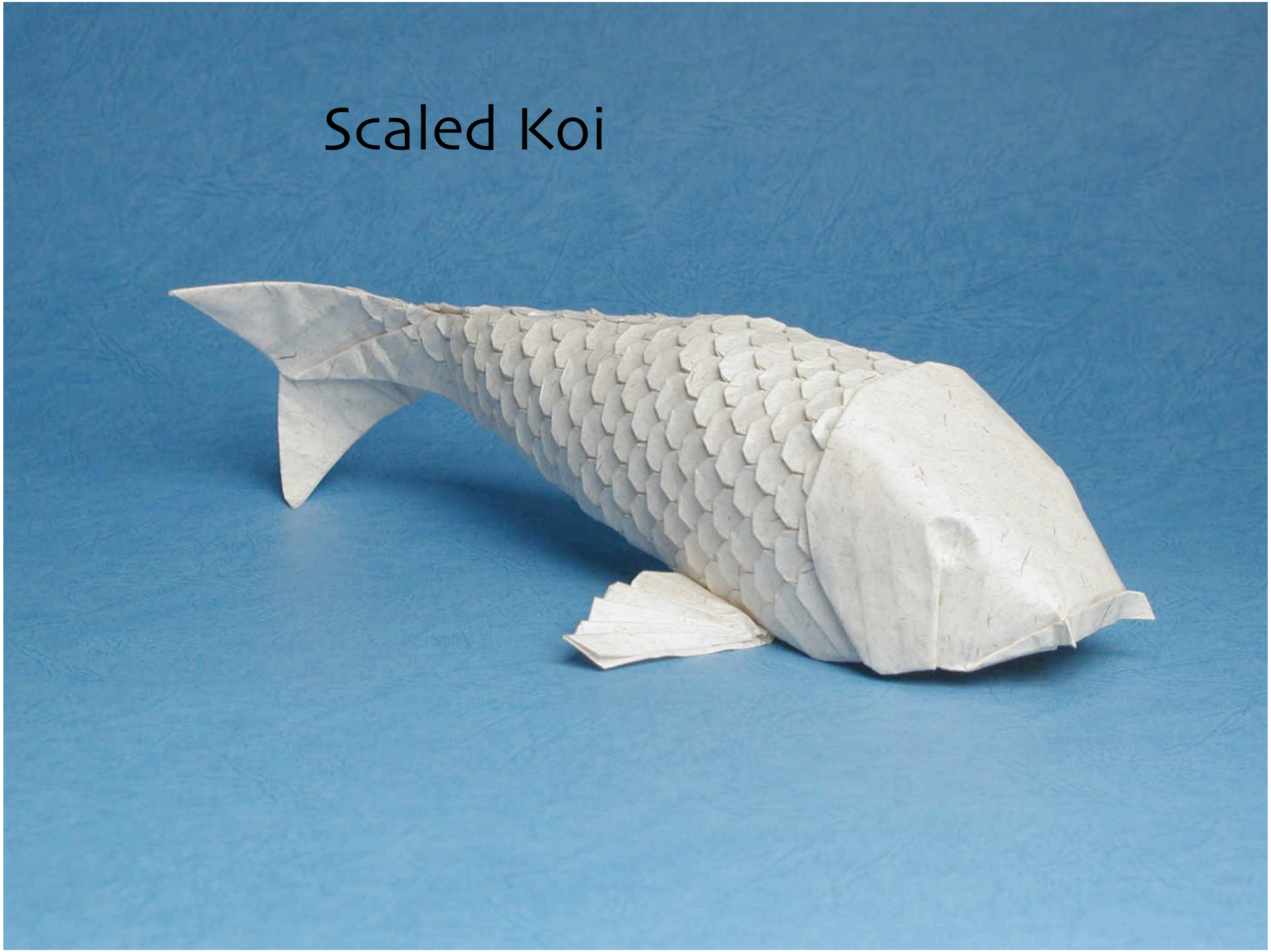
Origami today

- "Black Forest Cuckoo Clock," designed in 1987
- One sheet, no cuts
- 216 steps
  - not including repeats
- Several hours to fold

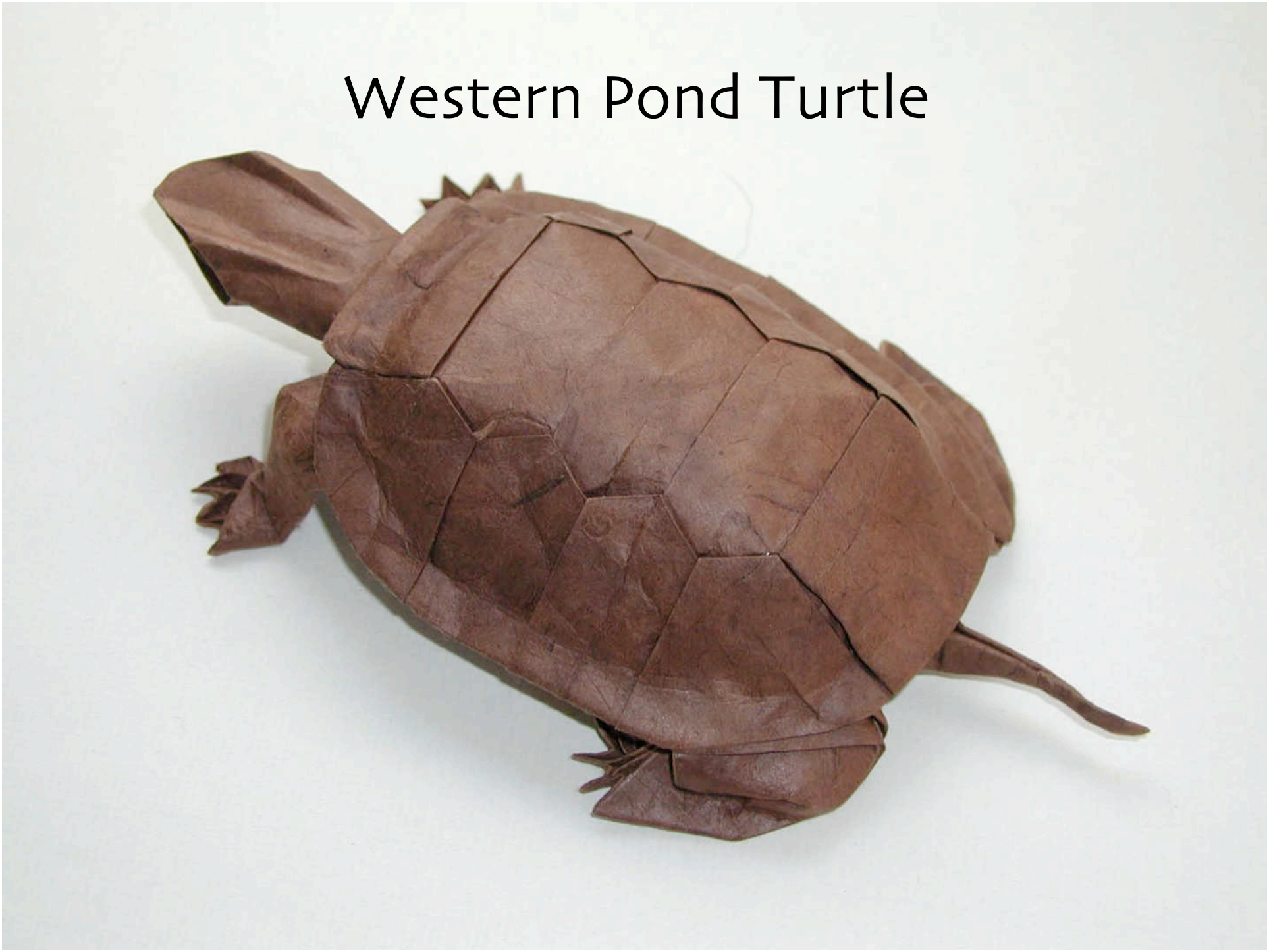
Ibex



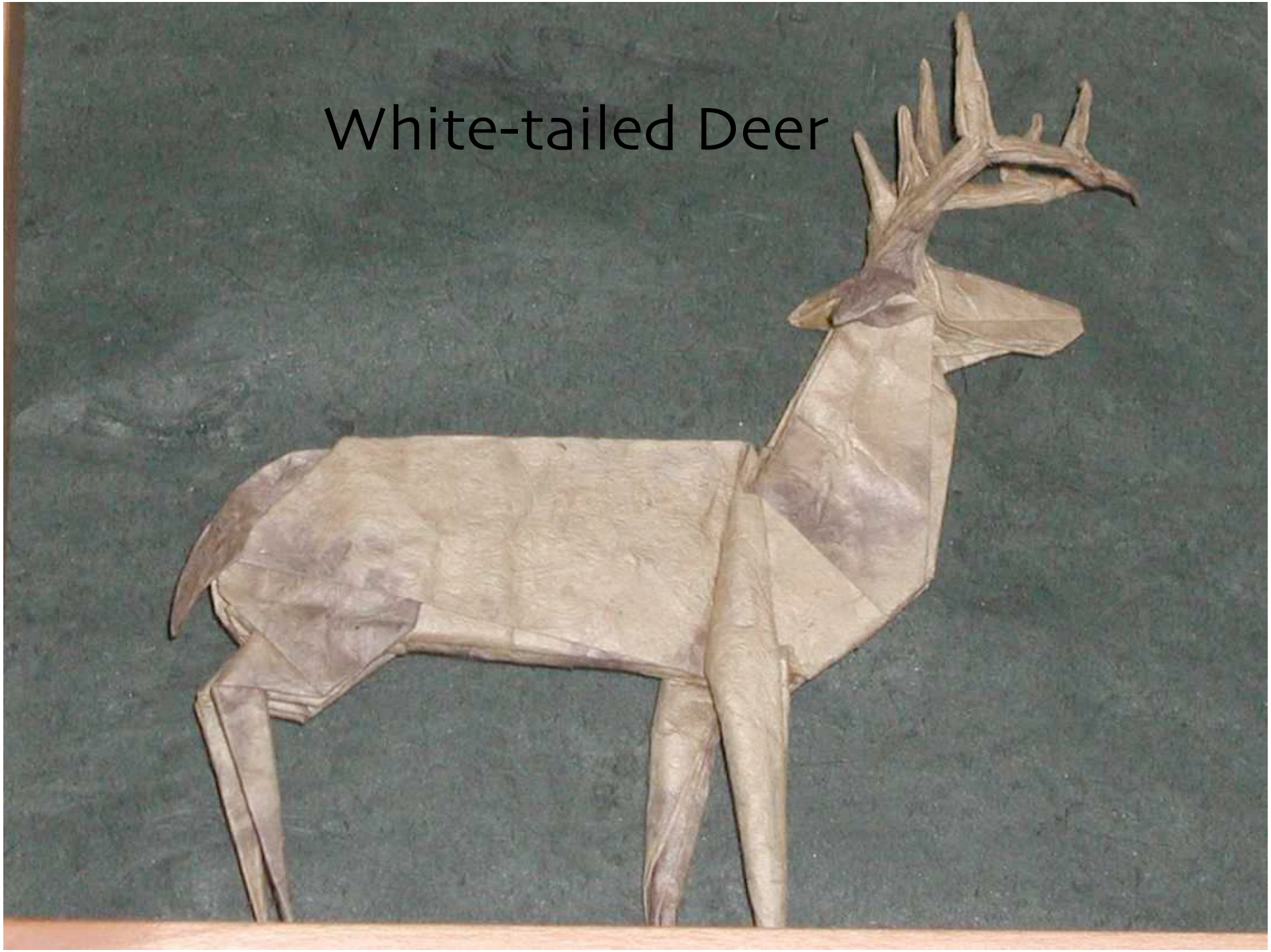
Scaled Koi



Western Pond Turtle

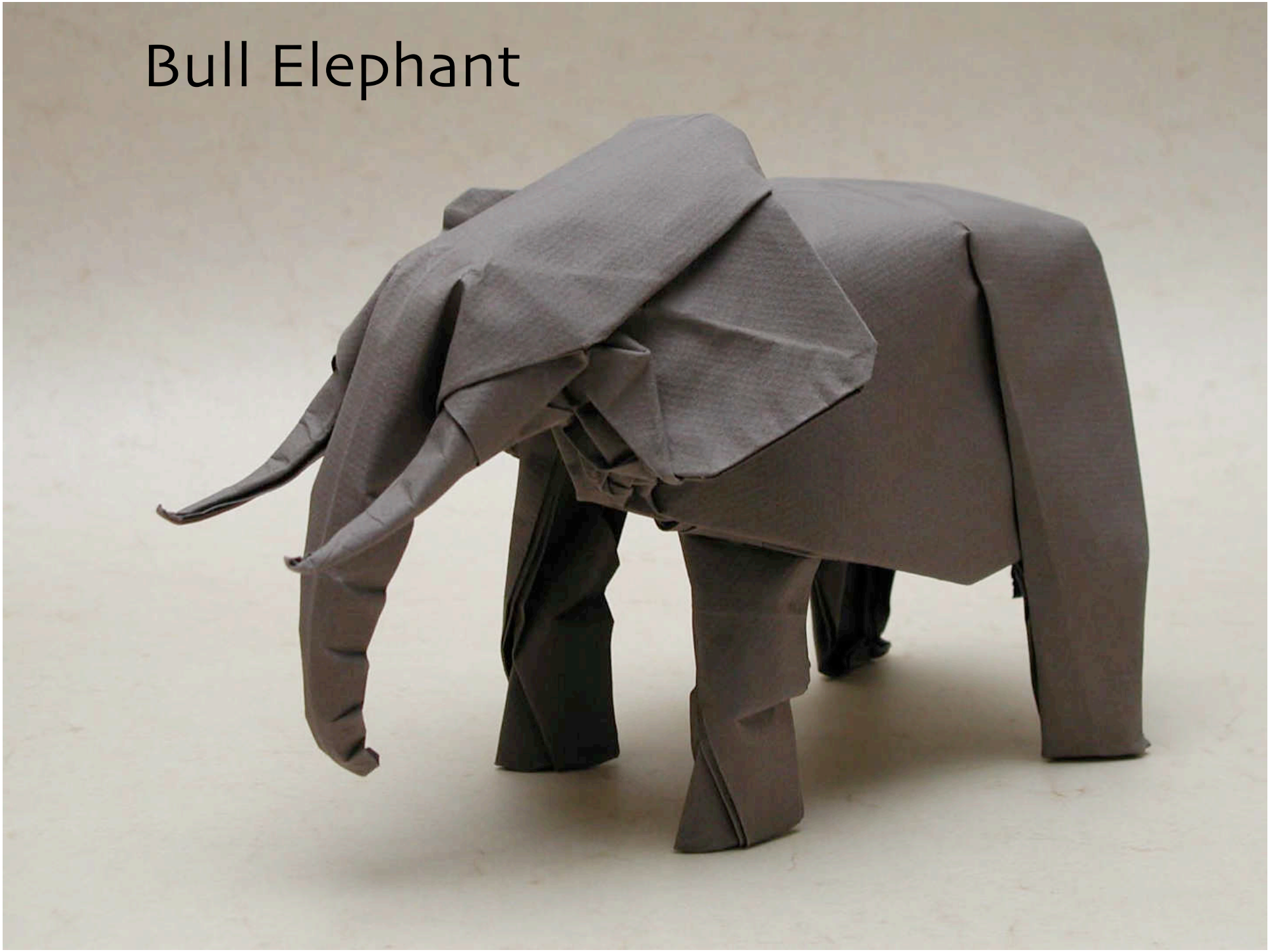


Rattlesnake


White-tailed Deer

Bull Moose

Bull Elephant

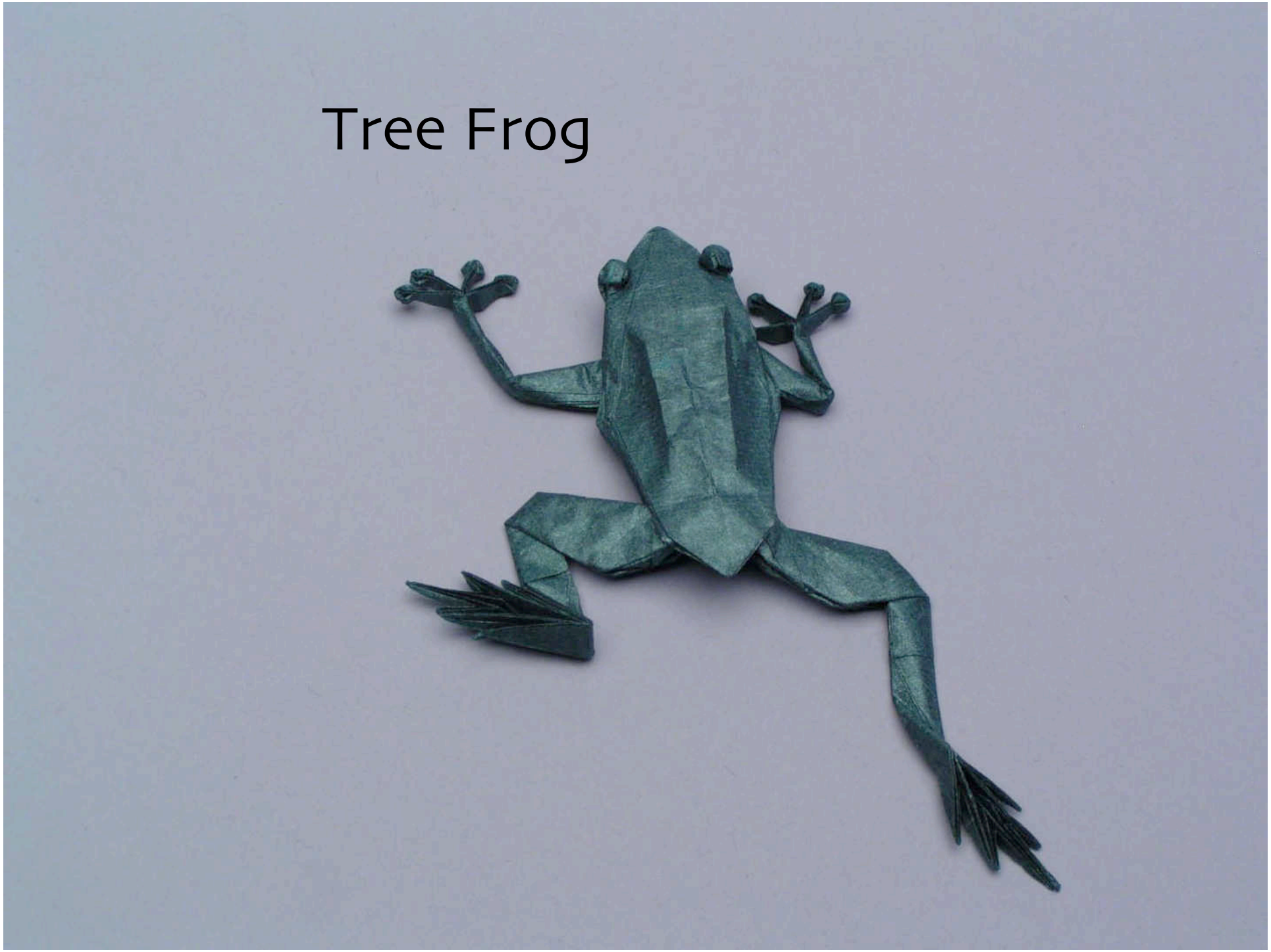


Hummingbird & Trumpet Vine

Grizzly Bear

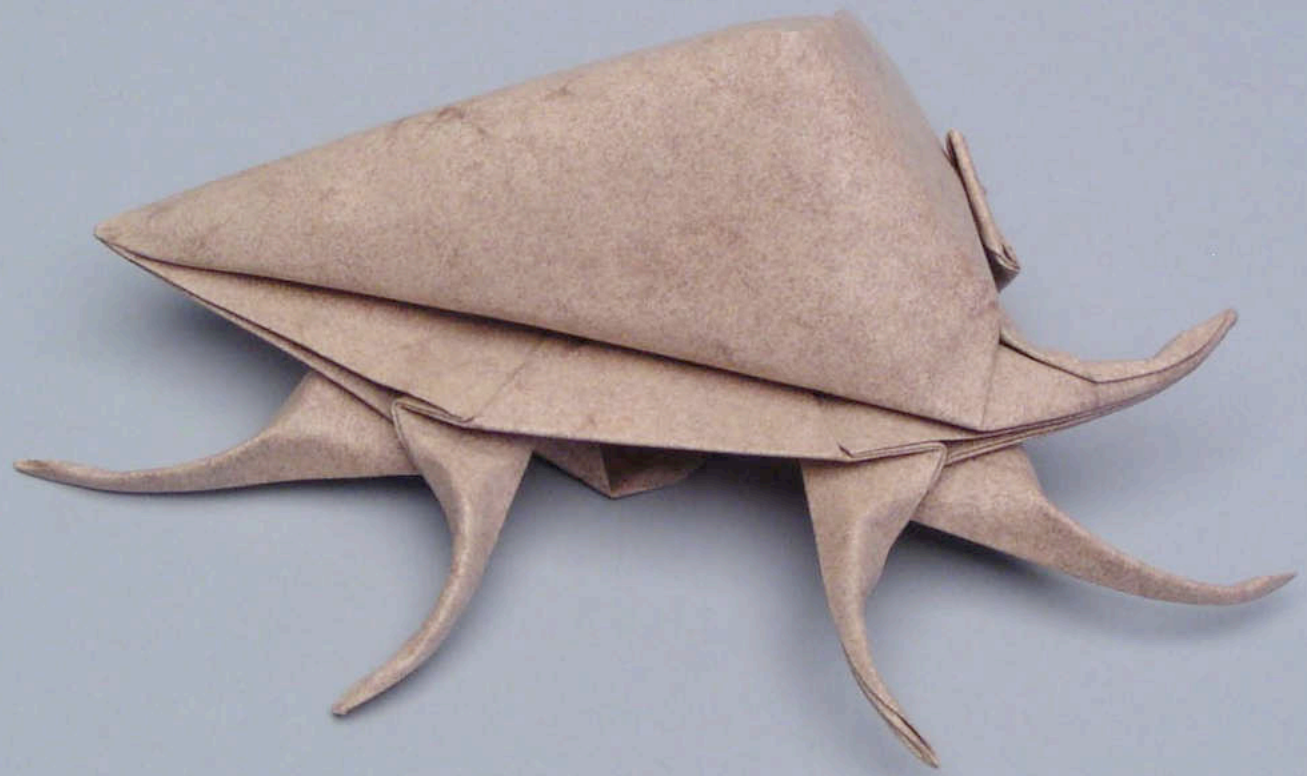
Roosevelt Elk

Tree Frog



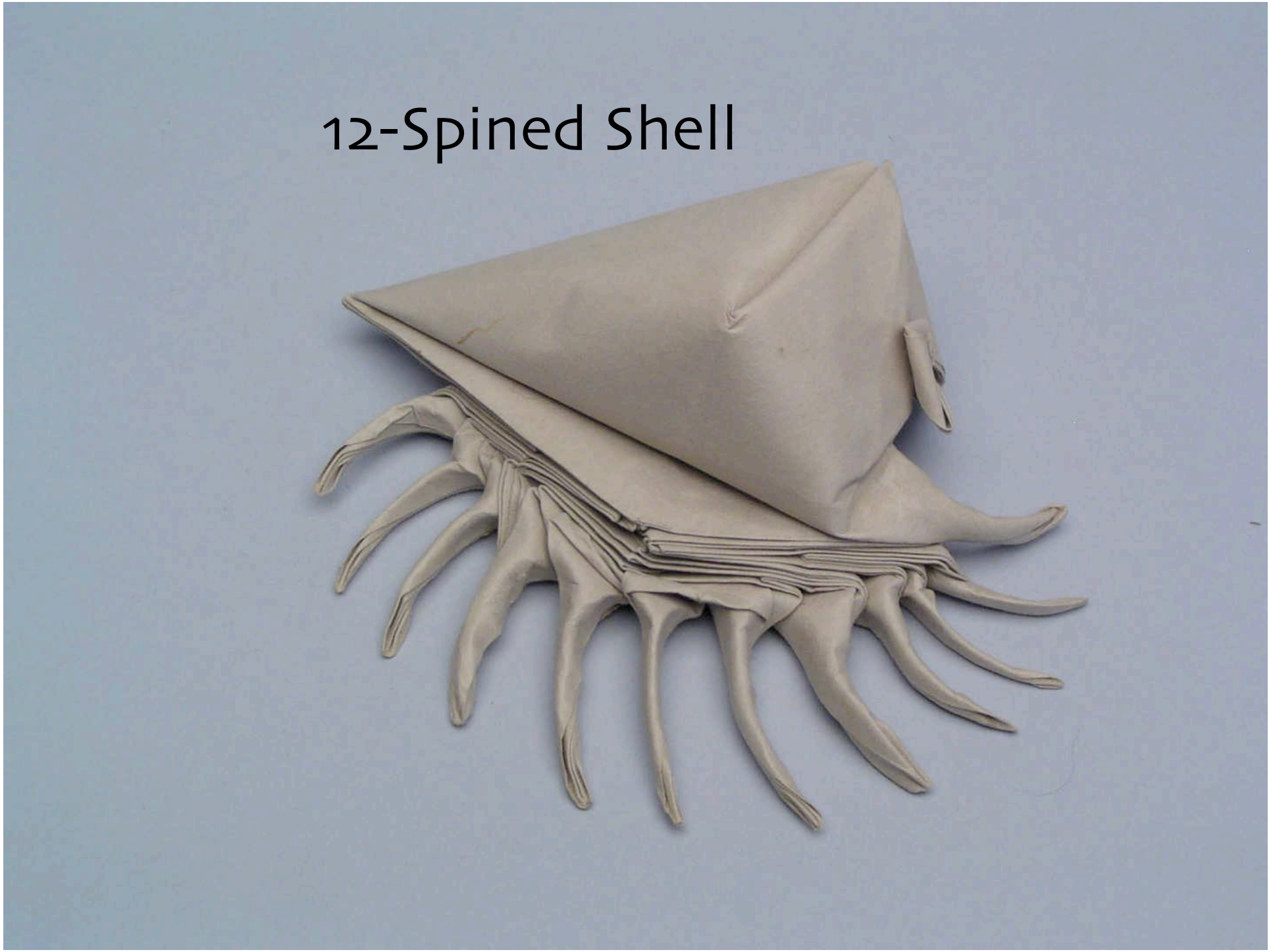
Tarantula

Murex



Spindle Murex

12-Spined Shell



Banana Slug

Spiral Tessellation

Egg17 Tessellation

Molecular Tessellation

Chalk time…

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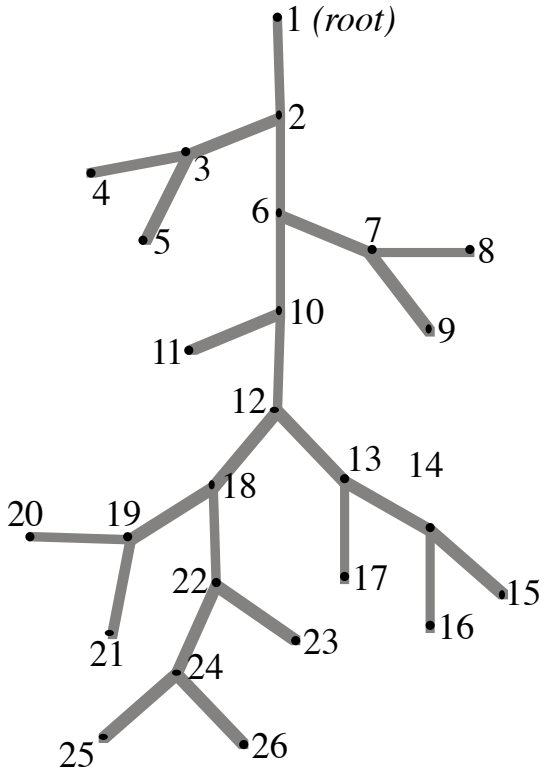
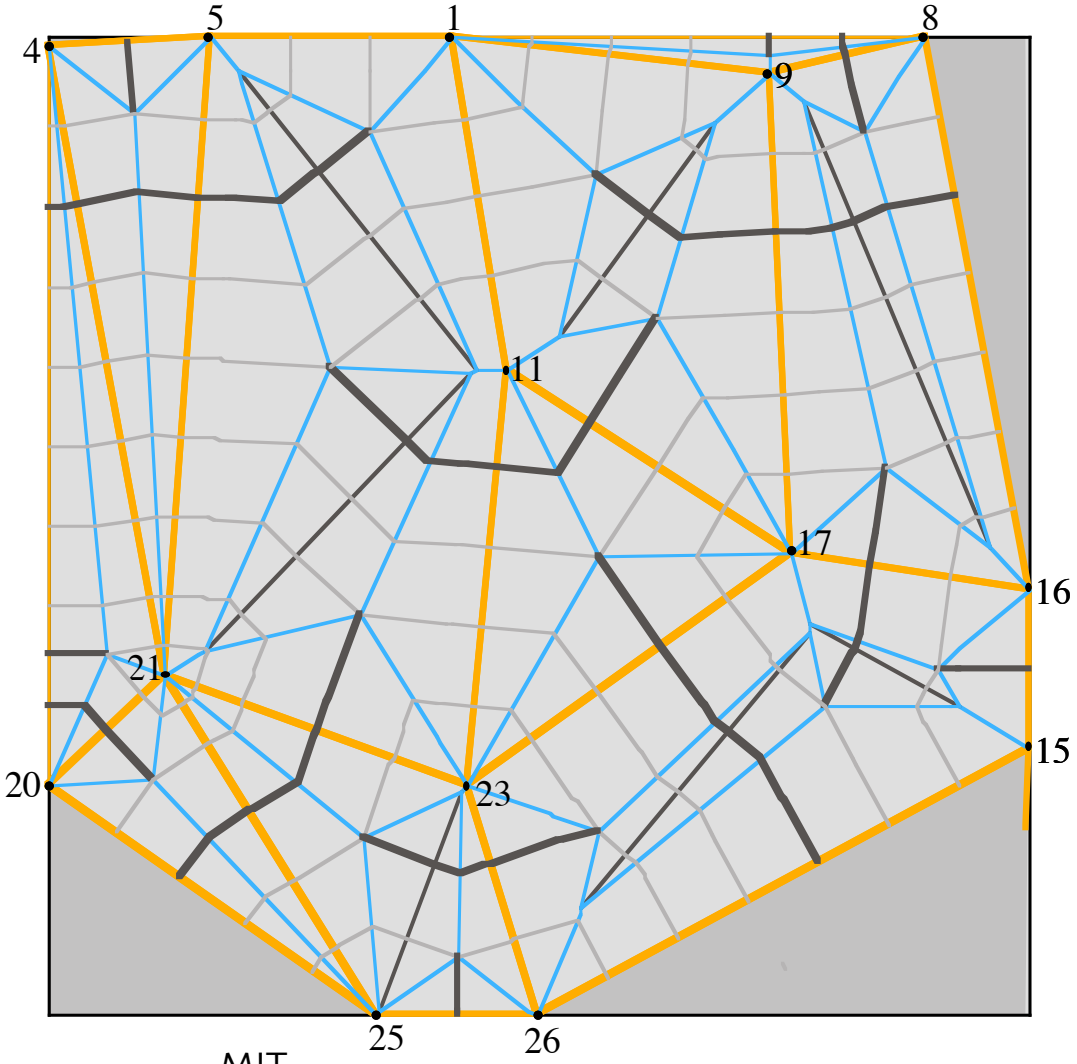
A Tree & Active Polygons





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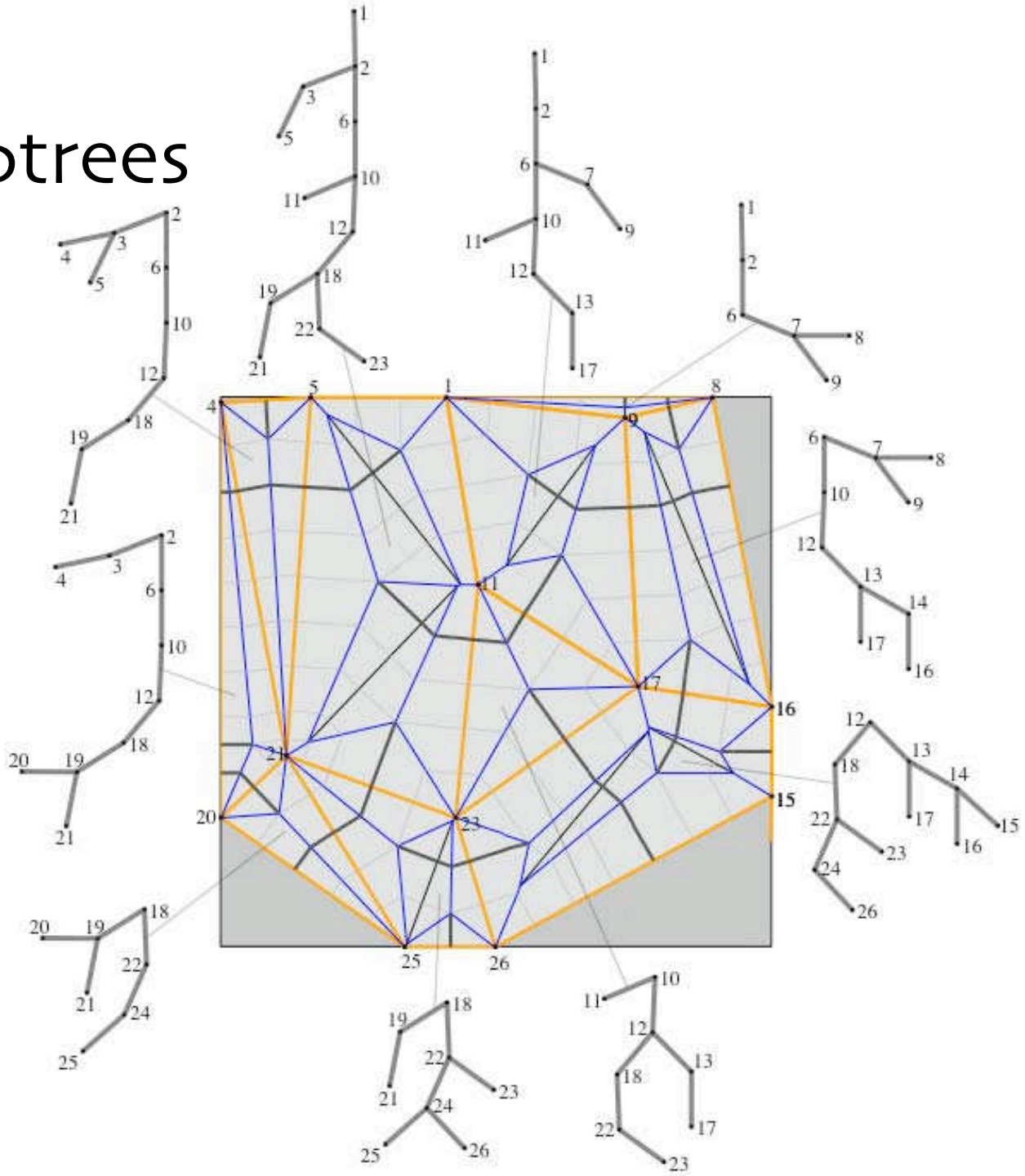
Subtrees



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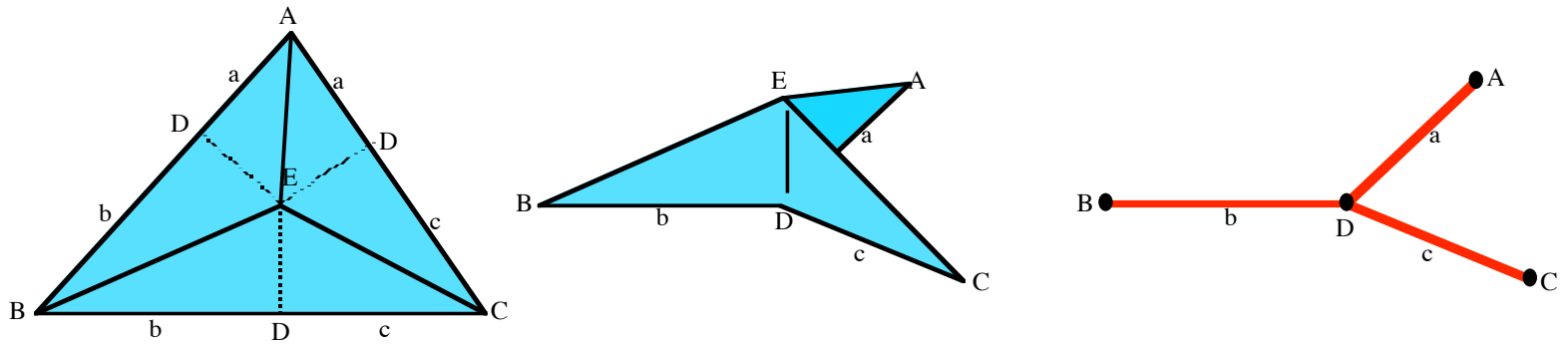
Molecules

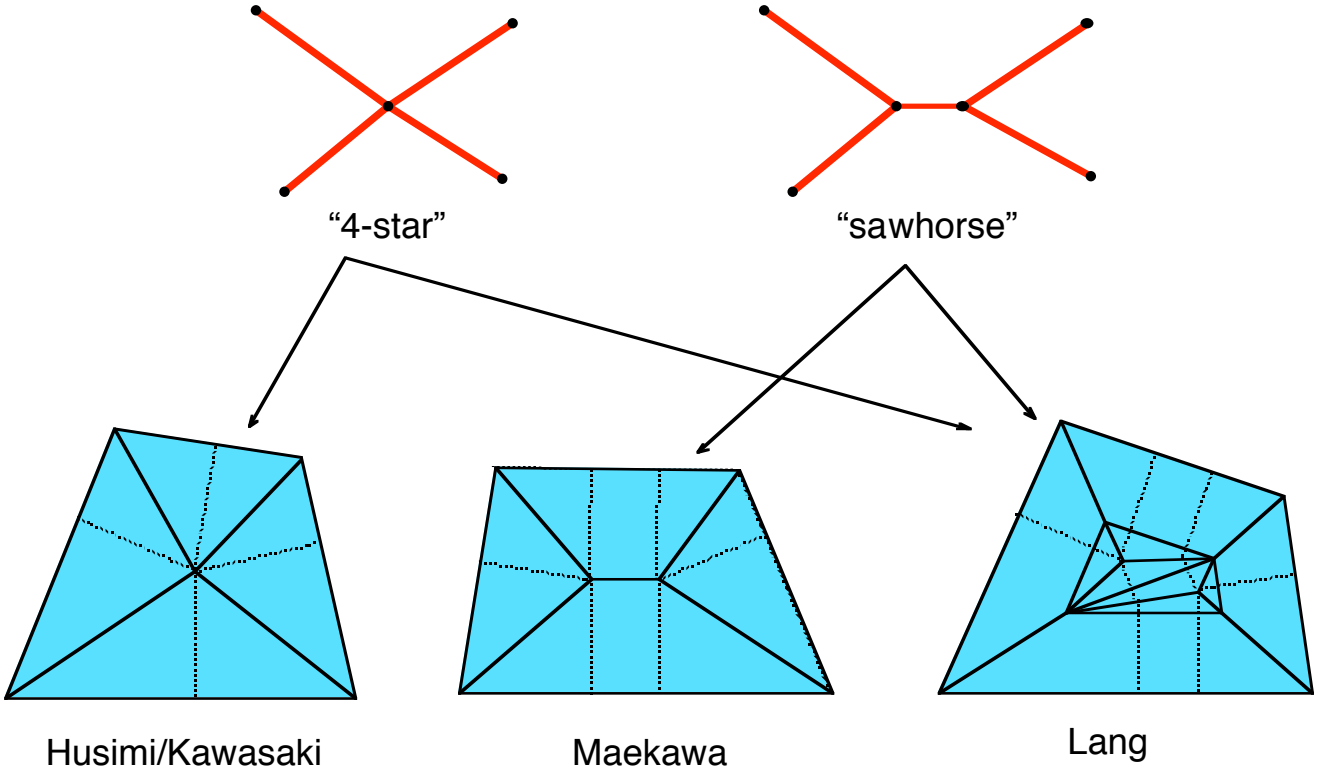
- Crease patterns that collapse a polygon so that all edges lie on a single line are called "bun-shi," or molecules (Meguro)
- Different bun-shi are known from the origami literature.
- Triangles have only one possible molecule.



the "rabbit ear" molecule

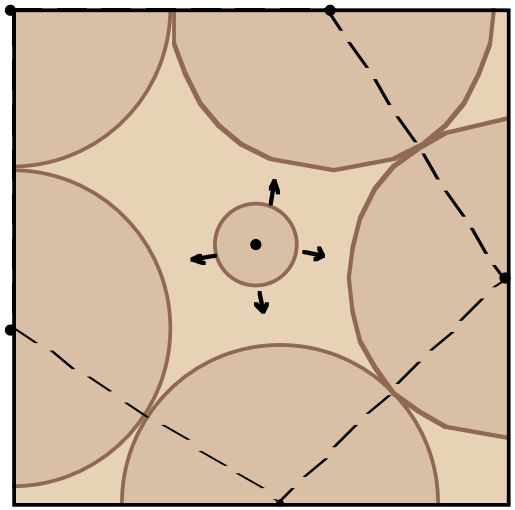
Quadrilateral molecules

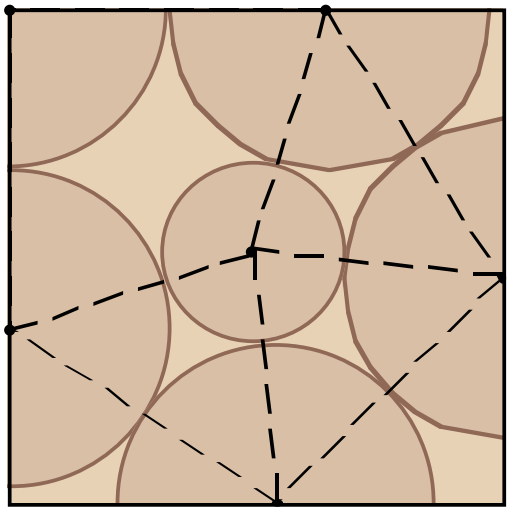
- There are two possible trees and several different molecules for a quadrilateral.
- Beyond 4 sides, the possibilities grow rapidly.

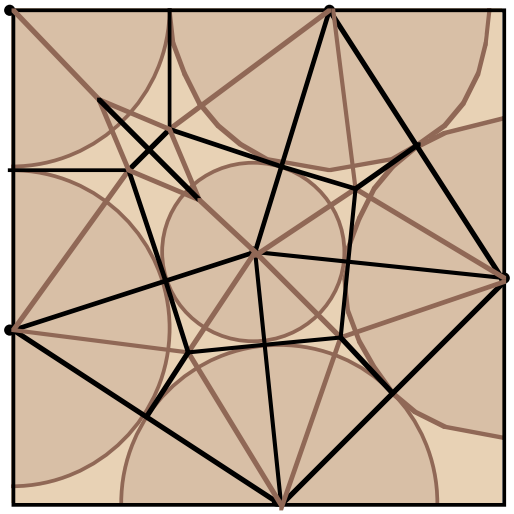


Four is enough

- It is always possible to add flaps (circles) to a base so that the only polygons are triangles and quadrilaterals, so these molecules suffice.

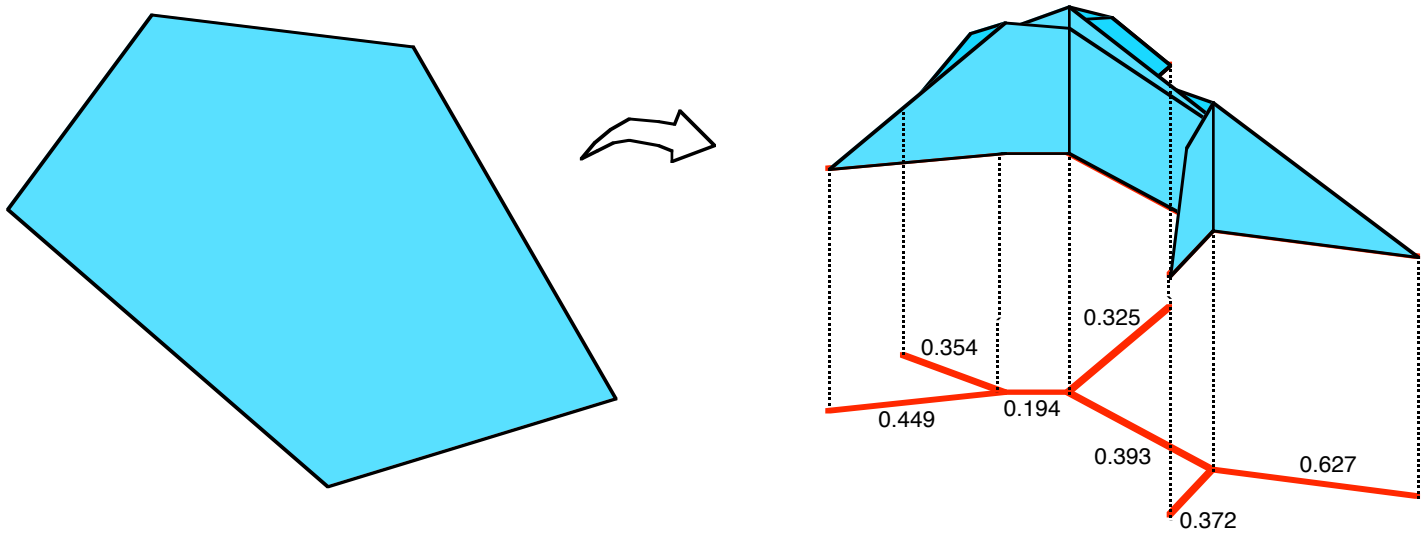




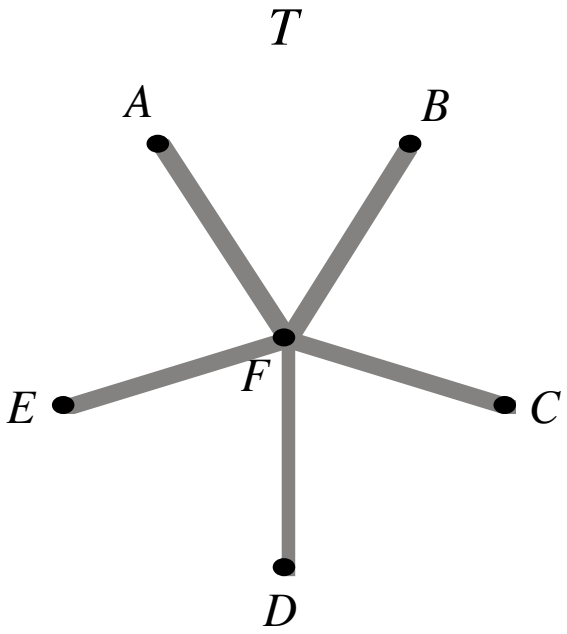


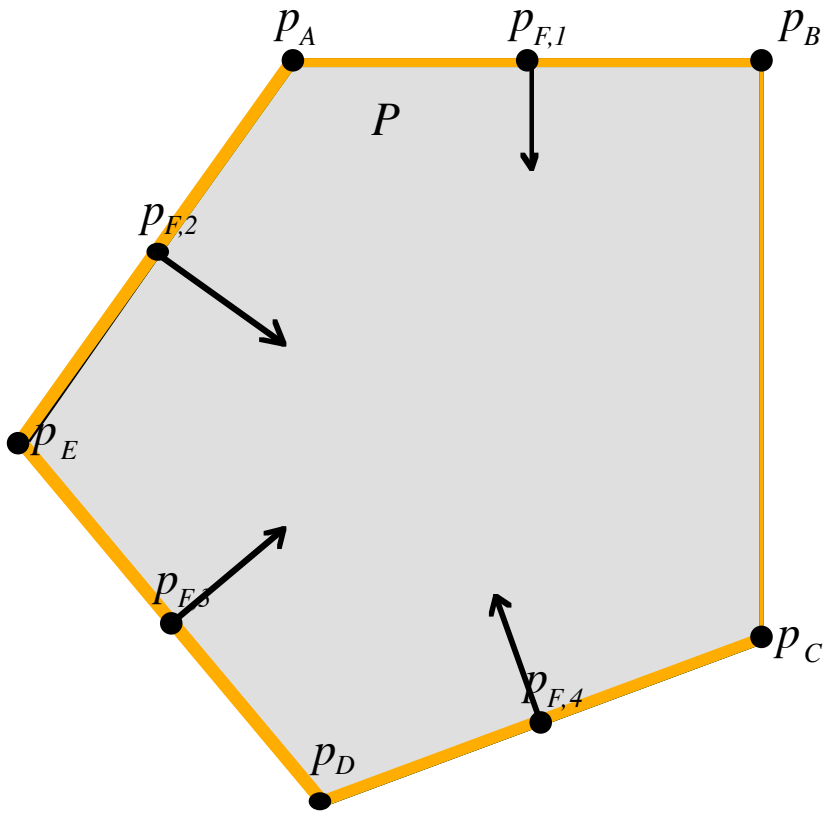
Universal molecule

- An algorithm that produces the crease pattern to collapse an arbitrary valid convex polygon into a base whose projection is a specified tree.

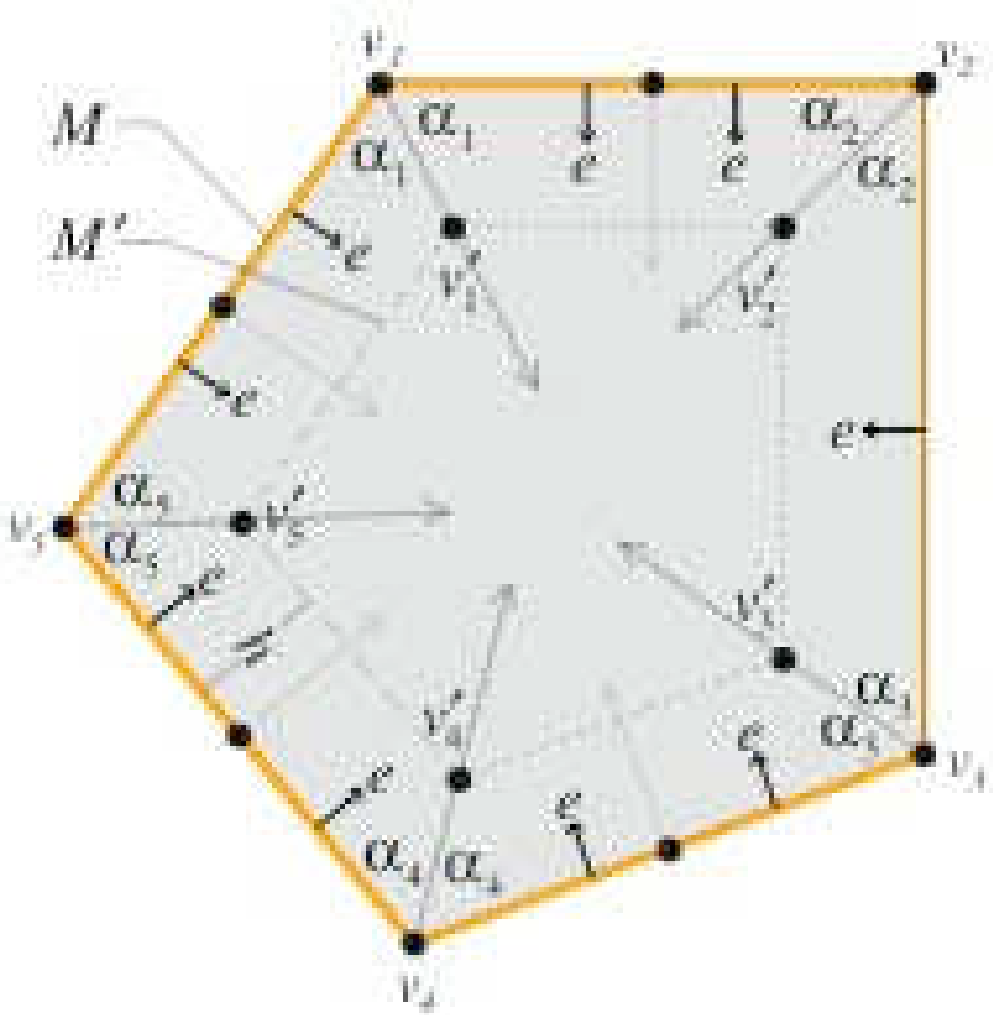


A pentagonal UM

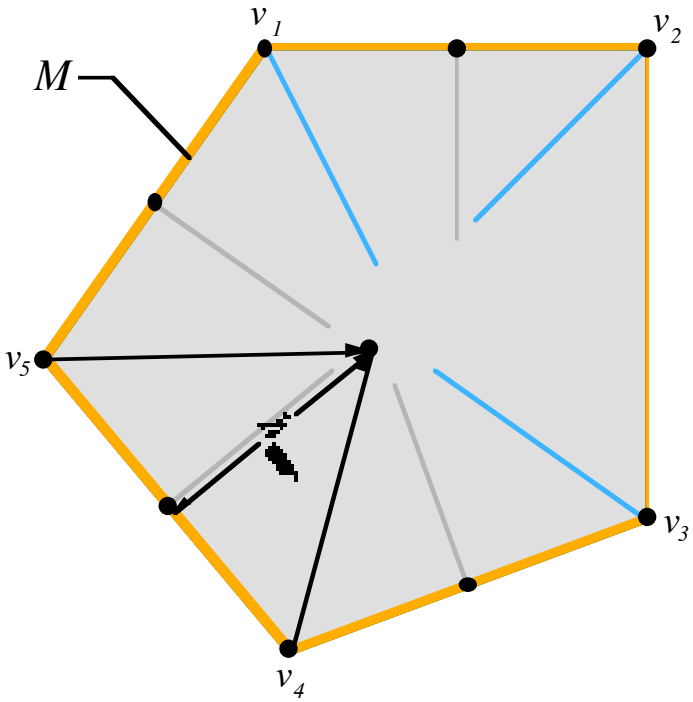


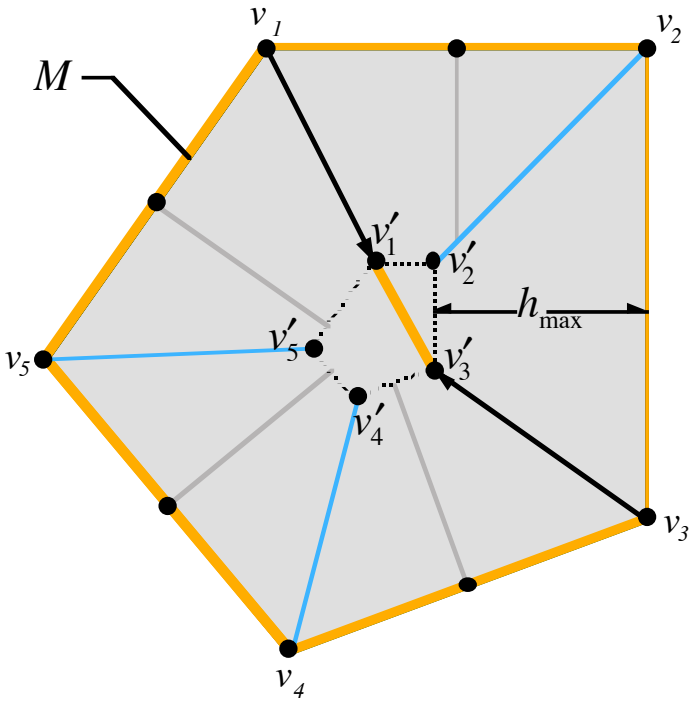


Insetting

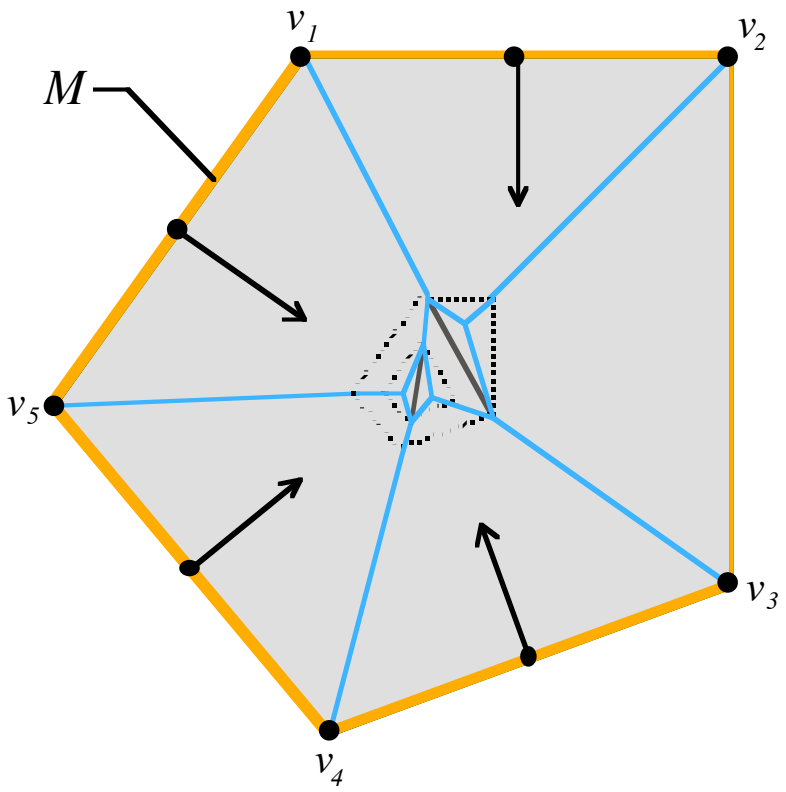


Gusset formation

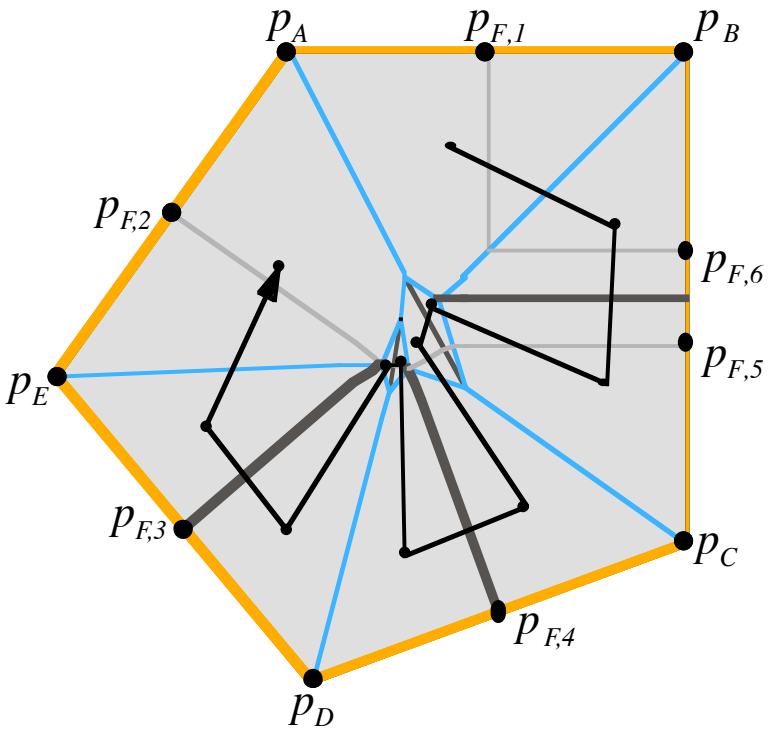


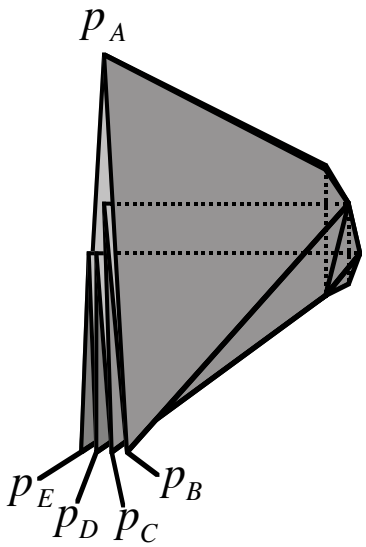


Finished gussets



Creases & Folded Form





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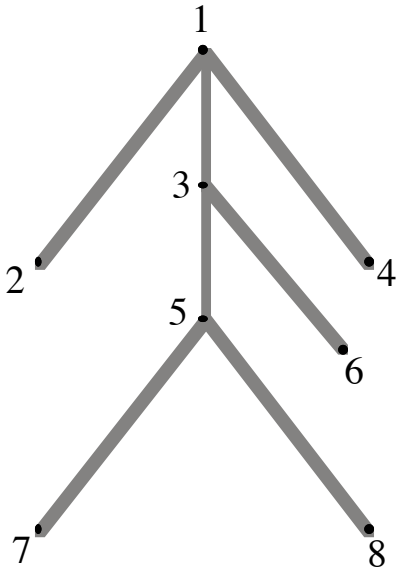
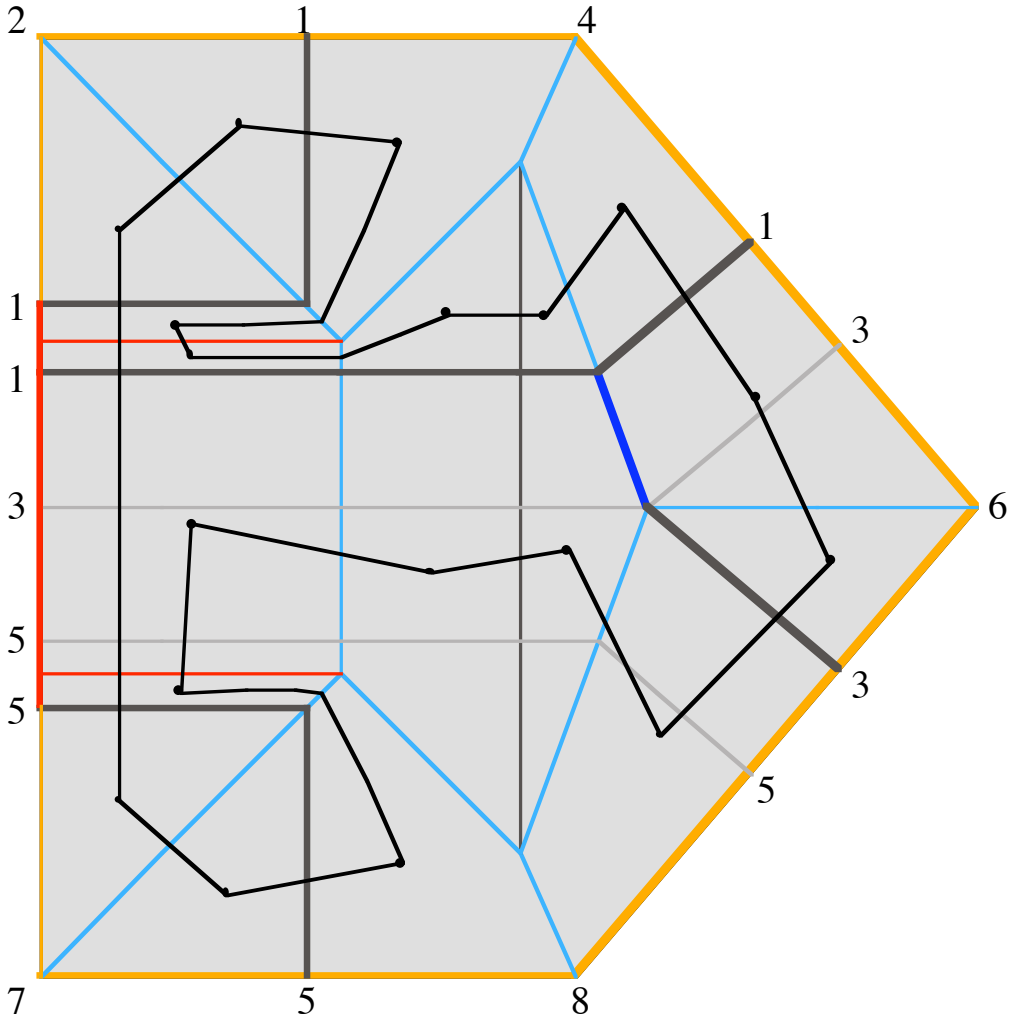
Universal Molecule 1





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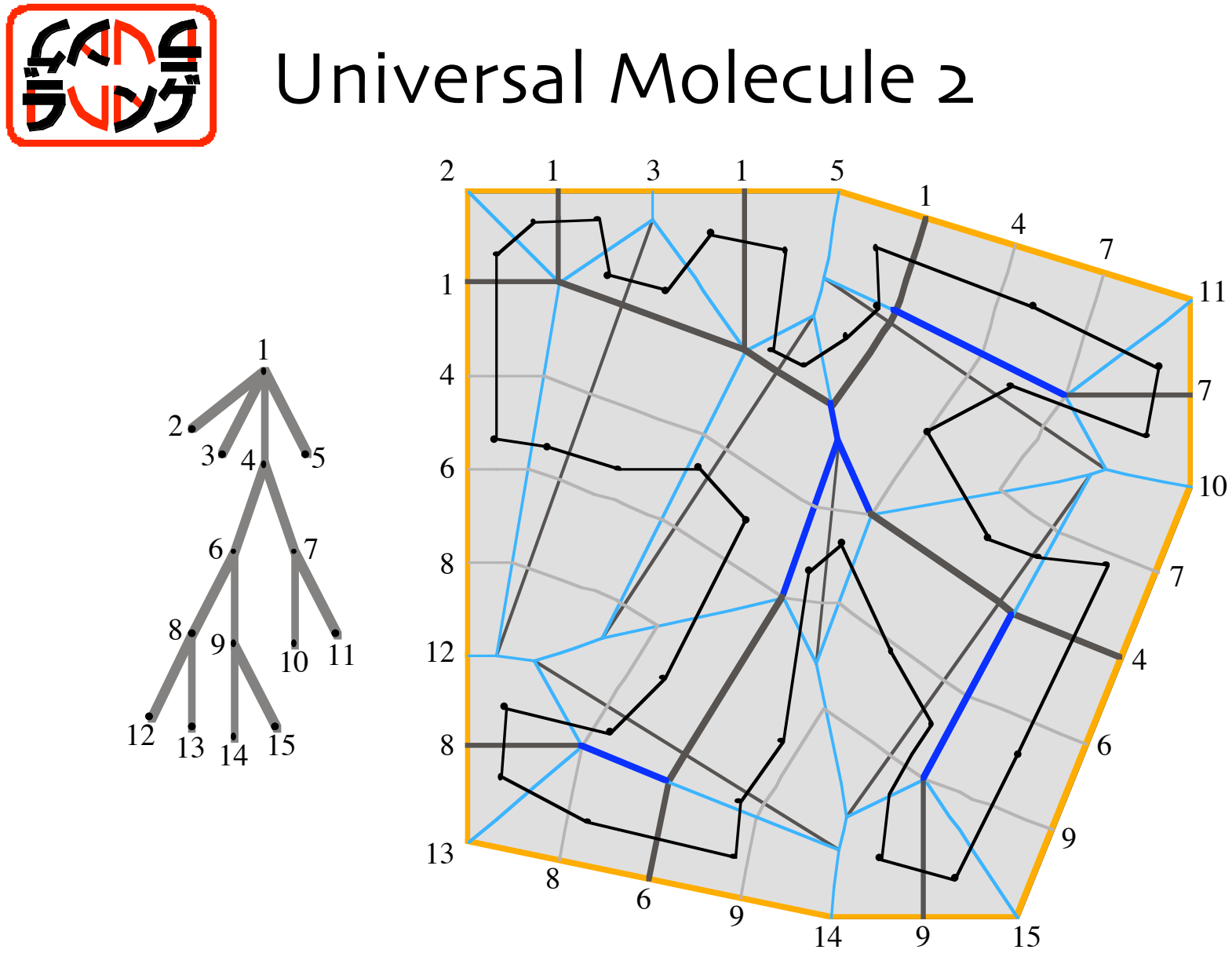
Universal Molecule 2
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Resources

- Origami design software *TreeMaker* (with 170 pp manual) can be downloaded from:
  - http://origami.kvi.nl/programs/treemaker
- …or Google-search for "TreeMaker"
- Version 5.0 (Mac/Linux/Windows) is under construction.
- Other origami-related software, including *ReferenceFinder*, is at the same site
- Theory described in 12 ACM SCG paper, "An Algorithm for Origami Design" (1996) by Robert J. Lang.

More Resources

- *Origami Design Secrets*, my new book teaching how to design origami (and more), was published by A. K. Peters in October 2003.
- *Origami Insects II*, my latest, contains a collection of fairly challenging insect designs
- Both (and other books) available from the OrigamiUSA Source (www.origami-usa.org).

- Further information may be found at **http://www.langorigami.com**, or email me at robert@langorigami.com