



Origami Design

Tree Theory for Uniaxial Bases

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Context

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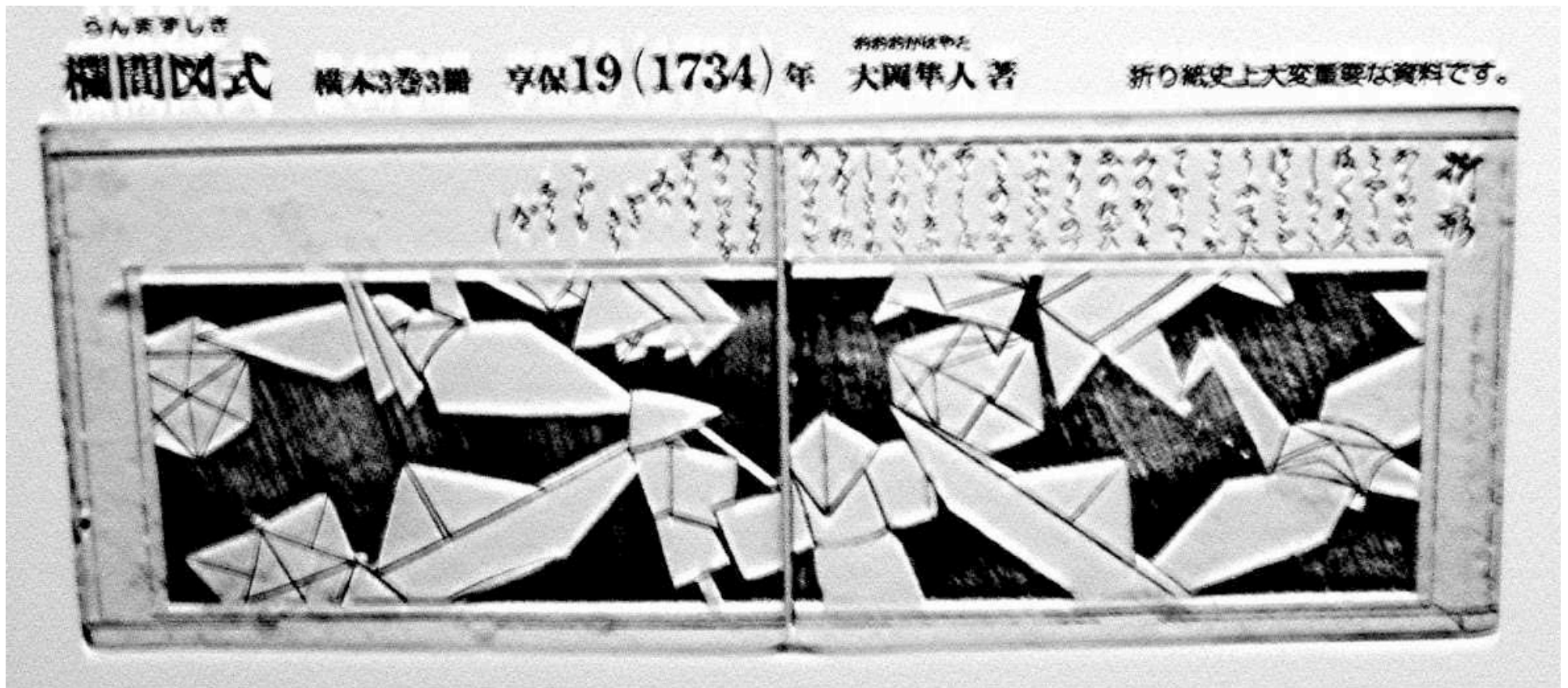
Background

- 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

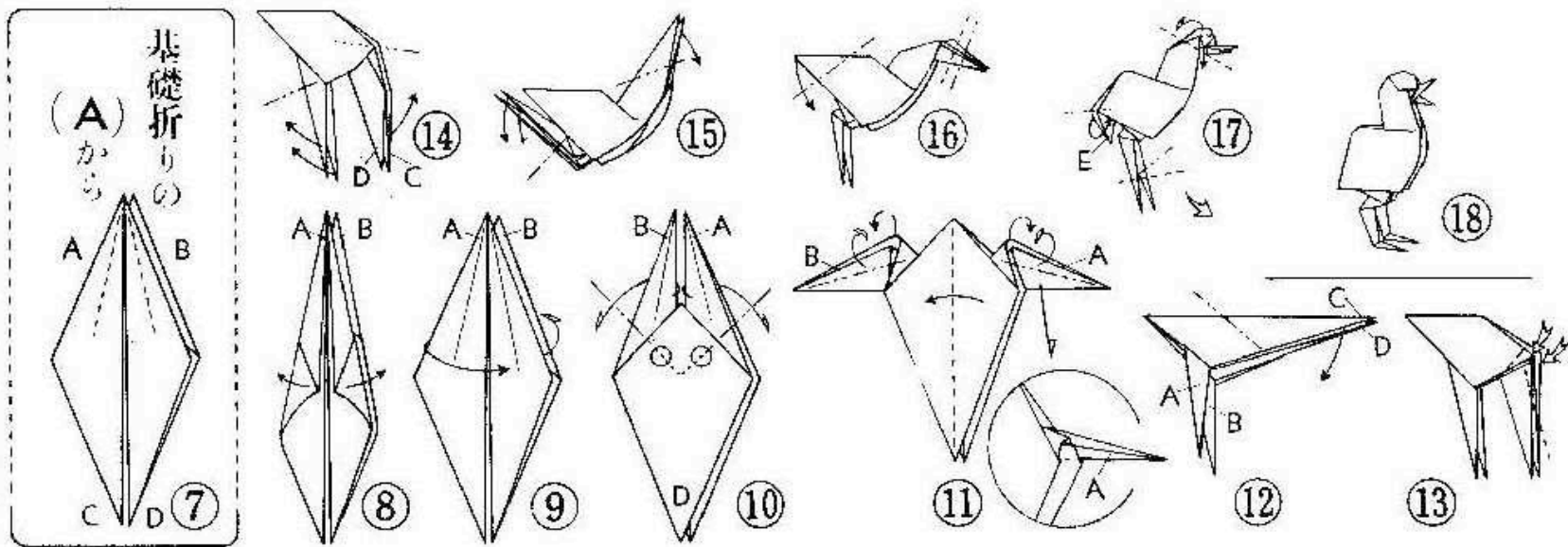
- Japanese newspaper from 1734: Crane, boat, table, “yakko-san”
- By 1734, it is already well-developed





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

誌上作品展

“造形の魔術師”

ロバート・J・ラング

不切二枚折りの可能性に挑む



アメリカの物理学者にして折り紙作家、ドクター・ラング。折りの技術の粋を集めたような彼の作品群は、折り紙を知らない人々をも驚かせずにはおかない。なにしろすべての作品が、一枚の紙だけを使い、一か所たりとも切らず、貼らずに作られているのだから。しかし何より驚くべきは彼の造形センスだろう。対象の特徴を的確にとらえリアルに折り出す力量は、折り紙の一方の可能性である具象造形の最光輝をいく。なにはともあれ彼の作品を鑑みれば、彼自身のコメントも何記したが、シンプルで、芸術性といった点について、日本人とは微妙に異なる感性がうかがえ興味深い。

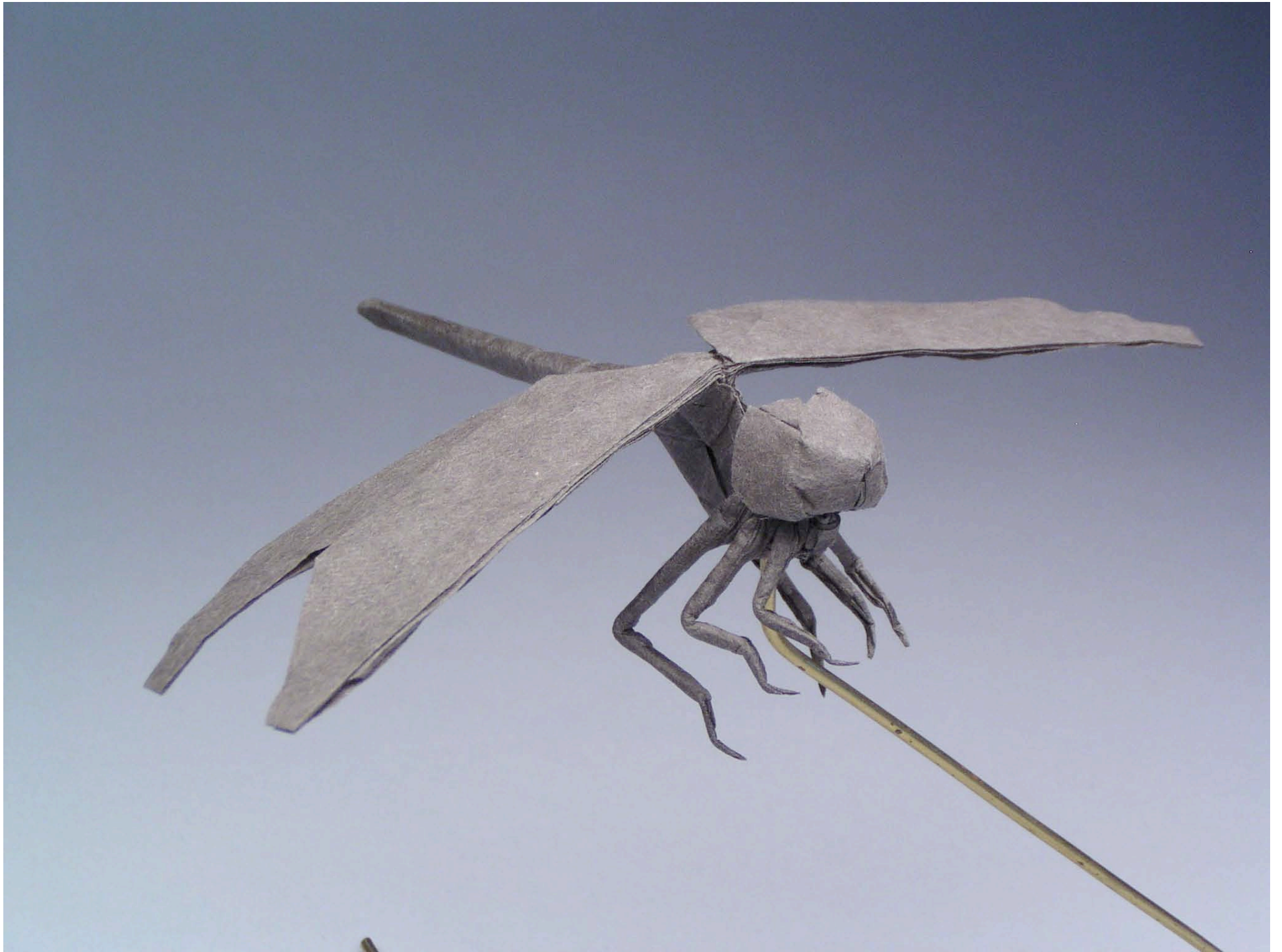
CUCKOO CLOCK 鳩時計

作者より●これはドイツの本製の鳩時計。私はこの作品には芸術的側面があると思っている。実はこれ以前にいくつか、パズル的な鳩時計を折った。それらには葉も鹿の頭もついていなかったが、振り子を引くとドアが開き、鳥が出てくるものだった。しかしこの作品は動かない。芸術作品としてその必要を感じなかったから。1対10の比率の長方形の紙(マーブルペーパー)を使っている。もっと長くすればより容易に折れるが、チャレンジという側面も残らなかった。

Photo: Studio Horna
Interview & Translation: Miki Nakayama

Ibex





Scaled Koi



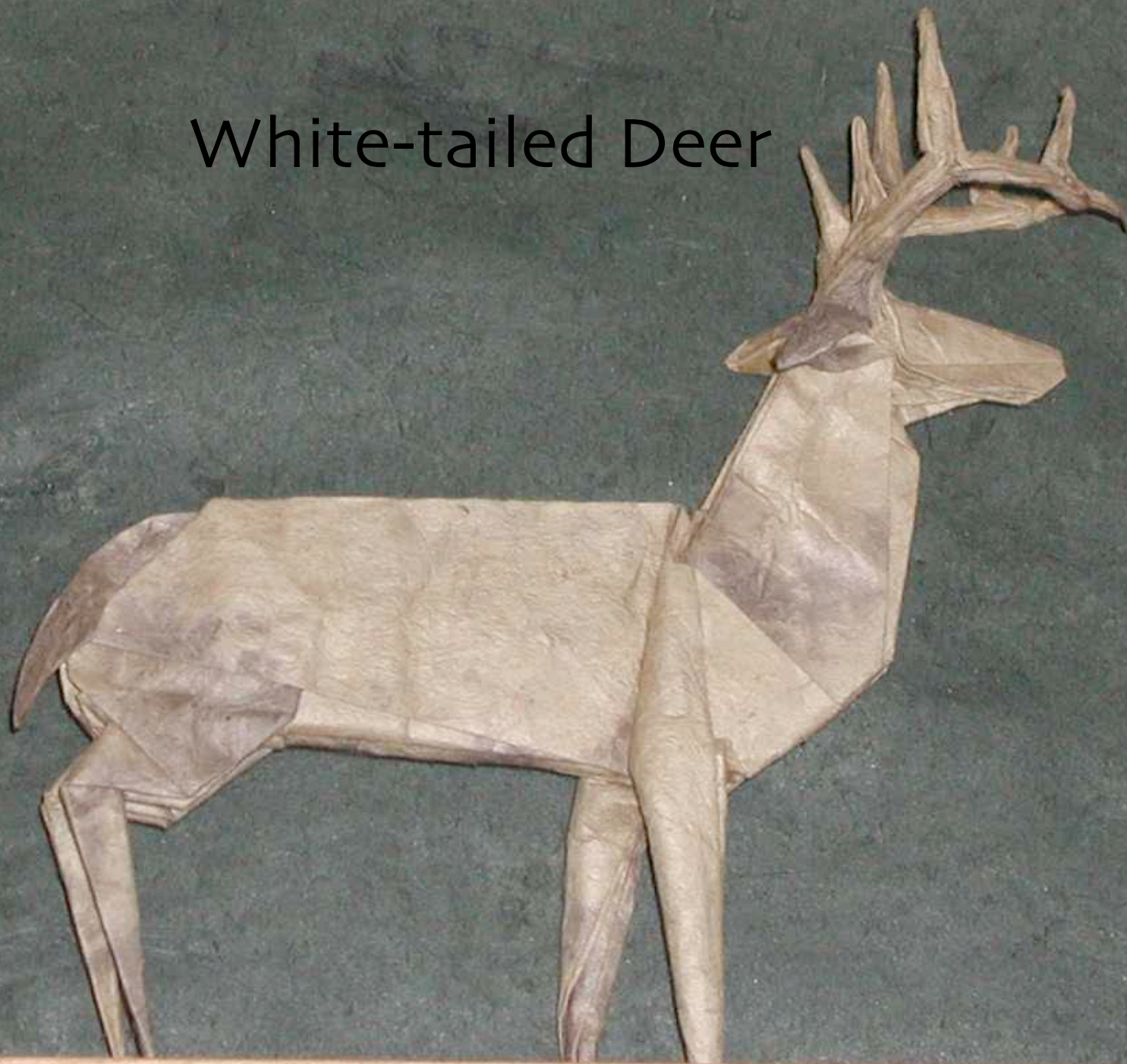
Western Pond Turtle



Rattlesnake



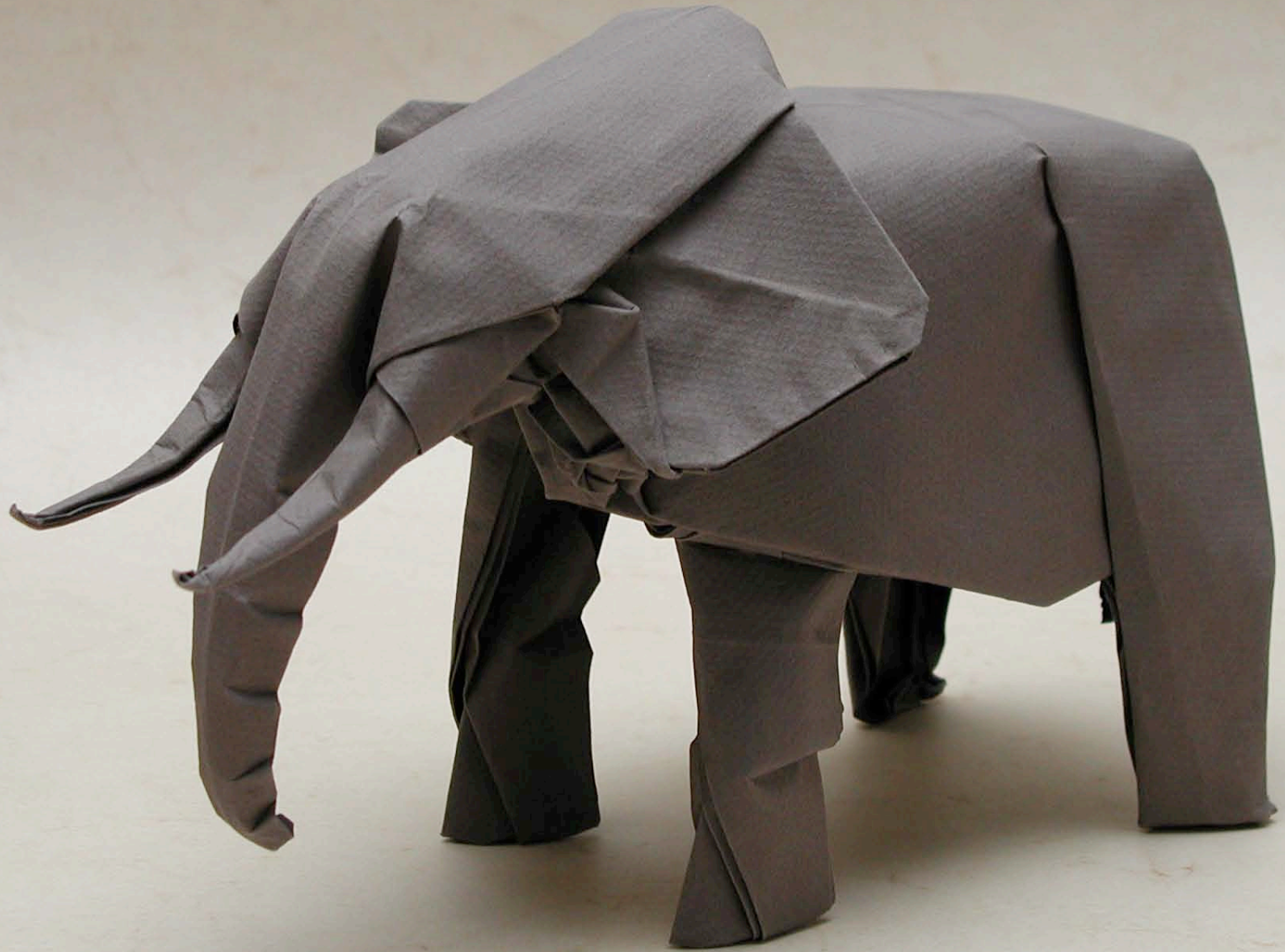
White-tailed Deer



Bull Moose



Bull Elephant



Hummingbird & Trumpet Vine





Grizzly Bear





Roosevelt Elk

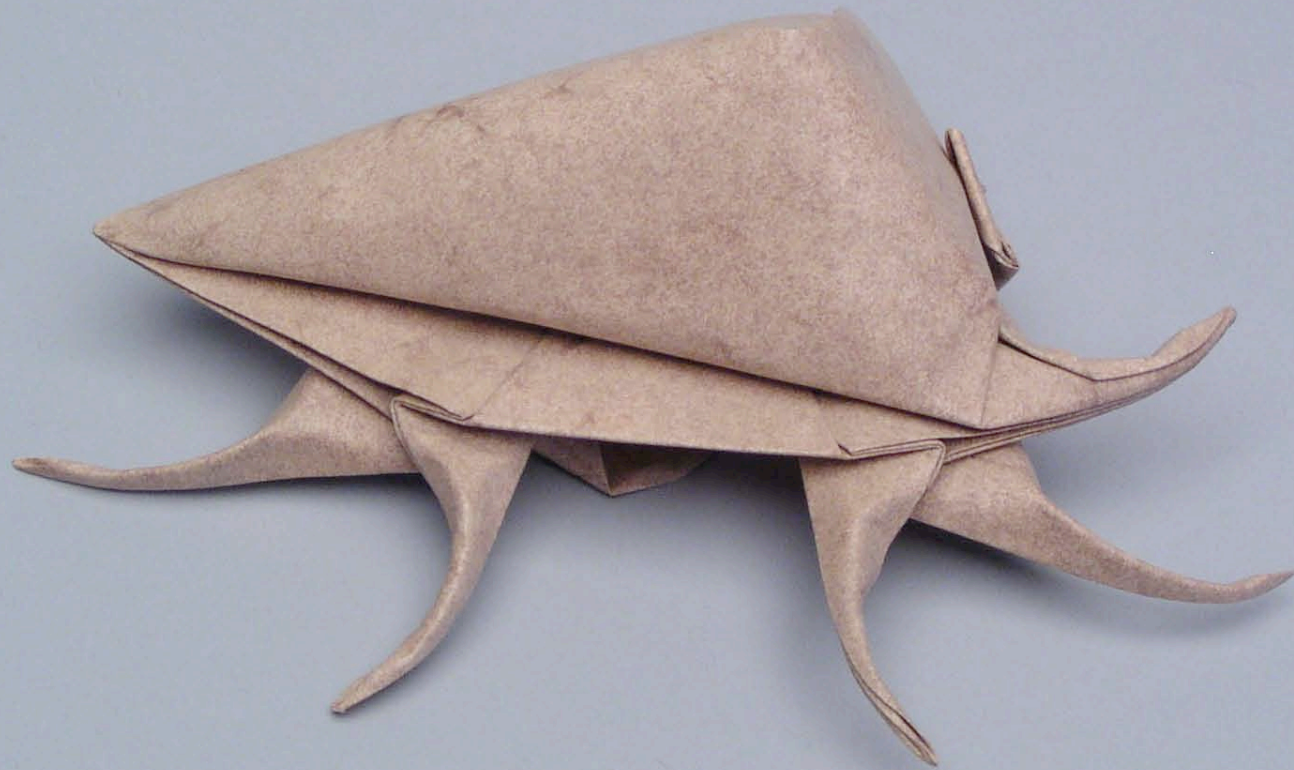
Tree Frog



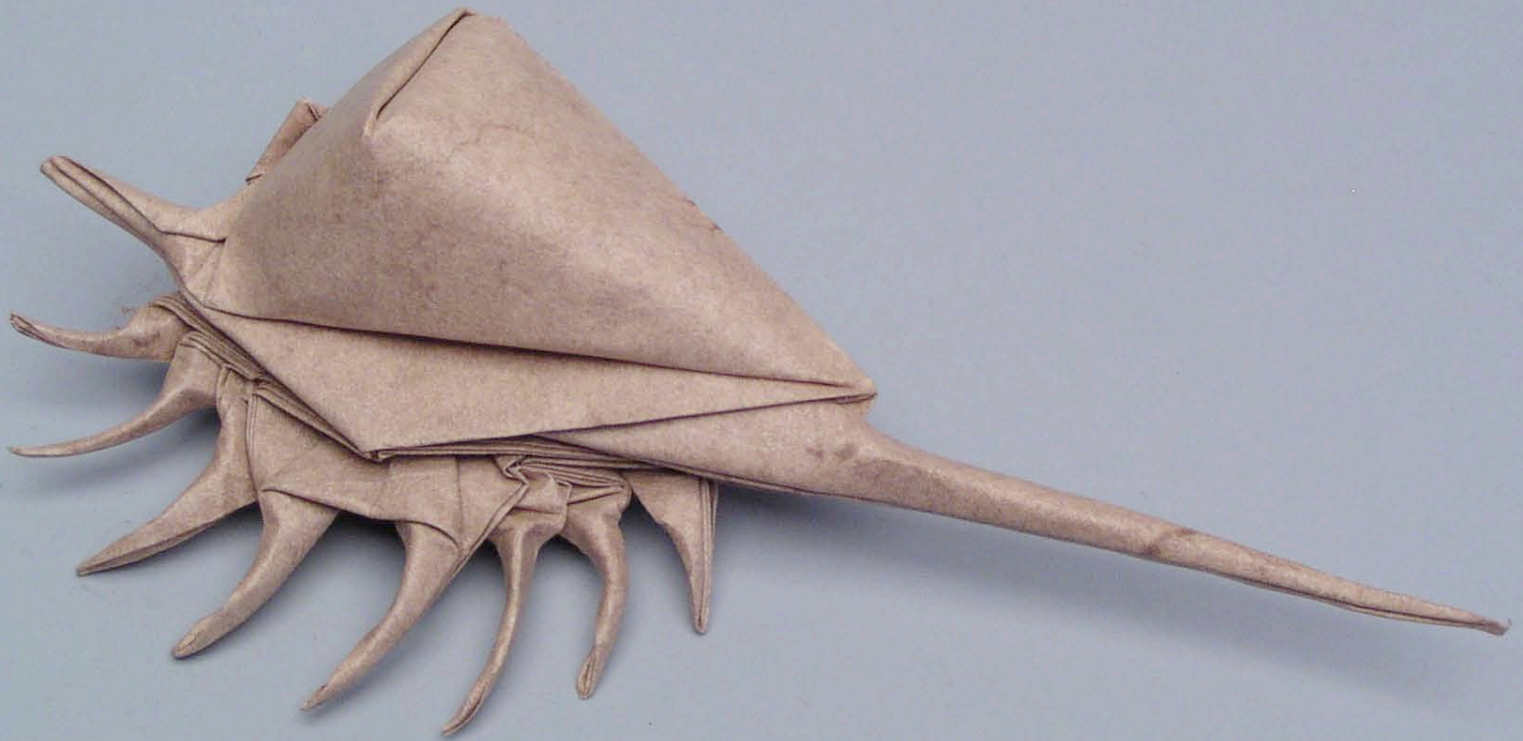
Tarantula



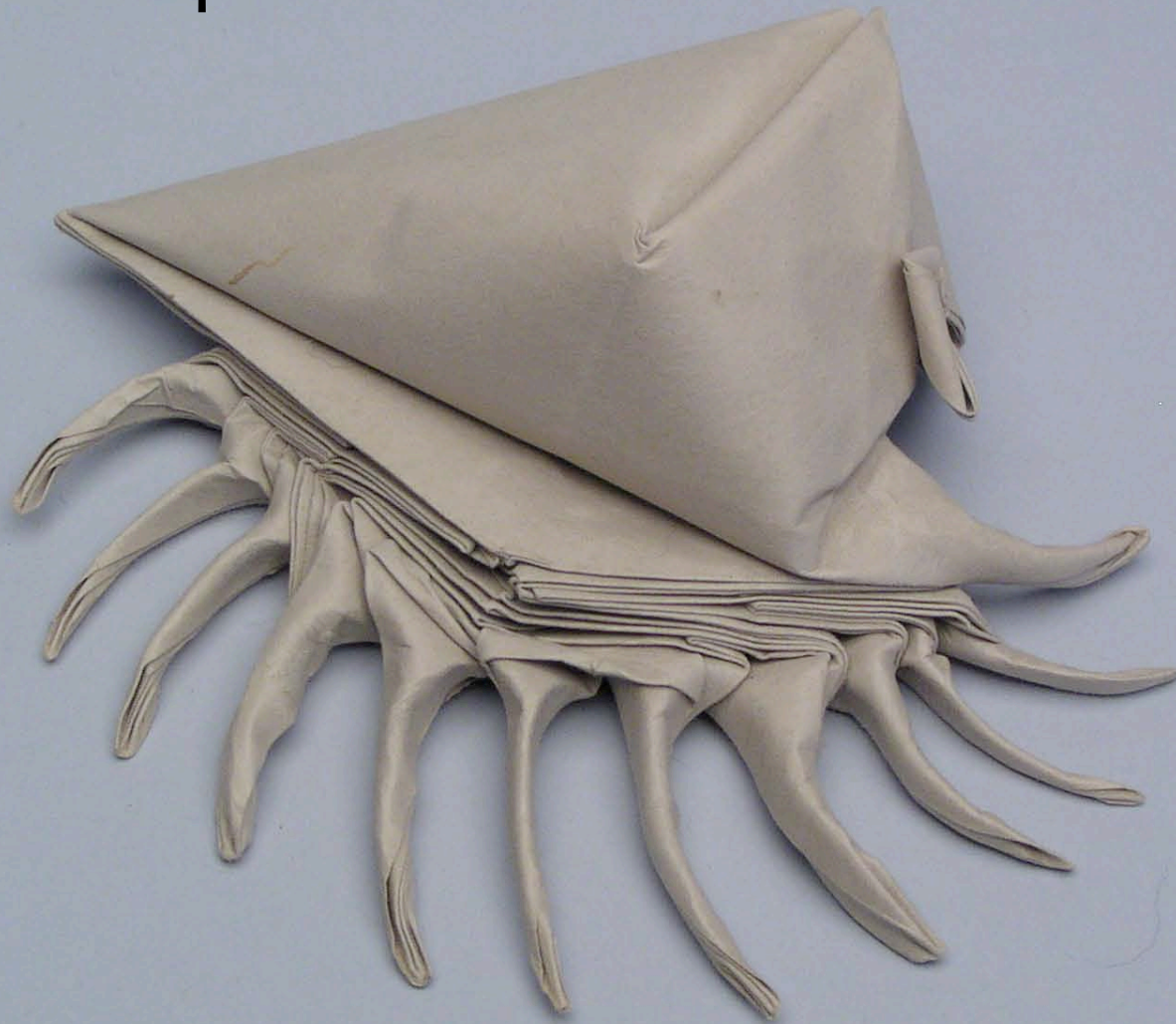
Murex



Spindle Murex



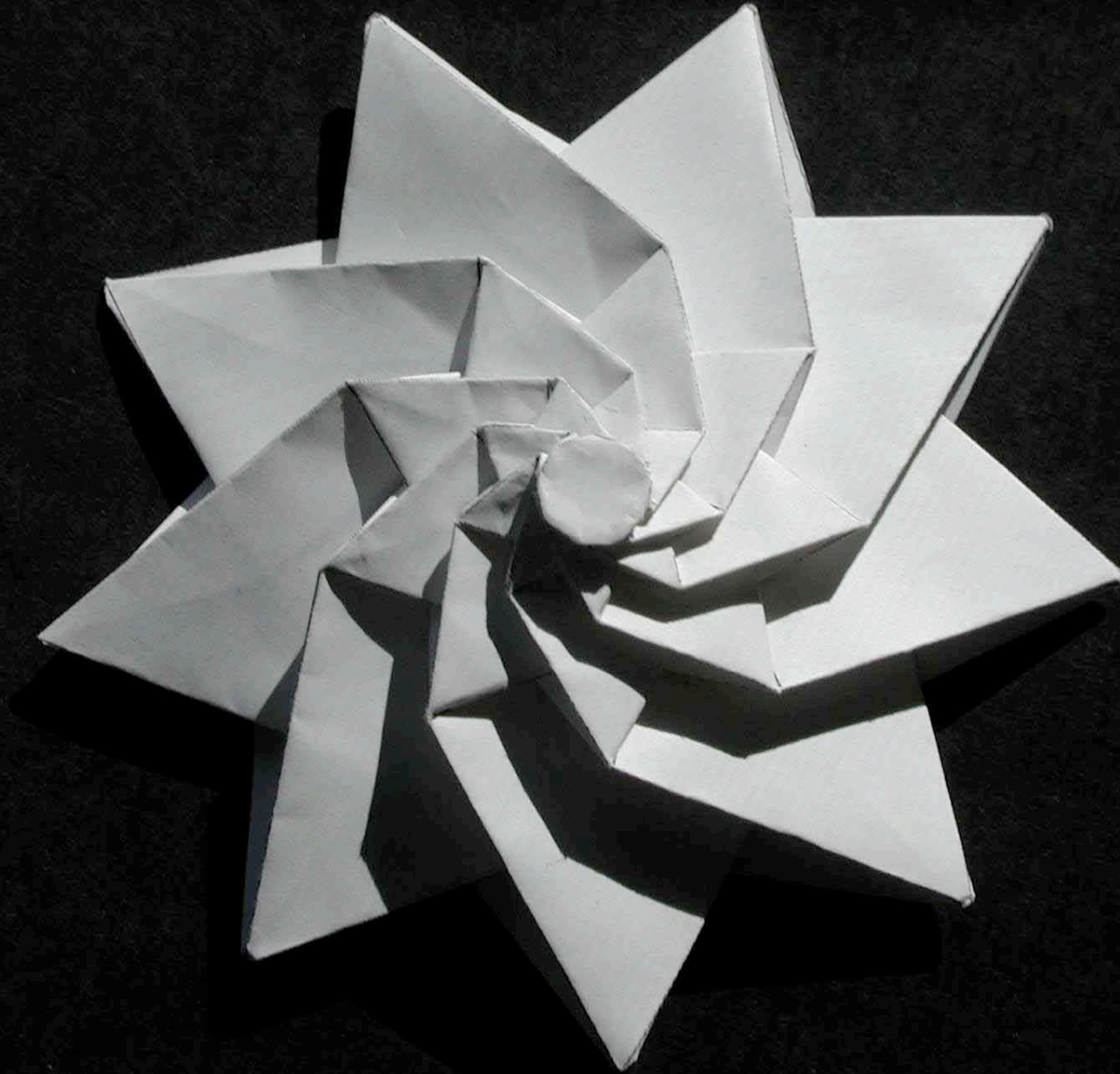
12-Spined Shell



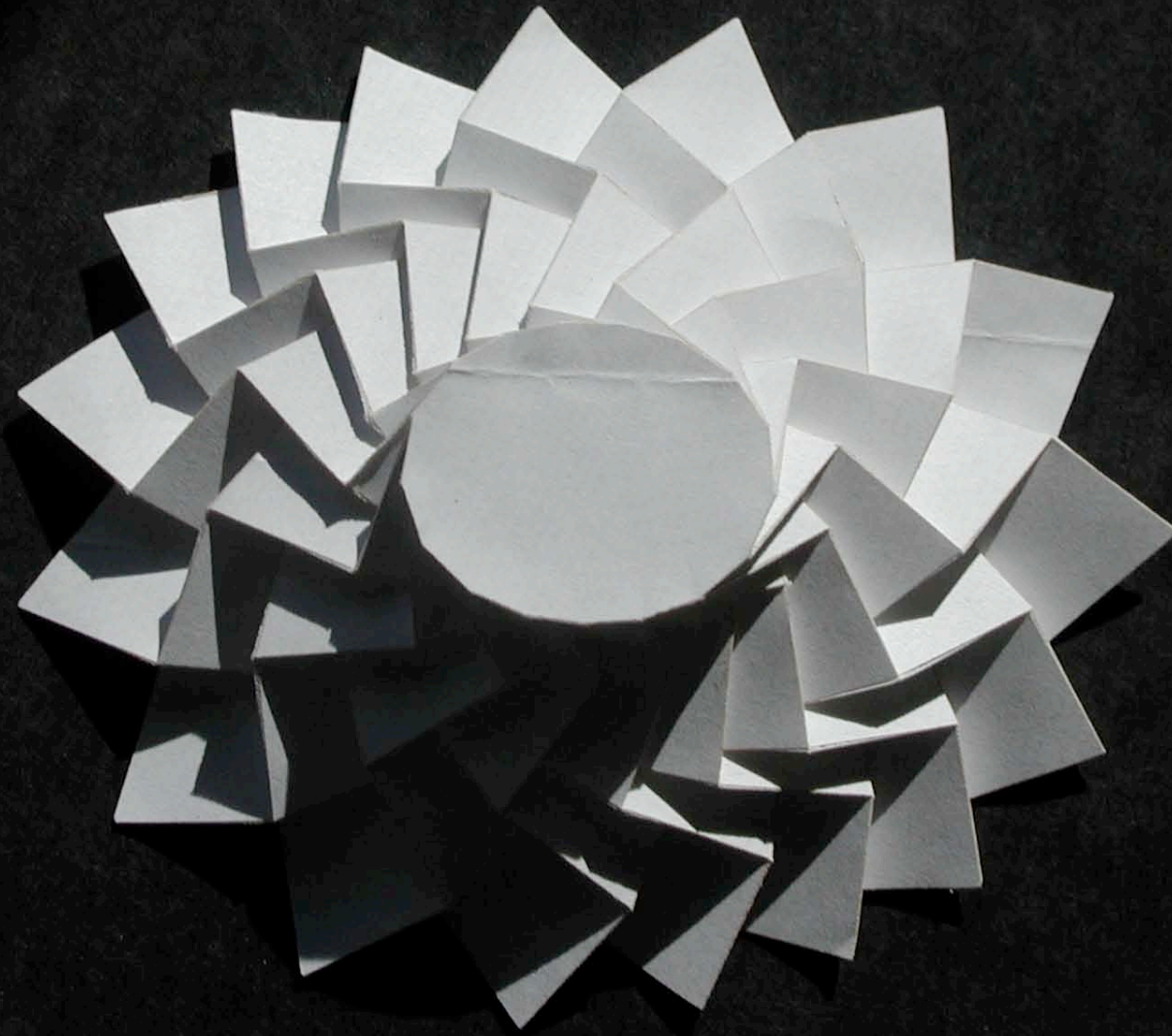
Banana Slug



Spiral Tessellation



Egg17 Tessellation

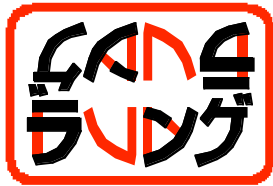


Molecular Tessellation

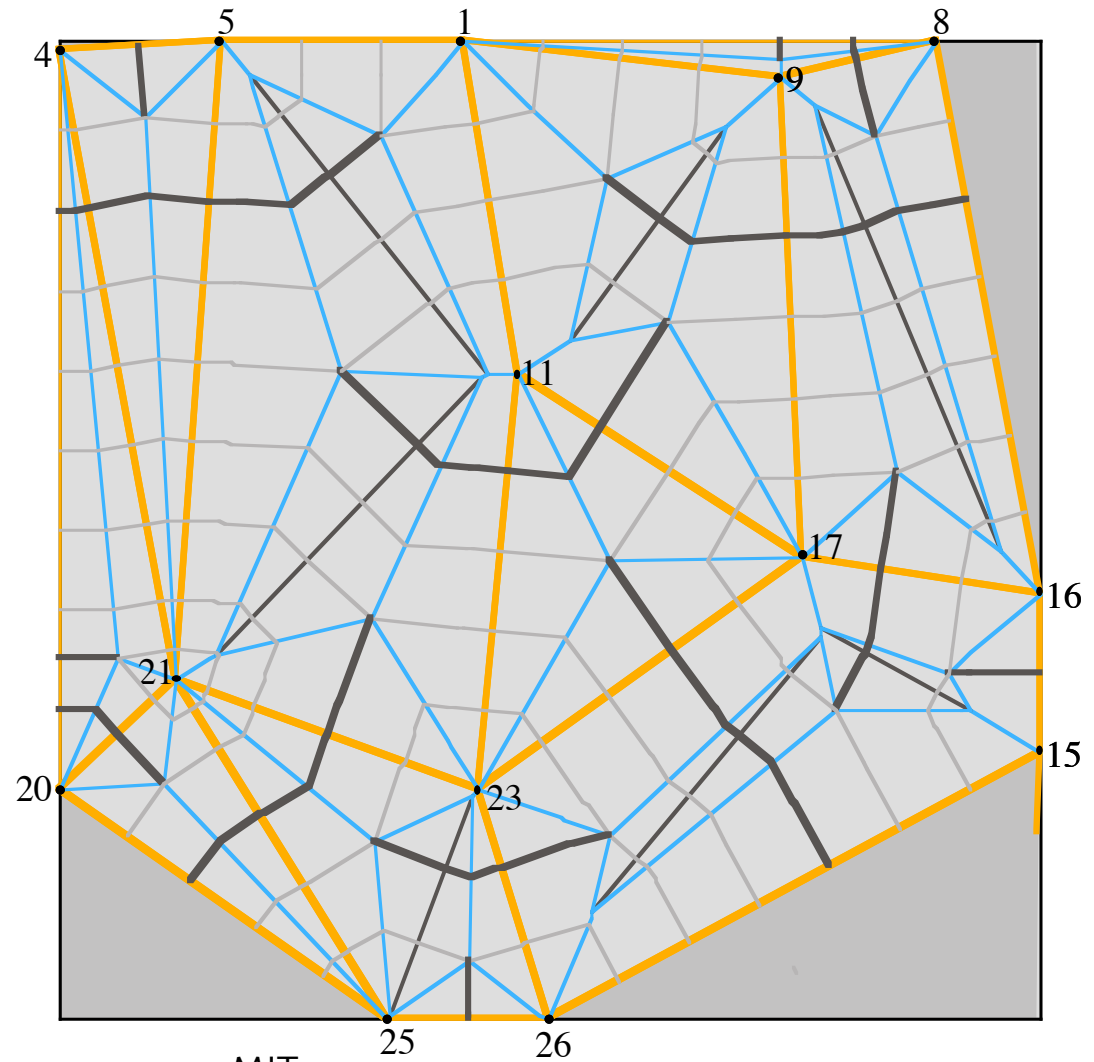
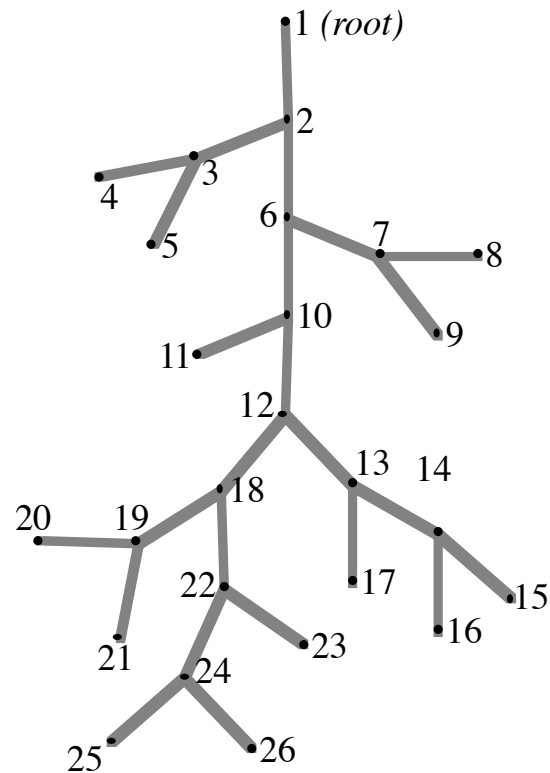




Chalk time...



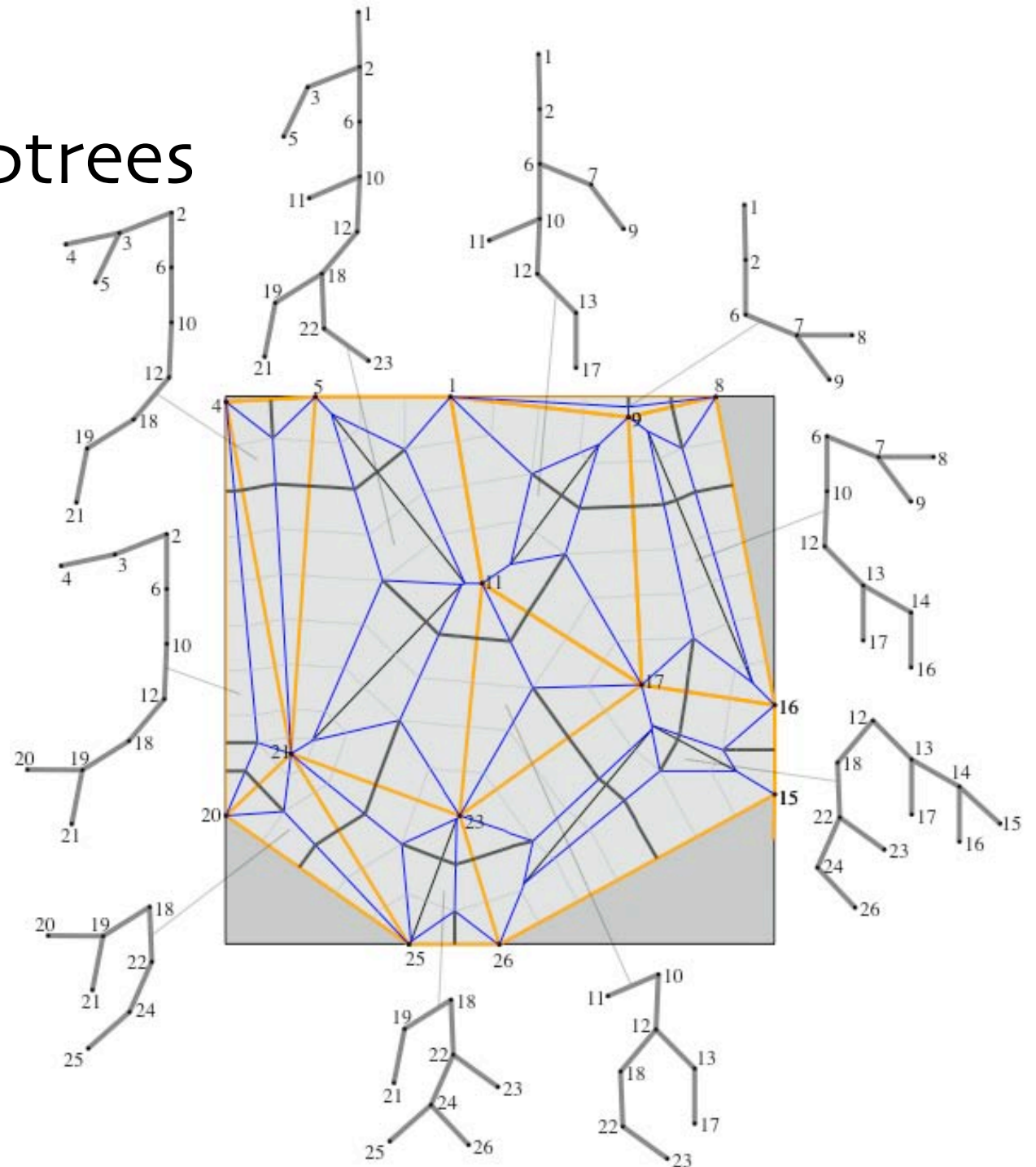
A Tree & Active Polygons



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Subtrees



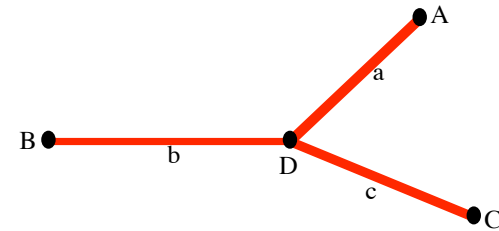
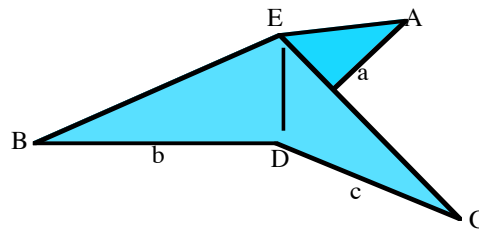
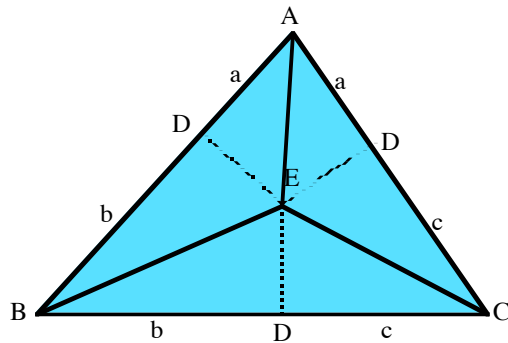


Chalk time...



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.

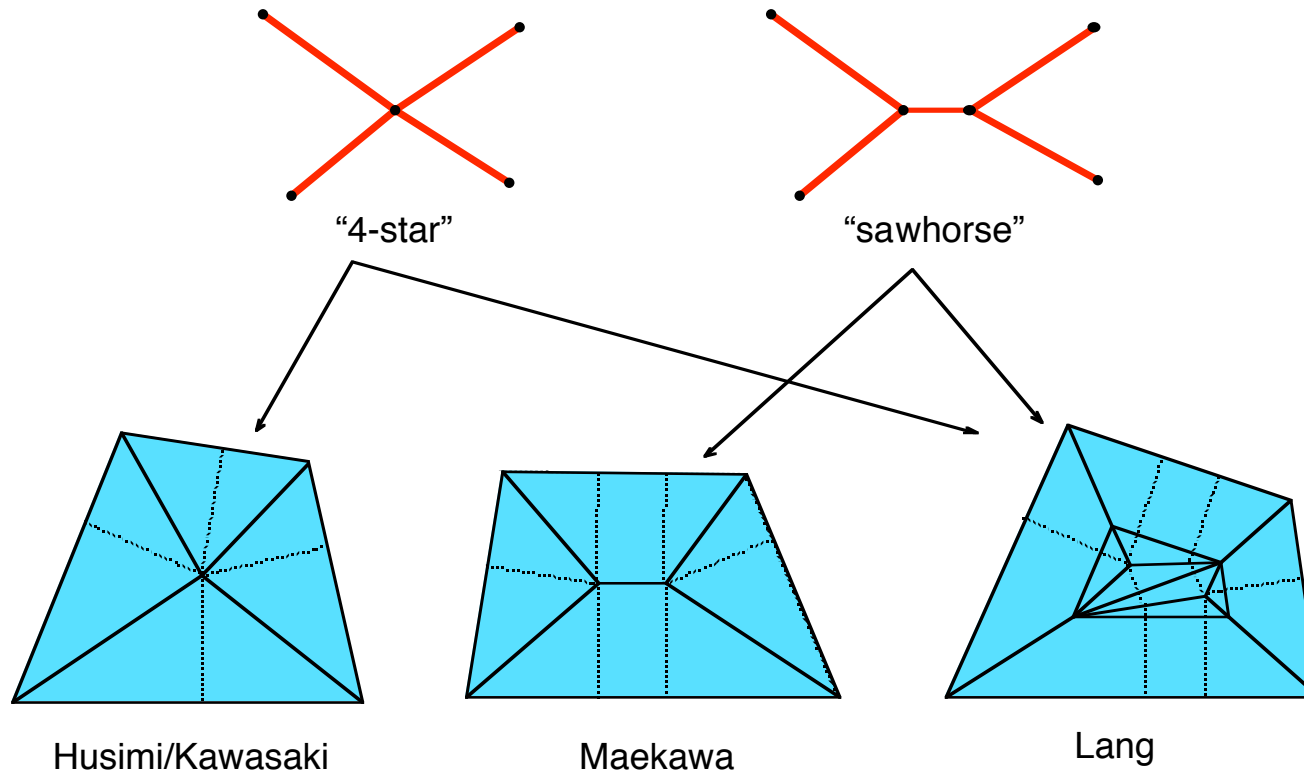


the “rabbit ear” molecule



Quadrilateral molecules

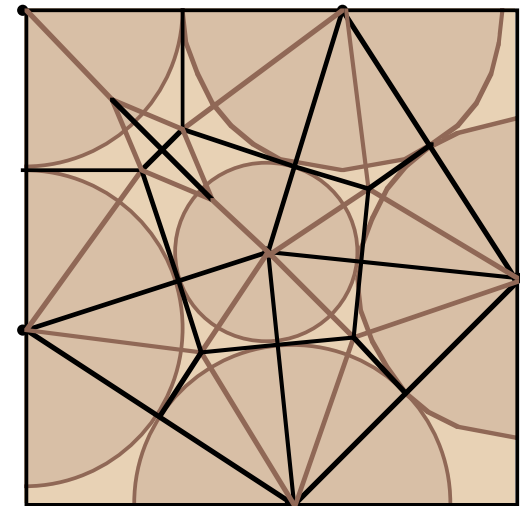
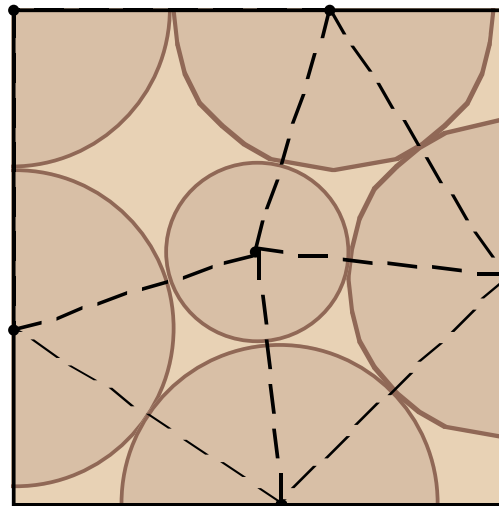
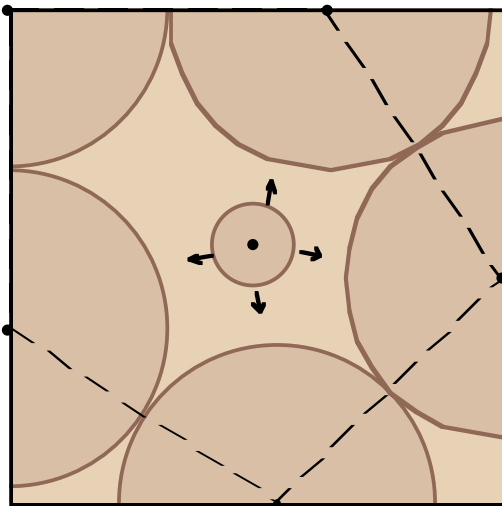
- There are two possible trees and several different molecules for a quadrilateral.
- Beyond 4 sides, the possibilities grow rapidly.





Four is enough

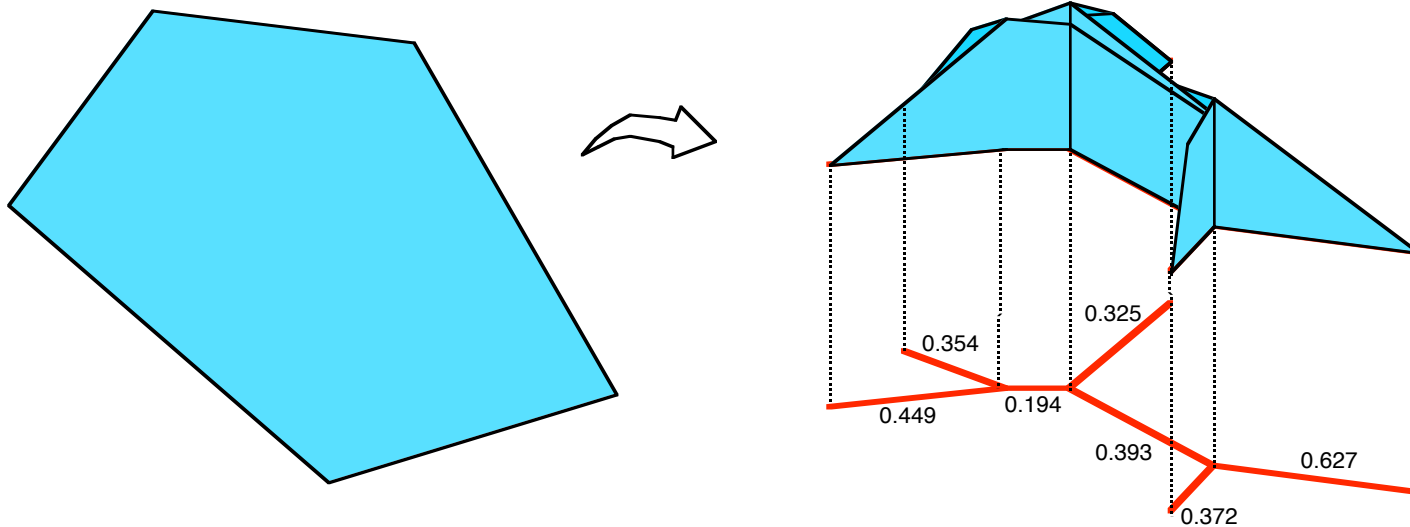
- It is always possible to add flaps (circles) to a base so that the only polygons are triangles and quadrilaterals, so these molecules suffice.

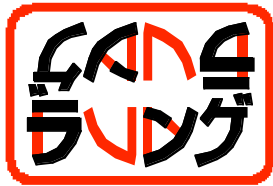




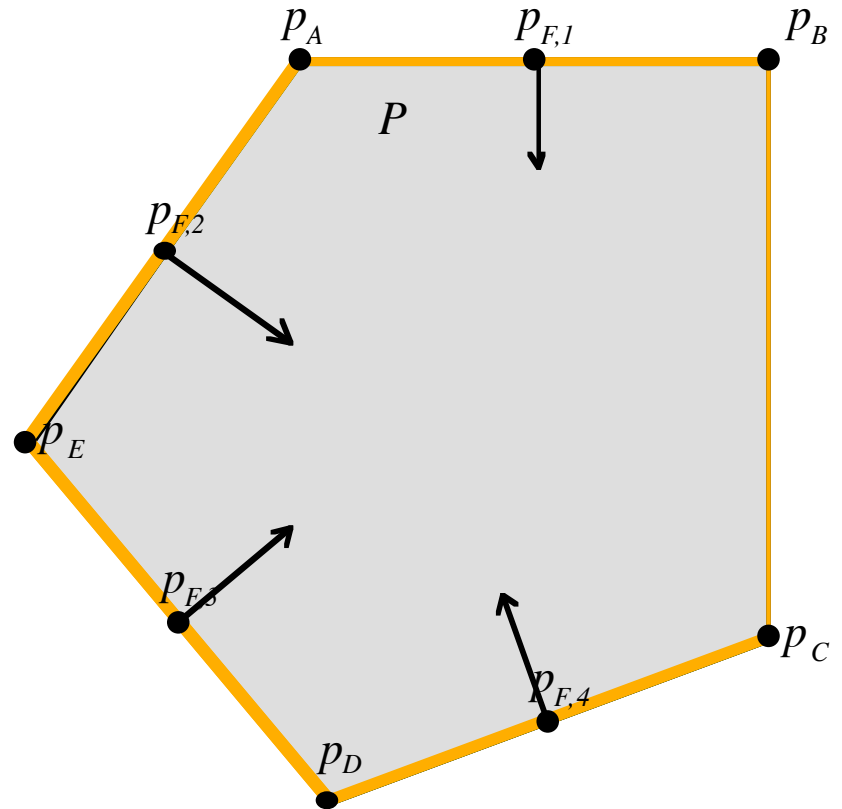
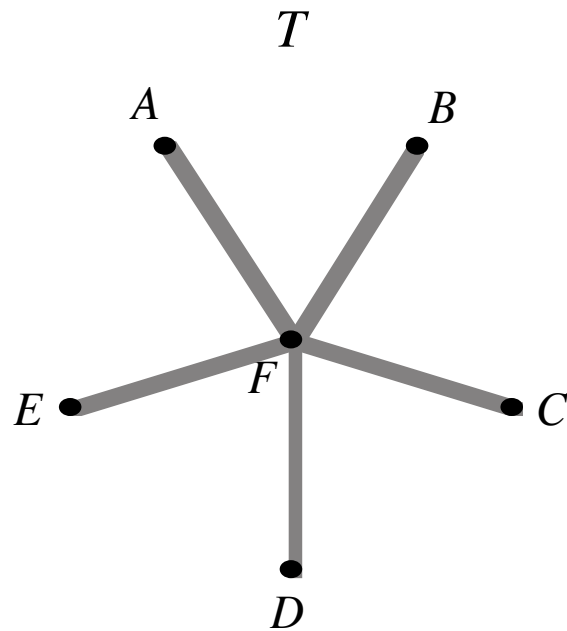
Universal molecule

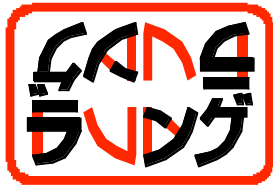
- An algorithm that produces the crease pattern to collapse an arbitrary valid convex polygon into a base whose projection is a specified tree.



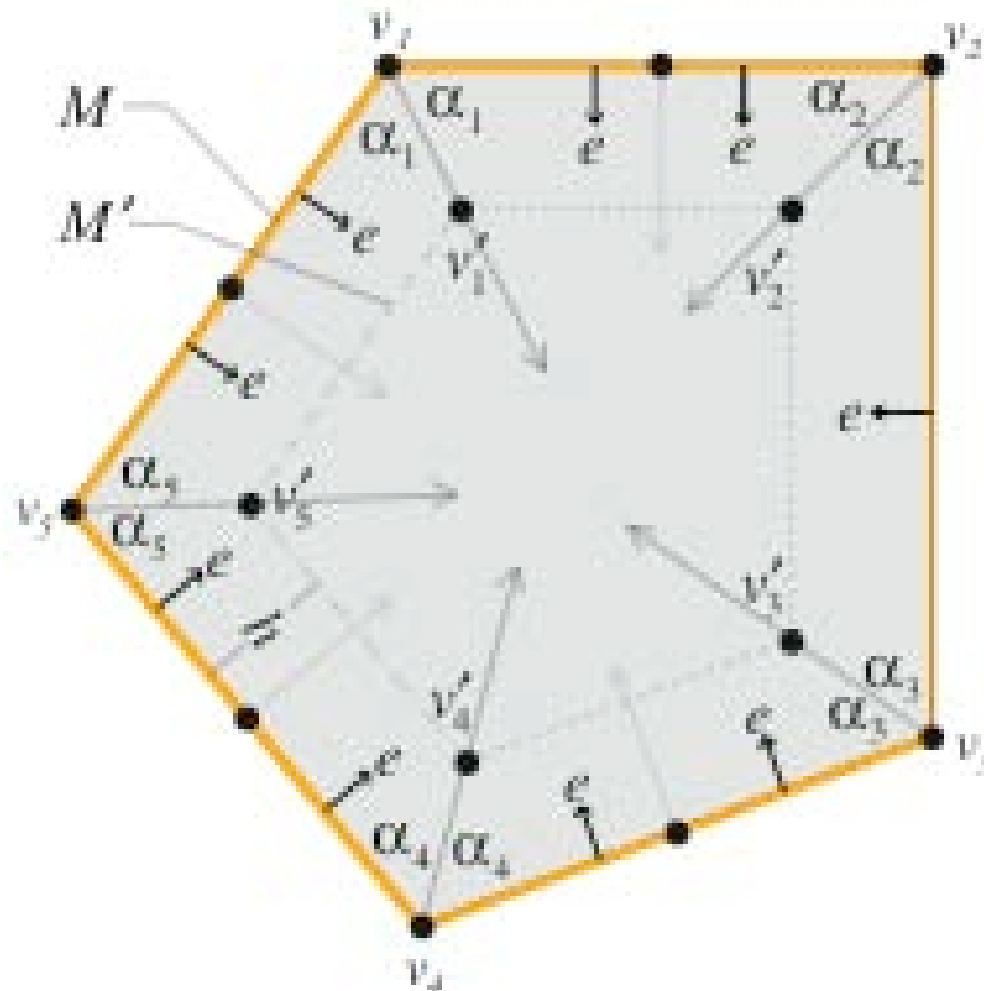


A pentagonal UM



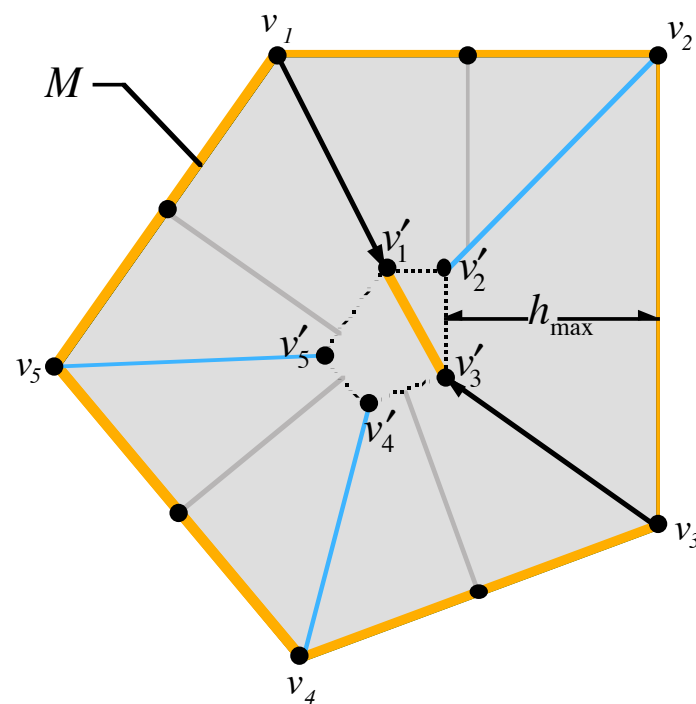
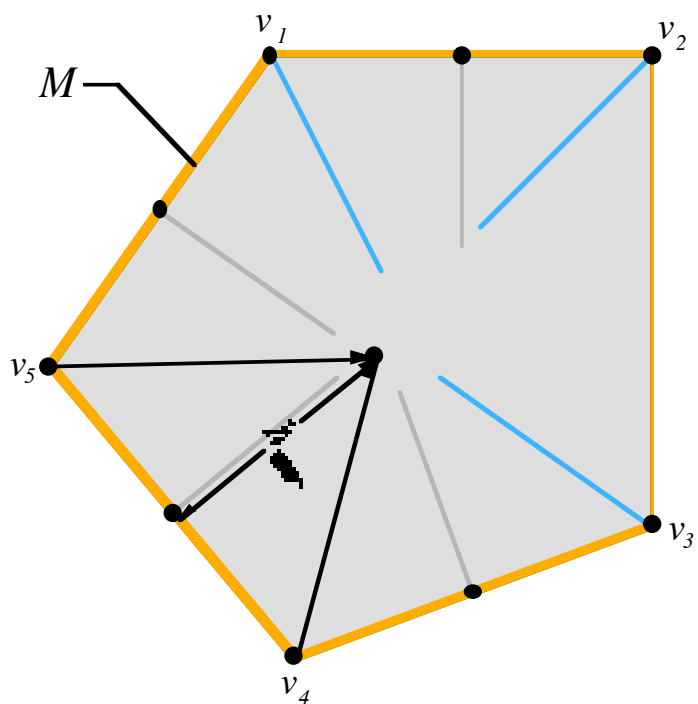


Insetting



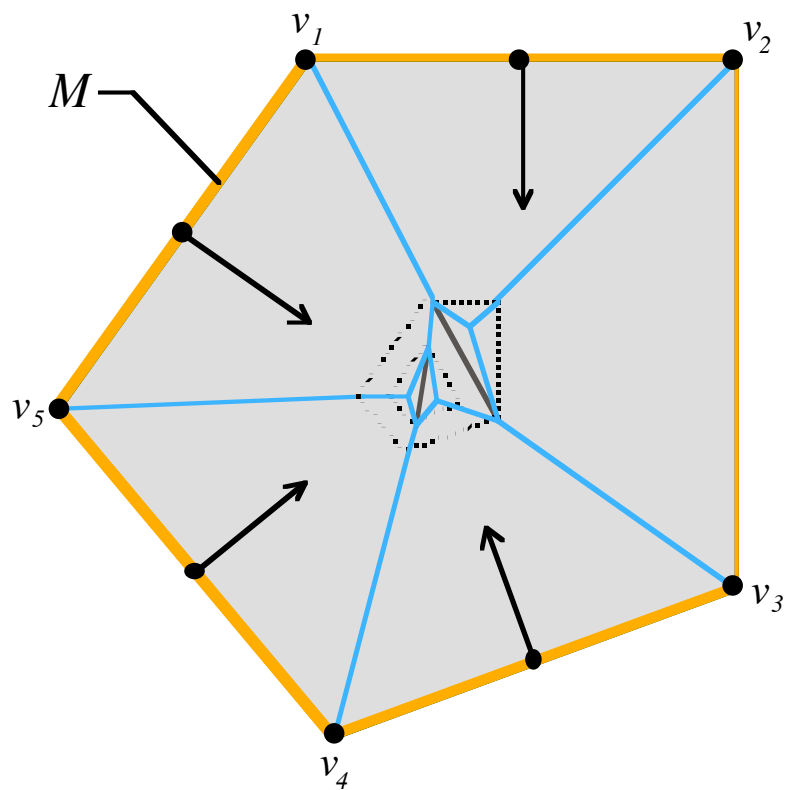


Gusset formation



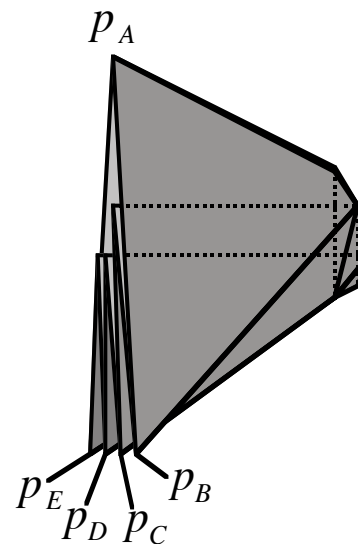
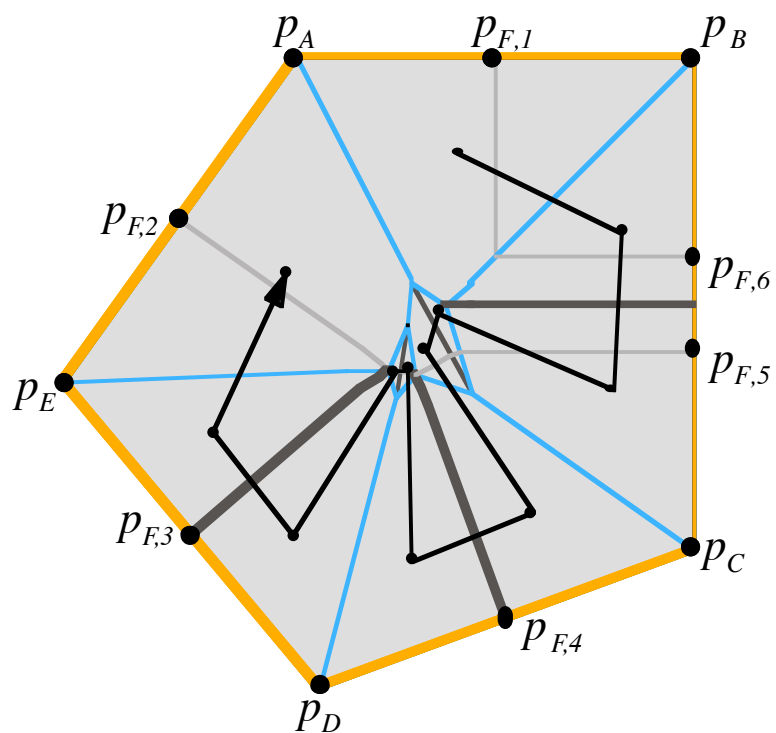


Finished gussets





Creases & Folded Form

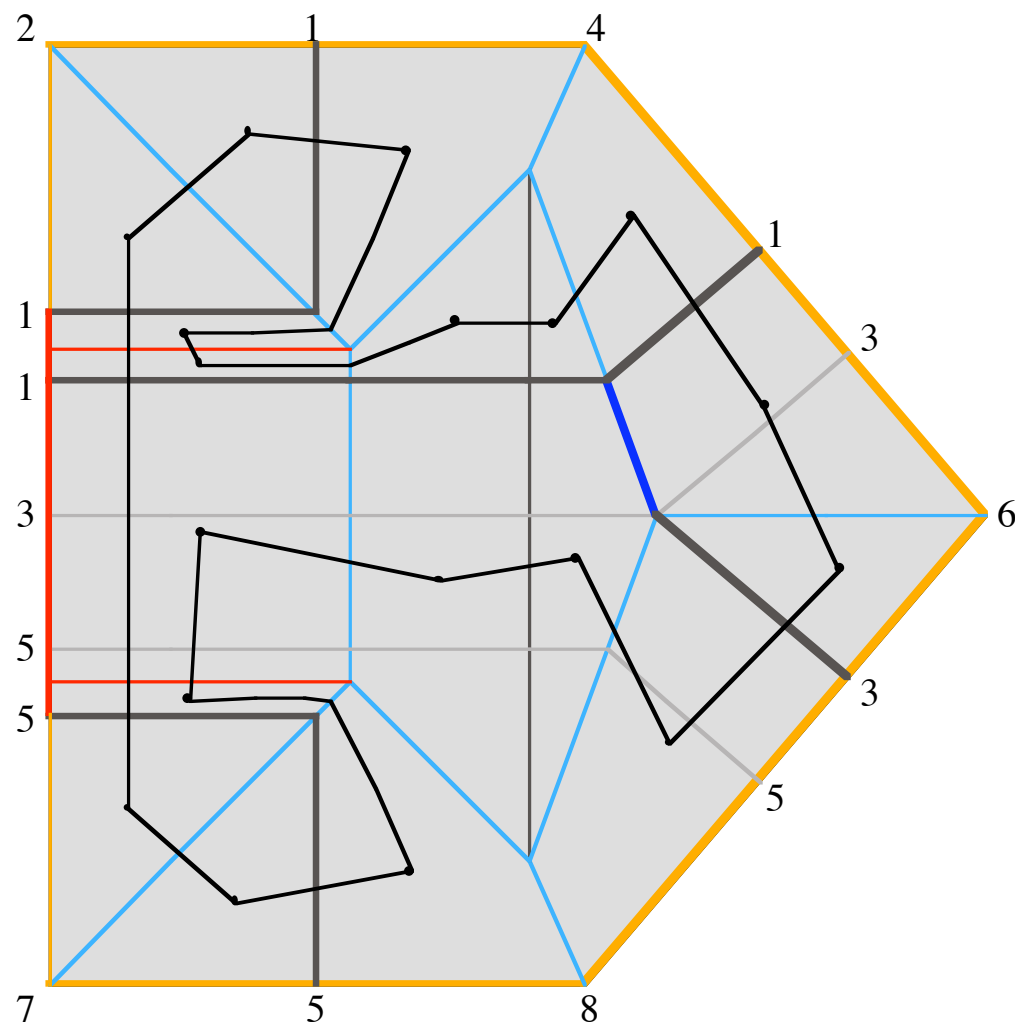
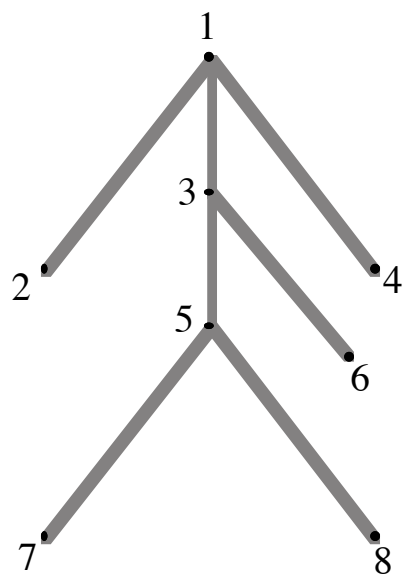




Chalk time...



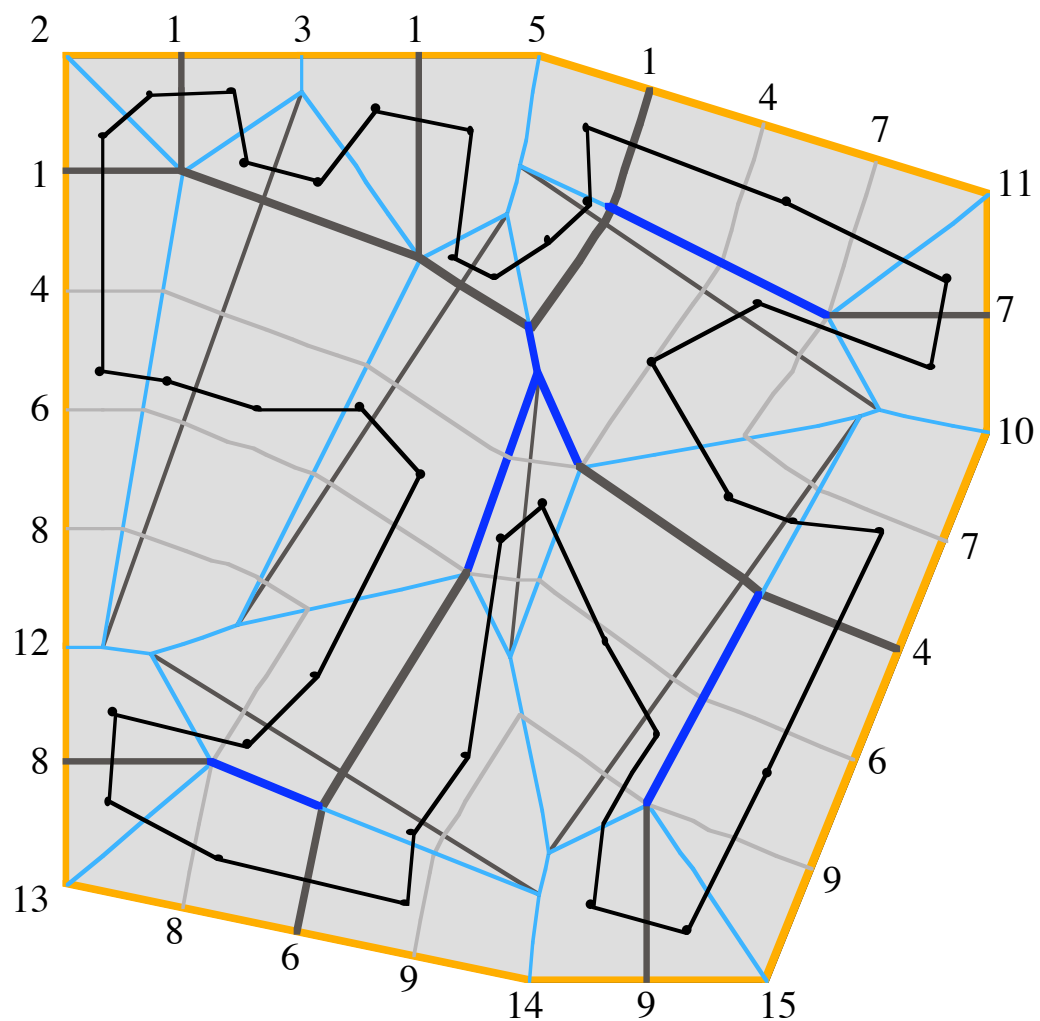
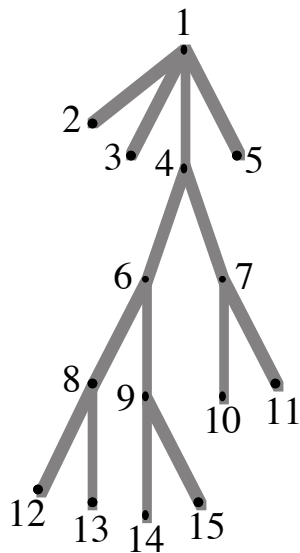
Universal Molecule 1



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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