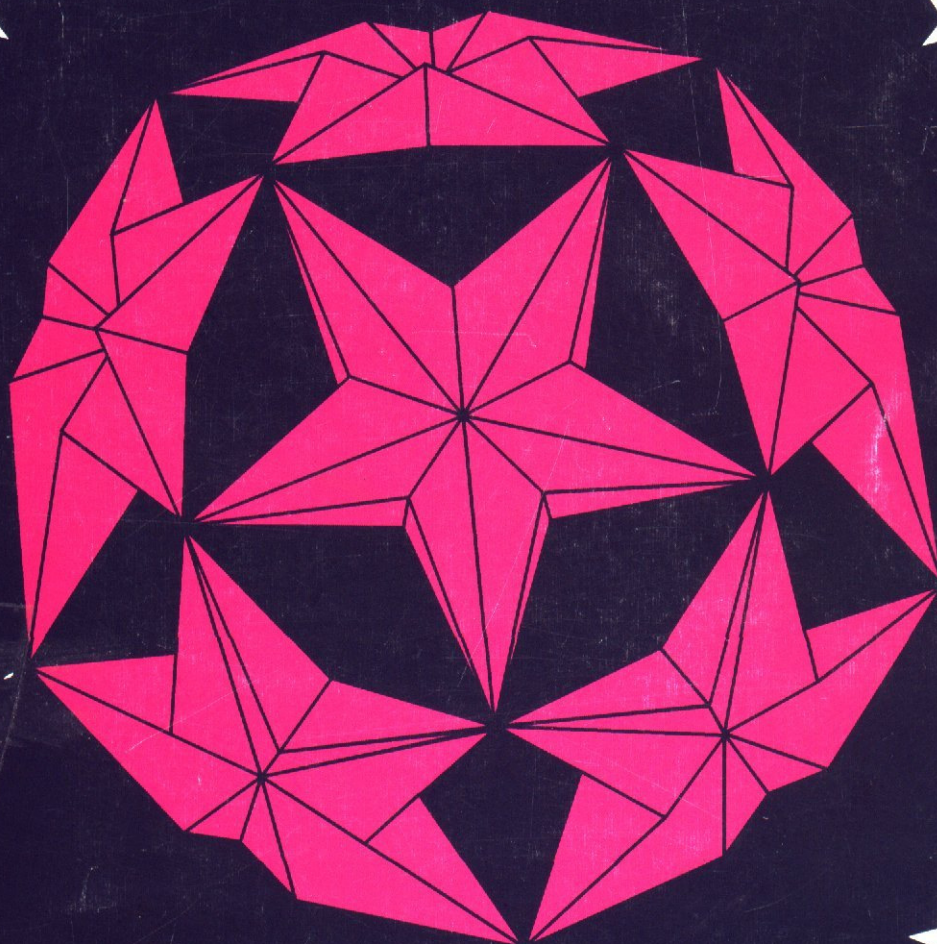



PAPER CRYSTALS

HOW TO MAKE ENCHANTING ORNAMENTS FROM
SIMPLE UNITS MADE OF FOLDED PAPER



DAVID MITCHELL

A WATER TRADE publication



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Contents

Introduction	Page 3
How to cut squares from rectangles	Page 4
How to understand the diagrams	Page 5
Metamorphosis	Page 6
Spiral Cluster	Page 9
Cloud of Stars	Page 12
Sappho	Page 16
Aurora	Page 19
Gemini	Page 22
Electra	Page 25
Proteus	Page 28
Andromeda	Page 32
Omega	Page 36
The Enigma Cube	Page 39

Introduction

Paper Crystals are enchanting to look at and fascinating to make, and like naturally occurring mineral crystals they seem to have the ability to focus harmony and peace wherever they are displayed, making them perfect ornaments for your home (or perhaps to brighten up your workplace) and ideal gifts to share with your closest friends.

Each of the crystals explained in this book is made from several (or sometimes many) simple folded-paper units (called modules) which have been cleverly designed so that they will fit together without the need for sellotape or glue. This highly rewarding and slightly magical handicraft is known as modular origami.

All creative handicrafts require some degree of dexterity, and modular origami is no exception, but everything you could possibly wish to know is explained in the clearest detail and the simple skills you need are easily acquired. This book has been arranged so that the easier crystals come first but with a little practice and perseverance you will be able to master them all.

Hints and tips

When choosing the paper for your crystals try to bear in mind not only the nature of the design but also the position where the crystal will be displayed and aim to achieve a harmonious interaction between the crystal and its immediate surroundings. It is often a good idea to practice folding and assembling a few of the modules from cheap paper (white or coloured 80gsm photocopy paper is ideal) before deciding on the paper you will use for your final display version. The folding instructions offer some guidance on which type of paper is likely to produce the best result, but ultimately the choice is up to you.

Plain colour will show off the clean geometric lines of the crystal to best advantage. It is usually better to use *dyed* plain paper (the same colour all the way through) rather than *printed* plain paper (decorated on the surface but white or off-white underneath).

Pattern, particularly random or chaotic pattern, acts both to soften and balance the clean geometry of the designs. It also conceals minor errors. When choosing patterned paper bear in mind that most of the decorated surface will be folded away inside the modules, and even more will be lost to view as the modules are assembled.

Gift-wrapping is a good source of paper (but make sure it *is* paper not plastic foil). Interesting effects can also be obtained by using squares cut from old maps, advertising flyers, etc.

Using multiple colours of plain paper highlights the modular structure best, and is particularly effective for crystals such as Cloud of Stars. Using papers of contrasting patterns for different modules produces a patchwork appearance that can be equally attractive.

Folding the modules is straightforward as long as you follow the instructions given in the folding diagrams closely. The important thing to remember is to always look one step ahead so that you know exactly what the result of making the fold you are working on should be.

It will help you to fold accurately if you fold with the paper laid on a flat, hard surface.

With modular origami it is important to make all your creases really sharp. Fingernails help here, but the smooth curved handle of scissors or a knife will do equally well. It is a good idea to stop after every few steps and gently re-crease any folds that have been pulled out of alignment.

Sometimes the modules tend to fall apart in the early stages of assembly. There are three ways to overcome this problem, hire the services of a friendly octopus, build your crystal inside a

suitably sized transparent mixing bowl or clip the units temporarily together with the use of removable sticky strips cut from message notes. The use of paper-clips is not recommended since they almost invariably cause damage to the surface of the paper.

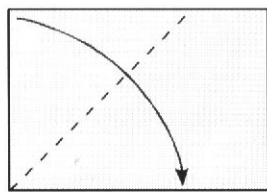
All the Paper Crystals in this book are based on mathematical forms known as polyhedra. (These are the 3-dimensional shapes with strange names pictured at the start of each section.) Like polyhedra, Paper Crystals can be viewed as 3-dimensional patterns. Provided you understand the pattern, and keep to it as you add modules to the design, the crystal will usually complete itself quite automatically.

Most paper is sold in rectangles, but the Paper Crystals explained in this book are all folded from squares. In the folding instructions large square paper means the largest size of square you can cut out of a sheet of A4 or US letter size paper. Small square paper means paper one quarter of this size. This information is given for guidance only. By all means experiment for yourself.

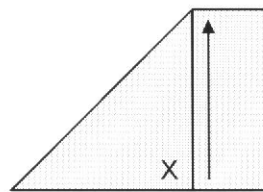
The best way to obtain lots of individual squares from a large sheet of wrapping paper is by dividing it into a grid of smaller rectangles of the appropriate size (by folding it in half, quarters or eighths, either or both ways), then separating the rectangles from one another and cutting them individually down into squares using either of the methods detailed below. This is slightly wasteful of paper but much easier than trying to fold a large rectangle into squares to begin with.

How to cut squares from rectangles

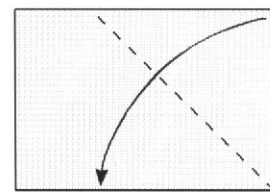
The one-crease method - using scissors.



Fold the left hand edge onto the bottom edge. Hold the edges together and crease firmly all along the fold-line.

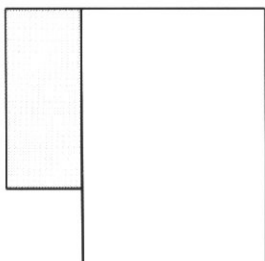


Hold the sheets firmly together and in alignment - especially at point X - and cut along the edge of the square working from bottom to top.



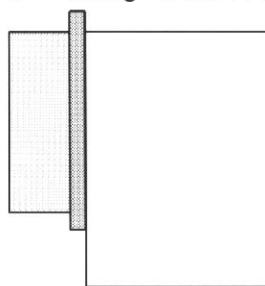
If you are left-handed you will probably find it easiest to make the fold in this direction, but the cut should still be made from bottom to top.

The no-crease method - using craft knife, metal rule and cutting mat.



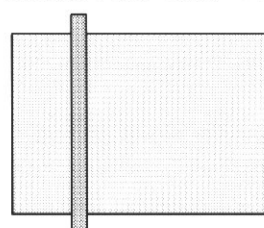
Line up the top and right hand edges of two sheets of paper exactly.

Hold both sheets firmly in place.



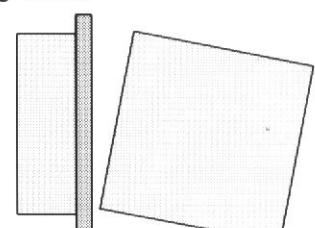
Lay the metal rule exactly along the left hand edge of the top sheet.

Hold the rule firmly in place.



Remove the top sheet.

Cut along the right hand edge of the metal rule taking great care that neither the rule nor the paper moves.



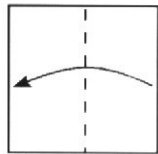
The result should be a perfect square.

If your knife is sharp enough you can cut several squares at a time in this way.

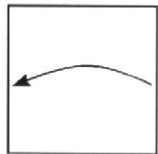
How to understand the diagrams



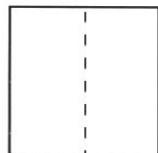
The edges of the paper are shown as solid lines.



A folding instruction consists of a movement arrow and a fold-line.



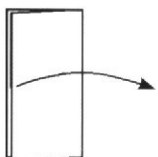
The movement arrow shows the direction in which the fold is made.



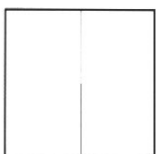
The fold-line shows where the new crease will form. A dashed fold-line means that the fold is made towards you.



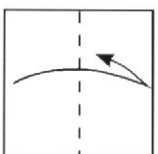
Edges which lie exactly on top of each other as the result of a fold are shown slightly offset on the after diagram.



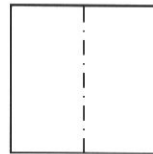
A movement arrow without a fold-line means unfold in the direction indicated.



Creases you have already made are shown as thin lines.



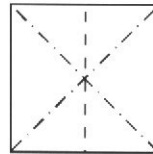
This version of the fold arrow means fold, crease, then unfold.



A dashed and dotted fold-line means that the fold is made away from you.



This symbol tells you to apply gentle pressure to the model in the direction the arrowhead is pointing.



This combination of symbols is used to show you how the existing creases can be used to collapse the paper into a 3-dimensional shape.



Pull the paper gently in the direction of the arrow.



Turn the paper over sideways before continuing.



In folding diagrams shading is used to distinguish one side of the paper from the other.



In assembly diagrams shading is used to distinguish one module from another.



This symbol is sometimes used to show how different modules fit together and sometimes to show the existence of secure pockets within a module.



This symbol indicates that the next diagram is on a larger scale.

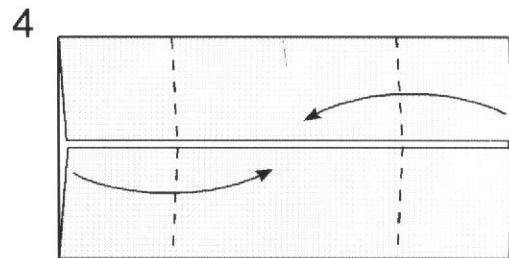
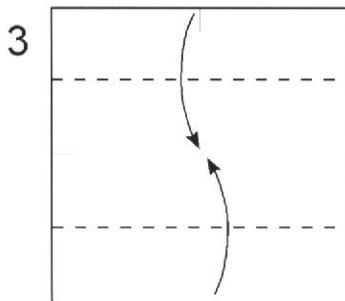
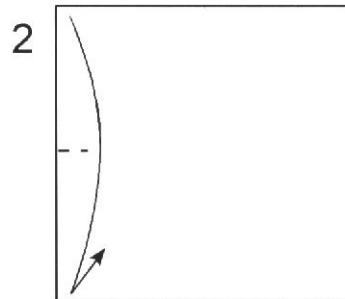
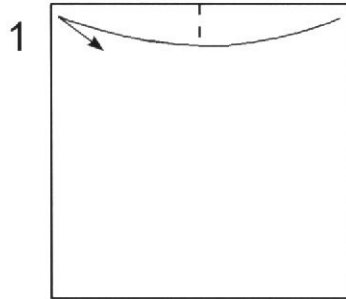
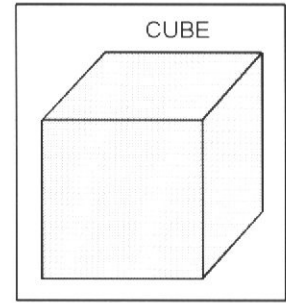


A circle is used to draw attention to some particular part of a picture.

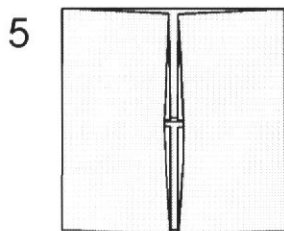
Metamorphosis

6 sheets of large square paper are required. For best effect use paper decorated with a chaotic or random design.

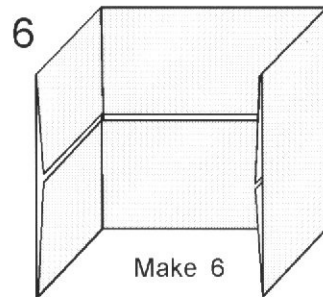
If using printed paper begin white side up.



This crystal is made by altering one corner of the classic modular paperfold known as Paul Jackson's Cube. Although in its final clean form the design is my own it also owes much to the earlier work of Iris Walker, Ricky Wong and Wayne Brown.



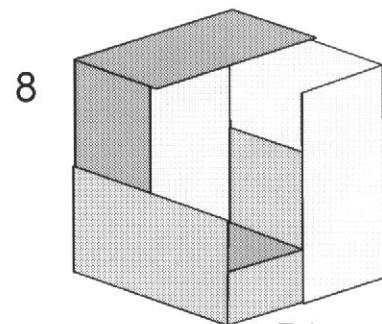
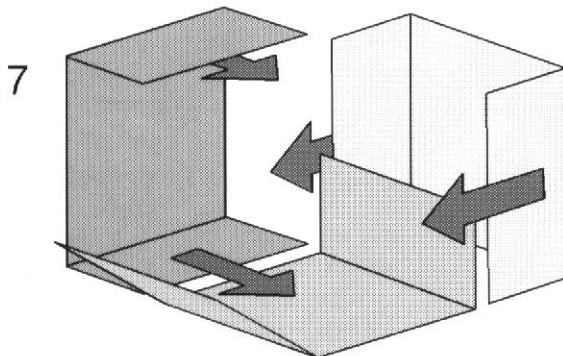
Open out at right angles.

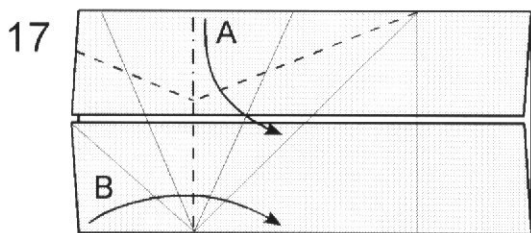
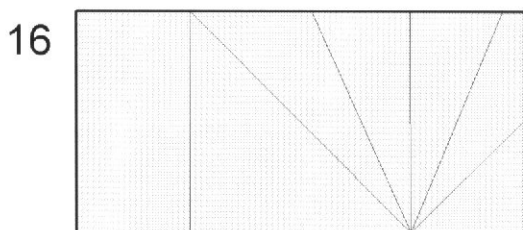
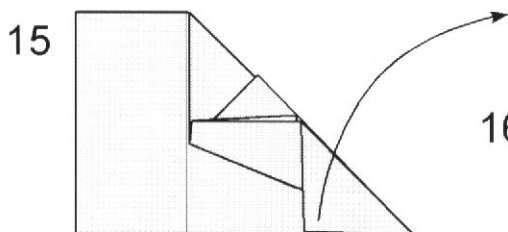
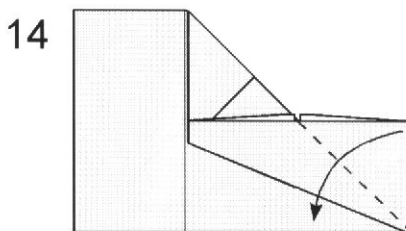
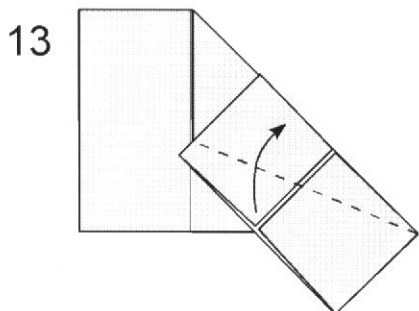
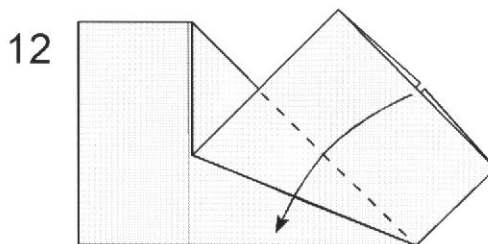
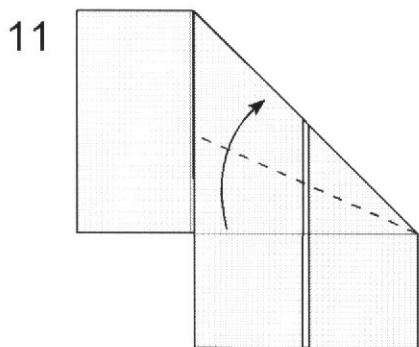
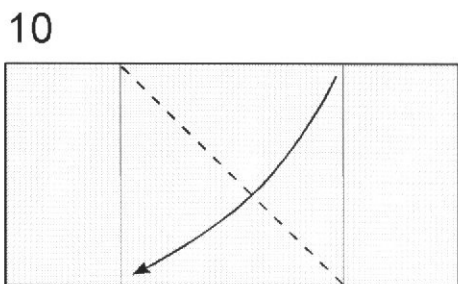
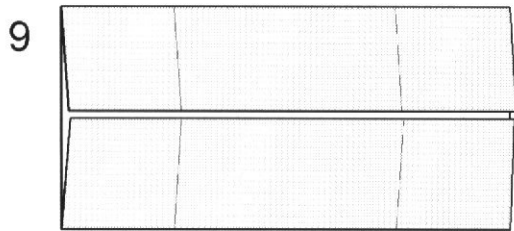


3 of these modules will fit together to form the back half of Metamorphosis in the way shown in steps 7 and 8.

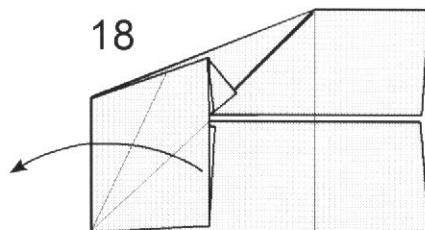
The front half of Metamorphosis is made by modifying the 3 remaining modules in the way shown in steps 9 to 22.

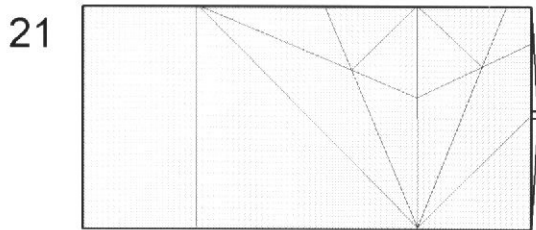
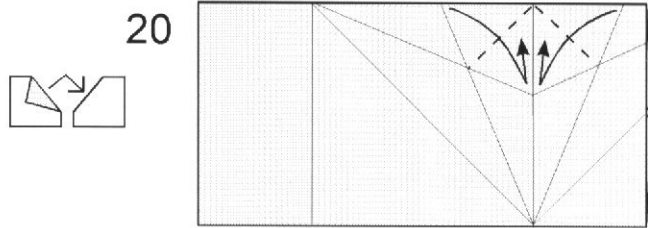
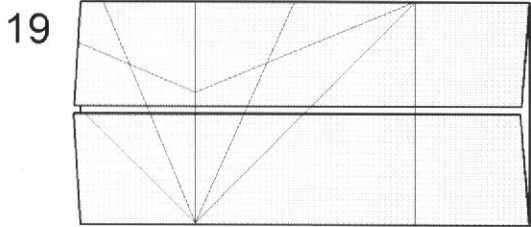
The extra creases make it possible to distort the front of the crystal into an entirely different shape.



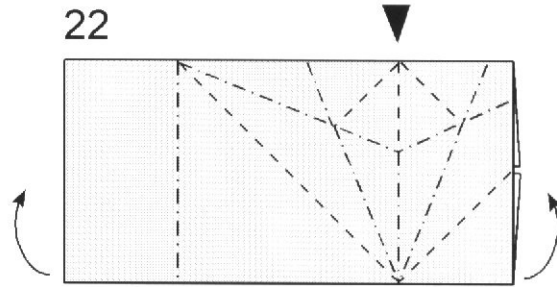


Make fold A first, then fold B and crease firmly.

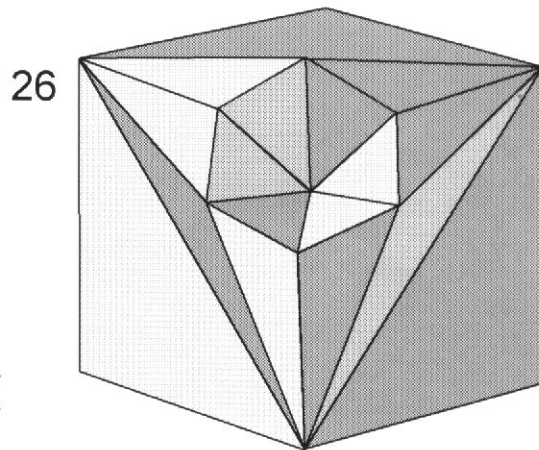
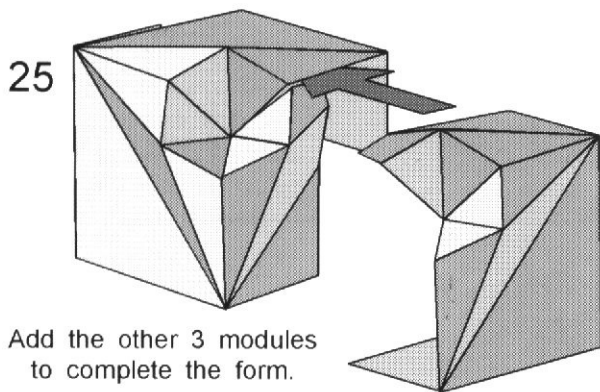
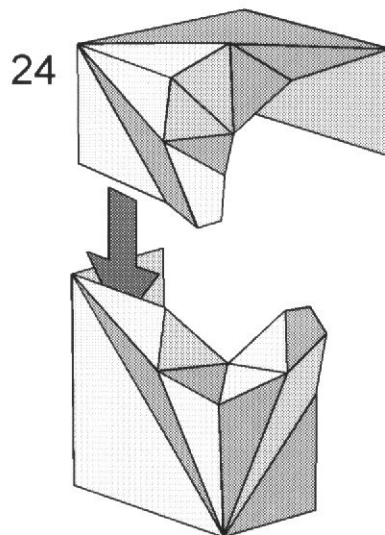
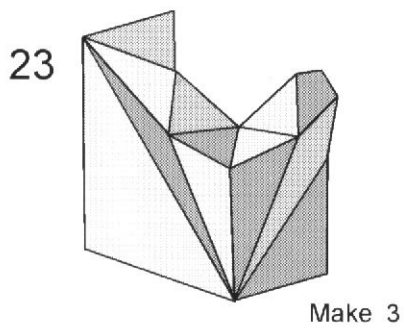




Check that you have made all the creases shown here.



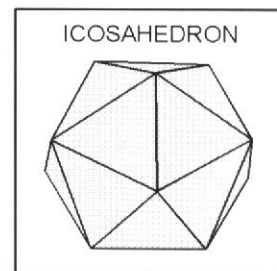
Fold both ends back at right angles and collapse the module into shape.



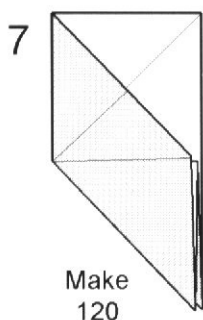
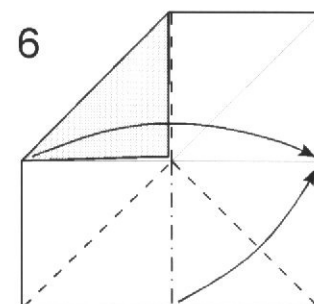
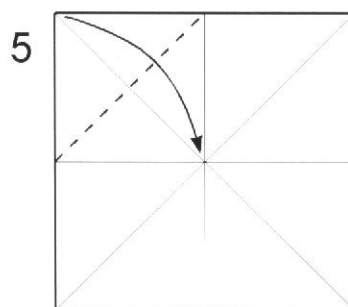
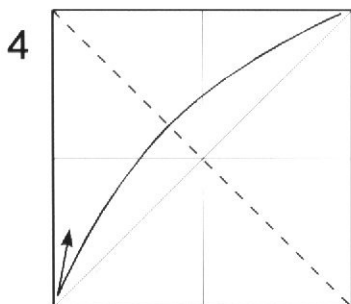
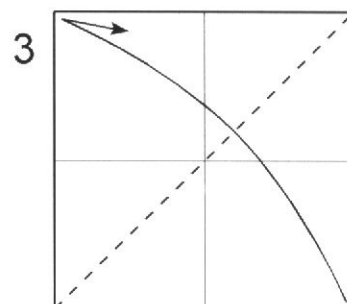
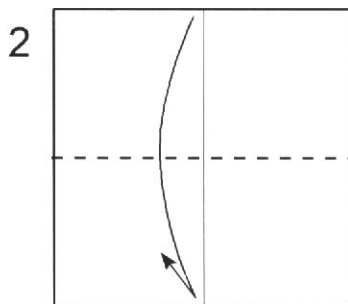
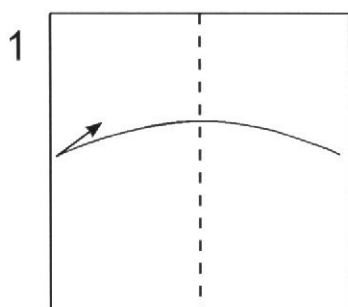
Many other Paper Crystals can be created by distorting one or more corners of cubes and other shapes in this and similar ways, but Metamorphosis is probably the most elegant and attractive of them all.

Spiral Cluster

120 sheets of small square paper are required. For best effect use 60 sheets of plain black (or possibly dark blue) paper and 10 sheets of each of 6 plain contrasting but complementary bright or pastel colours. The black paper will be used for the modules forming the background and the other colours for the modules forming the spirals.



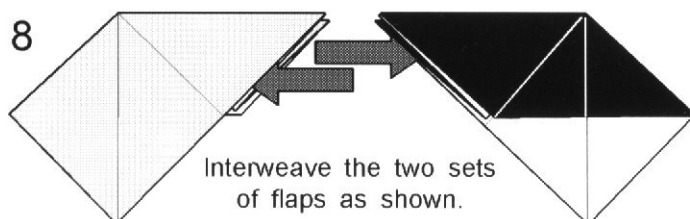
If using printed paper begin white side up.



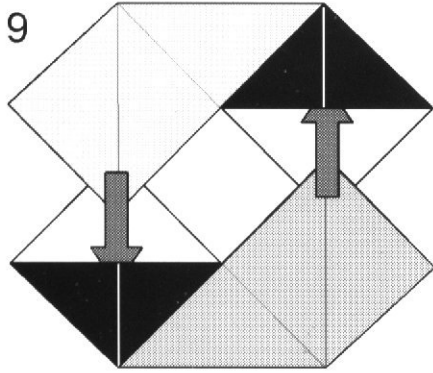
4 modules go together to form a sub-assembly. Each sub-assembly should be made of 2 modules of the background colour and 1 each of 2 different colours from those chosen to form the spirals. You can, if you wish, make up the complete set of sub-assemblies in advance by working out all the possible combinations of these colours - 2 of each combination are required - but it is far easier to make them up as they are required during the assembly process.

Forming the sub-assemblies

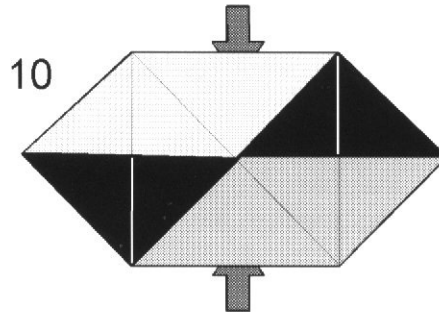
Begin by putting 2 modules together like this.



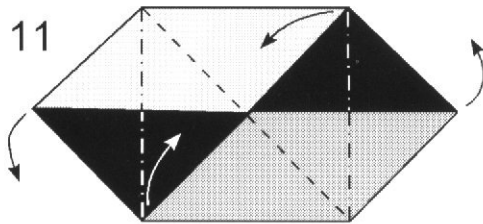
The rear flap of the left hand module goes inside the rear flap of the right hand module. The top flap of the right hand module goes inside the top flap of the left hand module.



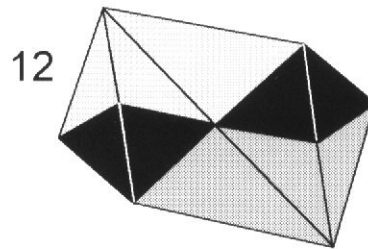
Note that the two flaps at the back also slide into pockets as the sub-assembly goes together.



Check that the sub-assembly has pockets in the positions shown and that these pockets are secure.



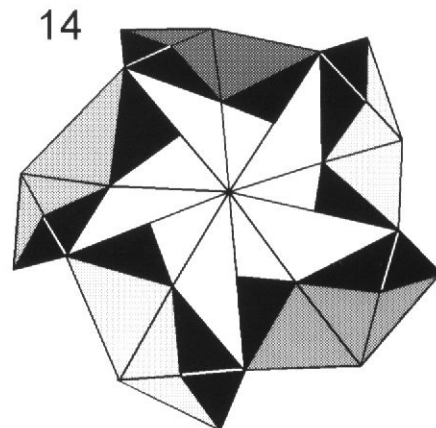
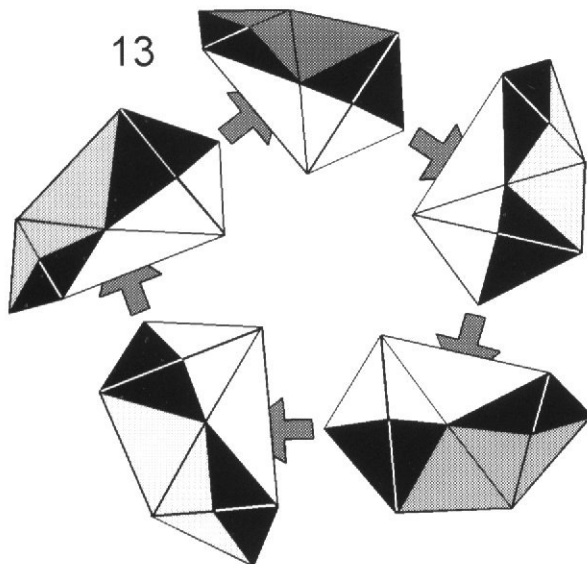
Make the sub-assembly 3-dimensional. All 3 folds should be right angles.



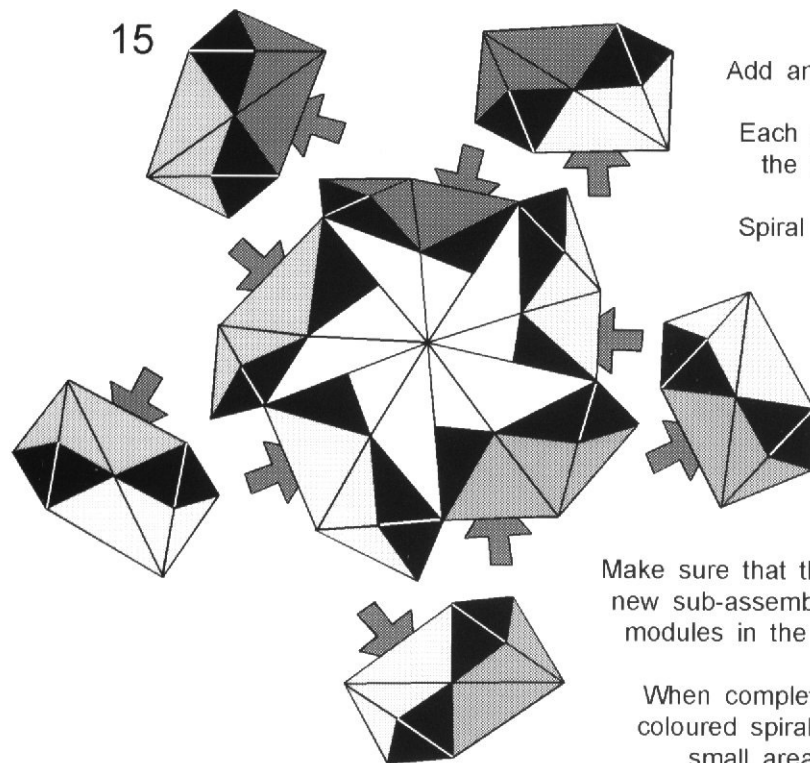
A finished sub-assembly.

Putting the sub-assemblies together

5 sub-assemblies go together to form a ring in the way shown here. You will notice that the 5 modules of the same colour in the centre of the ring form a spiral pattern. This spiral pattern is surrounded by some of the 60 black modules that form the background. In the finished crystal each of the other 5 modules will form part of another spiral. Each one of these modules should be of one of the remaining five colours - a different colour in each case.



Note that this assembly does not lie flat.



15

Add another sub-assembly to each edge.

Each of these sub-assemblies will form the third side of a 3-sided pyramid.

Spiral Cluster is built from 20 pyramids of this kind.

Make sure that the colours of the modules in these new sub-assemblies match with the colours of the modules in the sub-assemblies already in place.

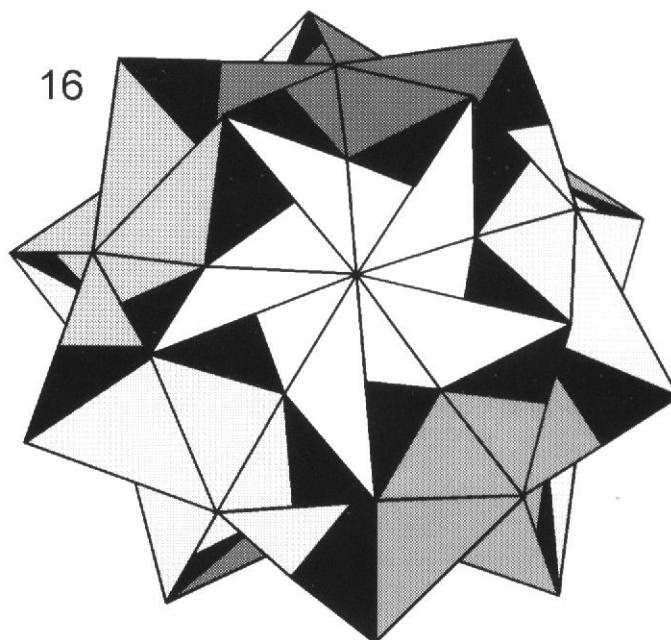
When complete, Spiral Cluster consists of 12 coloured spirals separated from each other by small areas of the background colour.

There are 2 spirals of each colour. These are found on opposite sides of the crystal.

Continue adding sub-assemblies to form new pyramids - taking care to keep to the colour scheme - until Spiral Cluster is complete.

You may wish to turn the 5-pyramid ring upside down and assemble the remainder of the crystal inside a suitably sized transparent mixing bowl. This will help to support the sides until the top is in place.

Alternatively, you can temporarily hold the modules together by the use of sticky strips cut from message notes. These can normally be removed without leaving marks.

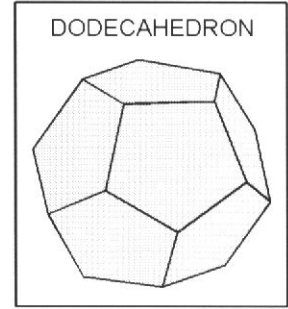


16

A second Spiral Cluster crystal can be built from 48 modules. It requires 24 square sheets of the background colour and 8 square sheets in each of 3 other colours for the spirals. The modules go together to form 12 sub-assemblies and the sub-assemblies in turn form 8 3-sided pyramids. Each of the 6 spiral patterns has just 4 arms, not 5.

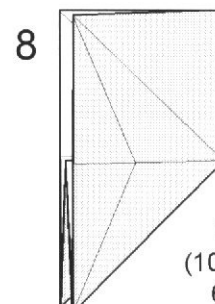
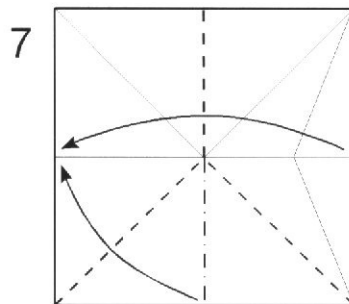
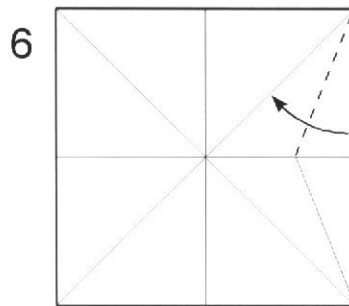
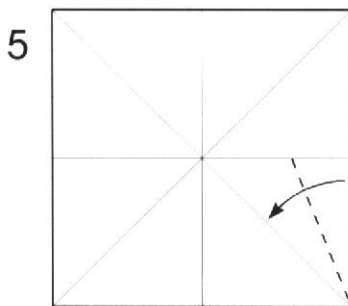
Cloud of Stars

Two kinds of modules are required, 60 A-modules and 30 B-modules. The A-modules are folded from square paper and the B-modules from 2 by 1 rectangles (2 squares of the same size side by side). The best way to obtain this paper is to start with large squares, cutting them in half for the B-modules (15 large squares required) and in quarters for the A-modules (3 large squares of each colour required). For best effect use dark blue or black paper for the B-modules (which form the background) and 6 contrasting but complementary bright or pastel colours for the A-modules (which form the stars).



The A-module

If using printed paper begin white side up. The first 4 steps are the same as for the Spiral Cluster module (see page 9).



The 12-star form of Cloud of Stars was probably first developed from the well-known 20-pyramid form of Spiral Cluster in Japan.

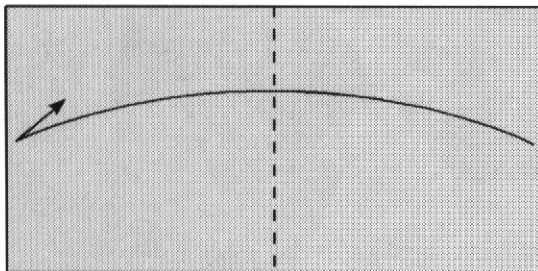
The modular method that allows each star to be made in a different paper is my own.

Make 60.
(10 in each of 6 colours)

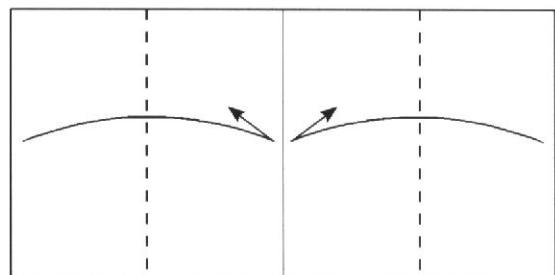
The B-module

If using printed paper begin decorated side up.

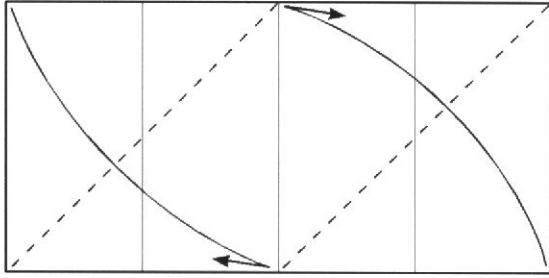
9



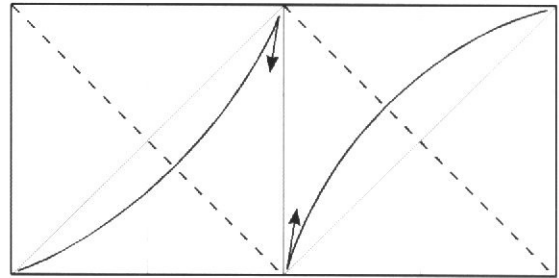
10



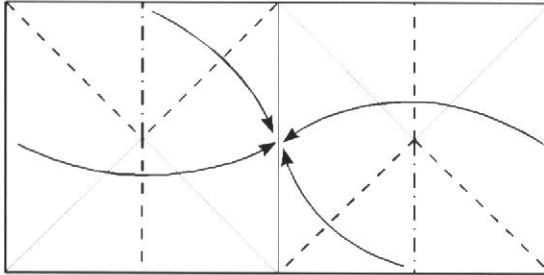
11



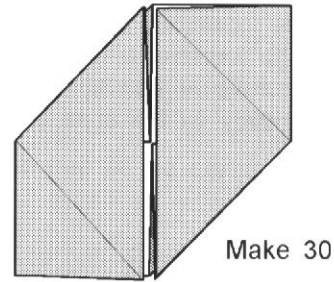
12



13



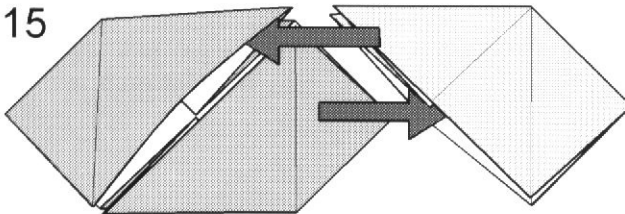
14



Forming the sub-assemblies

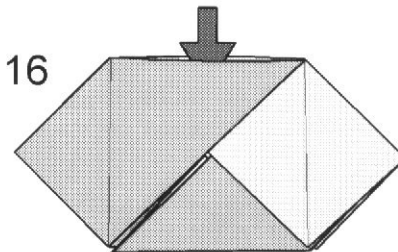
2 A-modules are attached to each B-module to form a sub-assembly. The A-modules attached to a B-module will always be of different colours. You can, if you wish, make up the complete set of sub-assemblies in advance by working out all the possible combinations of colours - 2 of each possible combination are required - but it is far easier to make them up as they are needed during the assembly process.

15



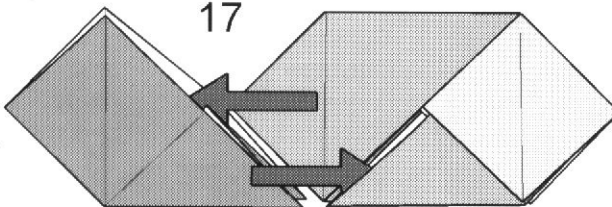
The rear flap of the left hand module goes inside the rear flap of the right hand module. The top flap of the right hand module goes inside the top flap of the left hand module.

16



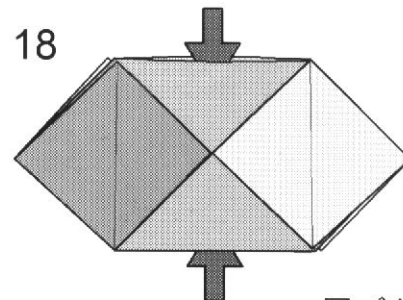
Check that joining the 2 modules has formed a secure pocket at the top of the sub-assembly.

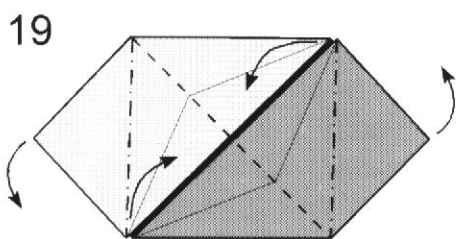
17



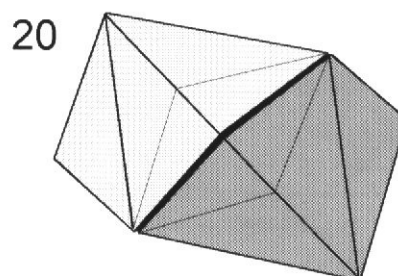
Add the second A-module in exactly the same way to form a second secure pocket at the bottom of the sub-assembly.

18





Make the sub-assembly 3-dimensional.
All the folds should be right angles.



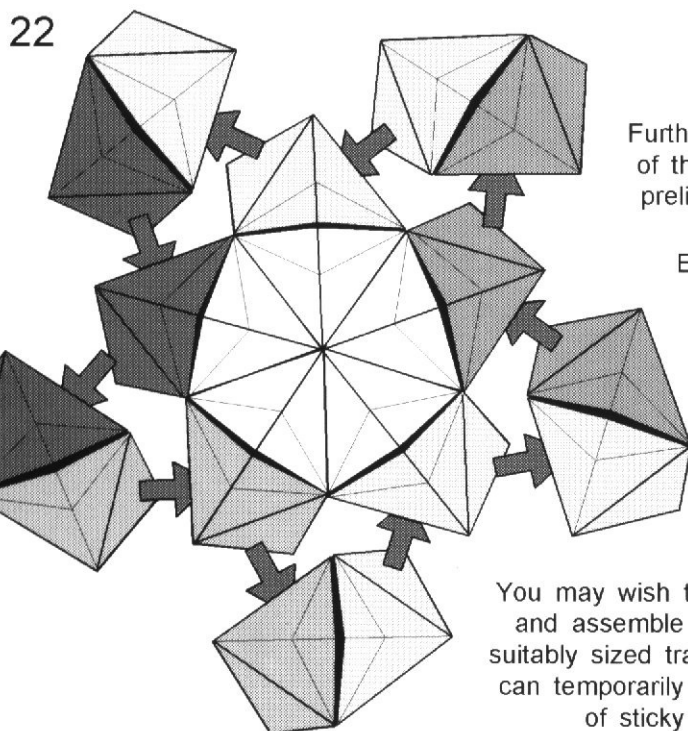
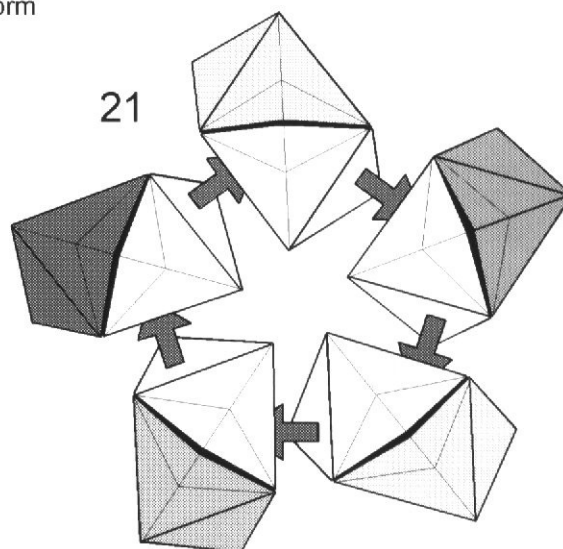
Putting the sub-assemblies together

Cloud of Stars is formed in 2 stages. To begin with the sub-assemblies go together to form a 3-dimensional shape identical to that of Spiral Cluster but this preliminary form transforms completely as the stars are developed.

The centre of each ring of sub-assemblies must be formed from 5 A-modules of the same colour, each of which is partnered with an A-module of one of the five remaining colours.

(Note that in the finished crystal there will be 2 stars of each colour. These will be on opposite sides of the structure.)

This assembly will not lie flat.



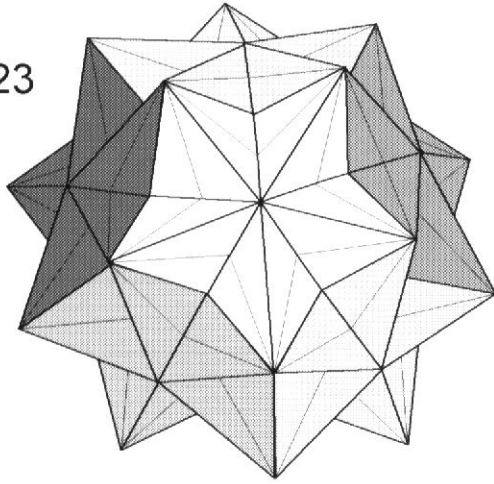
Further sub-assemblies are added to form 5 of the 20 3-sided pyramids from which the preliminary form of Cloud of Stars is built.

Each pyramid will be formed from 3 different colours of A-modules.

Continue adding sub-assemblies to form new pyramids - taking care to keep to the colour scheme - until the preliminary form is complete.

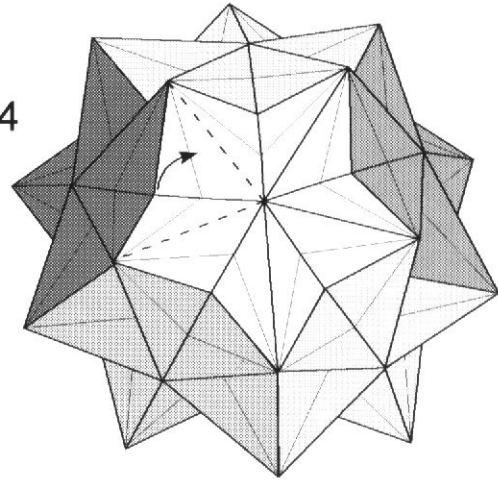
You may wish to turn the 5-pyramid ring upside down and assemble the remainder of the crystal inside a suitably sized transparent mixing bowl. Alternatively you can temporarily hold the modules together by the use of sticky strips cut from message notes.

23



This is what the preliminary form should look like.

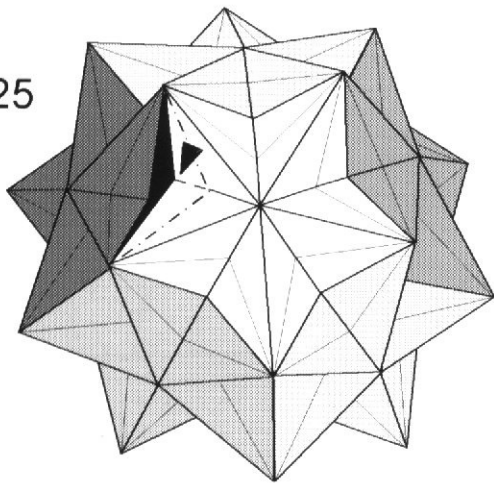
24



The final form is achieved by opening up each of the coloured areas in turn into a 3-dimensional star.

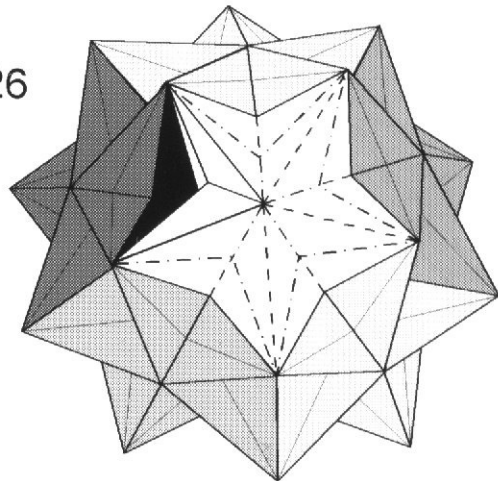
Begin by pulling up one of the 5 flaps making up one of the coloured areas.

25



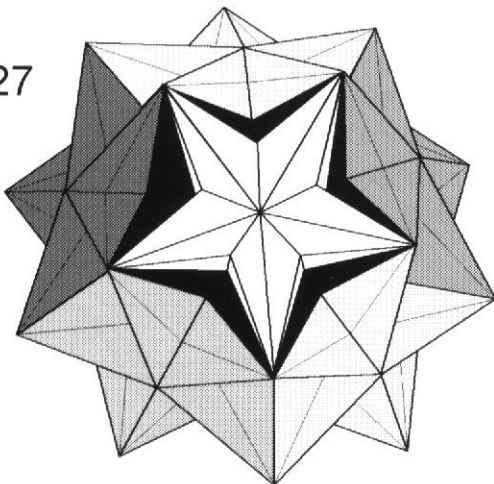
Gently fold the outer edge back down to form the first part of the star.

26



Repeat this procedure on the 4 remaining flaps of the same coloured area.

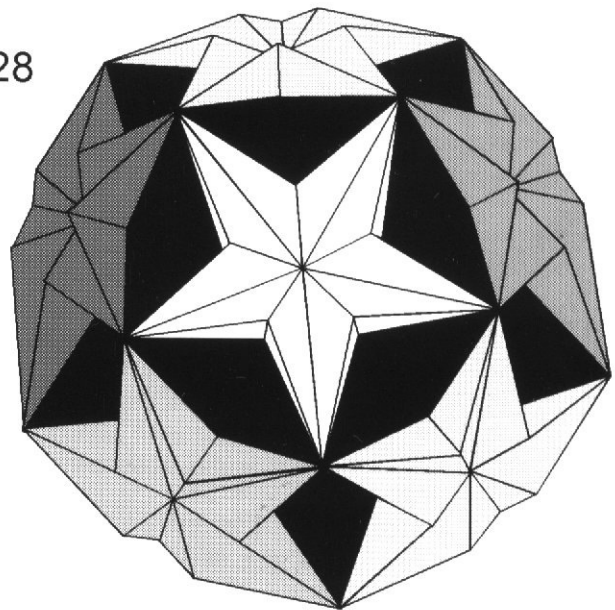
27



One star has been developed.

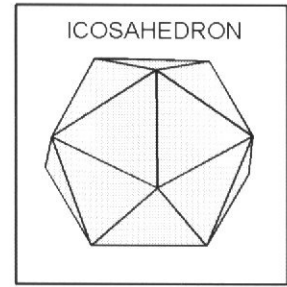
Develop the other 11 stars in a similar way.

28

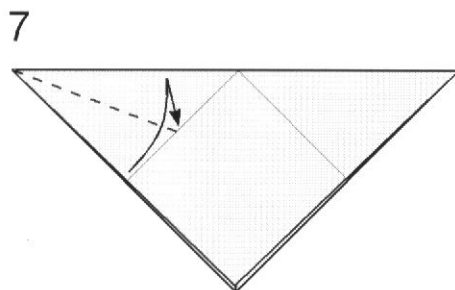
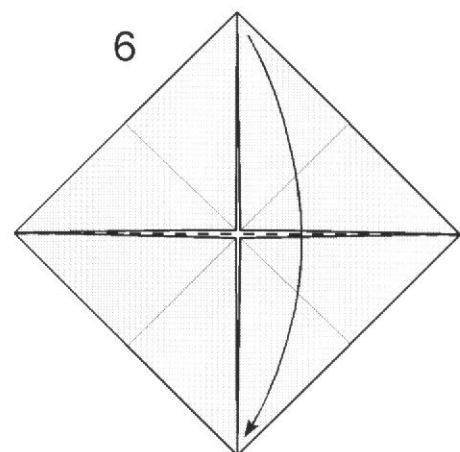
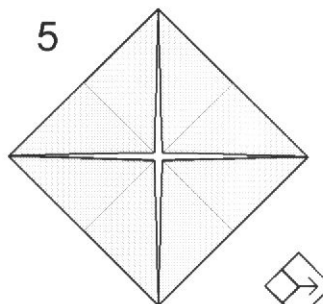
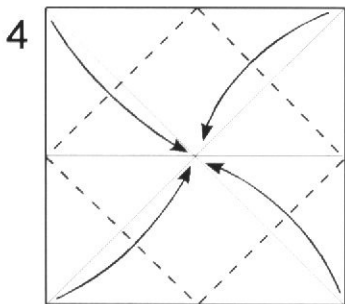
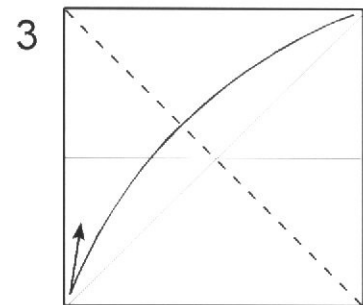
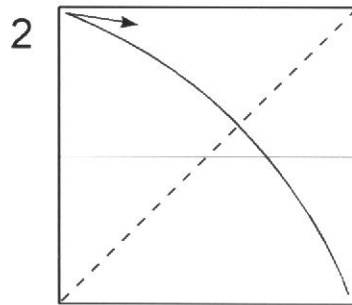
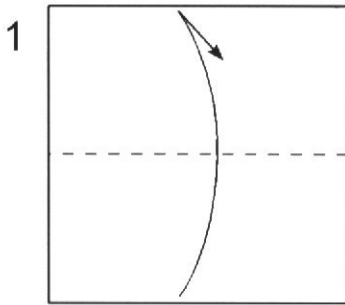


Sappho

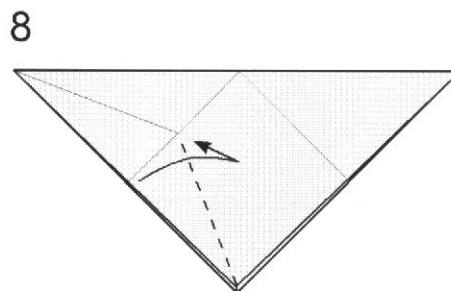
30 sheets of small square paper are required. Good results can be obtained by using a single strong plain colour, random or chaotic patterns or by combining many different types of paper in a patchwork effect.



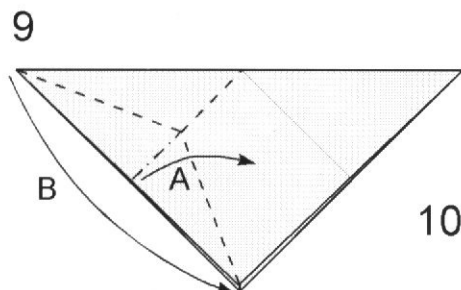
If using printed paper begin white side up.



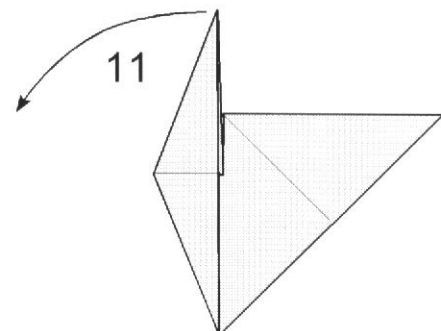
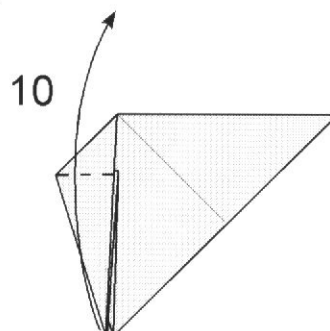
Crease through all layers.



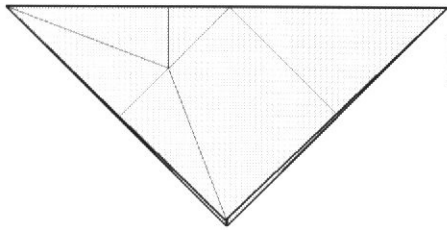
Crease through all layers.



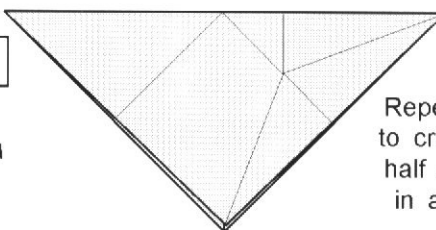
Make fold A before fold B.



12

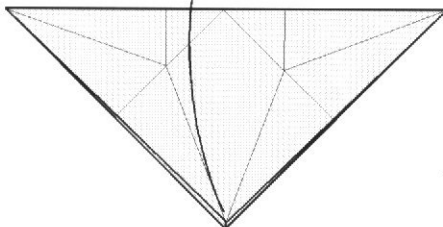


13

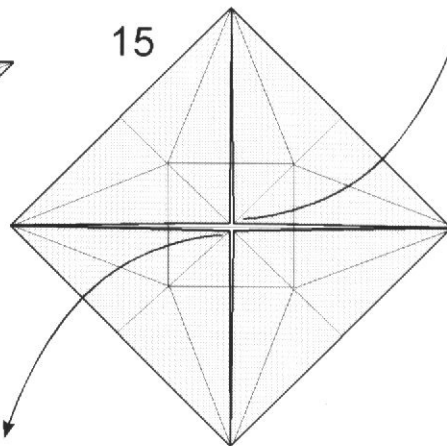


Repeat steps 7-11 to crease the other half of the module in a similar way.

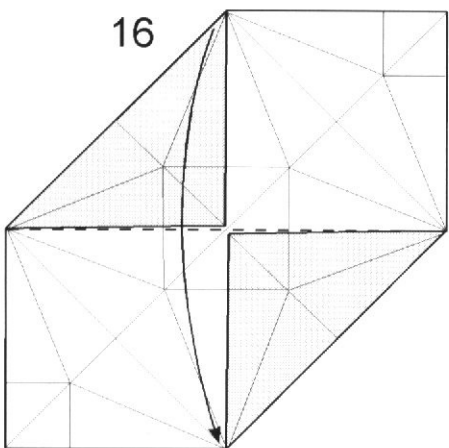
14



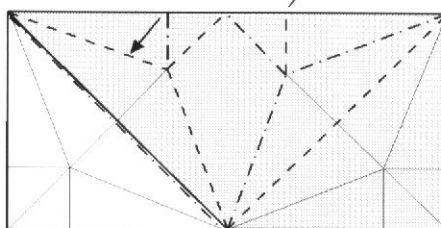
15



16

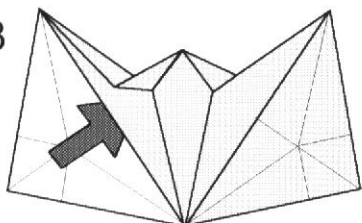


17



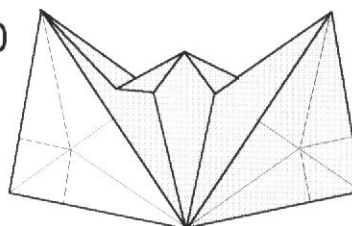
Collapse the module into shape like this.

18



Each module has 2 pockets. The other pocket can be located by turning the module over.

20



Swing this flap behind out of the way.

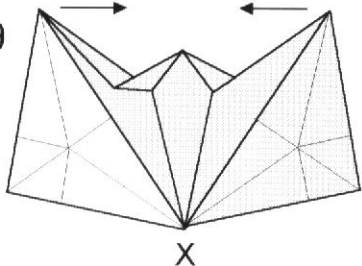
2 modules go together like this.

The wider the angle at point X the easier it will be to insert the flap inside the pocket.

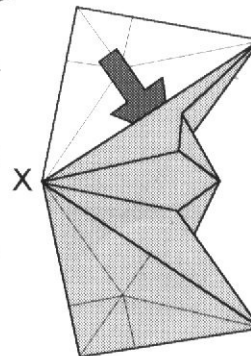
The flap will become locked in place as the host module is compressed back into shape.

Note that just one flap is inserted in just one pocket when joining 2 modules together.

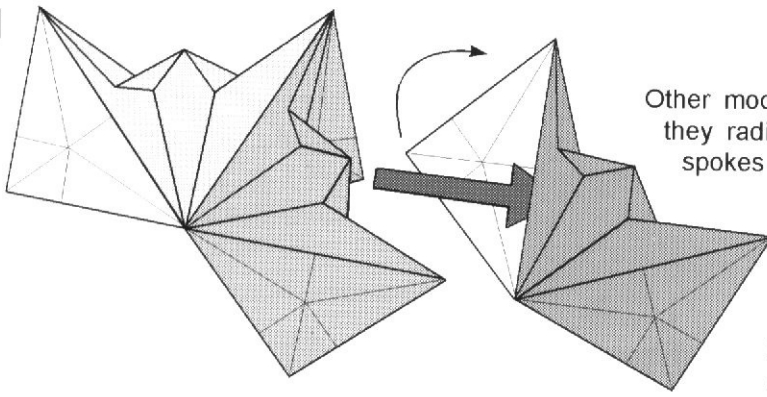
19



Note that the module can be compressed so that the angle at point X changes.



21



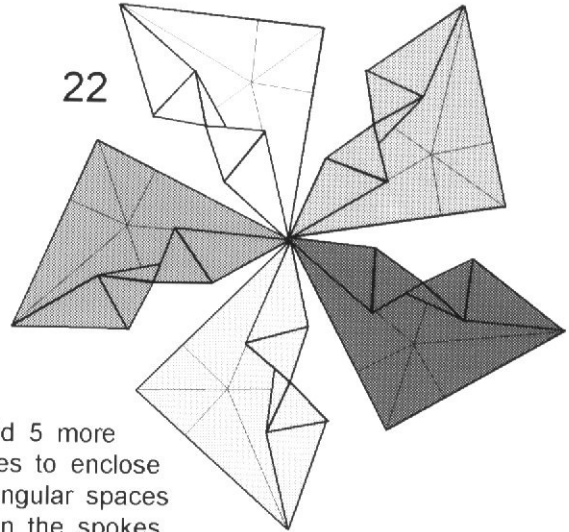
Other modules can be added so that they radiate from the joint like the spokes of a wheel from a hub.

Sappho has five modules radiating from every joint.

When adding the fifth module make sure it is linked to the first as well as the fourth so that the ring of modules is complete.

Because the angle at the centre of the Sappho module can be compressed and expanded (and also because any number of modules can be linked together at a joint) the Sappho module is very versatile and can be used to build crystals based on many other polyhedral patterns.

22

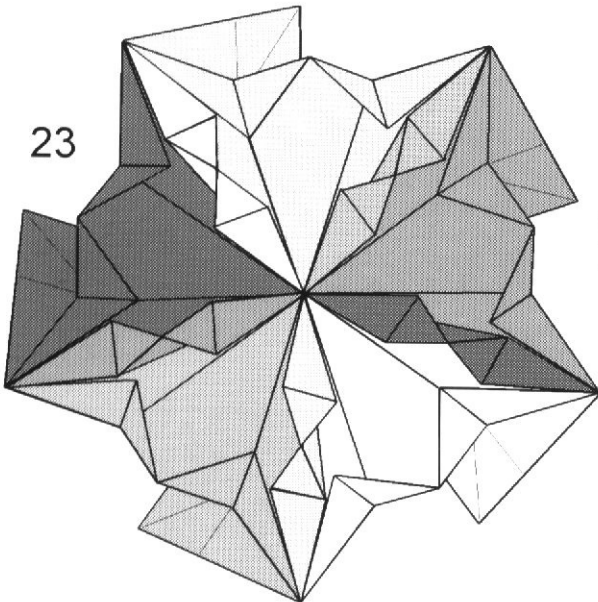


Add 5 more modules to enclose the triangular spaces between the spokes.

Sappho is one of the most beautiful crystals in this book and the drawings here do not begin to do it justice. This is because it has been necessary to distort the overall shape of the crystal to show the modular structure clearly.

In reality Sappho is more of a star than a ball and all the points are much more prominent.

23

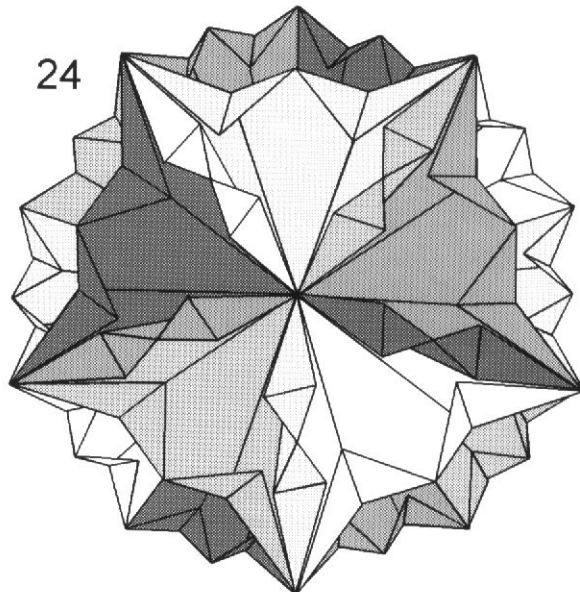


Add 2 further modules to each outside corner, then link these modules to each other to enclose the triangular spaces between them.

Remember that 5 modules radiate from each and every joint and that triangular - and only triangular - spaces are enclosed between them.

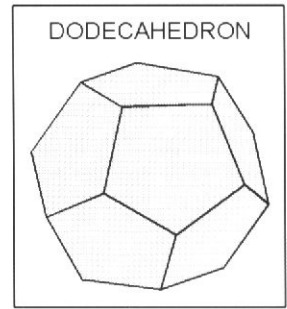
Provided you keep to this pattern as you add the remaining modules the Sappho crystal will form automatically.

24

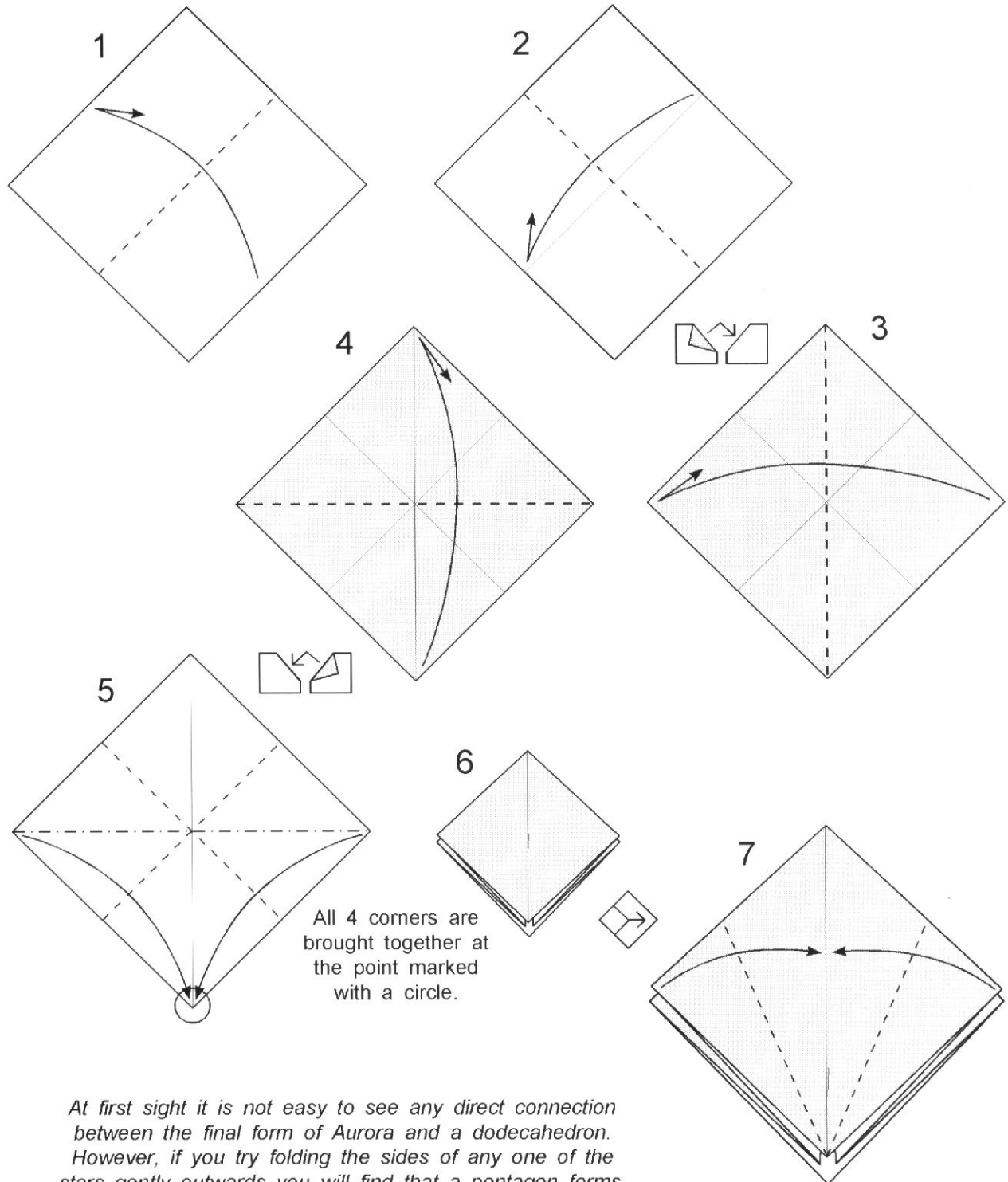


Aurora

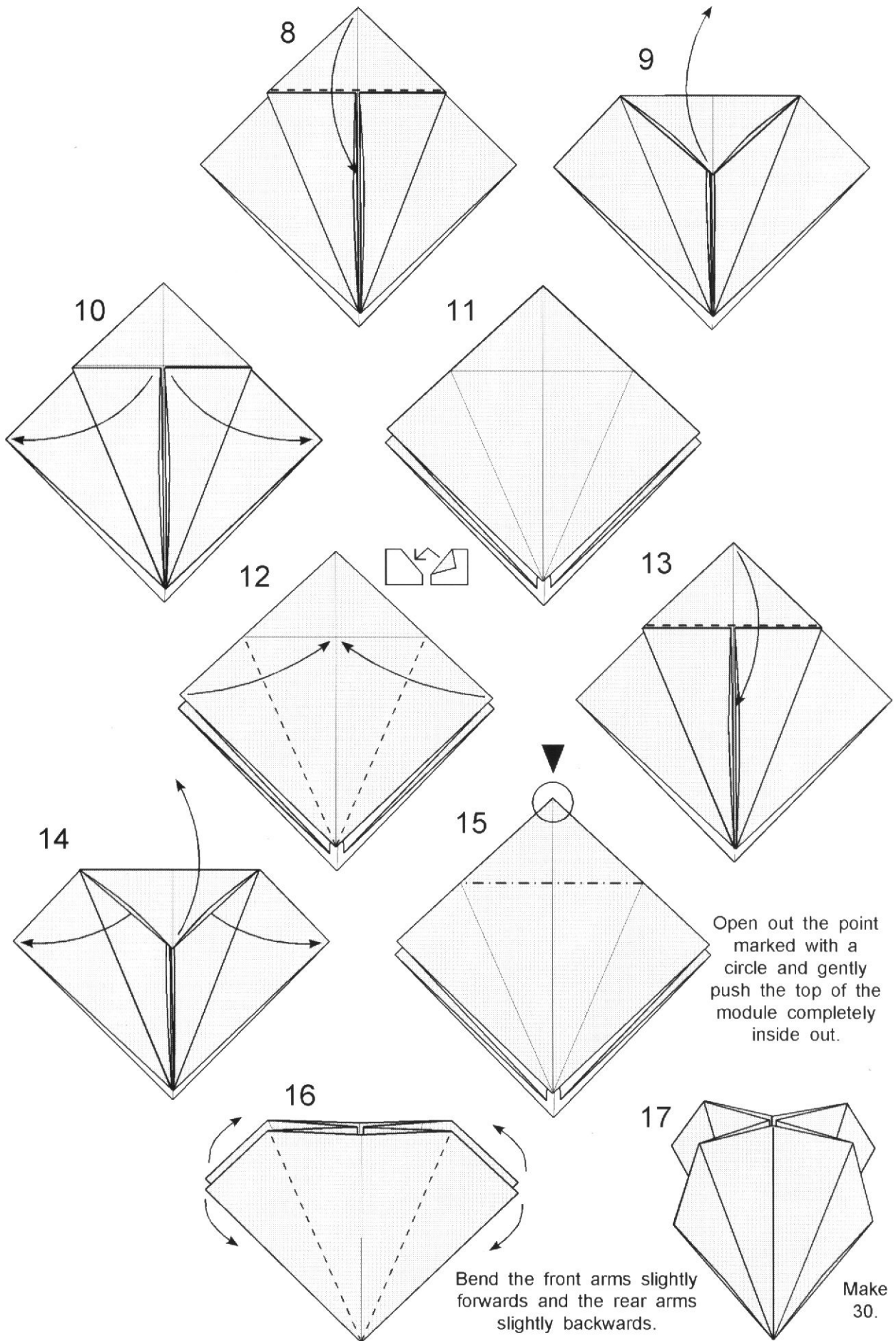
30 sheets of small square paper are required. The diagrams show how to make Aurora from 5 sheets in each of 6 plain contrasting but complementary colours, but Aurora also works well when made from 6 sheets in each of 5 colours or 30 sheets decorated with a random or chaotic design.



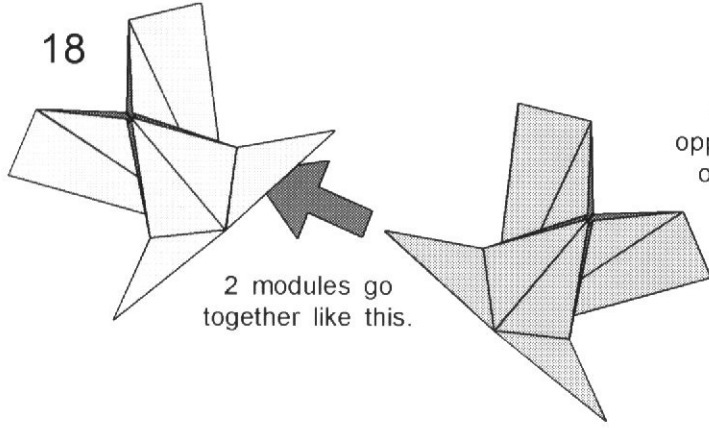
If using printed paper begin white side up.



At first sight it is not easy to see any direct connection between the final form of Aurora and a dodecahedron. However, if you try folding the sides of any one of the stars gently outwards you will find that a pentagon forms.



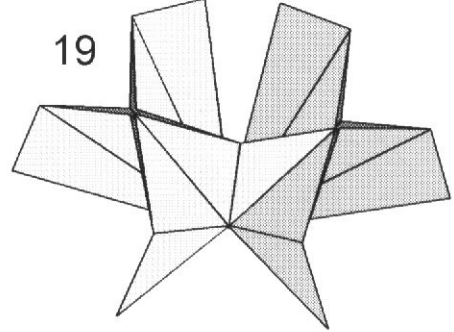
18



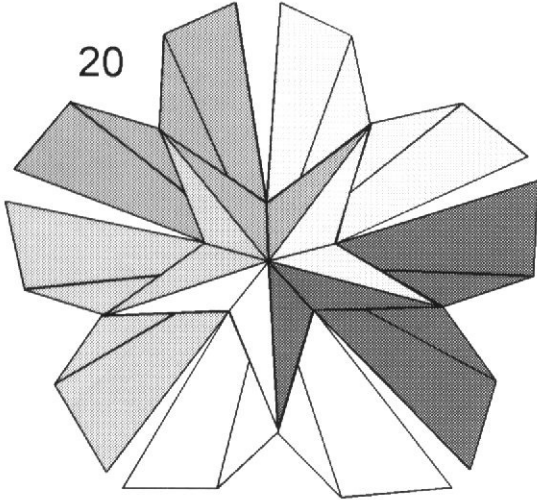
2 modules go together like this.

As the assembly progresses one pair of opposite arms of each module will go outside other modules and the remaining opposite pair inside other modules.

19

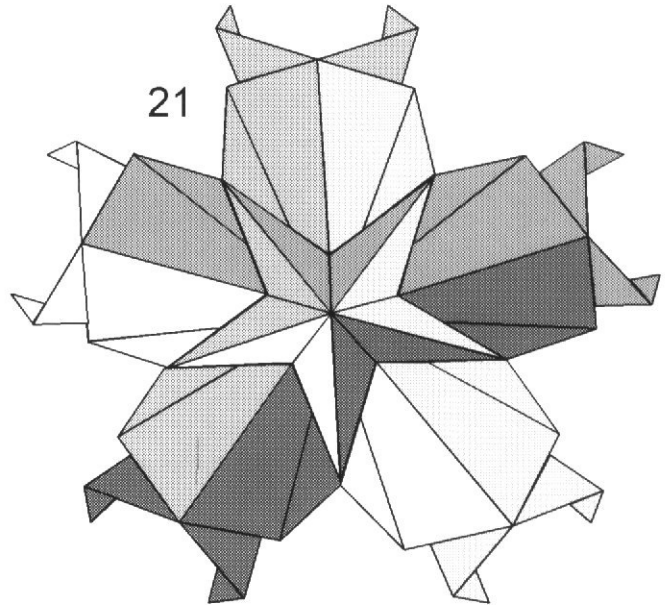


20



5 modules go together in the form of a 5-pointed star. The centre of the star is a deep hole.

21



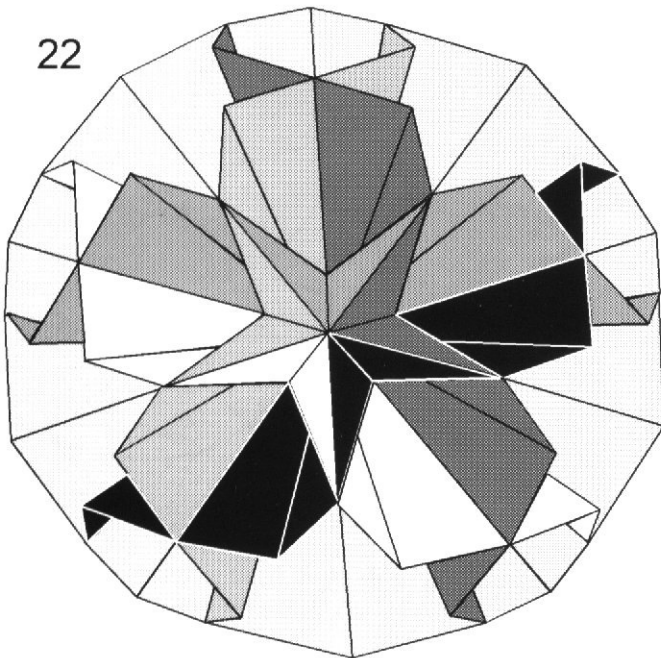
5 more modules can be added to form hexagonal holes surrounding the star.

Every star is surrounded by hexagons and every hexagon by stars.

Each colour forms a complete but slightly zig-zag ring around the crystal.

If you keep to this pattern of shape and colour as you add the other modules the Aurora crystal will automatically form.

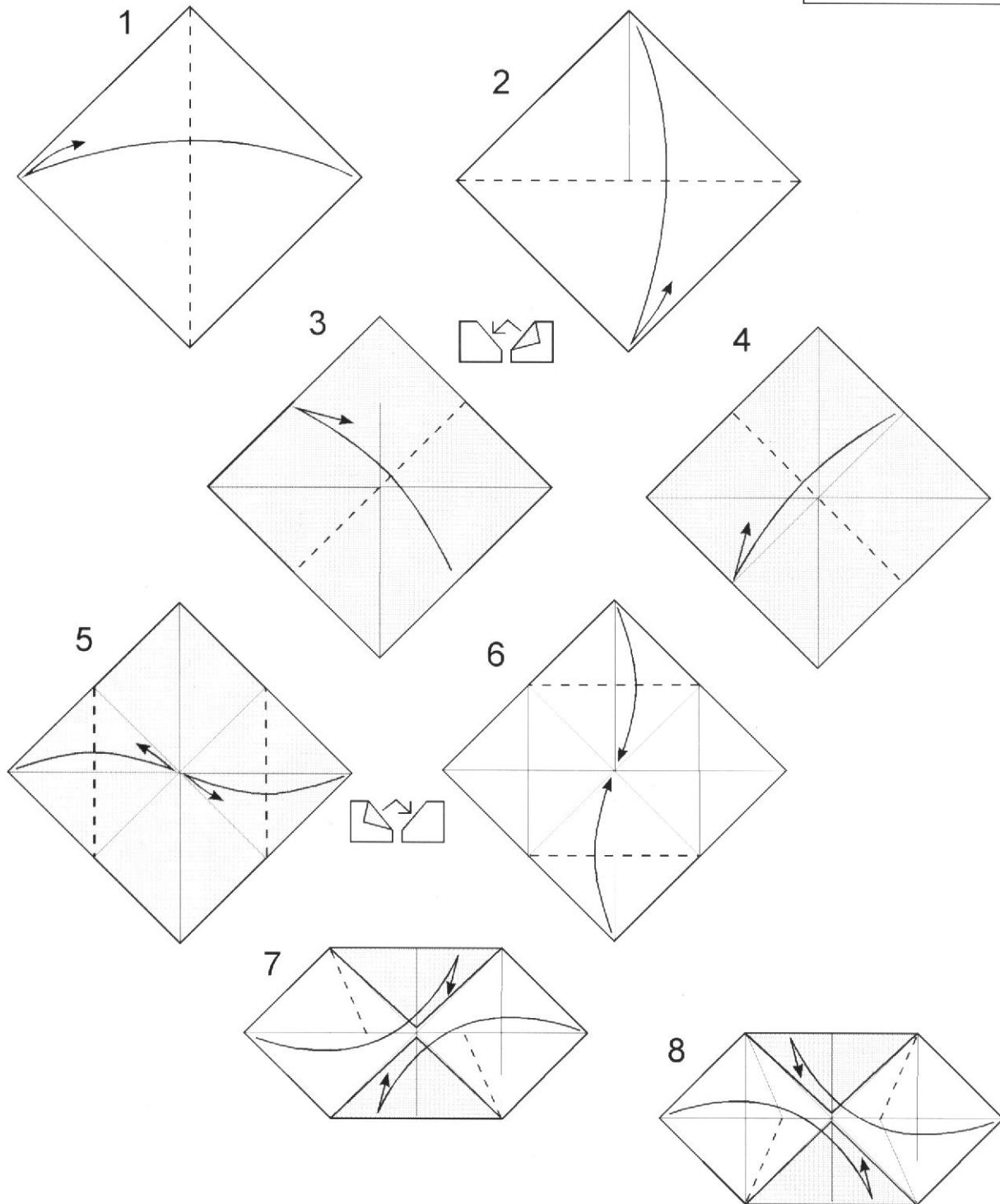
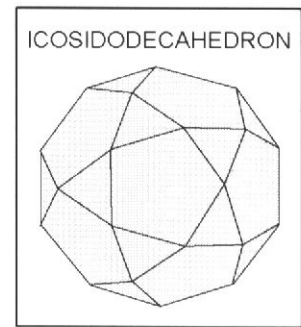
22



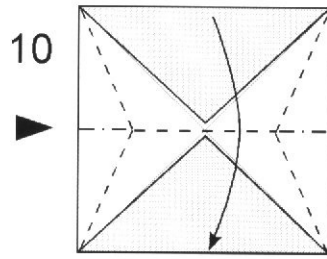
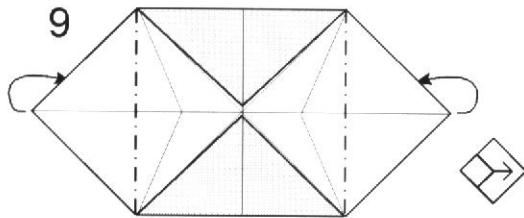
Gemini

Either 30 or 24 sheets of small square paper are required.
For best effect use paper decorated with a chaotic or random design.

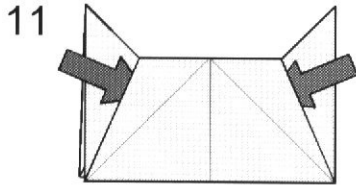
If using printed paper begin white side up.



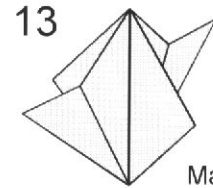
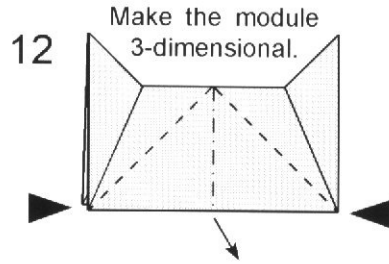
Make 2 other creases
in a similar way.



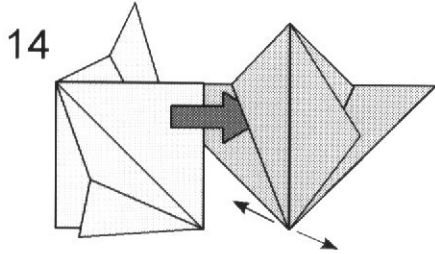
Allow the flaps folded behind in step 9 to flip into view again as you make these folds.



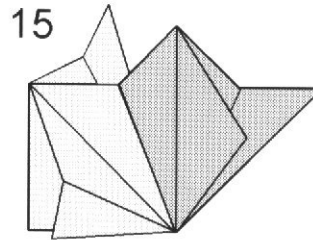
Note the location of the pockets at front and rear.



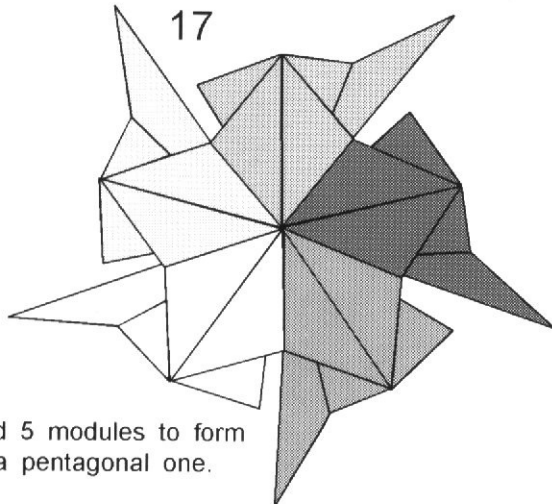
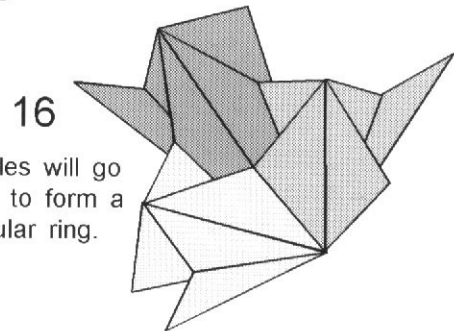
Make 30.



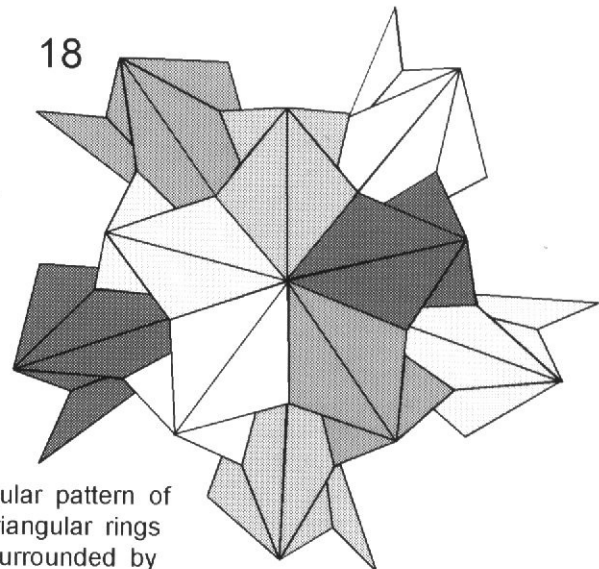
2 modules go together like this. You will need to open out the foot of the host module slightly in order to insert the flap fully inside the pocket.



3 modules will go together to form a triangular ring.

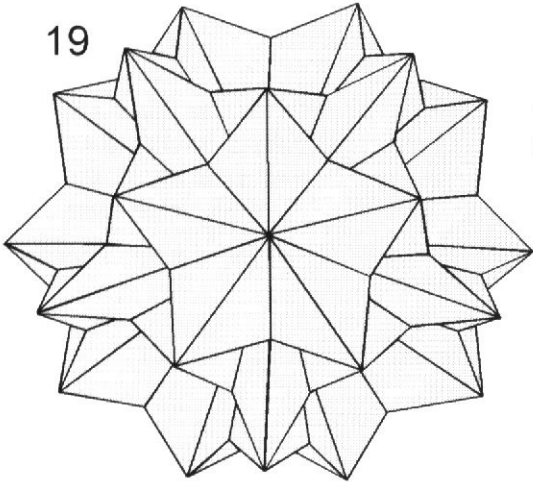


And 5 modules to form a pentagonal one.



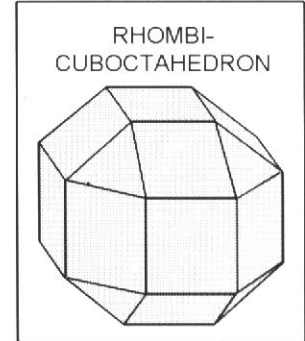
Assembling 30 modules into a regular pattern of pentagonal rings surrounded by triangular rings (and conversely triangular rings surrounded by pentagonal ones) will automatically produce the 30-module Gemini form.

19

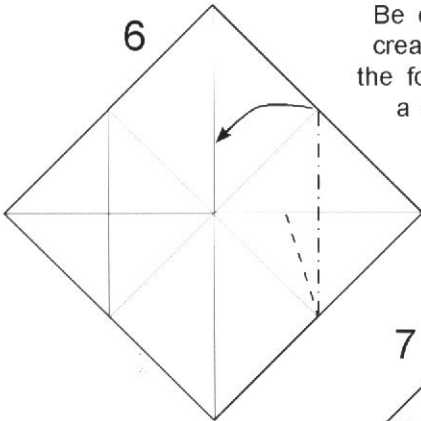


The 24-module twin crystal can be made using the same module but the result is better if the angles of the folds that form the pockets are modified slightly.

Steps 6, 6A, 7 and 8 here replace steps 6, 7 and 8 of the first set of instructions.

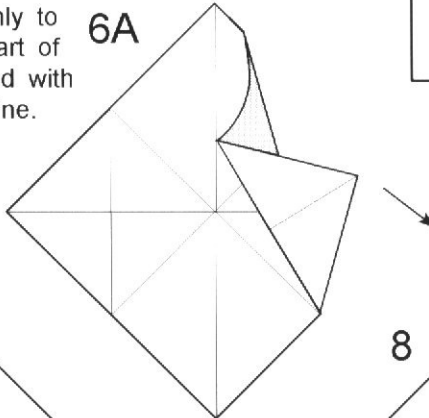


6

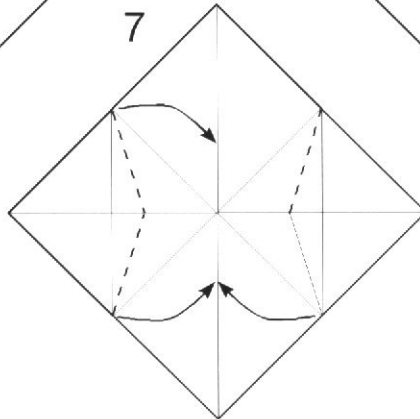


Be careful only to crease the part of the fold marked with a dashed line.

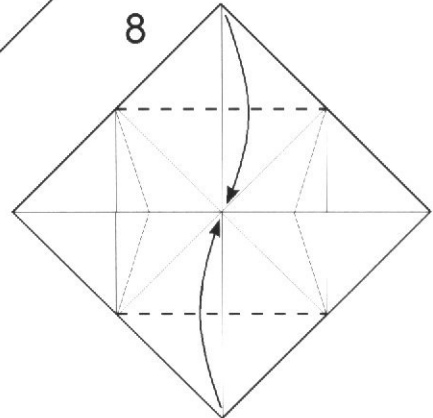
6A



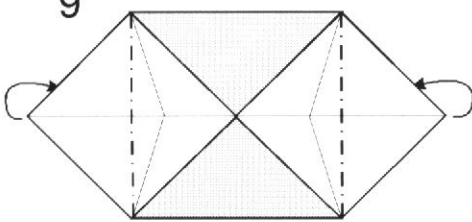
7



8



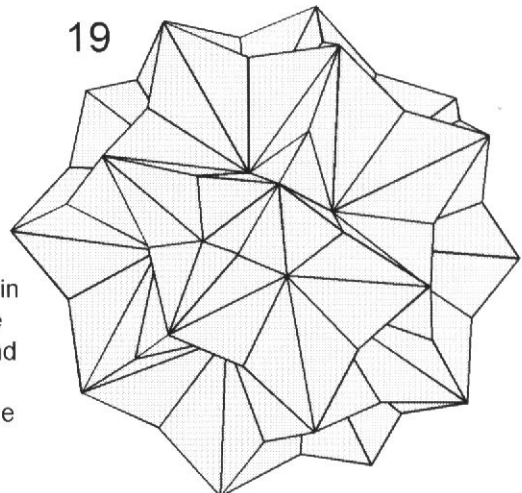
9



Follow steps 10-12 of the first set of instructions to complete the module.

Make 24

19

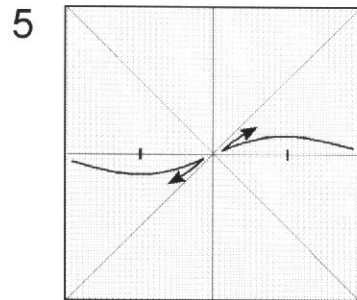
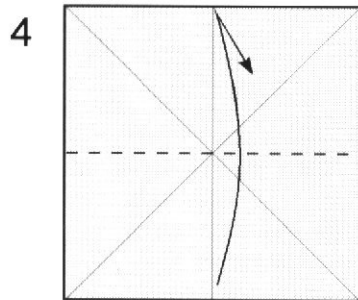
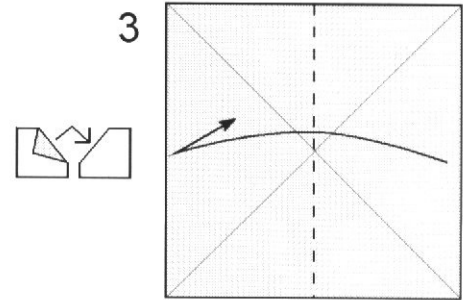
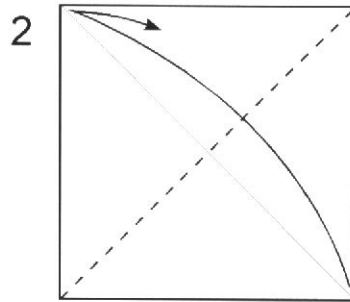
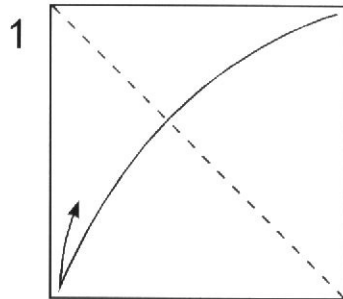
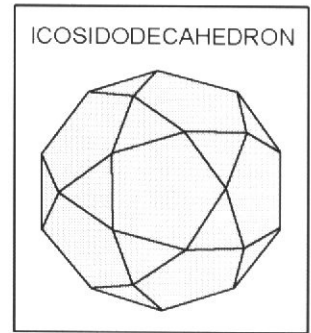


The key to completing the 24-module twin crystal is to understand that the square rings form three continuous bands around the crystal (all at right angles to each other) and that the triangular rings fill the gaps between them.

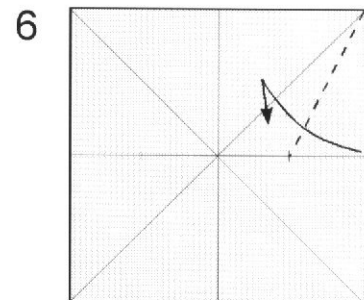
Electra

Either 30 or 60 sheets of small square paper are required.
For best effect use paper decorated with a chaotic or random design.

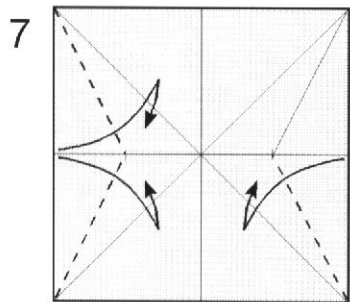
If using printed paper begin white side up.



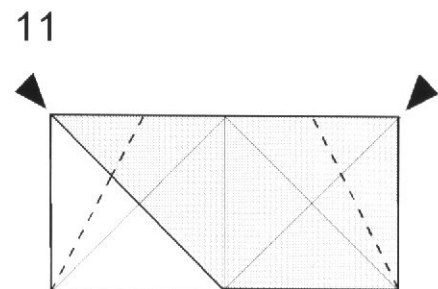
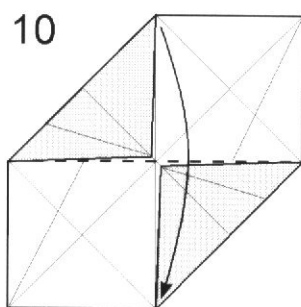
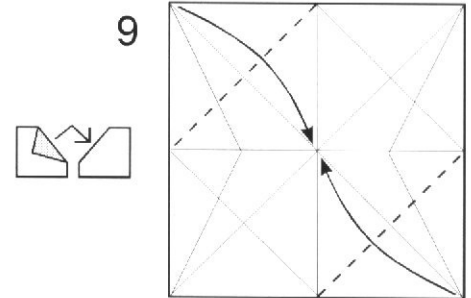
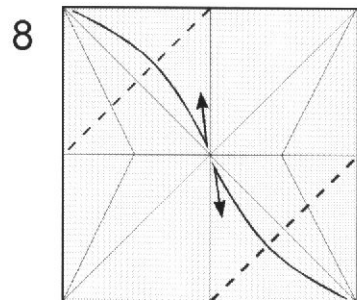
Pinch to mark the quarter points.



Use the pinch-mark to locate this crease.

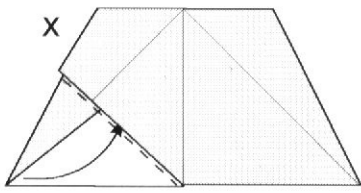


And these.



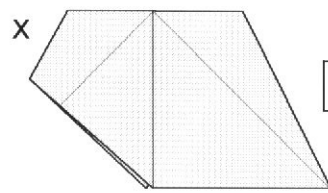
Fold both corners inwards inside the layers.

12

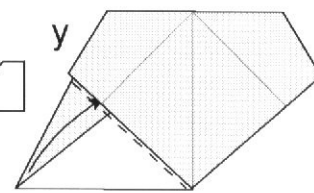


Fold this flap inside the module making sure you trap the internal layers inside the fold to form a pocket at point X.

13

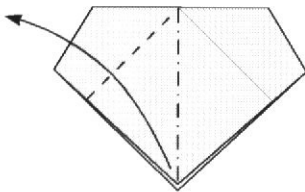


14

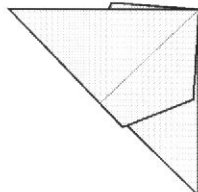


Repeat fold 12 on the other flap to form a pocket at point y.

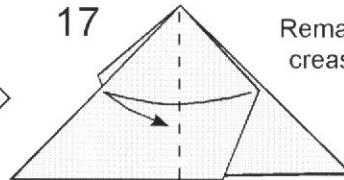
15



16



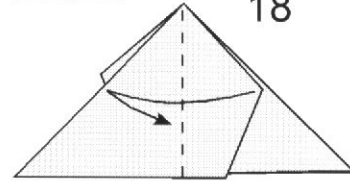
17



Remake the central crease through all layers.

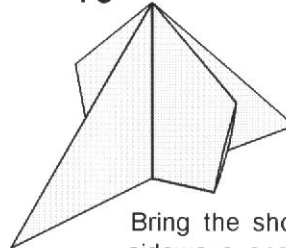


18



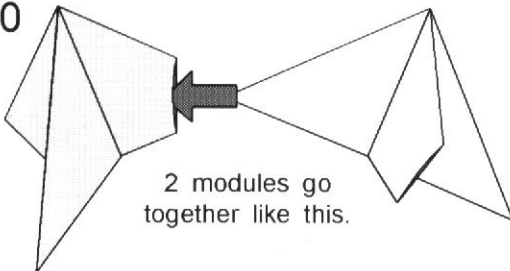
Then do the same on the other side.

19



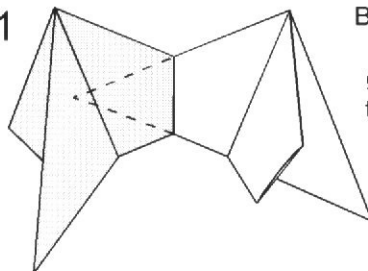
Bring the short arms out sideways and the Electra module is finished.

20



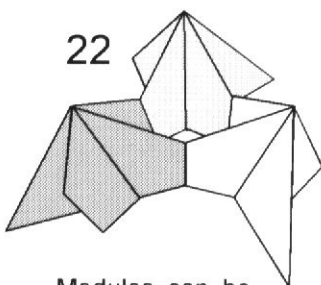
2 modules go together like this.

21



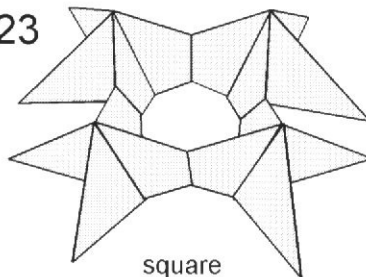
Because of the angle of the folds made in steps 6 and 7 the tip of the arm goes beyond the centre crease and is trapped by the central fold of the host module. This is all that locks the modules together in the early stages of assembly.

22



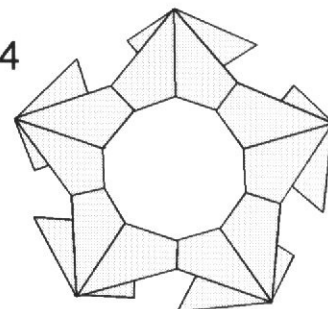
Modules can be combined into triangular,

23



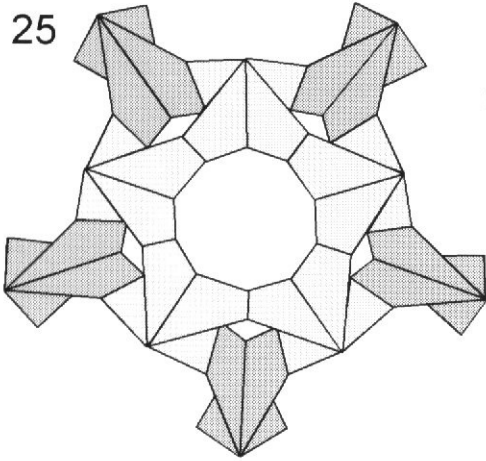
square

24



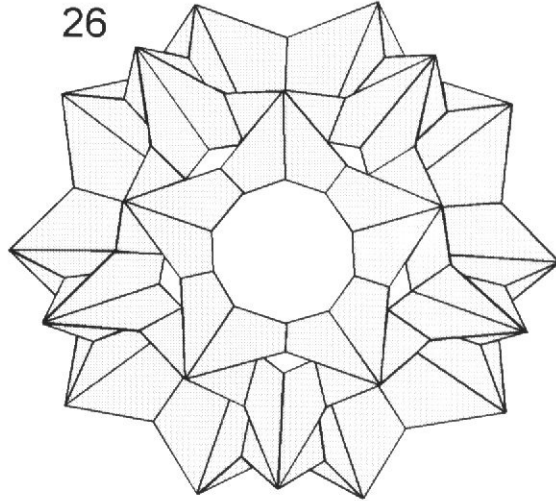
or pentagonal arrangements.

25

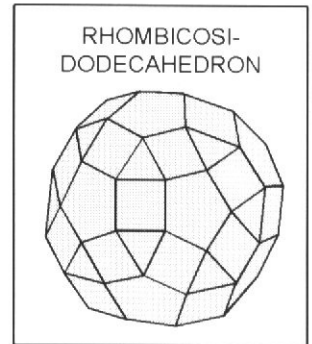


By assembling 30 modules in a pattern of pentagons and triangles, in which every pentagon is surrounded on all sides by triangles, and every triangle on all sides by pentagons, the 30-module Electra crystal will automatically form.

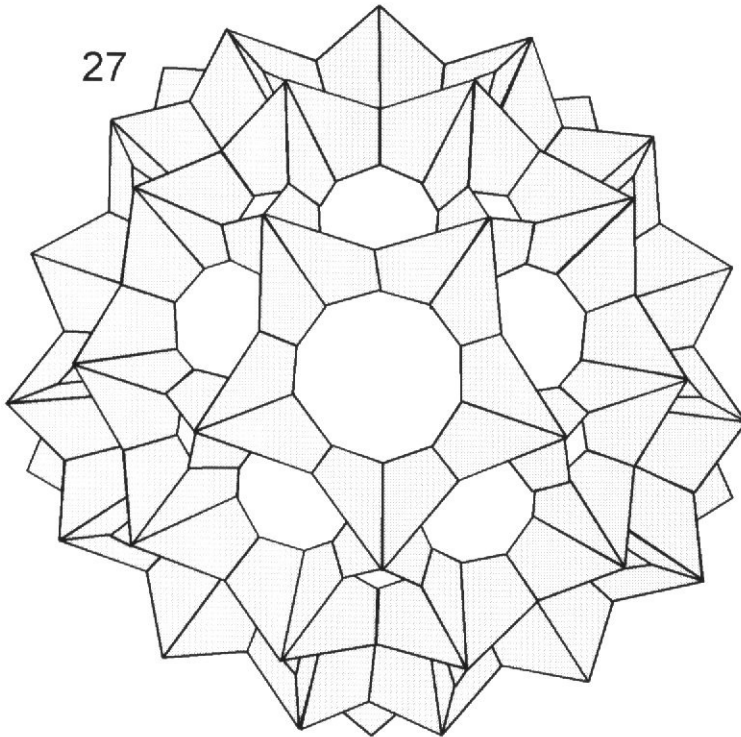
26



Alternatively, by assembling 60 modules in a pattern of pentagons, squares and triangles, in which every pentagon and every triangle are surrounded on all sides by squares, the 60-module Electra crystal will automatically form.

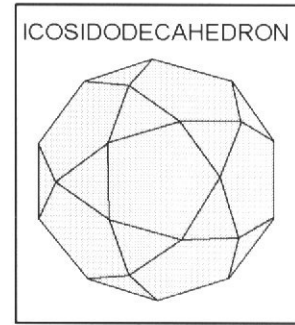


27



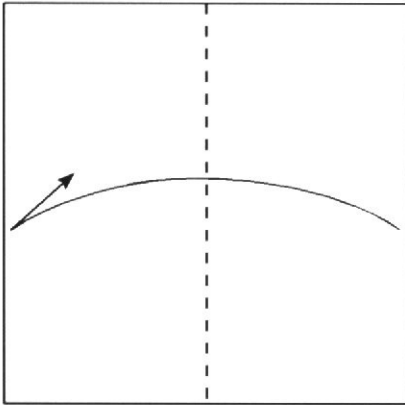
Proteus

30 sheets of small square paper are required. Good results can be obtained by using paper decorated with random or chaotic designs, although Proteus also works well when made from a single plain colour or 6 modules in each of 5 contrasting colours or patterns.

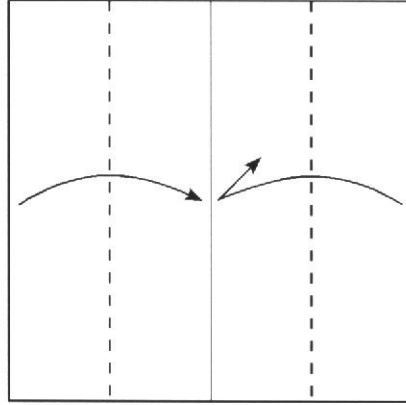


If using printed paper begin white side up.

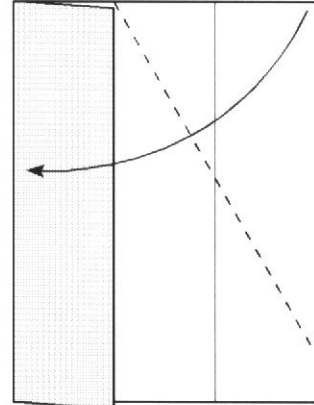
1



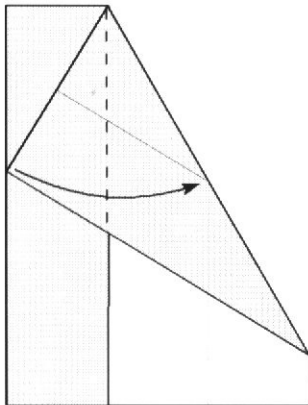
2



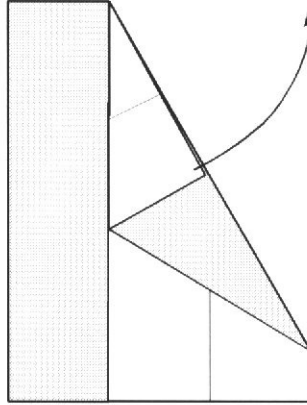
3



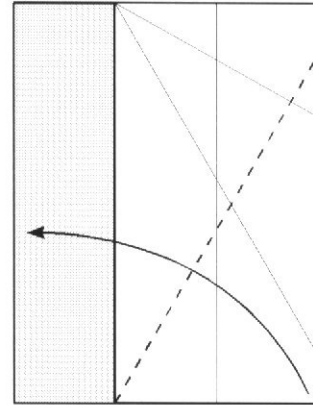
4



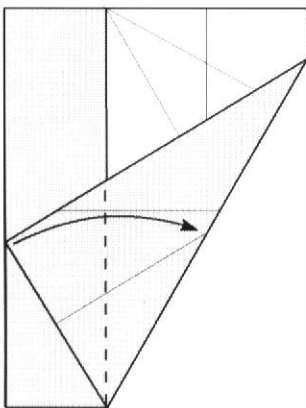
5



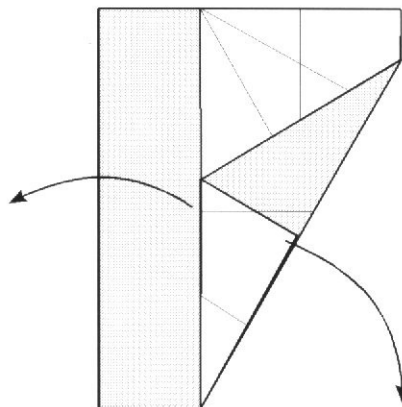
6



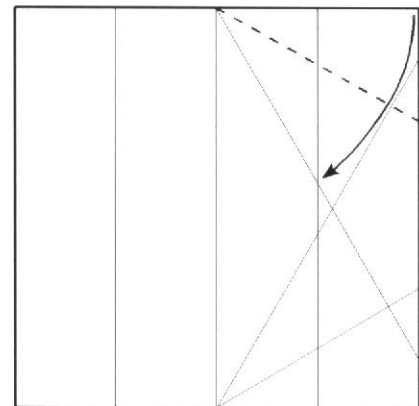
7

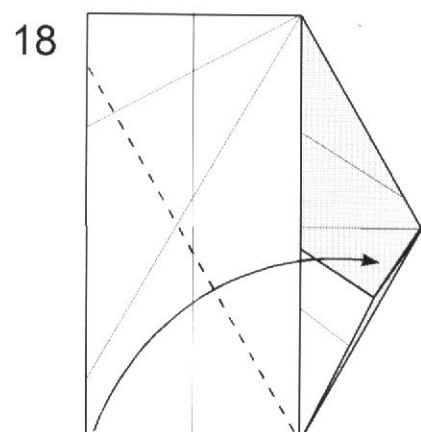
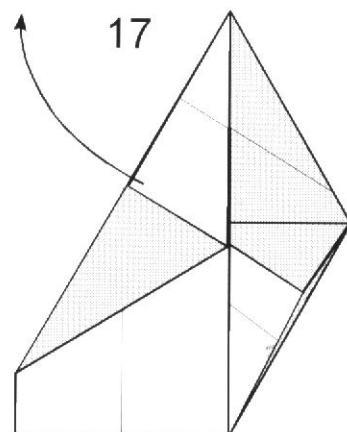
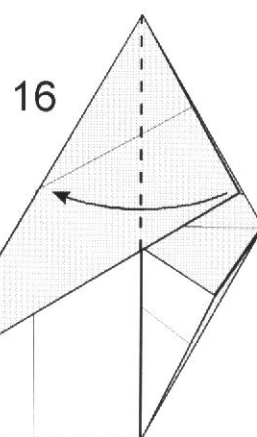
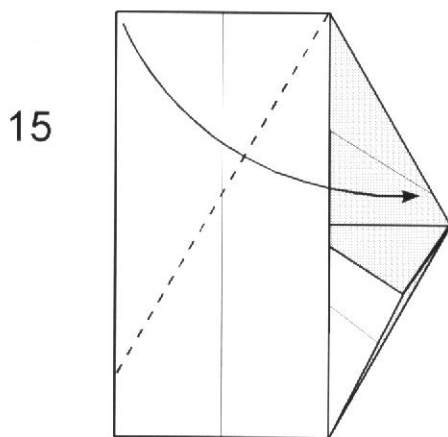
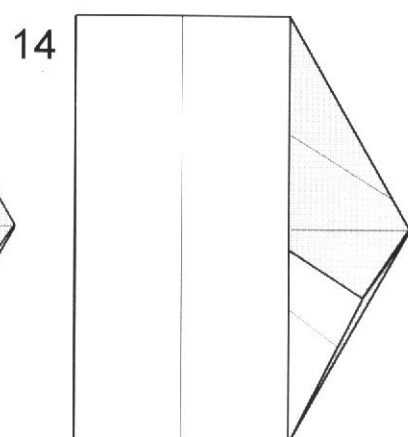
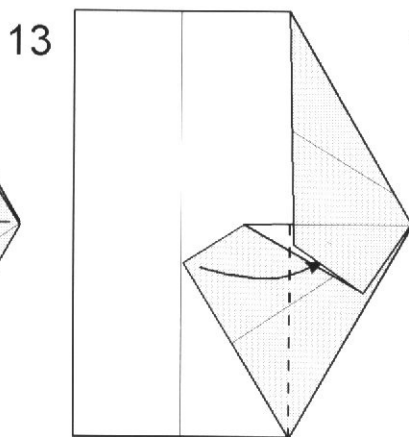
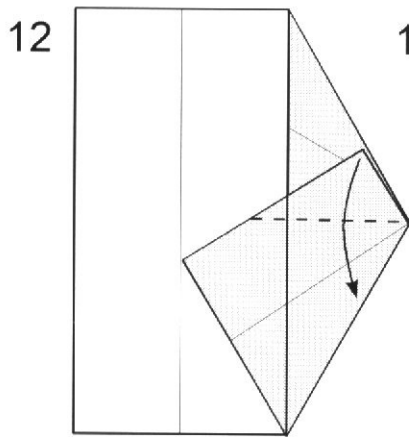
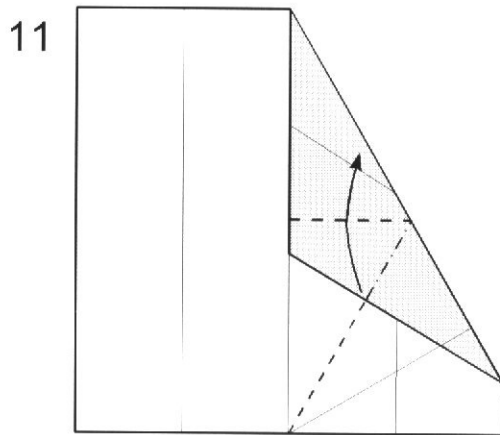
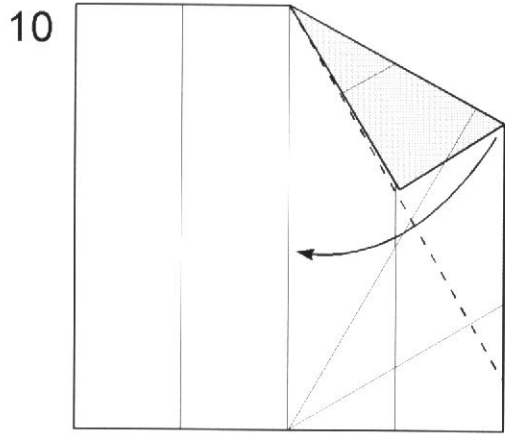


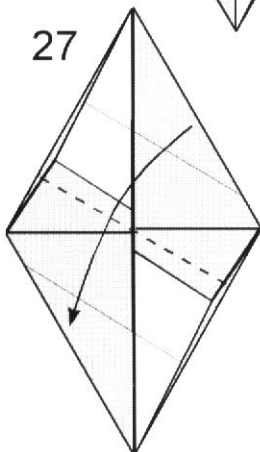
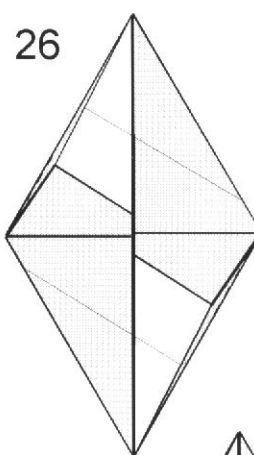
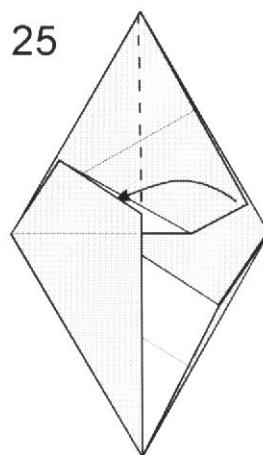
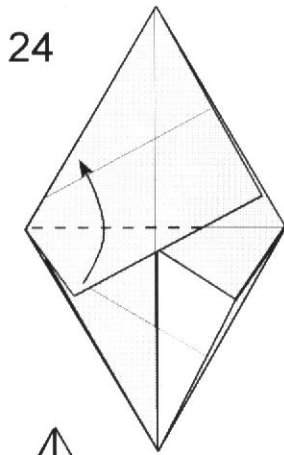
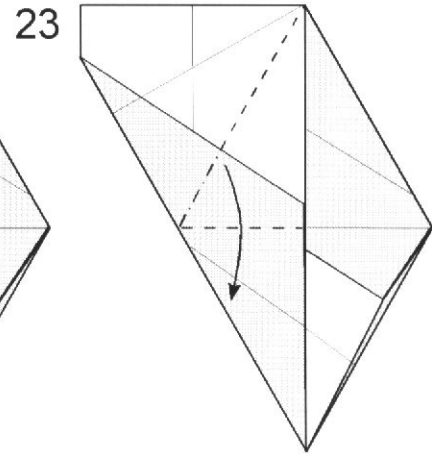
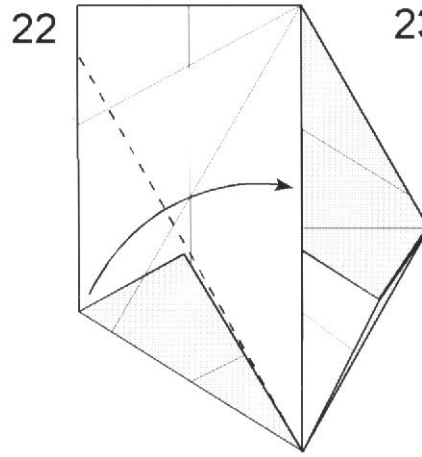
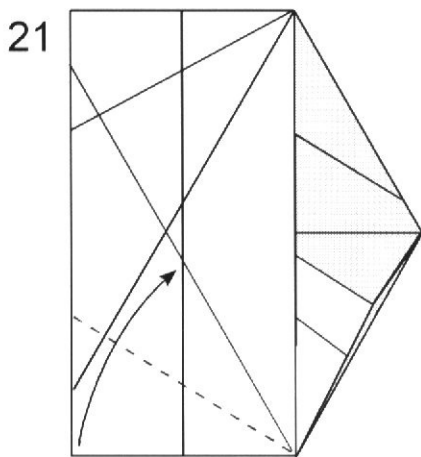
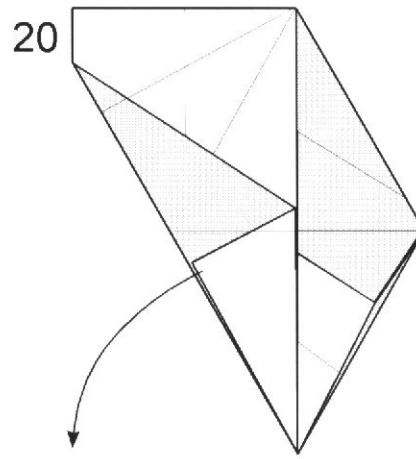
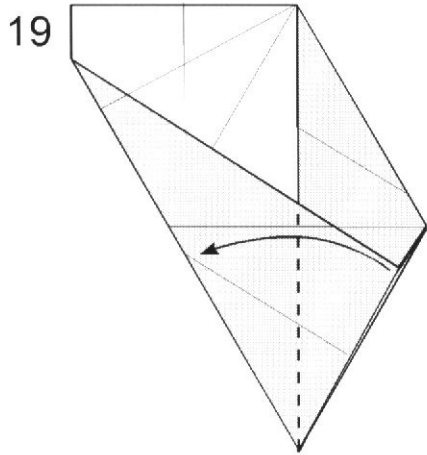
8



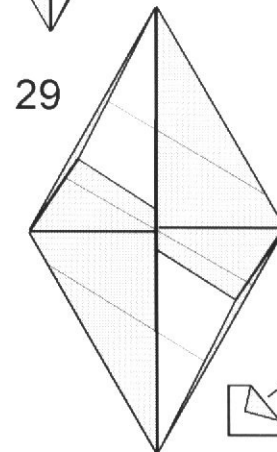
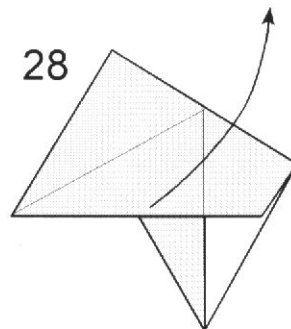
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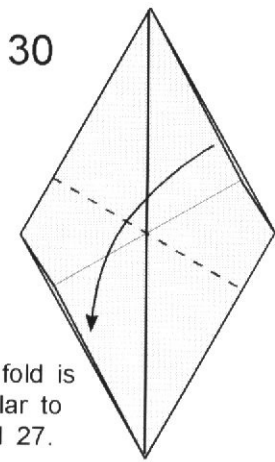




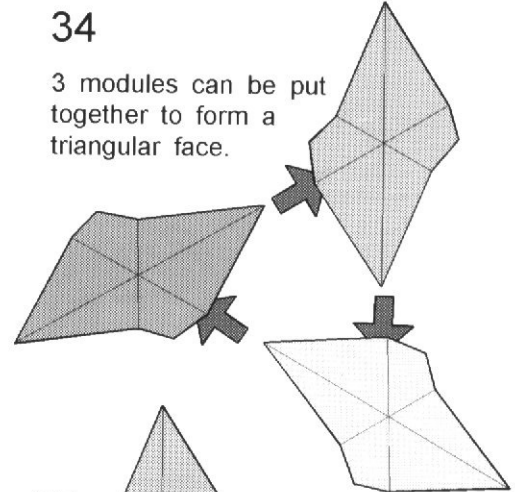
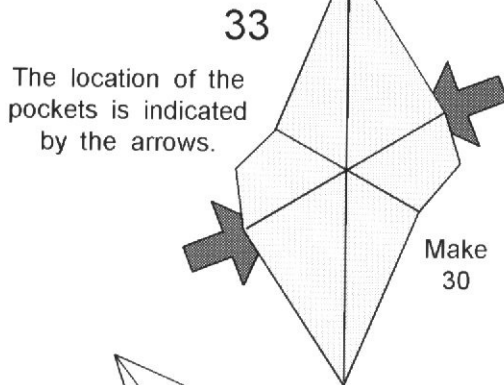
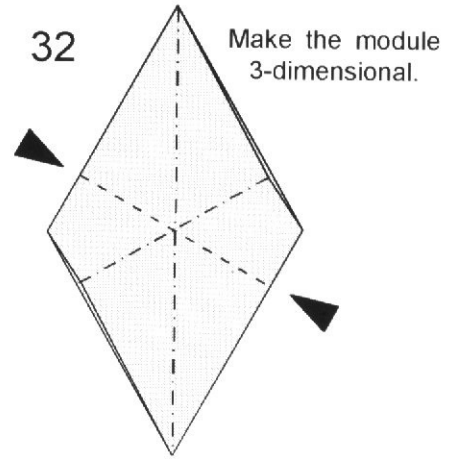
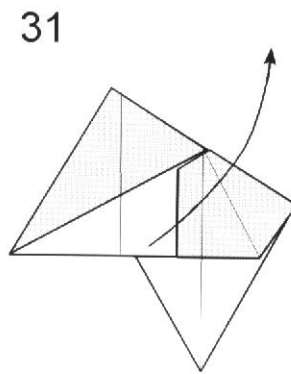


This is quite a difficult fold to make. Note that the crease line is at right angles to the edges of the module and that it passes exactly through the centre-point.

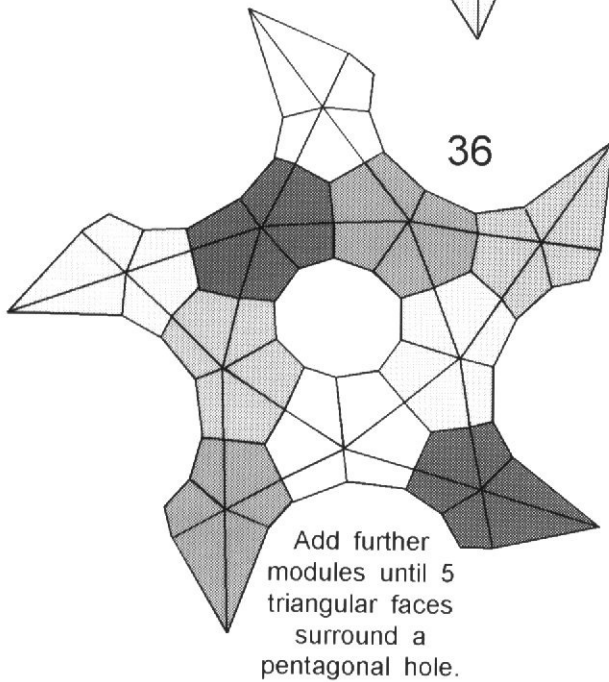




This fold is similar to fold 27.



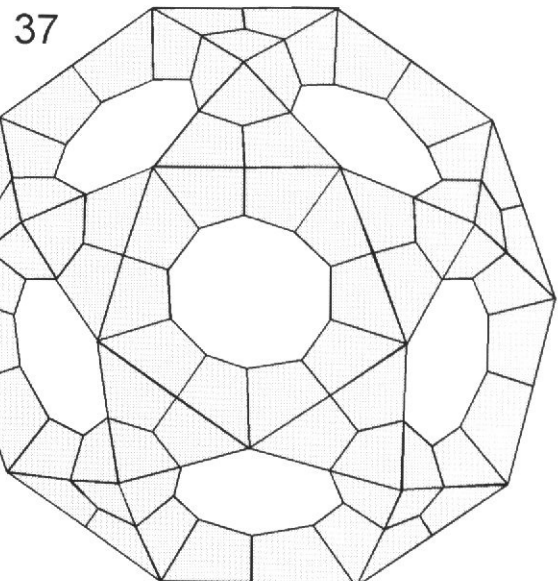
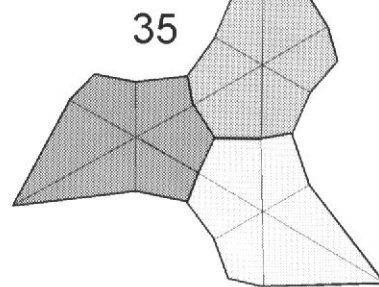
3 modules can be put together to form a triangular face.



In the finished crystal every pentagonal hole is surrounded by triangular faces and every triangular face by pentagonal holes.

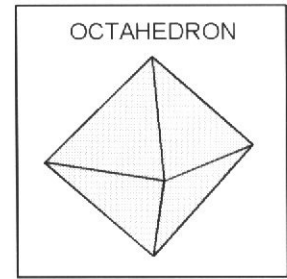
As long as you keep to this pattern while adding the remaining modules the Proteus crystal will automatically form.

A second Proteus crystal can be made by putting 12 modules together in a pattern of triangular faces both surrounding and surrounded by square holes.



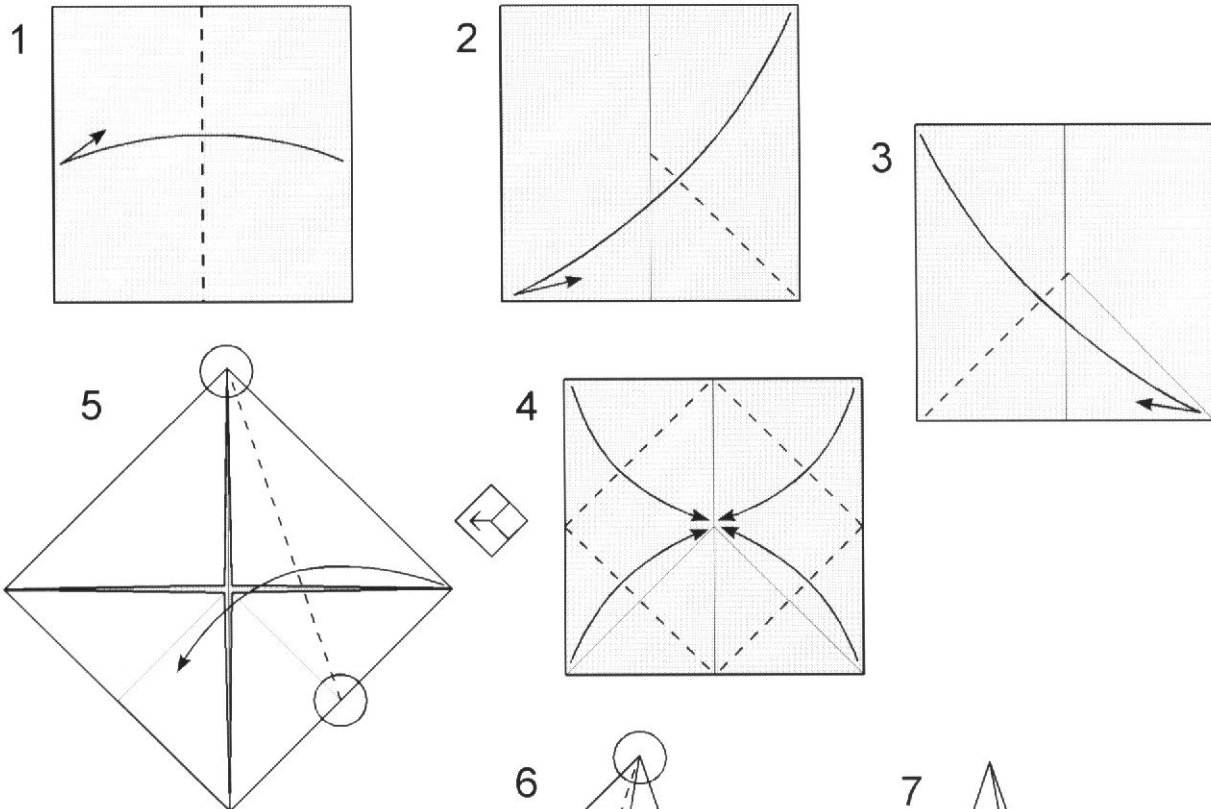
Andromeda

30 sheets of small square paper are required, 24 for the A-modules and 6 for the B-modules. For best effect use 2 plain contrasting but complementary colours.



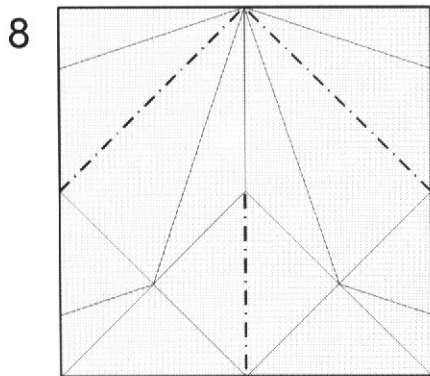
The A-module

If using printed paper begin decorated side up.



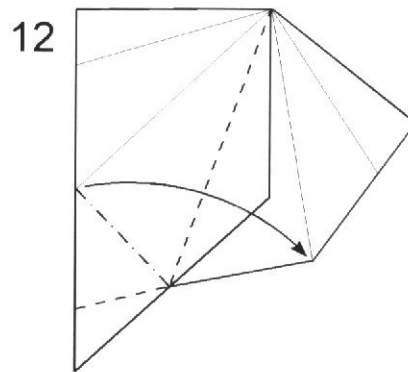
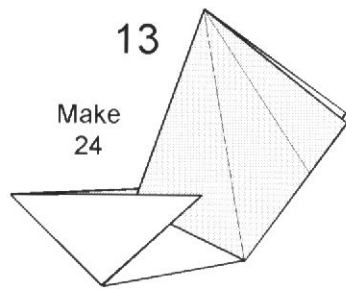
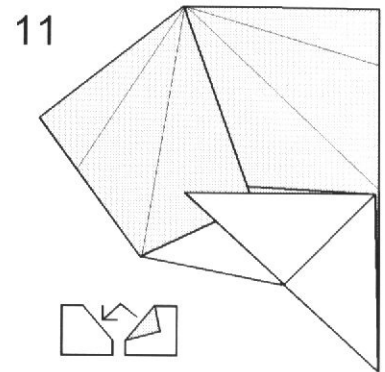
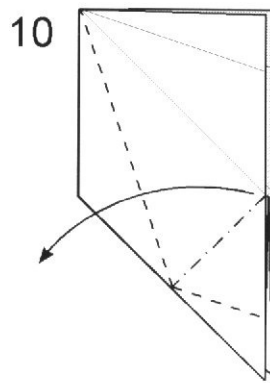
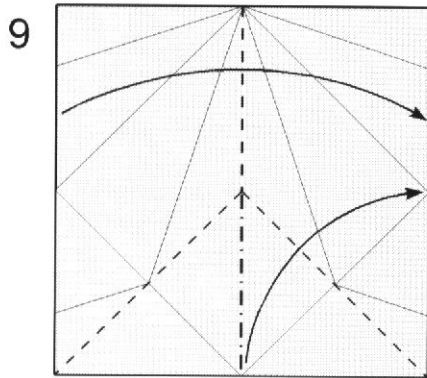
Make sure these creases start and finish exactly at the points marked with circles and that the two layers of the paper do not separate as you make the folds.

Open out completely



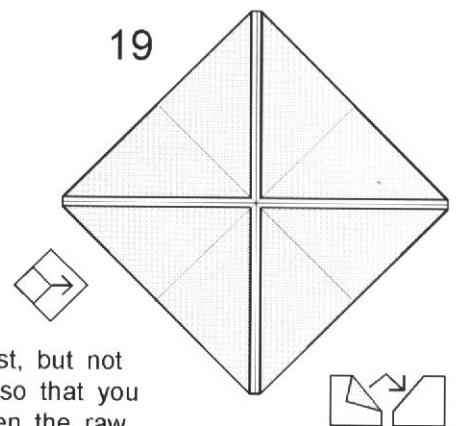
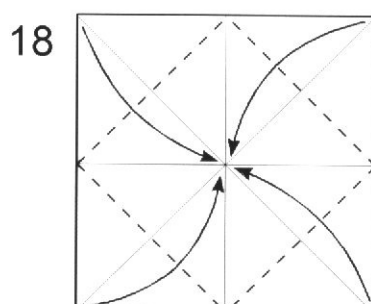
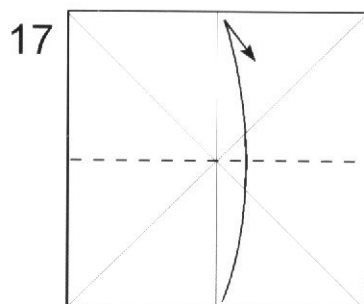
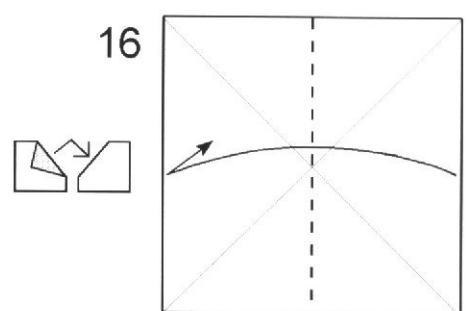
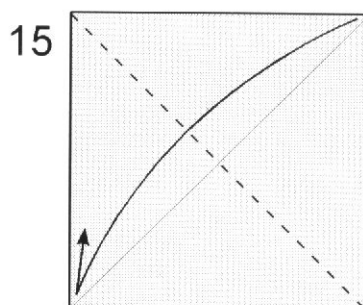
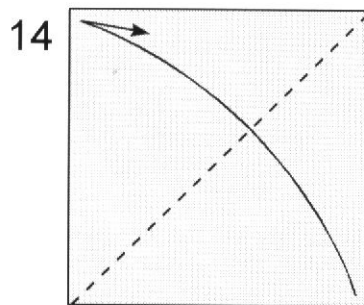
The pattern of the creases should now look like this.

The creases marked with dark lines are currently valley-folds (folds made towards you). Reverse their direction through the paper and turn them into mountain-folds (folds made away from you).

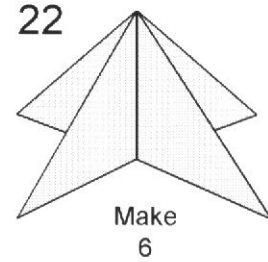
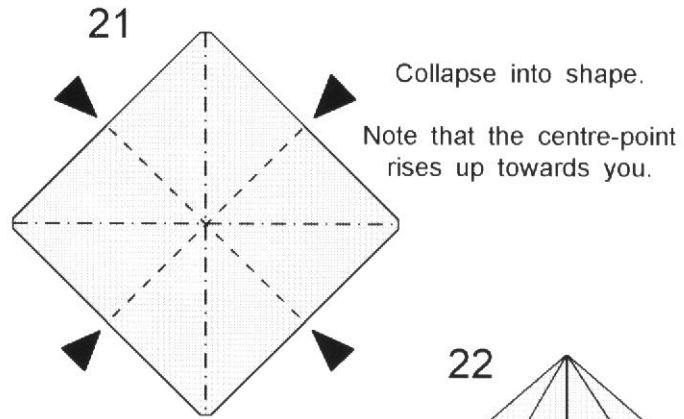
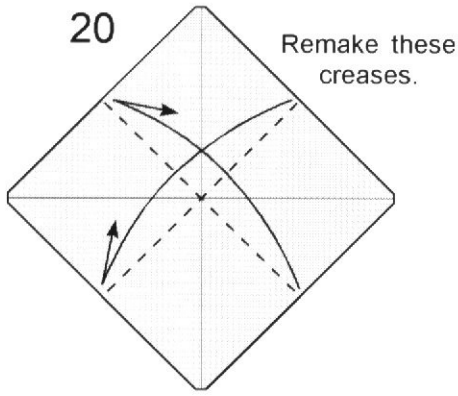


The B-module

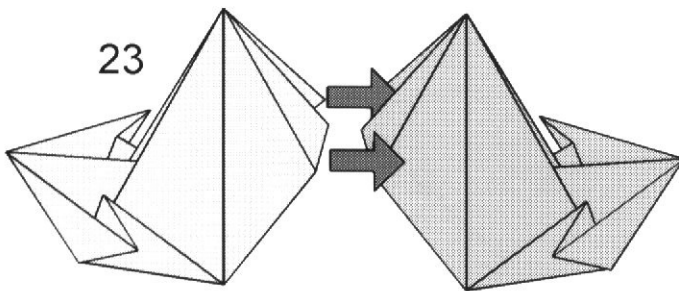
If using printed paper begin decorated side up.



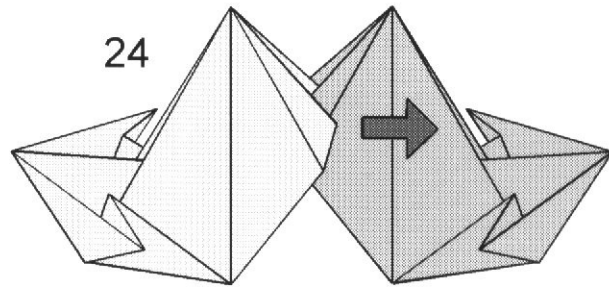
Fold the corners in almost, but not quite, to the centre point, so that you leave a small gap between the raw edges of the paper. The gap shown in picture 19 is slightly exaggerated. A 1mm gap is about right.



Assembling Andromeda

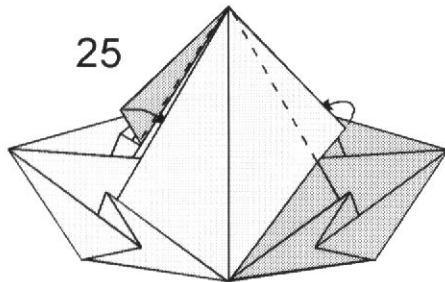


2 A-modules go together like this.

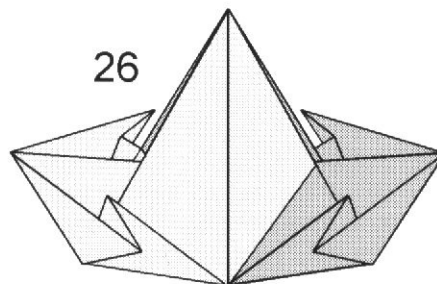


Make sure the nearest flap of the left-hand module and the farthest flap of the right-hand module end up outside the assembly.

The other flaps go inside the assembly. Make sure that all the corresponding parts of each module match up inside.

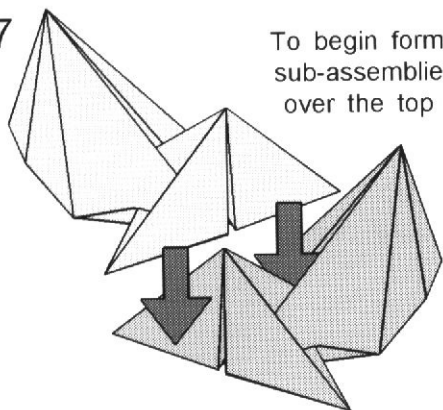


Both outside flaps tuck in to lock the modules firmly together.



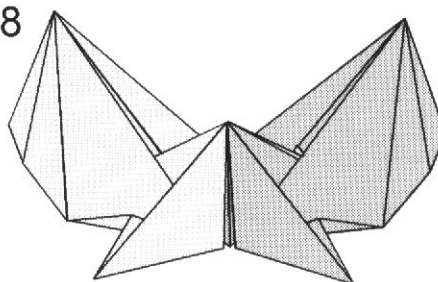
Once you understand how this works take the modules apart again.

27



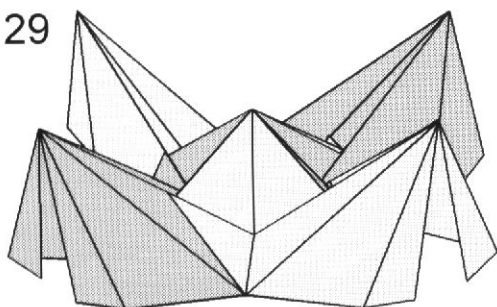
To begin forming the first of the 6 sub-assemblies slot one A-module over the top of another like this.

28



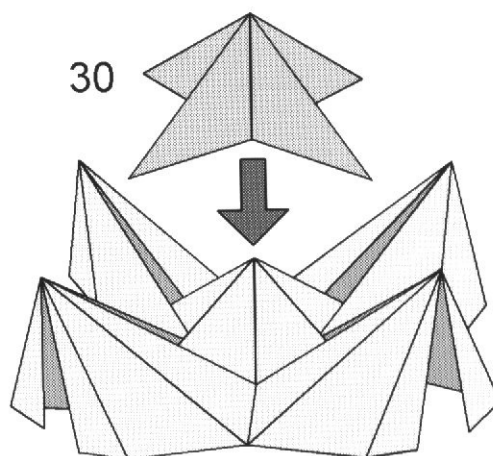
The modules should fit snugly inside each other both on top and underneath.

29



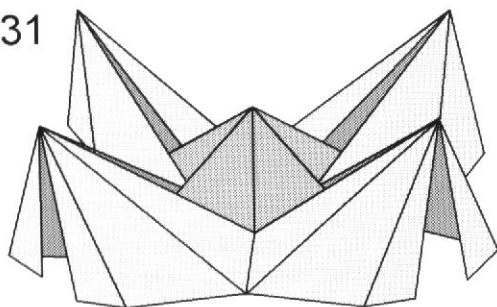
The third and fourth A-modules are added in the same way. The fourth then fits inside the first so that the sub-assembly forms a symmetrical ring.

30



A single B-module fits into the centre of the sub-assembly and holds it together.

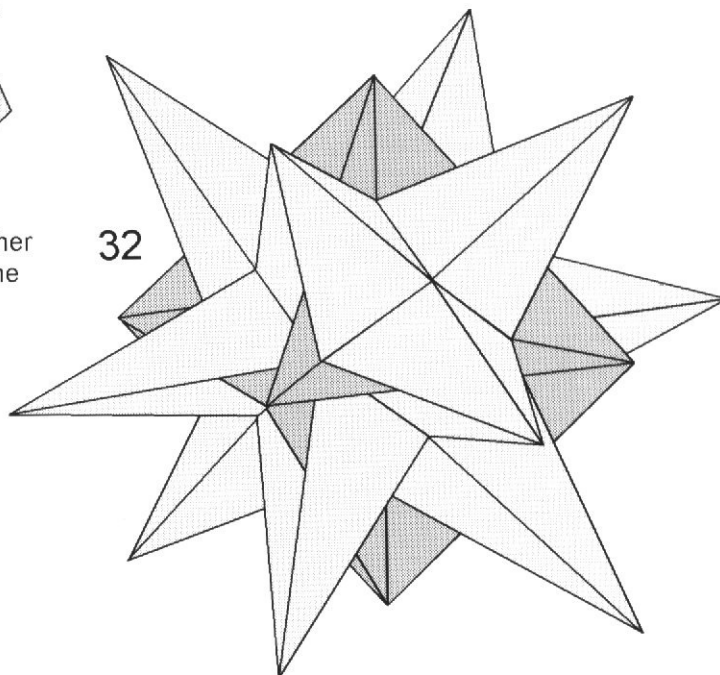
31



Make 6

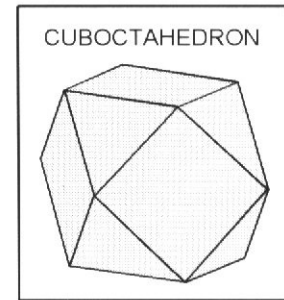
Join the sub-assemblies carefully together using the flaps of the A-modules in the way shown in steps 23 to 26.

32

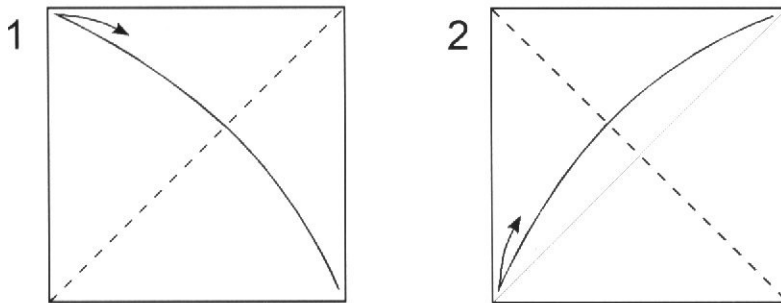


Omega

12 sheets of small square paper are required. For best effect use paper of a single plain colour or paper decorated with a chaotic or random design. Interesting effects can also be obtained by using 3 sheets in each of 4 plain colours or 4 sheets in each of 3 plain colours.

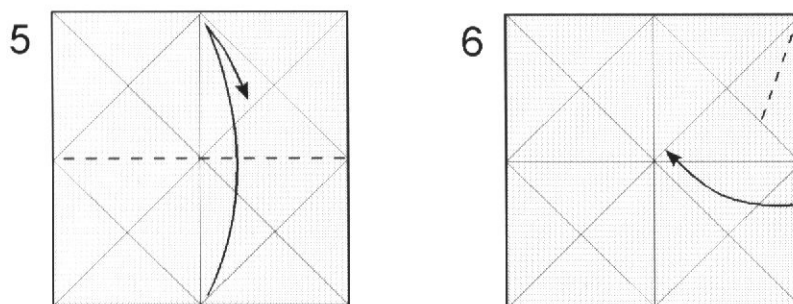
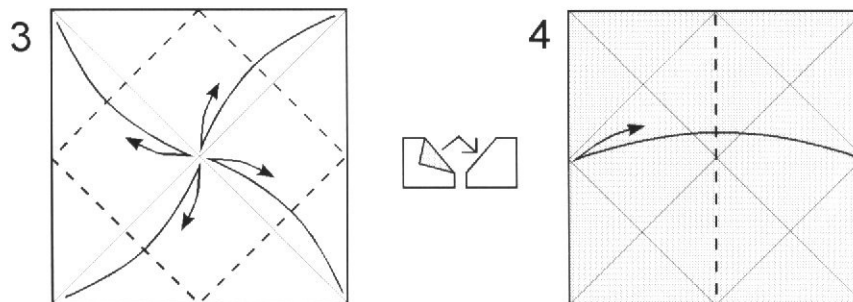


If using printed paper begin white side up.

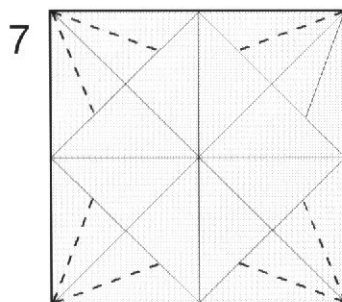


This modular method has also been independently discovered by Robert Neale and Michael Naughton.

Many other ways of making Omega are known.

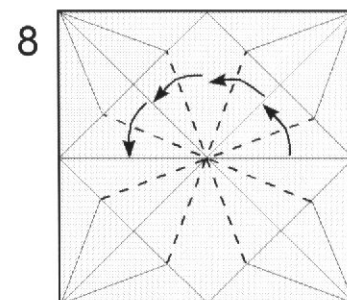


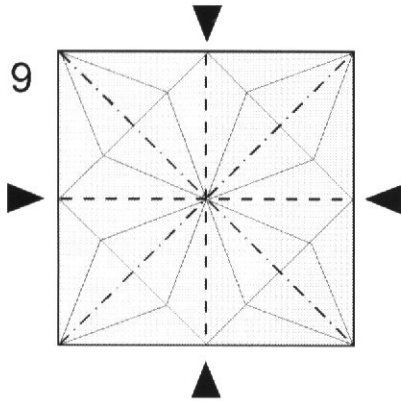
Try to make sure none of the creases made in this and the next 2 steps extend across the edges of the centre square.



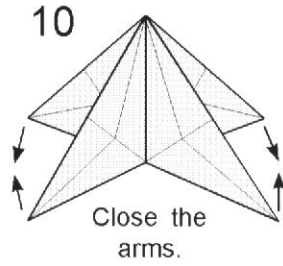
Put in these 7 creases in a similar way.

(The movement arrows would cross each other and so are omitted for clarity here.)

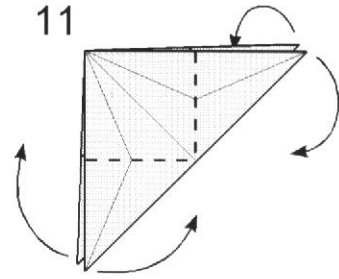




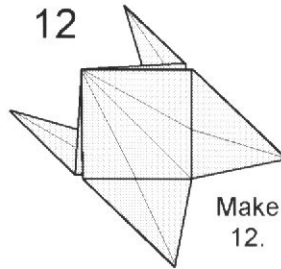
9
Collapse into shape.
The centre-point rises
up towards you.



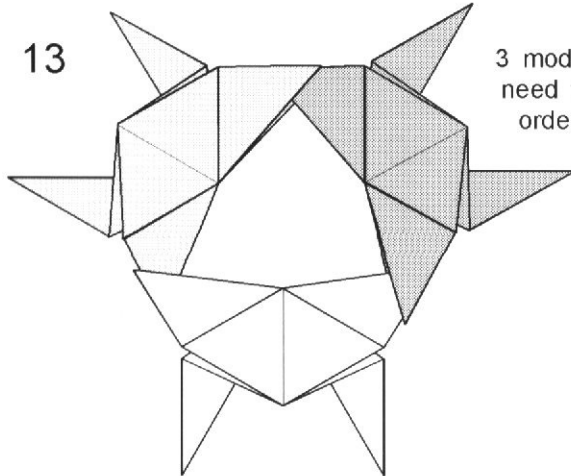
10
Close the
arms.



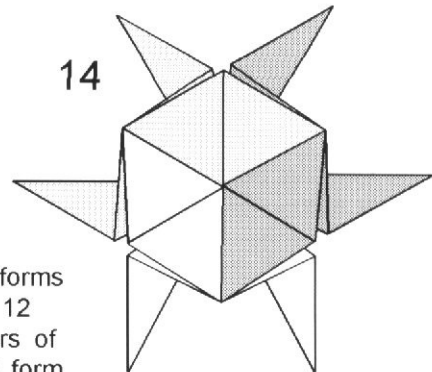
11
Fold the ends of all
4 arms outwards at
right angles



12
Make
12.

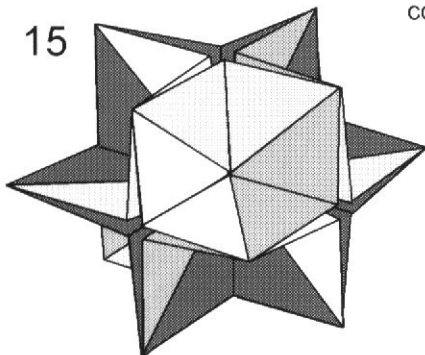


13
3 modules go together like this. You will
need to straighten or curve the arms in
order to slide them completely inside
each other.

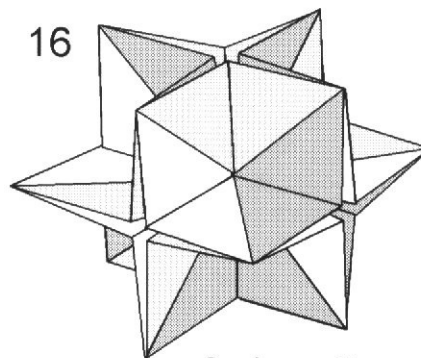


14
Each module forms
one of the 12
outside corners of
the preliminary form.

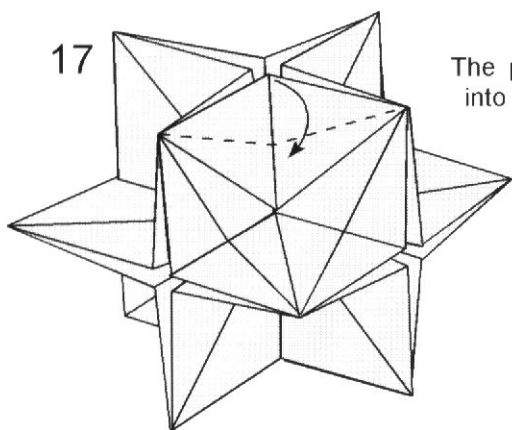
Further modules must be added one by one in the
same way, making sure the pattern of modules (and
colours if appropriate) is maintained, until the
preliminary form is complete.



15
4-colour pattern.

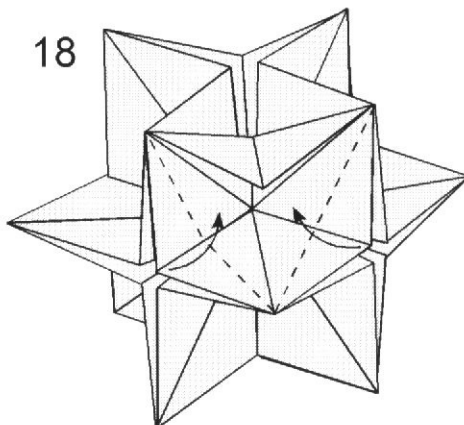


16
3-colour pattern.

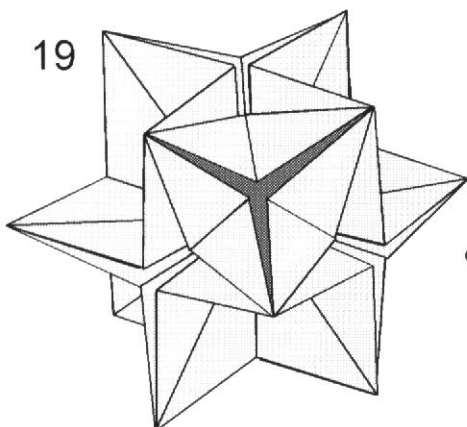


17

The preliminary form is transformed into Omega by turning the edges down to form collars.

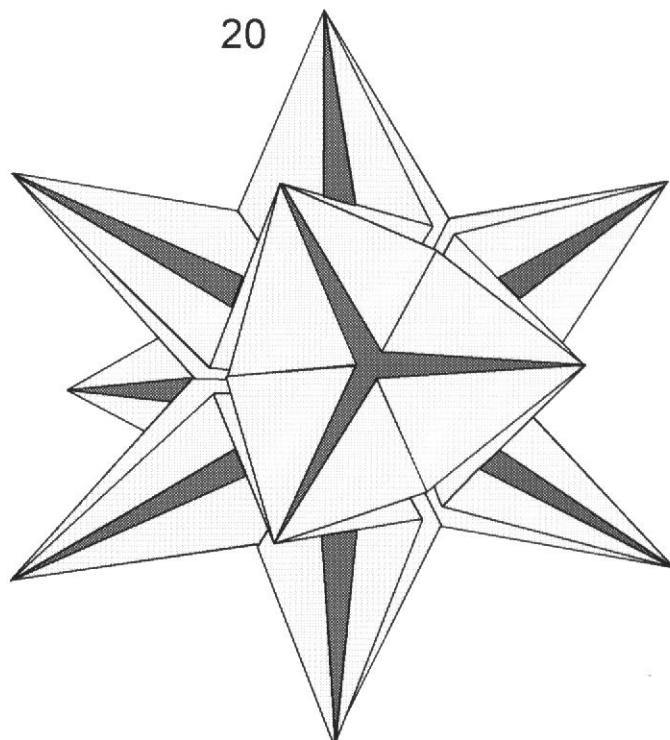


18



19

Continue this process until all the edges have been turned down.



20

Smoothing the collars into gentle curves will further enhance the beauty of this wonderful Paper Crystal.

Omega can be displayed either as a free-standing or a hanging ornament.

In order to hang it you need to thread a piece of cotton through the apex of one of the modules and glue it securely in place inside one of the arms.

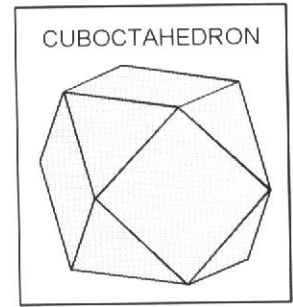
The preliminary form shown in pictures 15 and 16 was first discovered by Ed Sullivan, one of the early pioneers of modular origami in the USA. He christened it XYZ.

Sullivan's original XYZ was made from just 6 modules. The Enigma Cube diagrammed on pages 39 to 42 uses a similar modular method.

The form of Omega was developed from Sullivan's original XYZ by Philip Shen.

The Enigma Cube

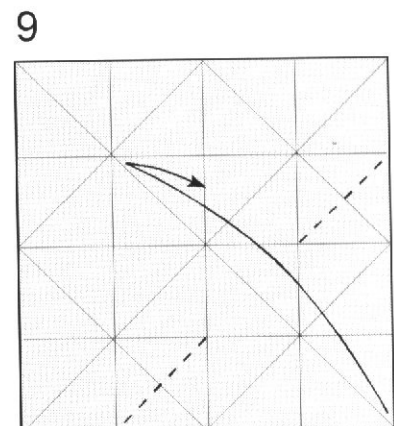
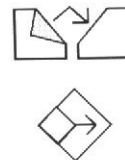
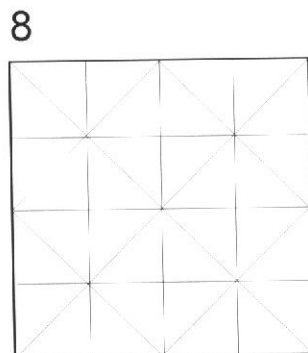
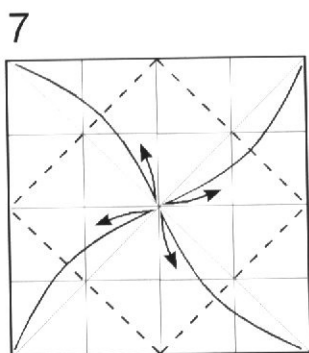
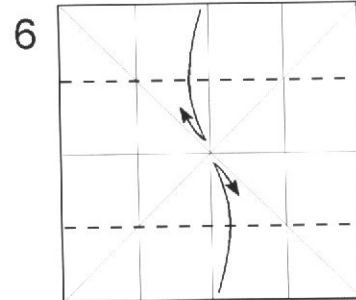
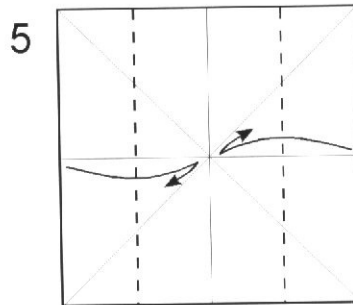
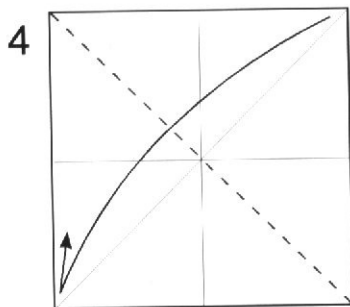
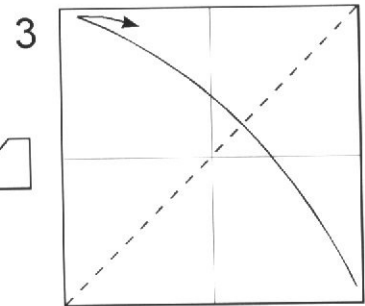
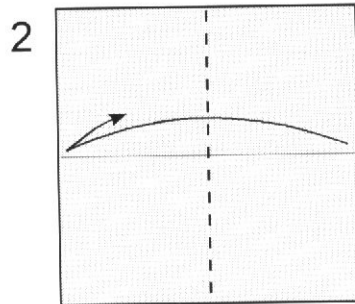
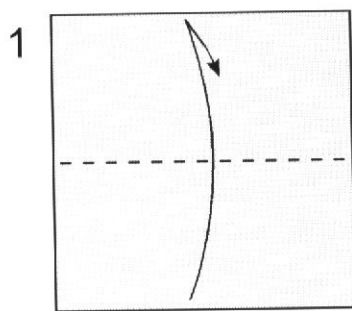
There are three quite different ways to make the Enigma Cube, each of which present their own particular challenges. 2 of the methods are explained here.



The 6-module method.

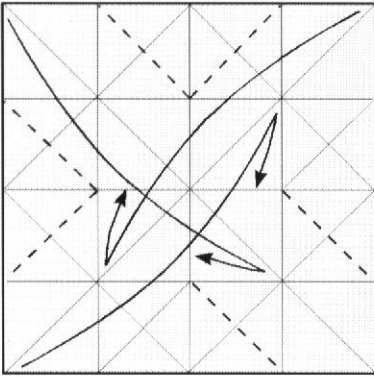
6 sheets of large square paper are required. For best effect use paper decorated with a random or chaotic design. You will get a better result using fairly stiff paper, and a better result still using paper backed with foil.

If using printed paper begin white side up.



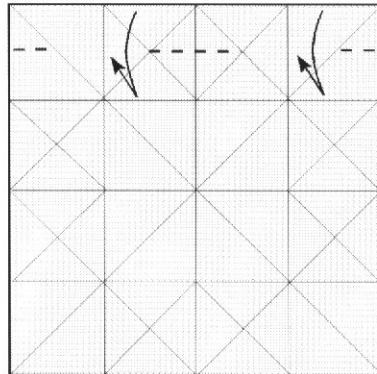
Be careful not to crease the paper all the way across the fold.

10



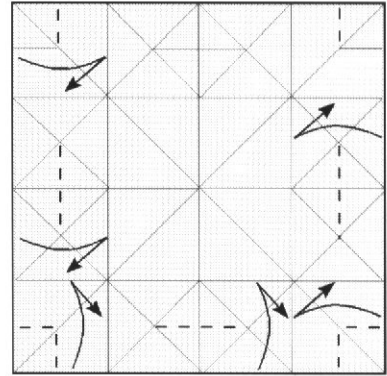
Put in these creases in a similar way.

11



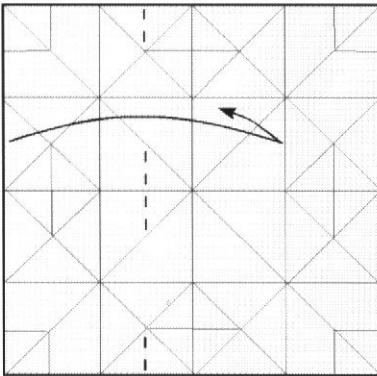
Be careful not to crease the paper all the way across the fold.

12



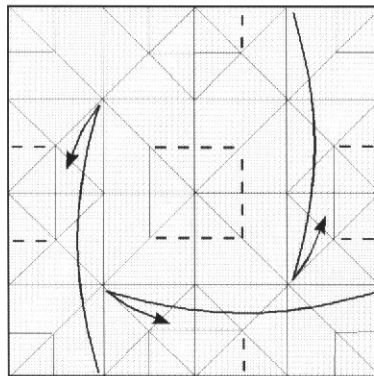
Put in these creases in a similar way.

13



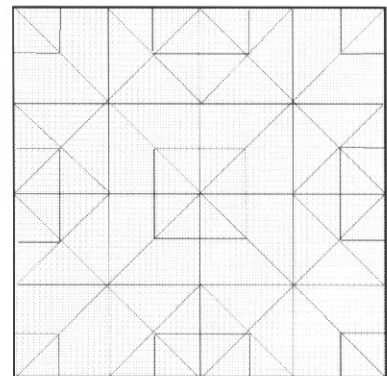
Be careful not to crease the paper all the way across the fold.

14



Put in these creases in a similar way.

15

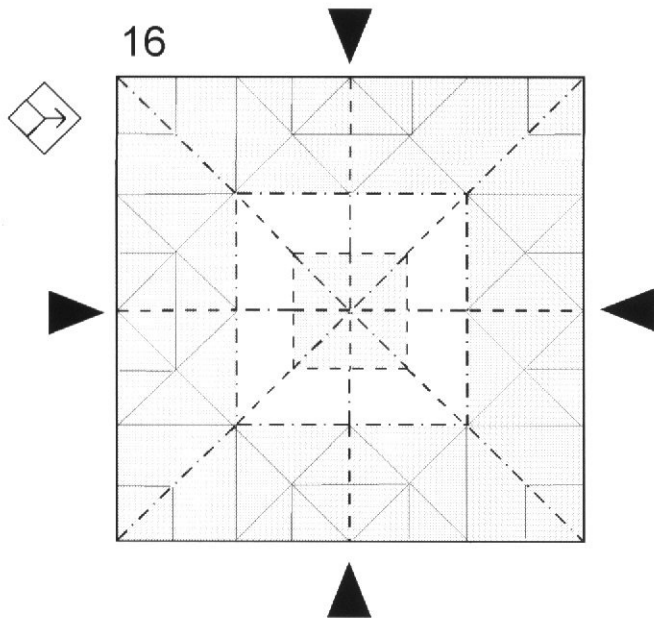


Check that all these creases are present and correct.

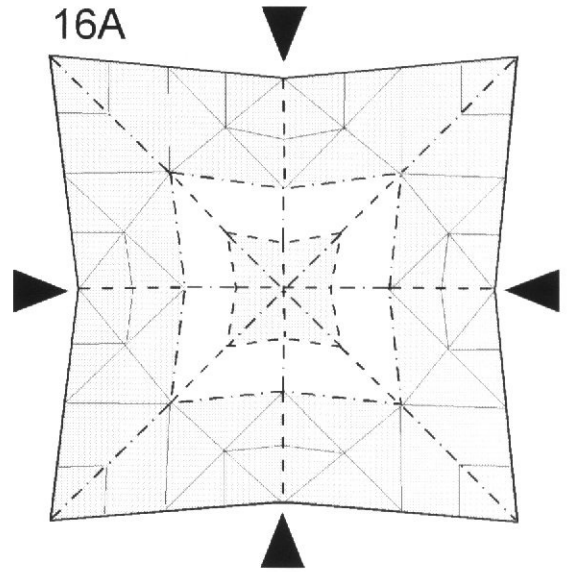
The 6-module method explained here is developed from a variation of XYZ, the preliminary form of Omega.

Although it suffers from the slight aesthetic defect that the curved collars are criss-crossed by rather too many creases (a defect that can be overcome by the use of foil-backed paper), this method is included because it provides the easiest bridge to an understanding of the form.

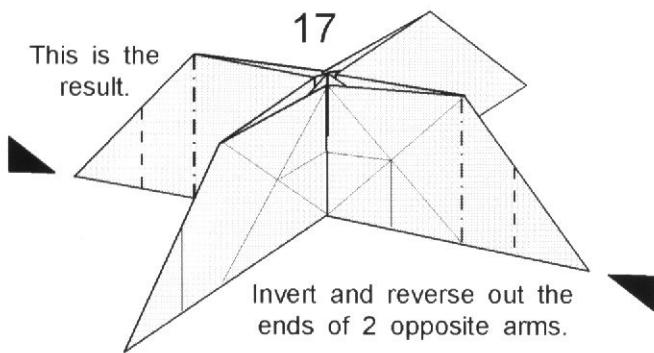
This method is also in itself a third fine example (the other two being Cloud of Stars and Omega) of the way in which it is occasionally possible to develop one 3-dimensional form from another after the modules have been assembled.



16
 Make 3-dimensional. The white area sinks and the central shaded area rises up to a point inside the sunken area.

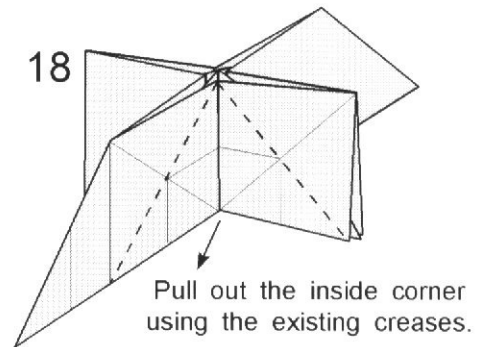


16A
 The collapse underway.

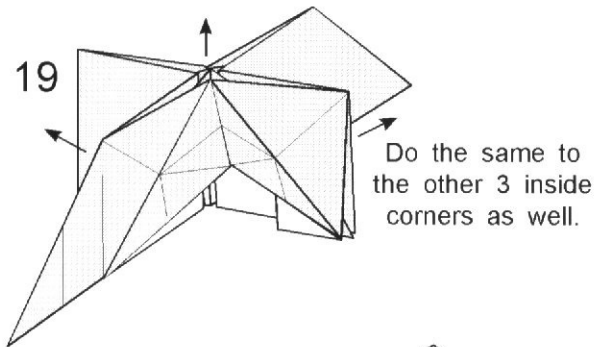


This is the result.

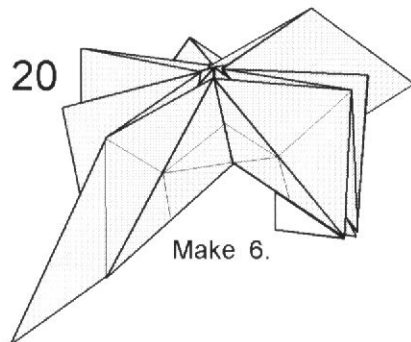
17
 Invert and reverse out the ends of 2 opposite arms.



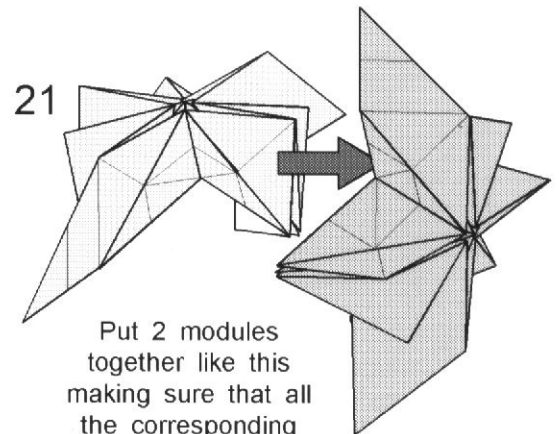
18
 Pull out the inside corner using the existing creases.



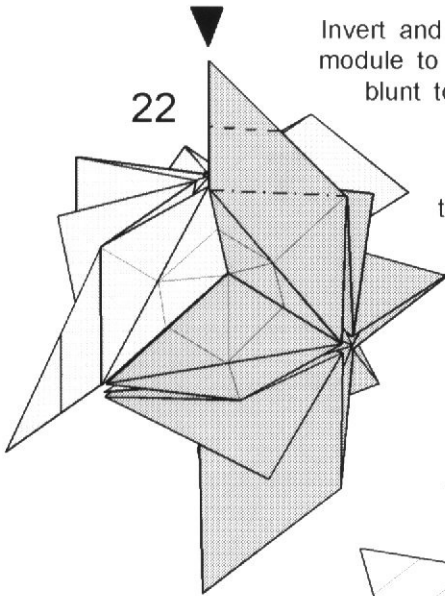
19
 Do the same to the other 3 inside corners as well.



20
 Make 6.



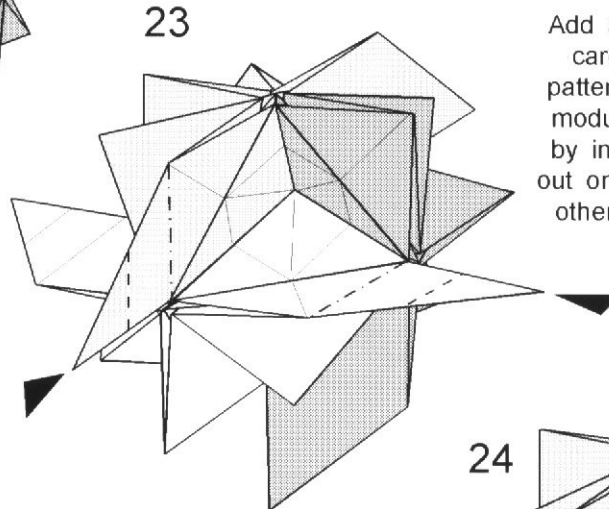
21
 Put 2 modules together like this making sure that all the corresponding parts of each module match up correctly inside.



22

Invert and reverse out the ends of the upper arm of the outer module to lock the modules together. You may find that a thin blunt tool is useful to help ease the layers of the outer module completely inside the joint.

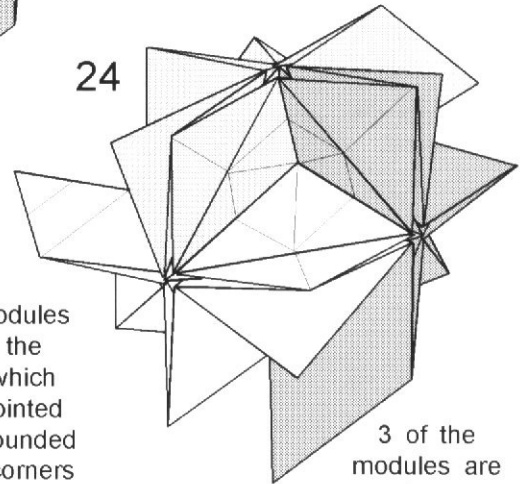
Make sure you don't create any new creases while you do this. The look of the finished model depends on achieving a good degree of accuracy here.



23

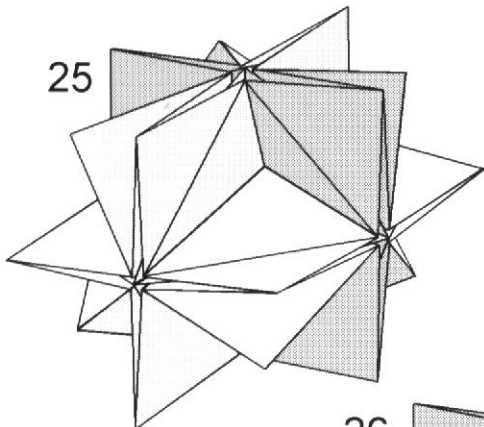
Add a third module, being careful to maintain the pattern of the weave. This module is locked in place by inverting and reversing out one flap on each of the other modules as shown.

Inverting the locking flaps becomes progressively more difficult as the remaining modules are added.



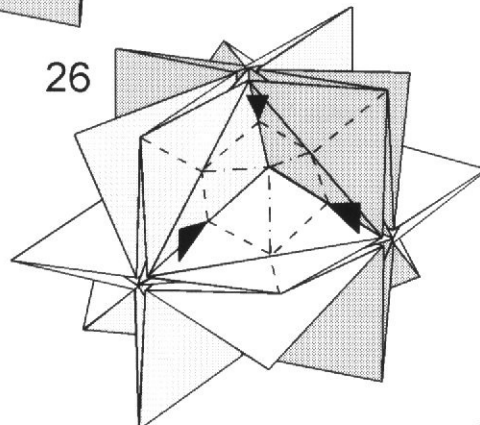
24

3 of the modules are now in place.



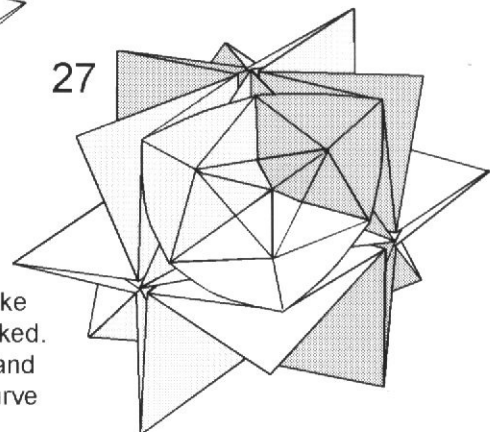
25

Continue to add modules one by one until the preliminary form, which consists of an 8-pointed star-like shape surrounded by the 12 outside corners of XYZ, is complete.



26

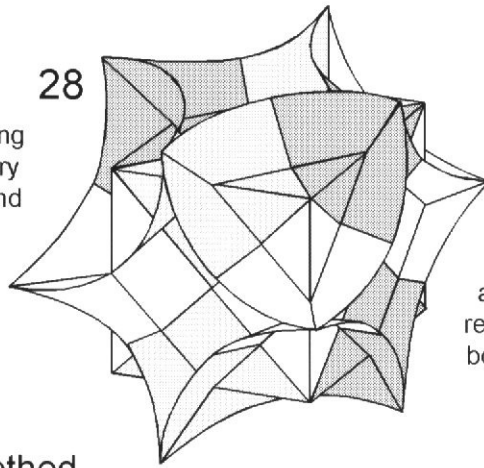
Transform one of the corners of the central star-like shape by pushing in gently at the three points marked. As you do this a smaller square corner will form and the surrounding flaps will be pulled into collars. Curve the collars gently to hold the form secure.



27

28

Transform the 7 remaining corners of the preliminary form in a similar way and the Enigma Cube will mysteriously appear.

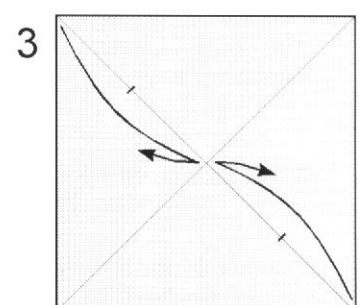
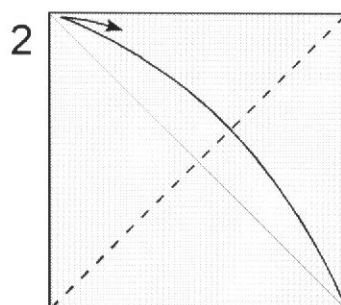
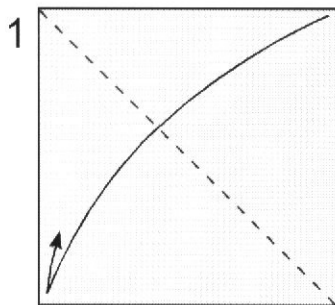


To improve the finished appearance of the crystal, gently remake the creases inside the top, bottom and sides and work all the collars into even curves.

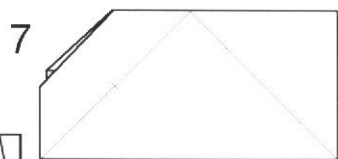
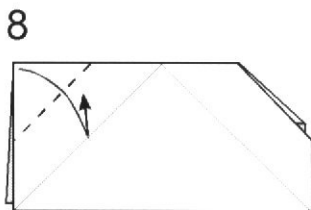
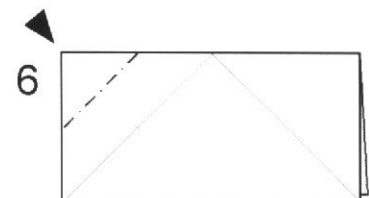
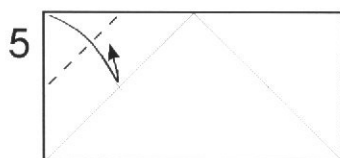
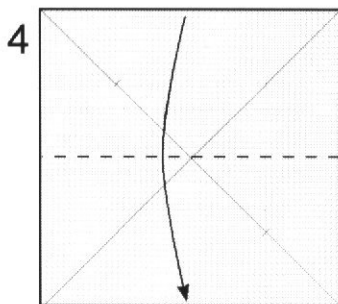
The 12-module method.

12 sheets of small square paper are required. For best effect use 4 sheets in each of 3 contrasting but complementary plain colours.

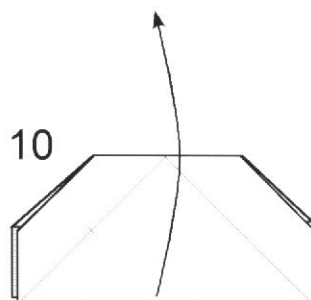
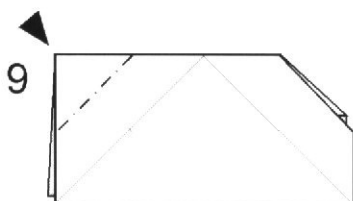
If using printed paper begin decorated side up.



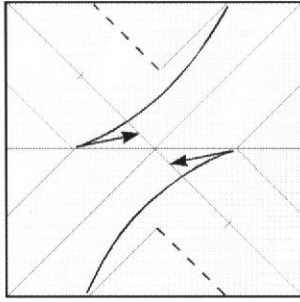
Make pinch marks at the quarter points of one diagonal.



Be careful not to crease the paper all the way across these folds.

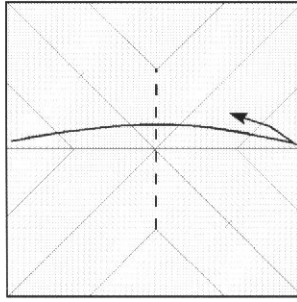


12



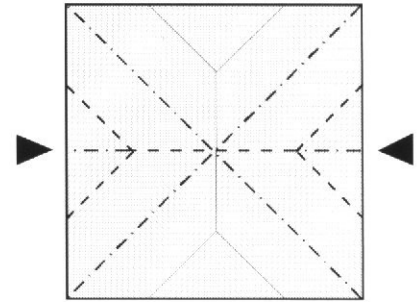
Be careful not to crease the paper all the way across the folds.

13

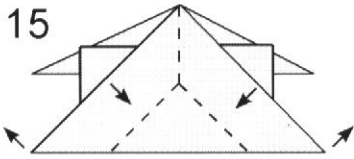


Be careful not to crease the paper all the way across the fold.

14

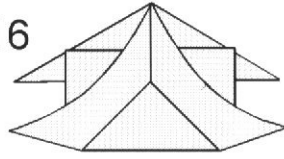


15



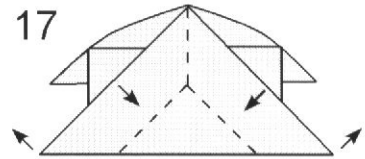
Curl the edges of the arms in the directions shown.

16

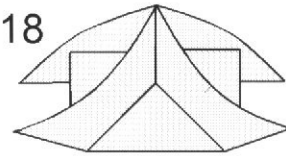


The tension in the creases should hold the curves firmly in place.

17



18

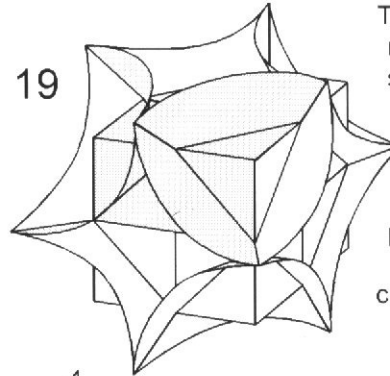


This 12-module method was devised by David Brill.

It produces a wonderfully clean result, but the modules can be hard to assemble unless you already have a good understanding of how the central cube and the collars are formed.

Valerie Vann has designed an 'Enigma Cube without the Cube' using 24 even simpler modules.

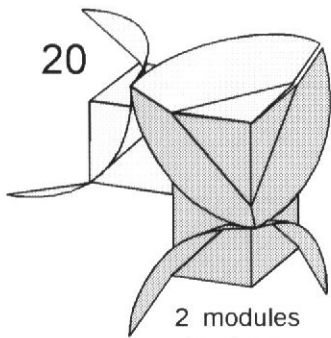
19



This diagram shows the relationship between a single module and the Enigma Cube as a whole.

The arms with visible pinch-marks should be concealed inside the clean arms as assembly proceeds

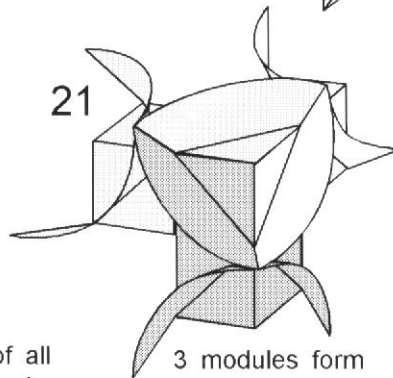
20



2 modules in place.

Make sure the curve of all the collars is maintained. This will make the assembly process much easier.

21



3 modules form one corner of the cube.

If you maintain this pattern as you add the remaining modules the Enigma Cube will automatically form.

22

