

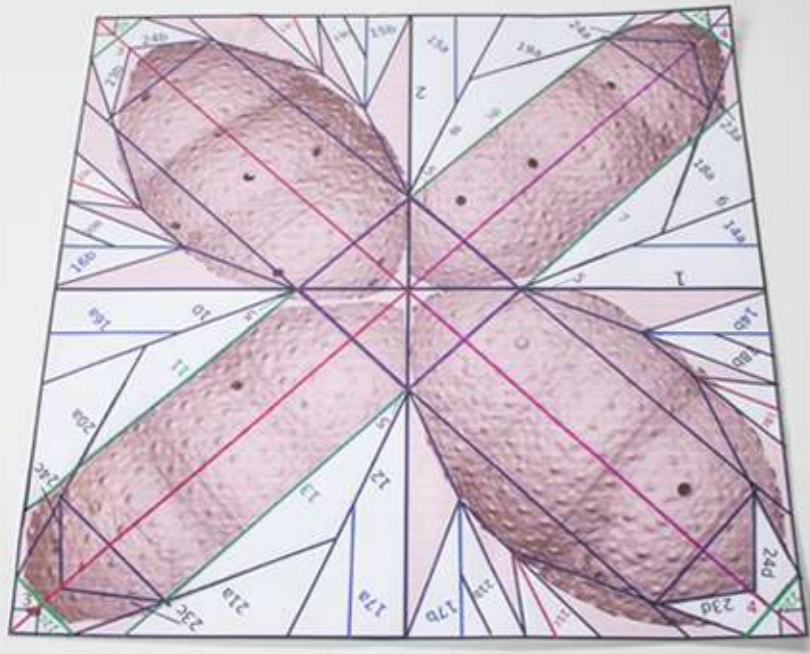
How to Build  
**An Origami Model of  
Covid-19**  
the SARS-CoV-2 Virion



For Video  
Instructions:

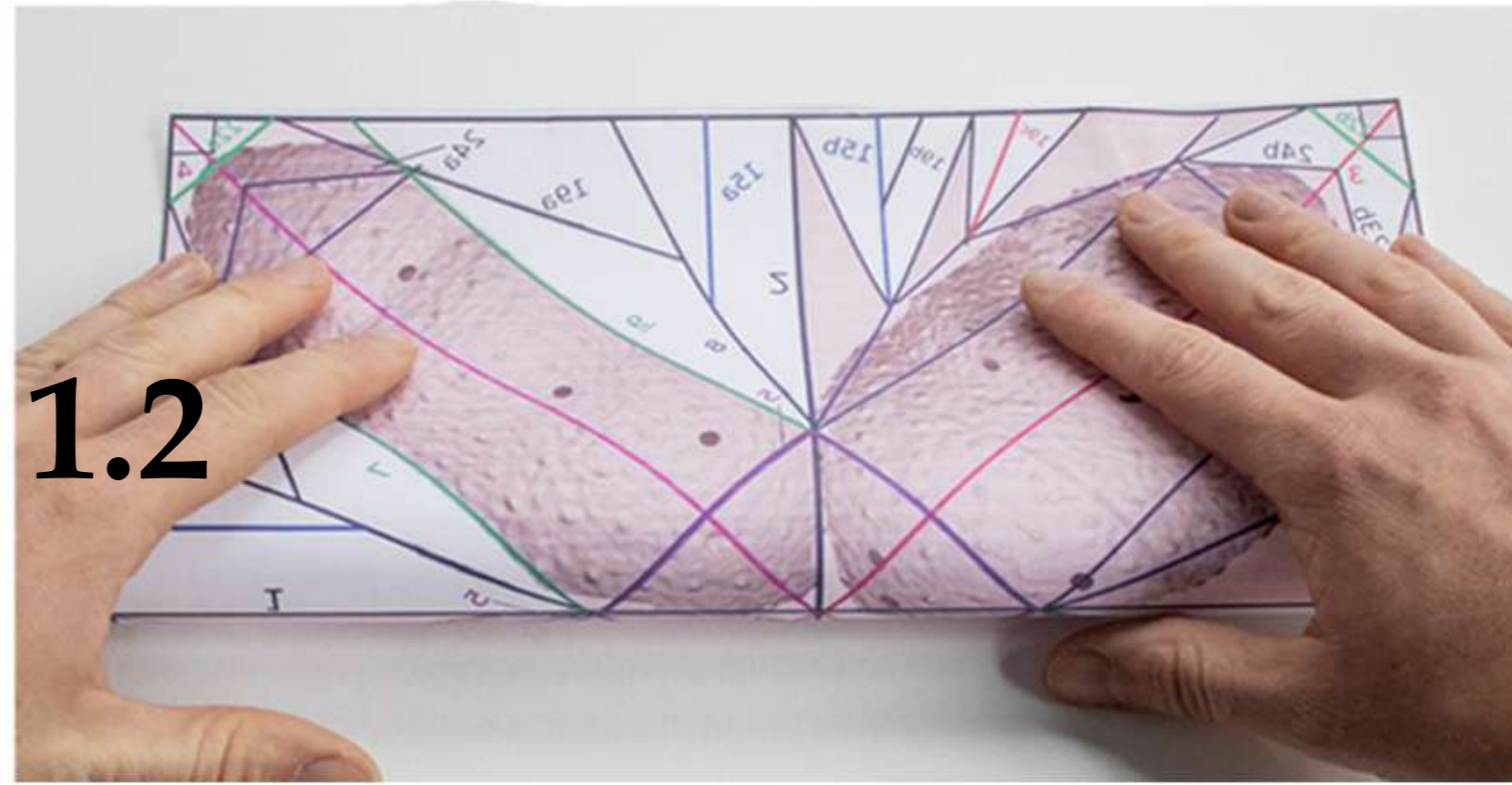
Scale:  
1,500,000 : 1  
15 cm : 100 nm



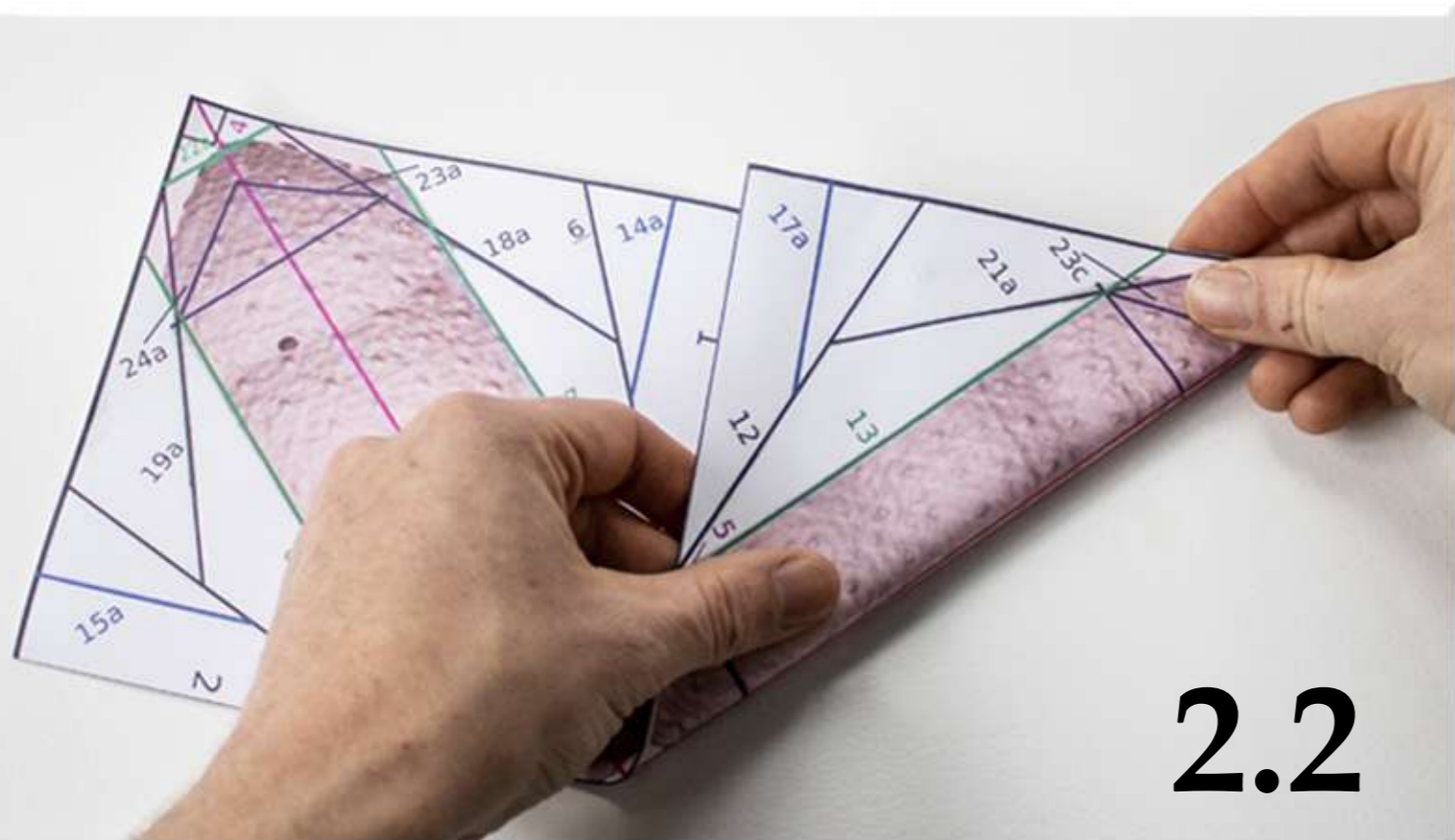


**1.1** Place the square virion sheet facing up on a hard surface. Fold in half along crease/line 1 with the printed side visible, then unfold. Rotate the sheet by 90° and fold in half along line 2.

This should result in the sheet being folded in half along line 2 with the opened end at the top, a crease down the middle, and the “lemon” shaped design on the right-hand side.

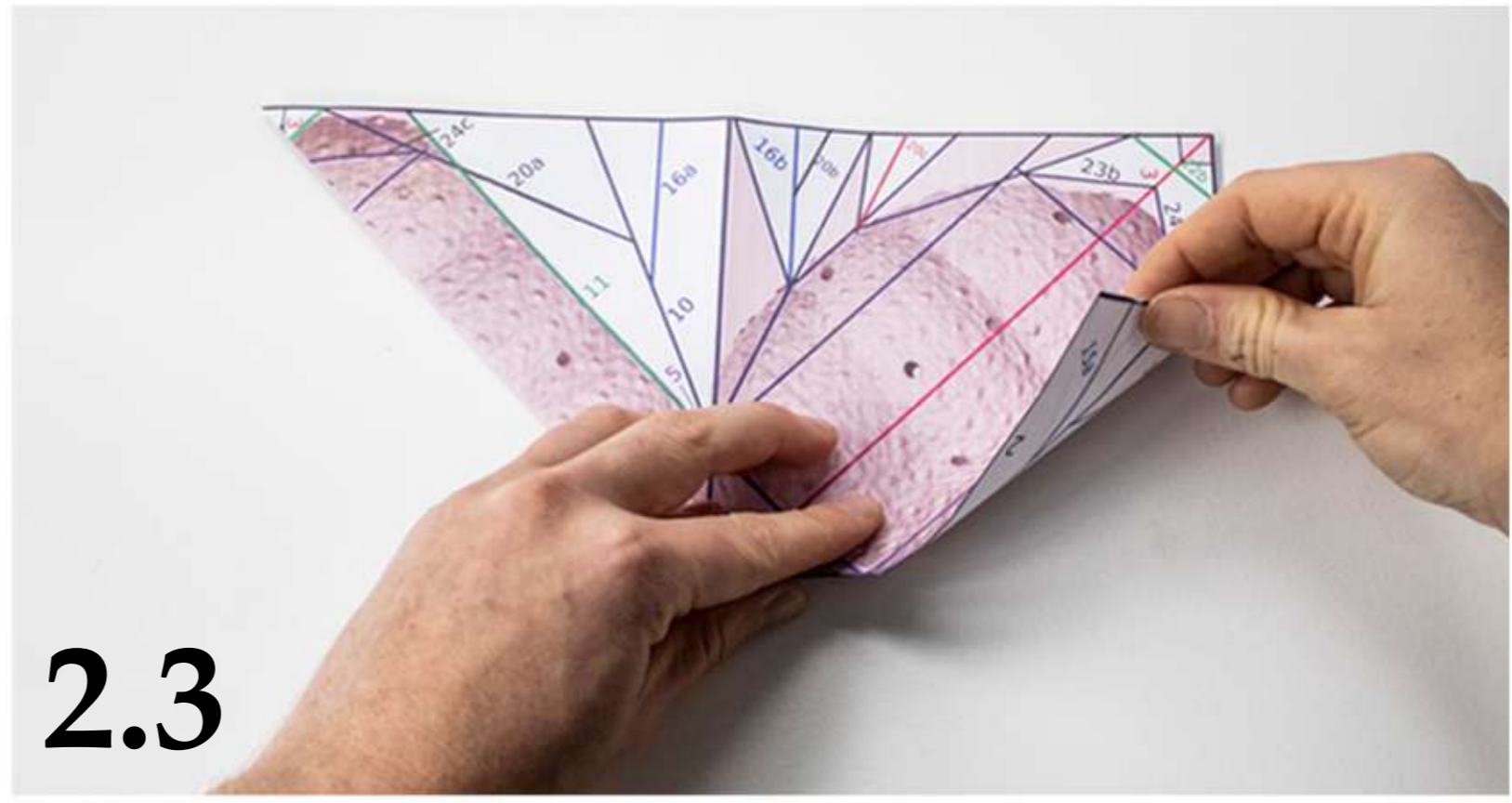


**1.2**



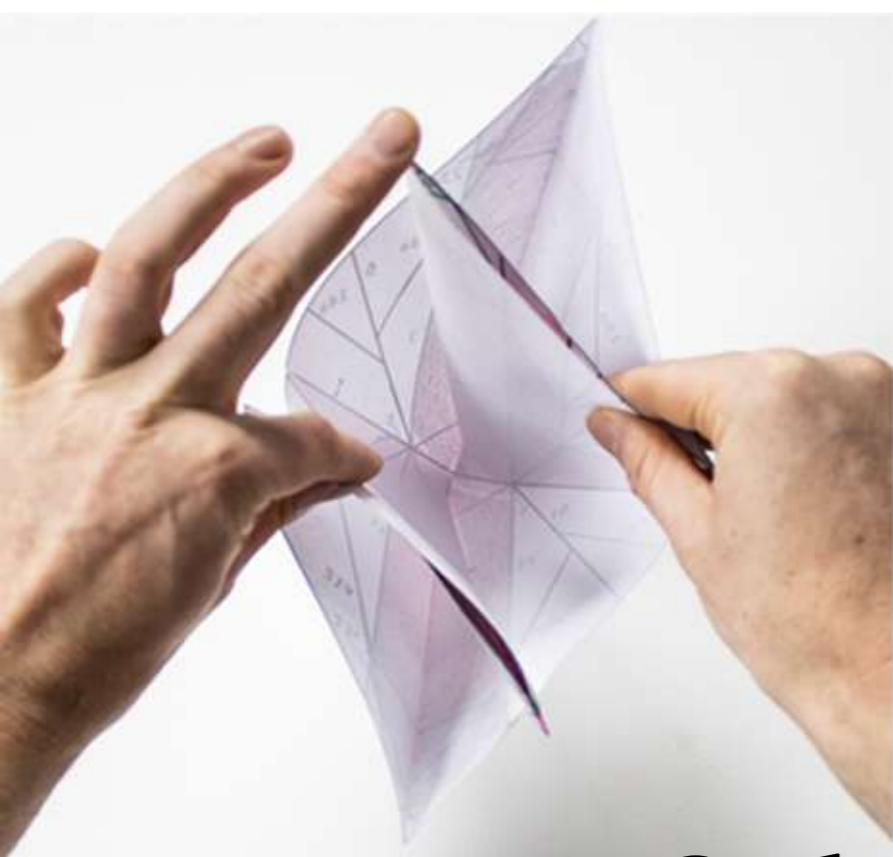
**2.2**

With the half sheet in front of you bring the right hand bottom corner to meet the centre of the top edge folding along line 3.



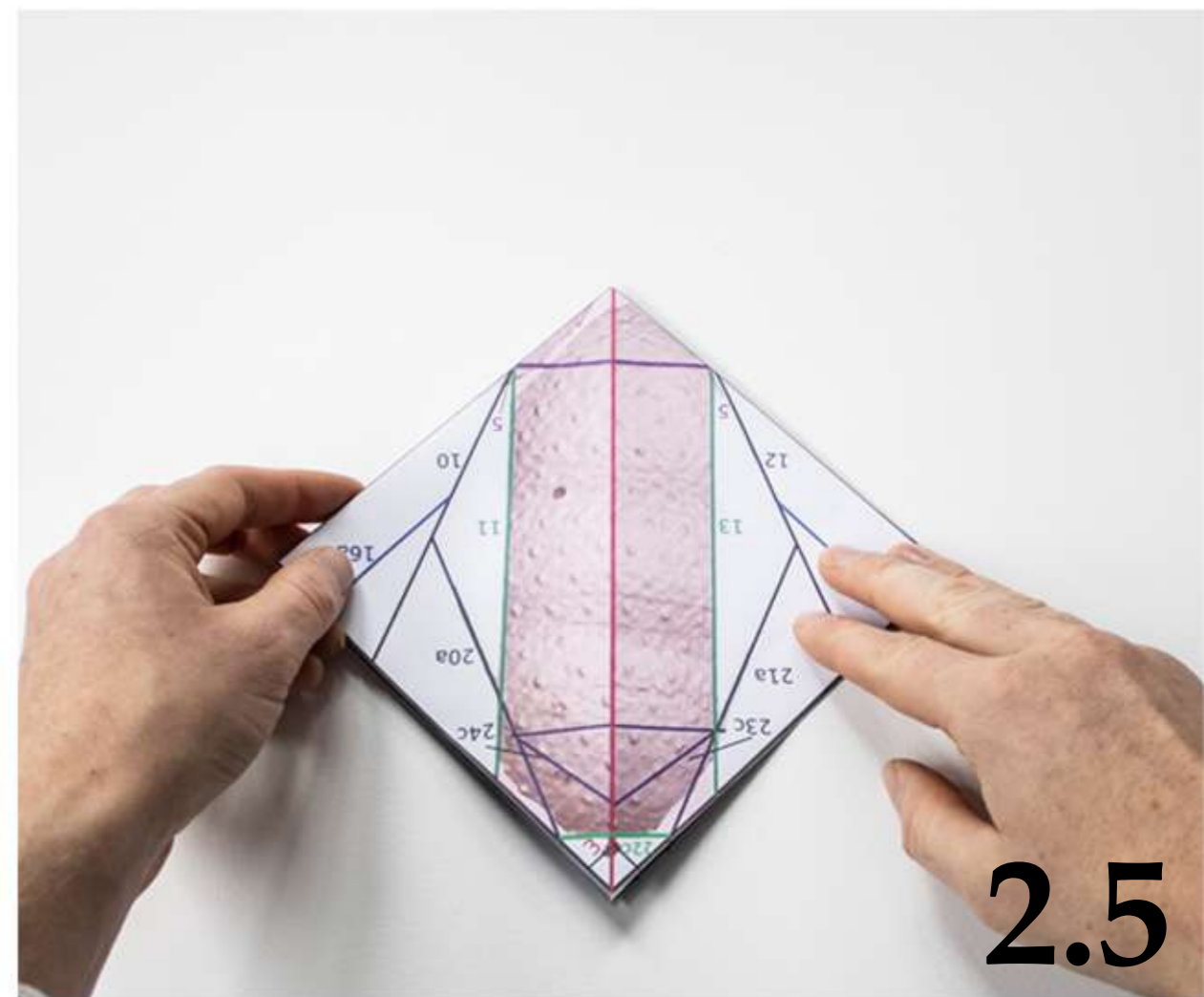
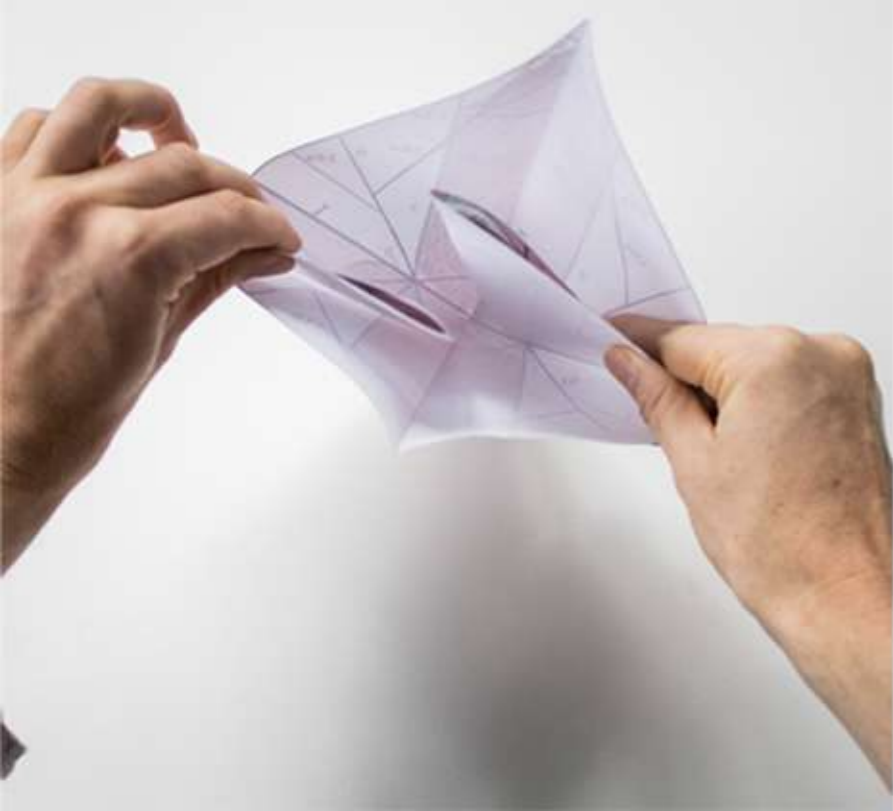
**2.3**

Flip over the sheet and again bring the bottom right corner to meet the centre of the top edge, folding along line 4.



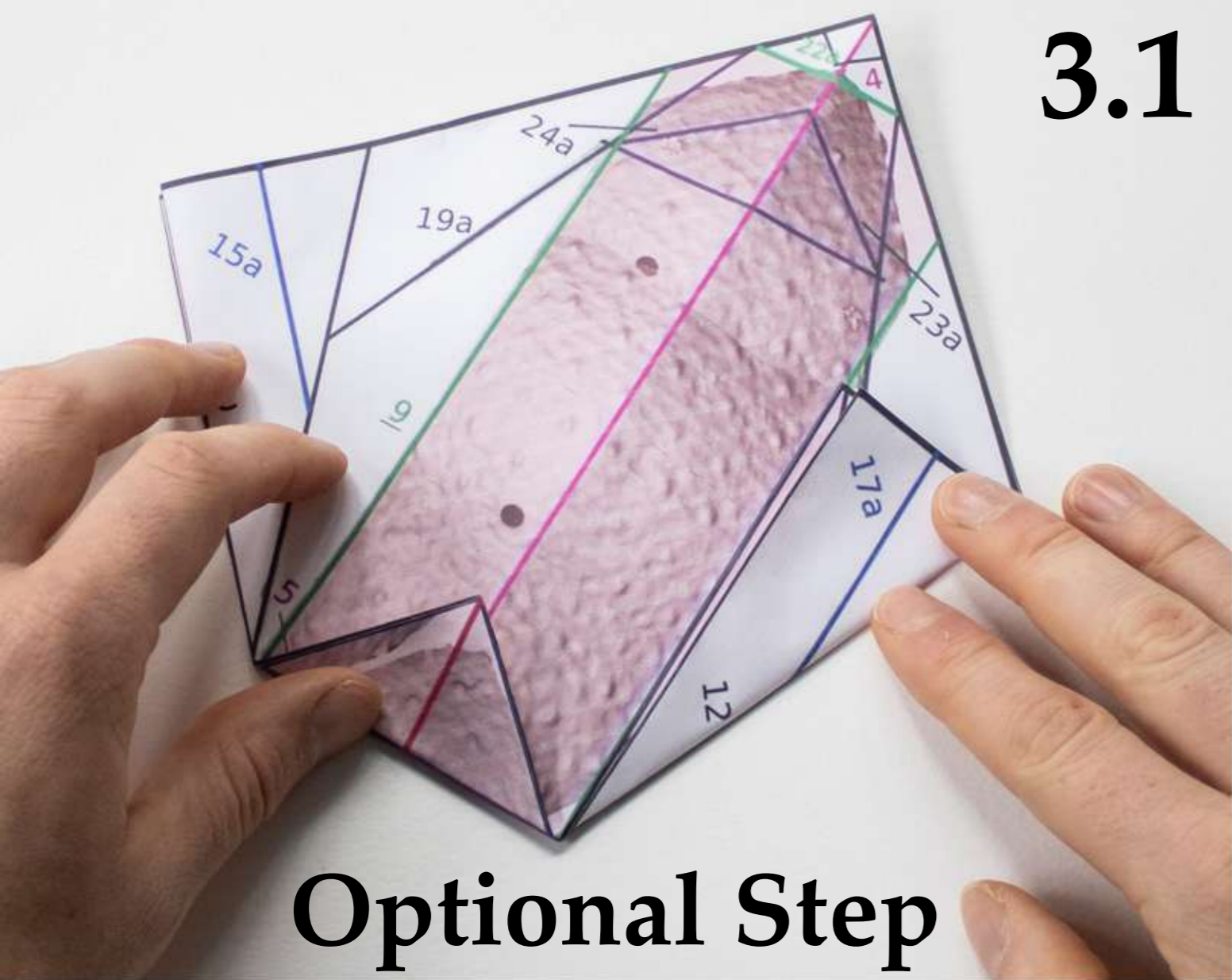
**2.4**

Lift the sheet up with the top open edge facing you. Insert your fingers into the newly created internal pockets. Twisting the internal flaps so they meet edge on while simultaneously pulling the sheet open so it creases along line 1. This should change the shape of the sheet from a triangle to a square.



**2.5**

The square you should now have is half the size or a quarter of the surface area of the original. Rotate this by 180° ready for the next step.

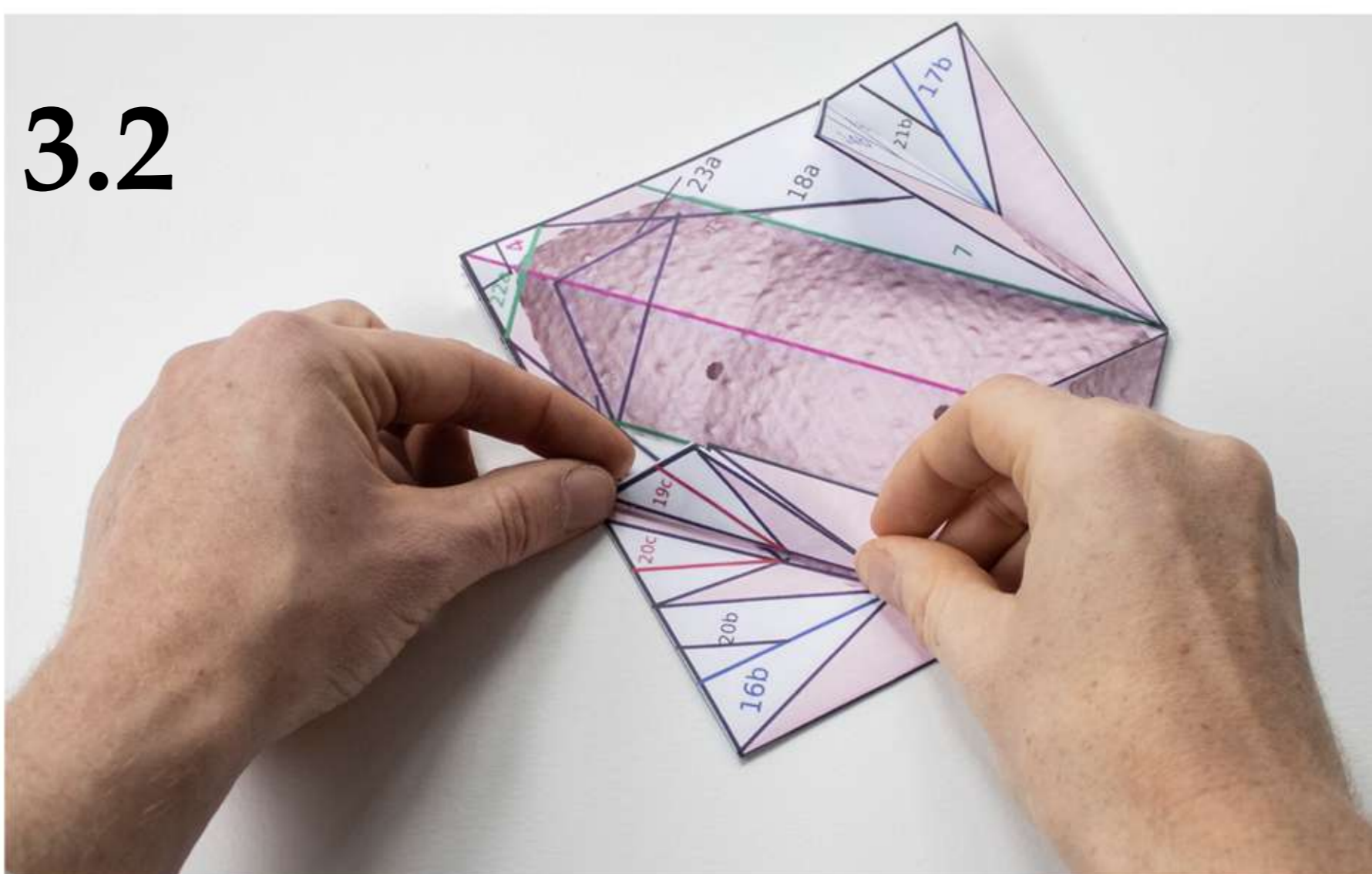


**3.1**

Find the green line marked 7 and bring the whole corner on the right-hand side (marked 1 to meet it). Then fold the bottom corner up creasing along the purple line (line 5). Fold the left-hand corner to the right so this corner overlaps line 7 and the bottom edge is in line with the top left-hand edge of the triangle you just folded (along line 5). Unfold the left and right folds.

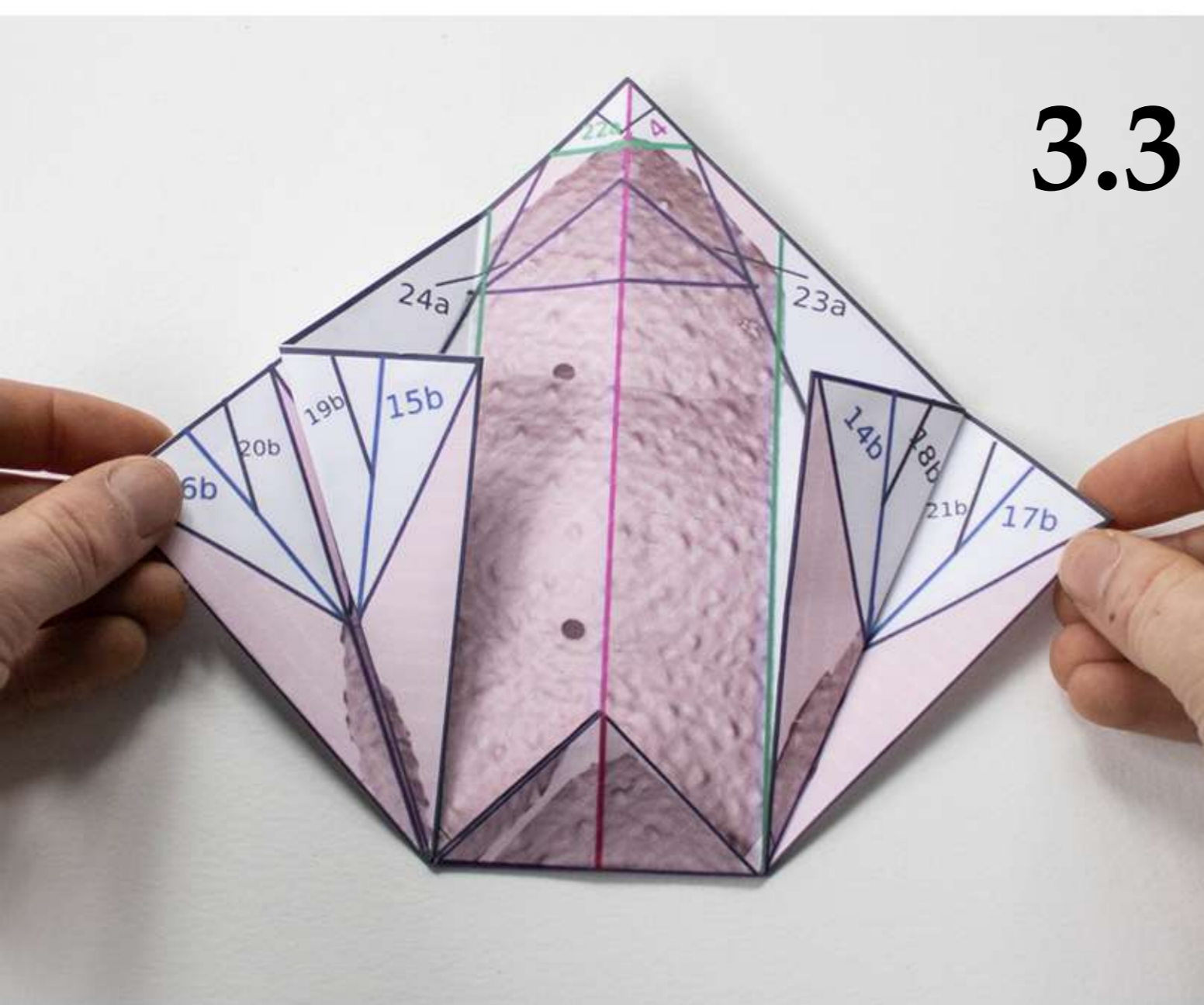
**Optional Step**

On the right refold only the top flap (making a blue 14b line visible) - bringing the edge marked 1 to meet line 7. Now fold the left-hand corner of the top flap to meet line 9, creasing along line 8 - this should make a blue 15b visible.



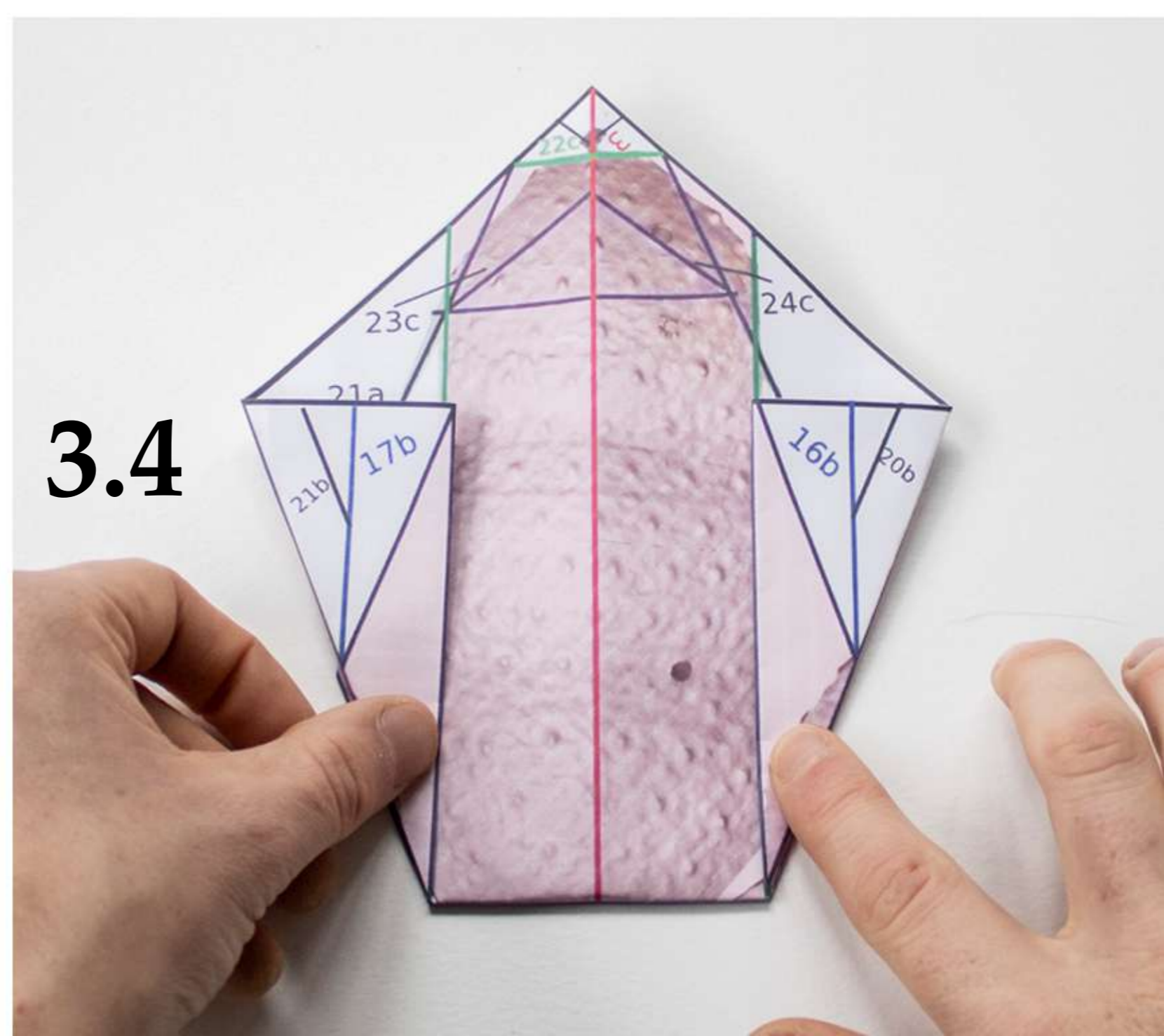
**3.2**

This should result in a square sheet with the bottom corner folded up and two flaps on either side; one on the left and one on the right.



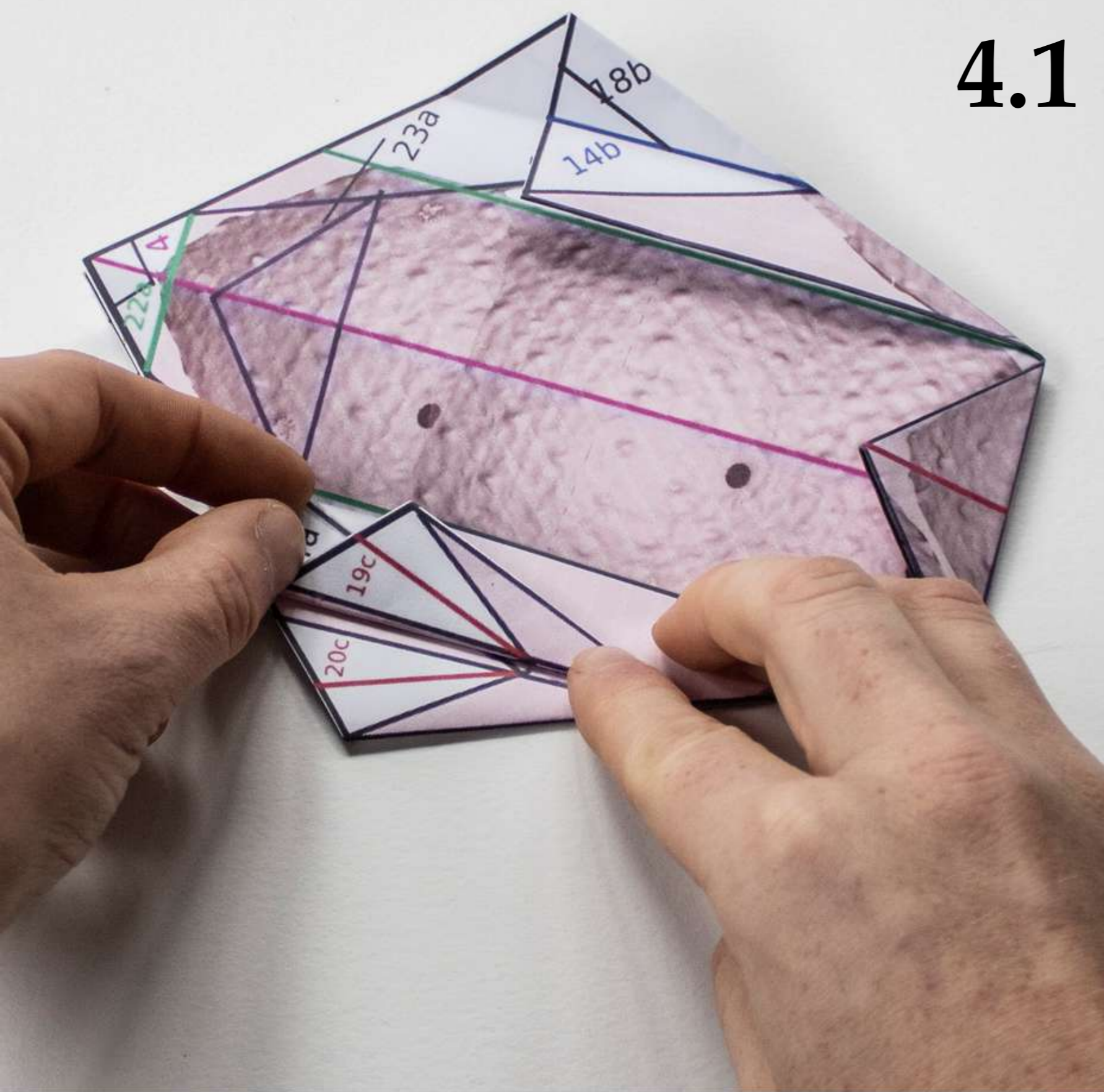
**3.3**

Turn the sheet over and repeat the process in step 3.2 for the other face - folding the right-hand corner to meet line 11 creasing along line 10, and bringing the left-hand corner to meet line 13 creasing along line 12.



**3.4**

## 4.1

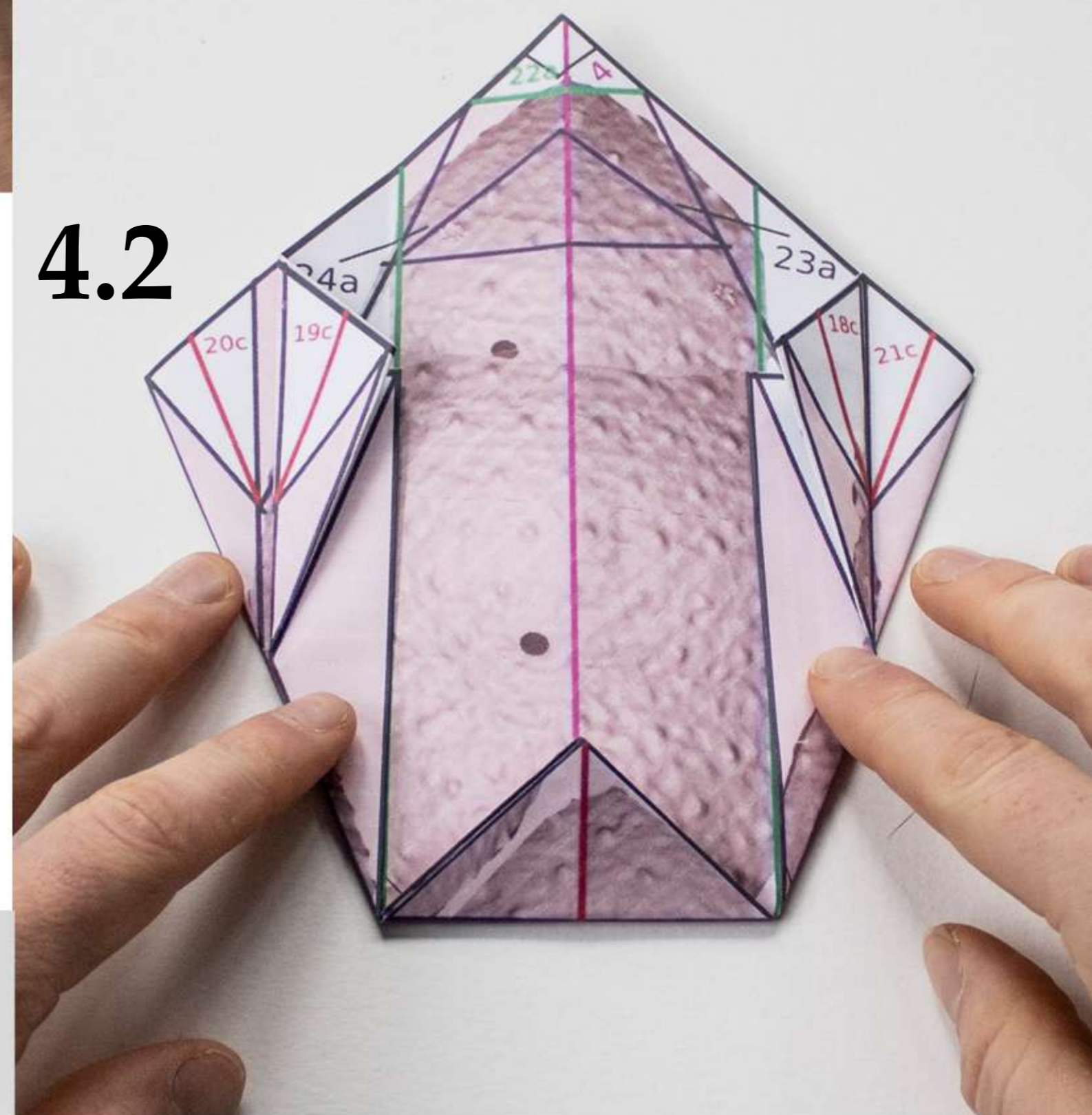


Next we want to fold the flaps from the previous step over on themselves. Start by holding the right-hand corner of the triangular flap, folding this till the tip meets the green line, thus folding a crease along the blue line, and making the flap double-over on itself.

Repeat this for the left-hand side as pictured.

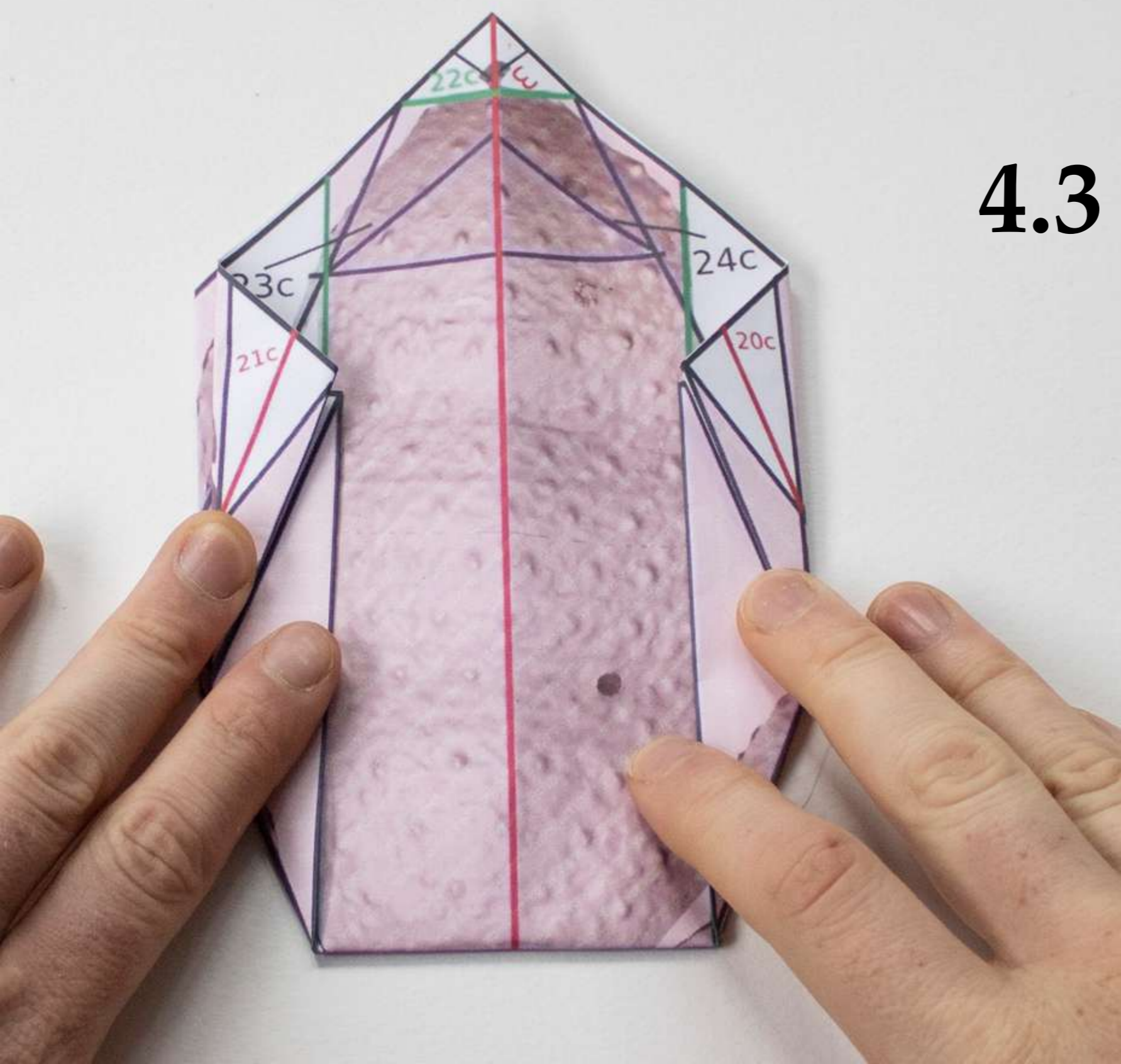
Once both the right and left flaps have this double fold. The top part of the sheet should have 7 edges the bottom 5.

## 4.2



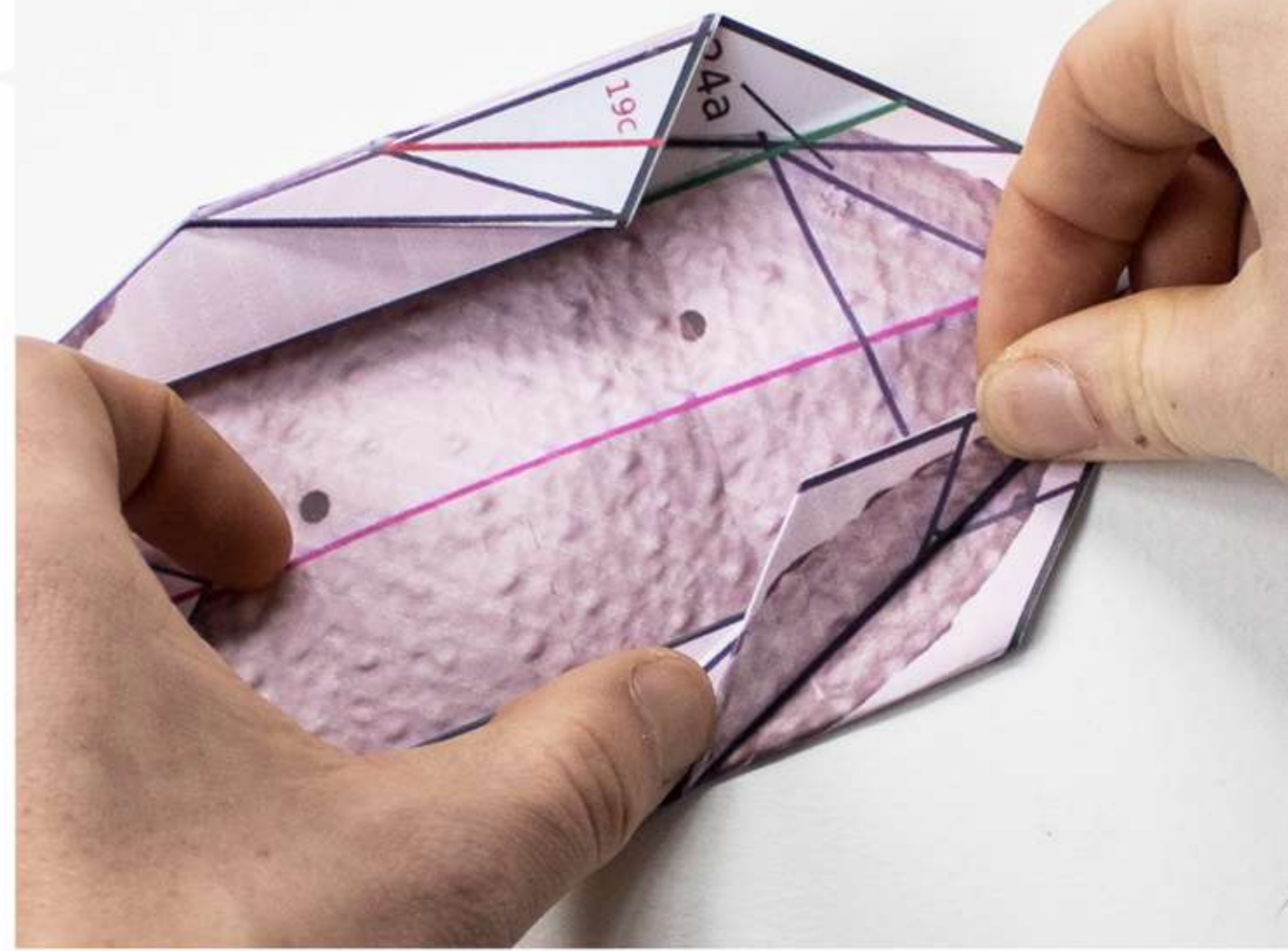
Then flip the sheet over and repeat step 4.1 until all four flaps have been folded over on themselves on both faces. In summary; for step 4.1 we should have creased along line 15b so the its edge met line 9, and creased along 14b so its edge met line 7. For step 4.3 we should crease along 17b so the edge meets line 13 and crease along 16b so its edge meets line 11.

## 4.3



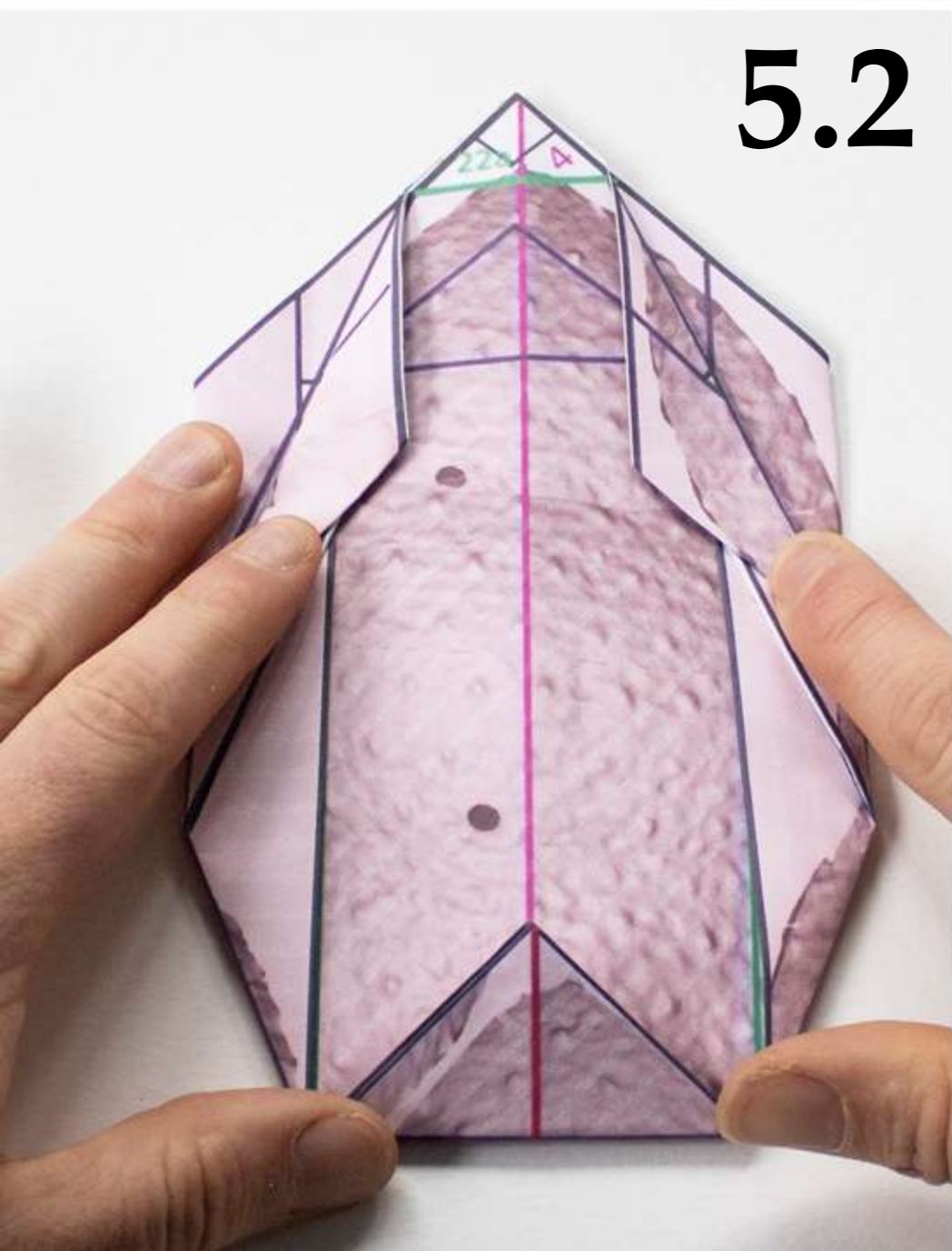
The folds in the previous step should have made short red lines visible on the top face; marked 19c on the left and 18c on the right. On the back face these should be 21c on the left, and 20c on the right. These lines should line-up with black lines on the paper underneath, these will have the same number but have the postfix "a". For the top face, hold the top flap only, creasing along 18a/c, bring the higher right-hand corner towards the centre of the sheet, forming an edge that's parallel with the central pink line on the model

5.1



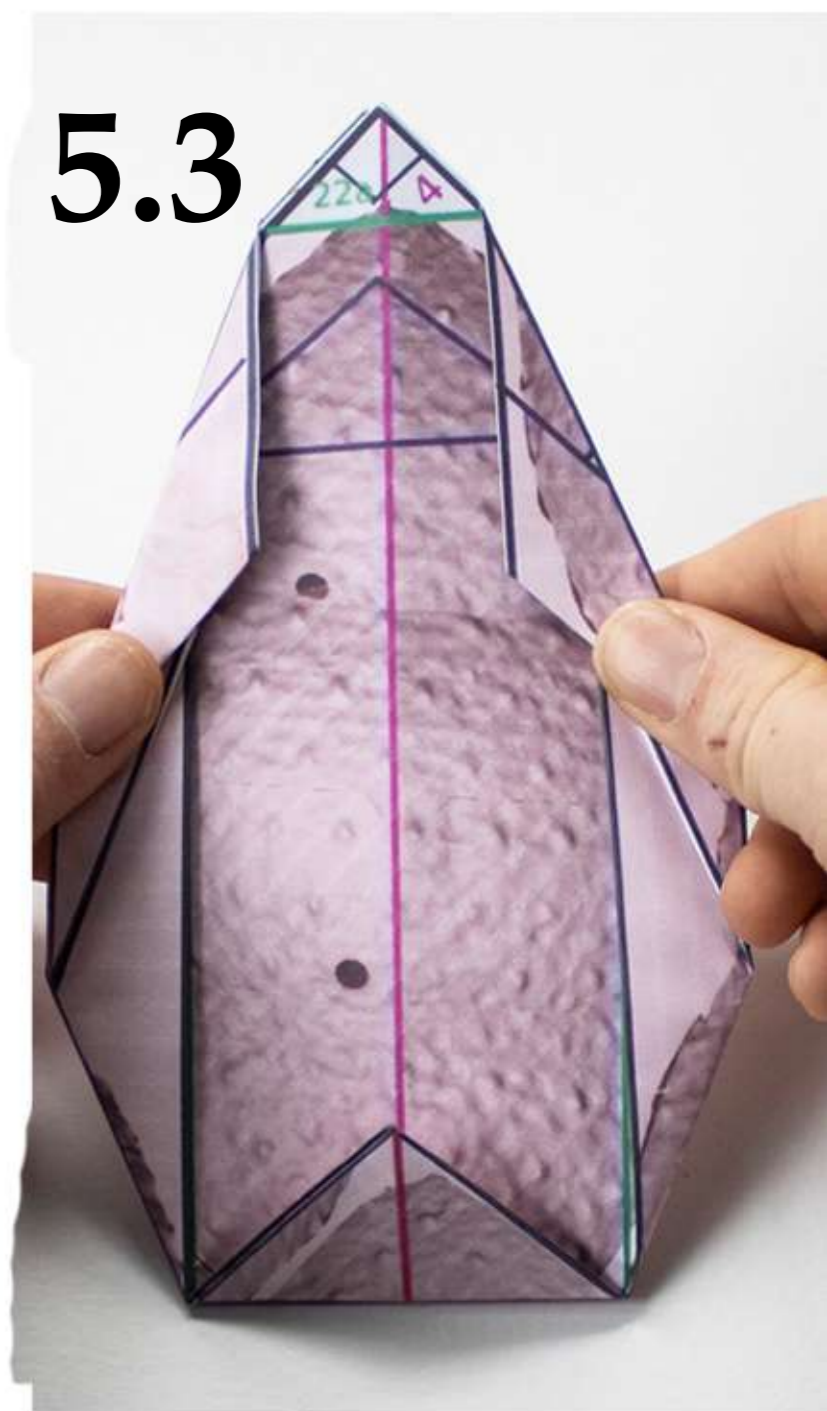
5.2

On the left, again holding the top flap only, crease along 19a/c bring the higher left-hand corner towards the centre, forming an edge, parallel with the central pink line.



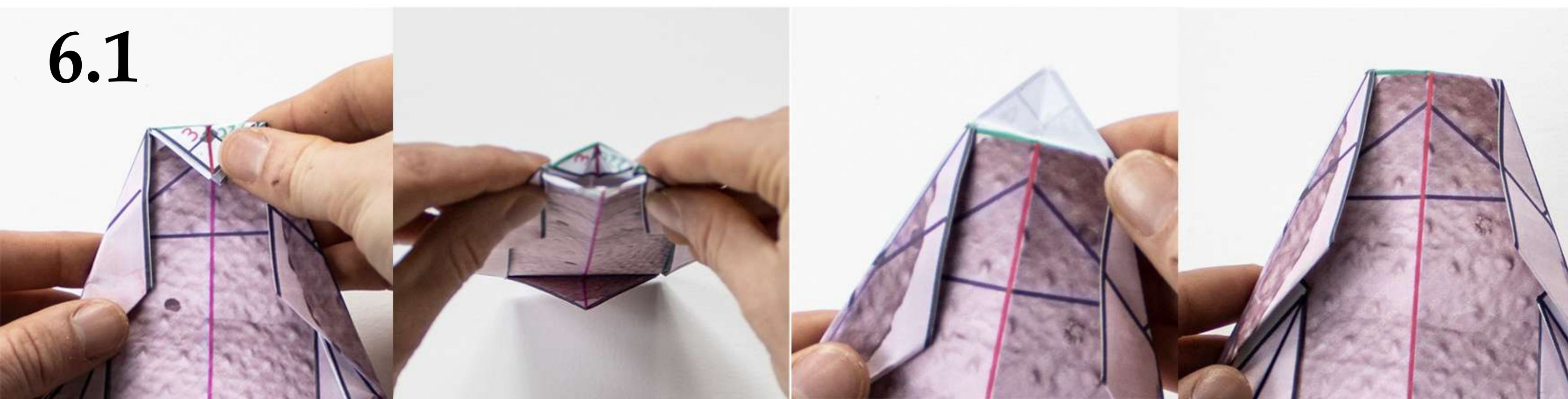
Turn the sheet over and repeat, this time creasing along lines 21a/c and 20a/c. Now the only white showing on the sheet should be a small triangle at the very top.

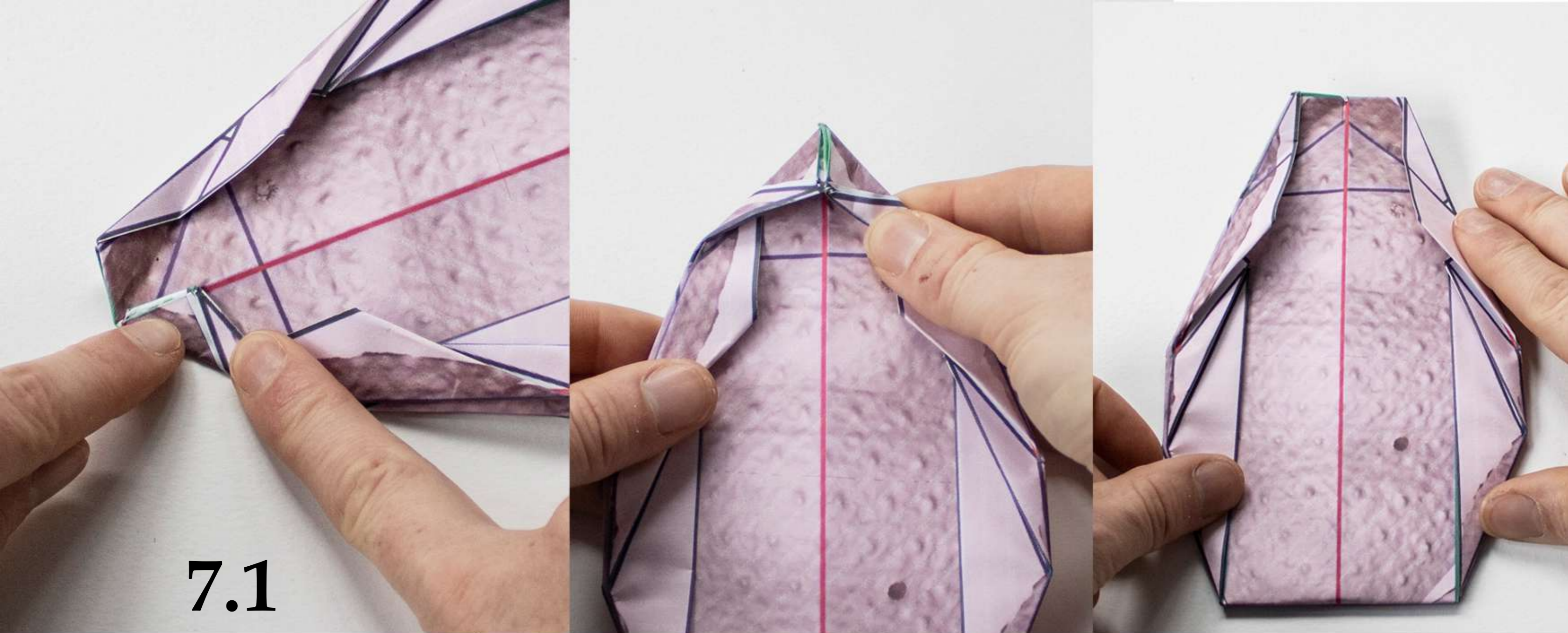
5.3



The white triangle at the top should be folded down creased along line 22a/c. Unfold this and carefully tuck the front flap of the white triangle down inside the paper model. Fold the other parts of the white triangle down and tuck them also inside the model. This should leave a short edge along line 22

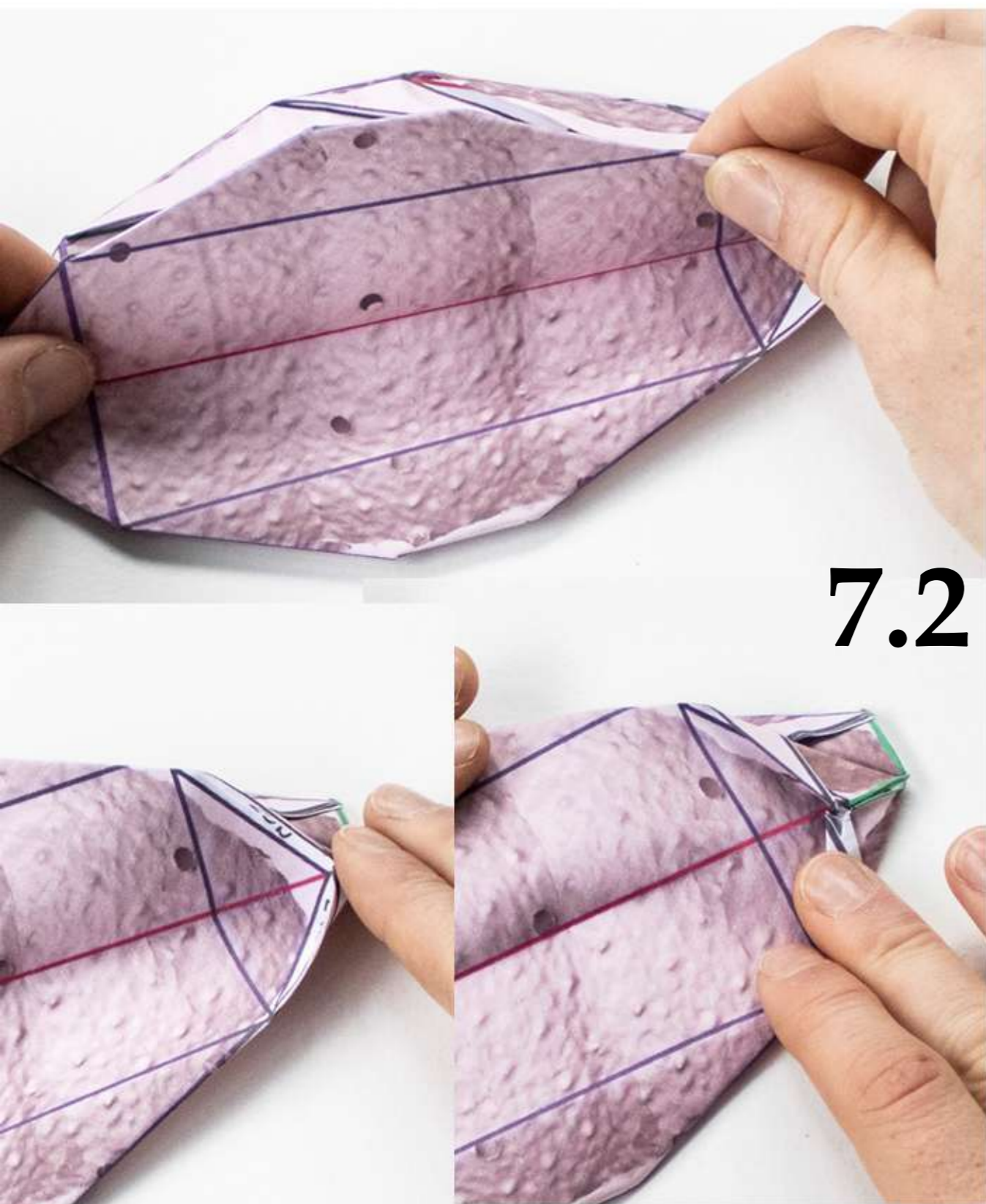
6.1





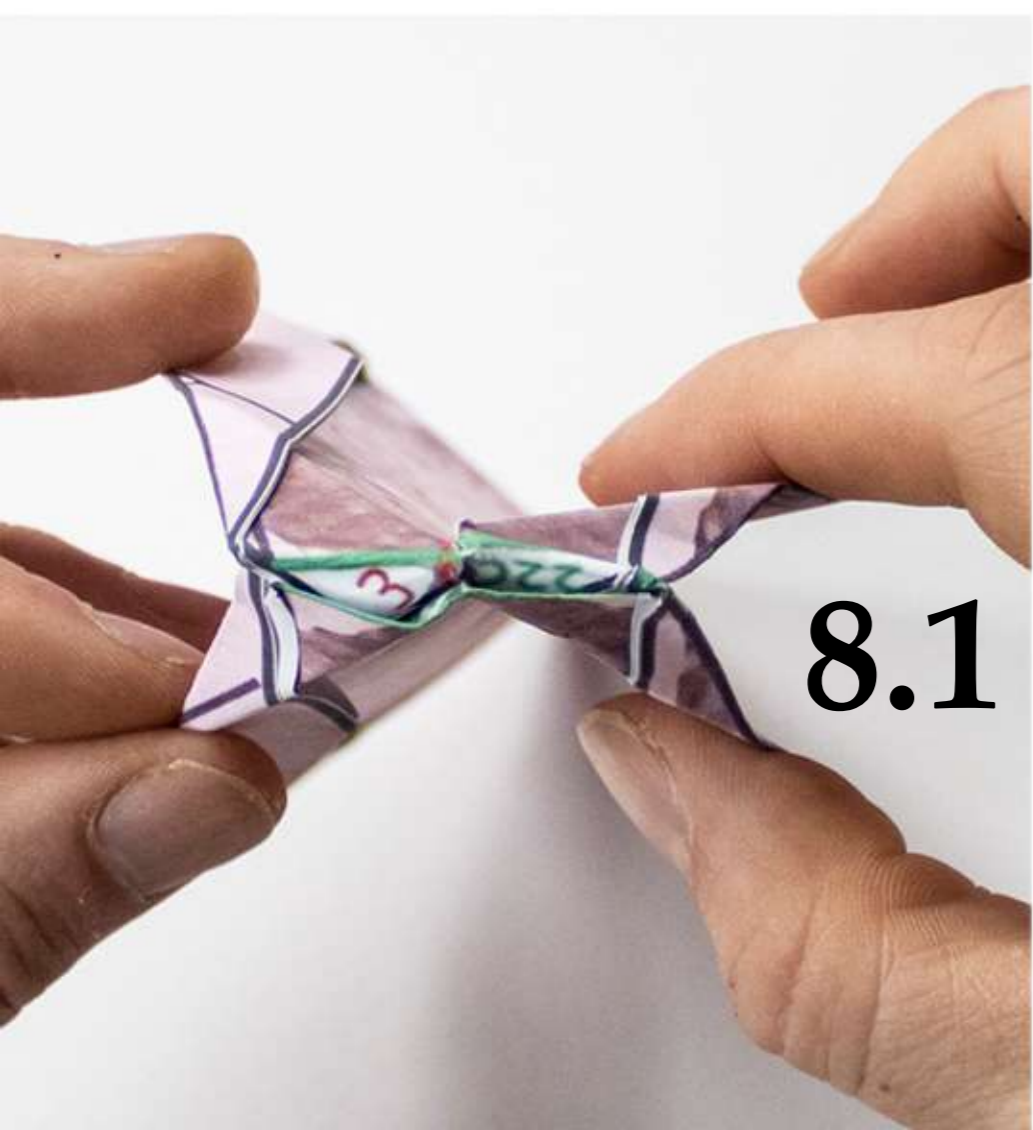
**7.1**

With the model facing you fold the top right and left corners towards the central pink line, this fold is much like a paper aeroplane fold, the creases should be near the dark purple lines at the top of the model. Unfold this step turn the model around and repeat for the back face of the model.



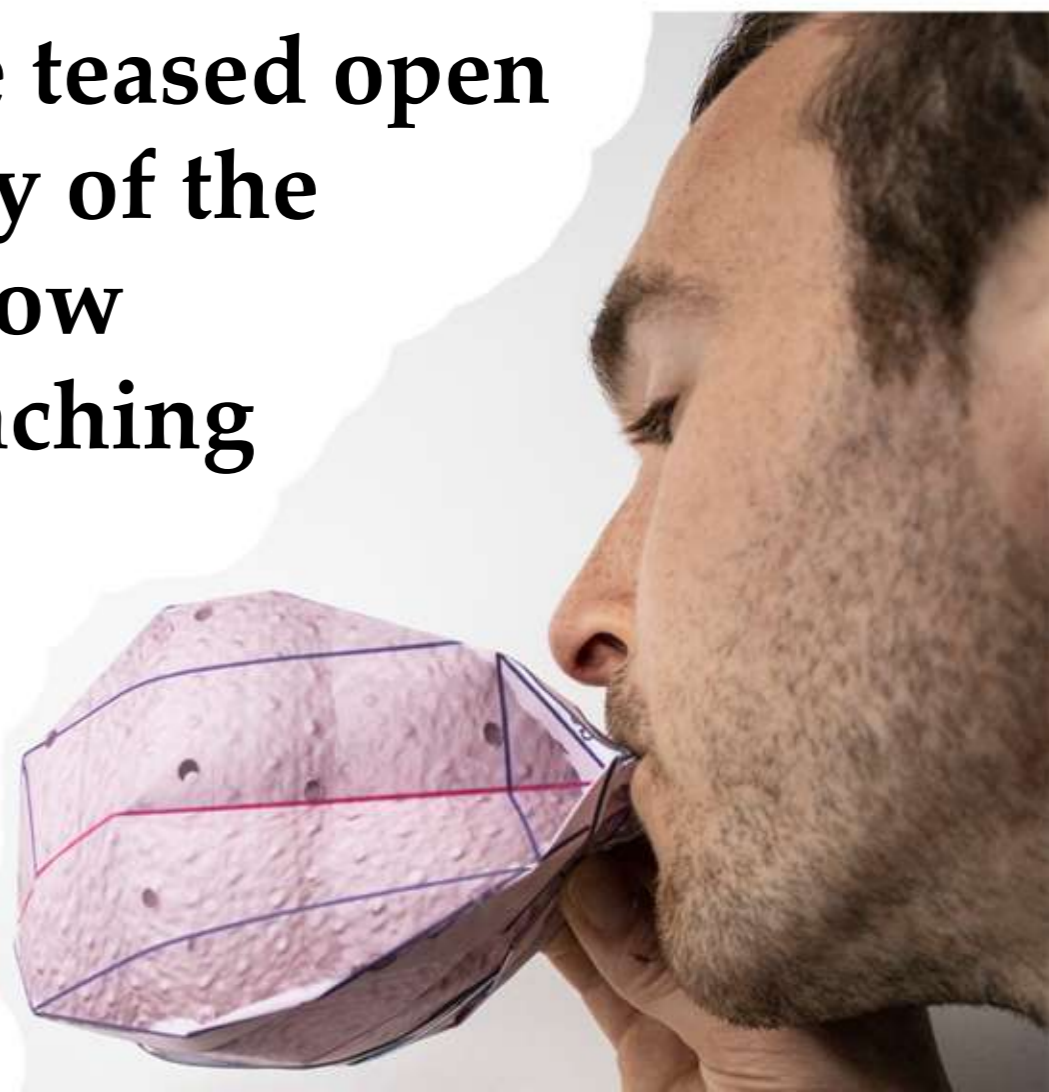
**7.2**

Make sure to unfold the bottom (undoing the second fold in step 3.1) so the model comes to a point that end, it should have a short flat edge the other end – like a lemon. Turn the model 90° clockwise so the central pink line is horizontal to you. At the bottom of the model hold the higher flap only, and crease along the central pink line, bring the flap from the bottom to the top. An aeroplane like fold should start to appear on the right end – help crease this fold as the paper bends. Flip the model over and repeat this fold on the opposite side.



**8.1**

Finally, pick the model up, there should be a small gap which can be teased open be careful not to damage any of the previous folds. Carefully blow air into the model while pinching either side of the gap. It should inflate and with a bit of tweaking be roughly spherical. Well done the shell is complete!



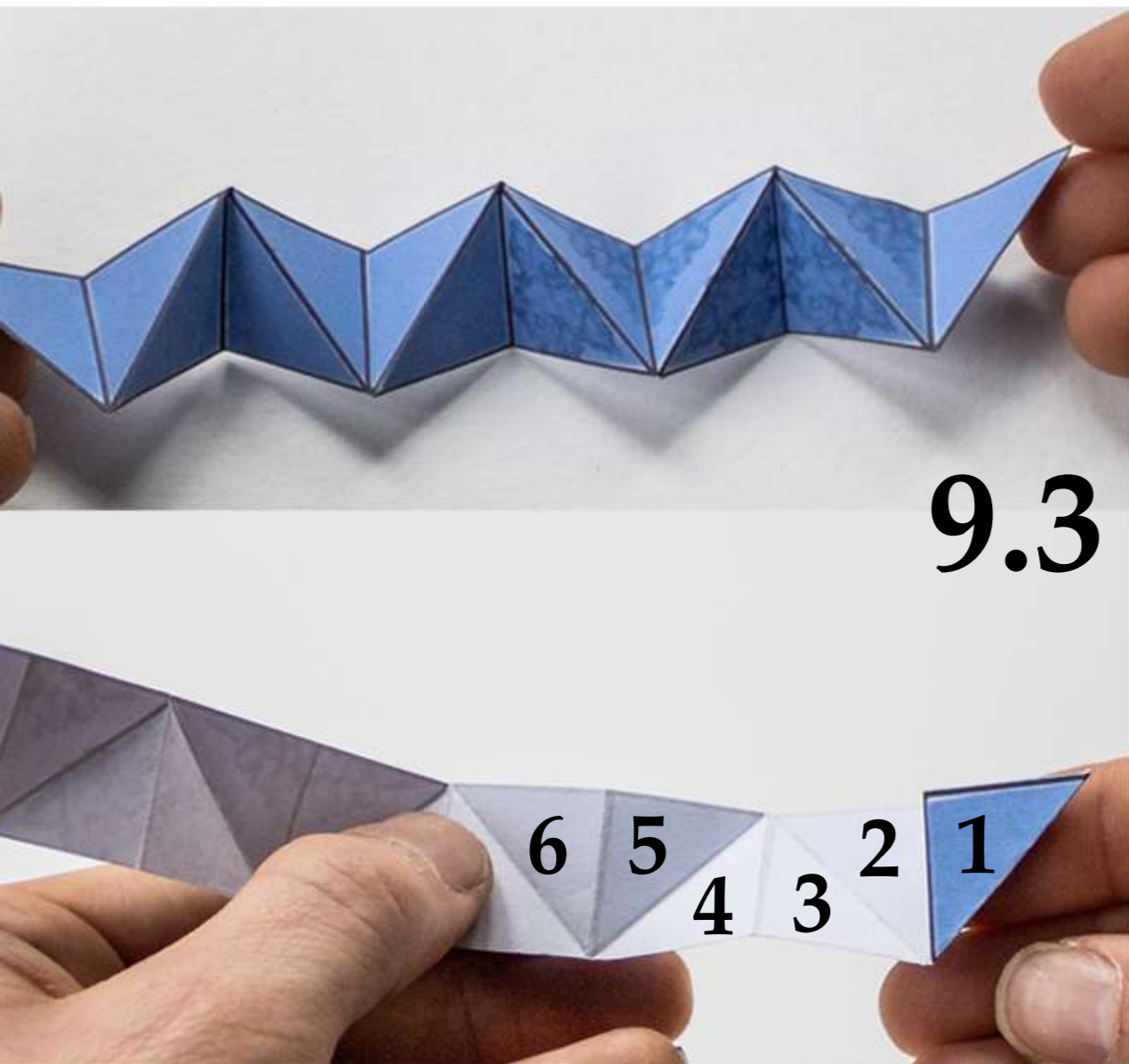
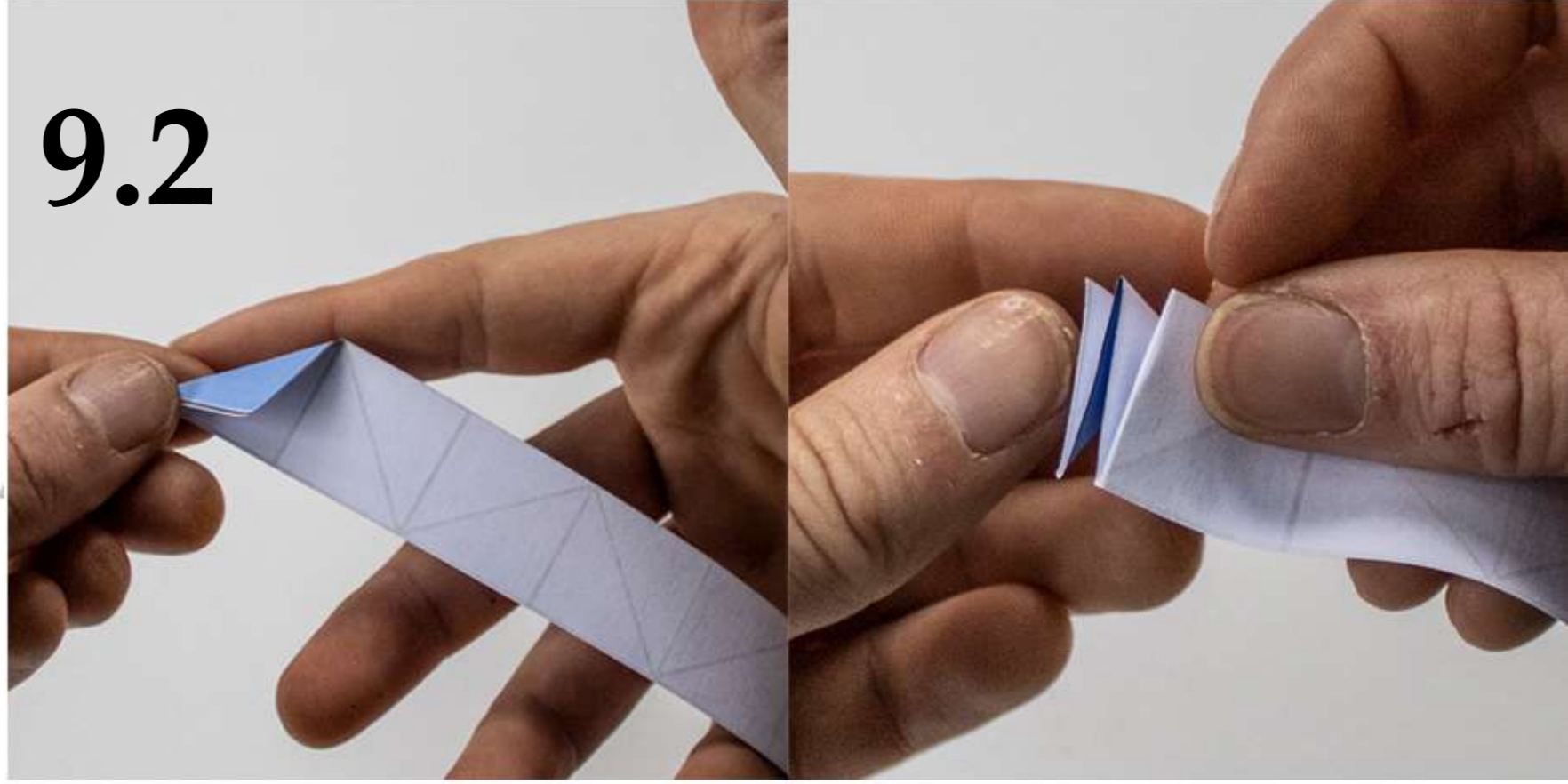
## 9.1

The Spike proteins are modelled as tetrahedrons, the triangular shape reflecting the trimeric symmetry of the protein unit. Take the paper strip and start folding from the end closest to the triangles filled in with protein images.



Fold into identically sized triangles, alternate the folds up and down. Try creasing along the black lines along the strip. However, it is more important to produce identically sized triangles than to follow the printed lines.

## 9.2



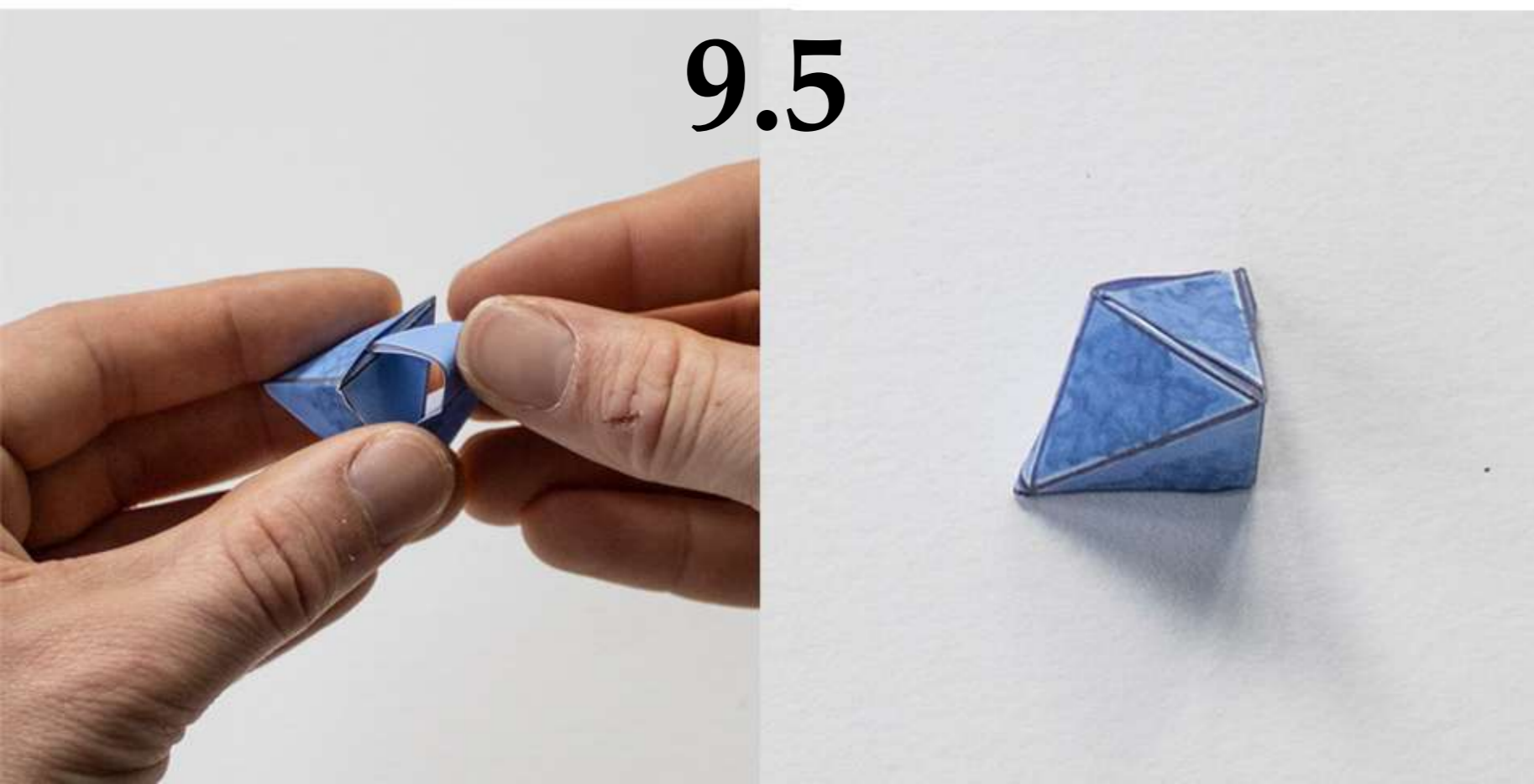
## 9.3

Stretch out the resultant concertina, the strip should have been folded into 16 triangles, turn over the first and last triangles. Go back over the new folds, insuring all the folds bend downwards from coloured side of the paper

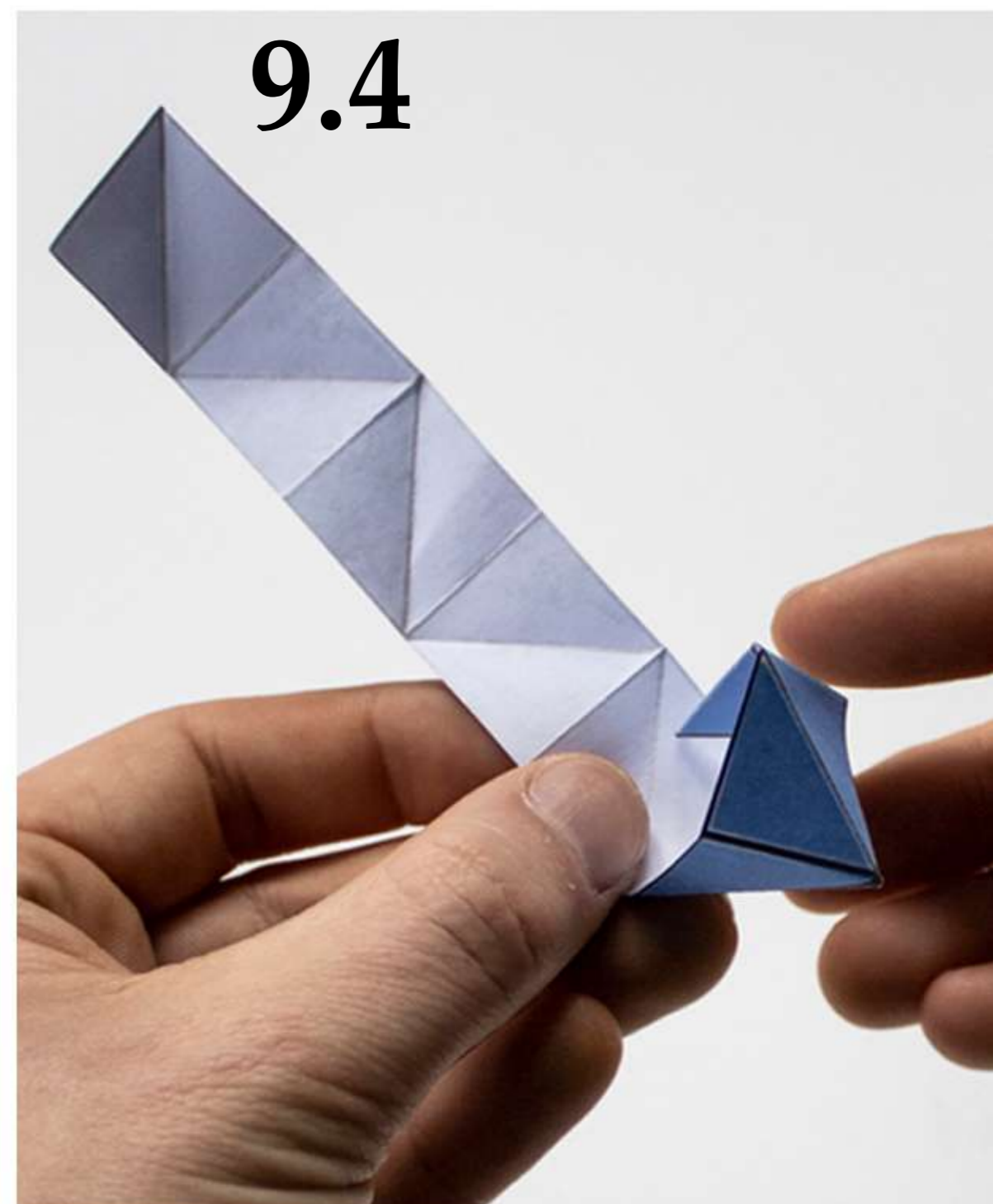
From the end furthest from the protein image-filled triangle, start bending the strip onto itself, the sixth triangle along should overlap the first – this is fiddly be patience. Continue overlapping the triangles till two remain.

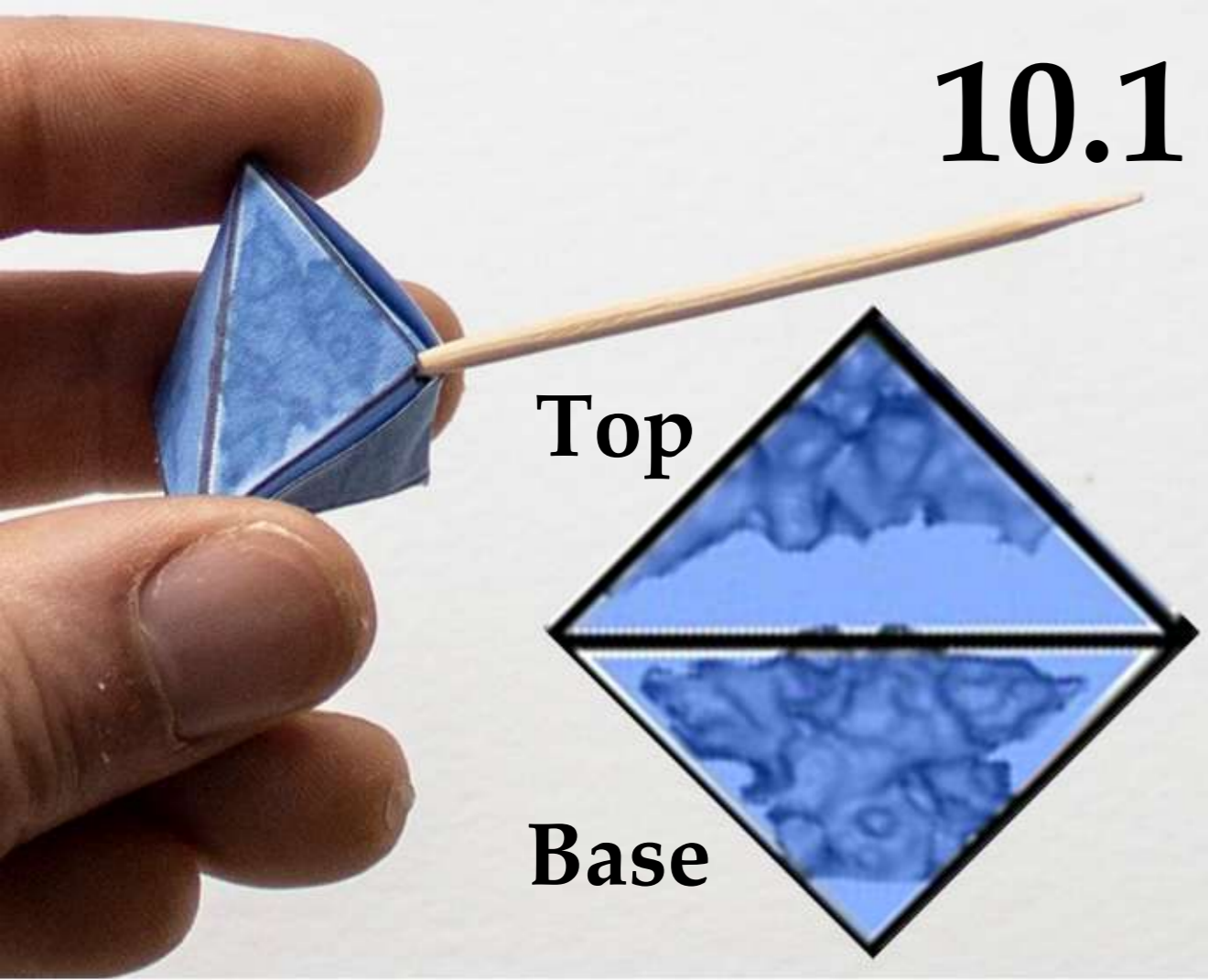
Finally, pucker the edge of the last triangle face to produce a gap. Slide the last triangle into this gap hiding it under the existing triangle face. Your Spike protein is complete!

## 9.5



## 9.4



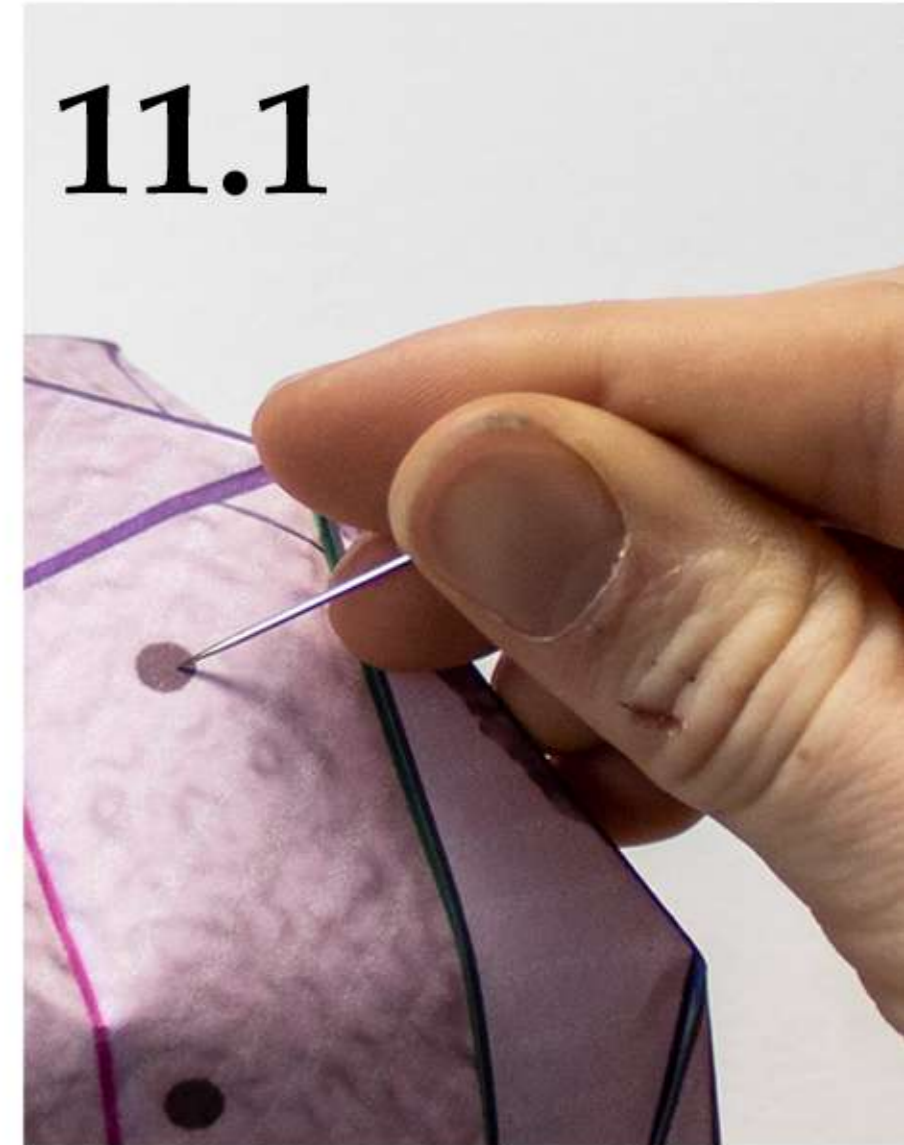


## 10.1

Holding a tetrahedron (paper Spike protein) you've just created, take a cocktail stick and use the point to tease out a hole in the base - the base of the tetrahedron has the triangle faces with the larger protein image, at the corner where that image ends in a sharp line. Push the cocktail stick in until it reaches the opposite corner.

Holding the paper model of the virion created earlier, take a pin or similarly sharp tool and carefully scrape a hole in the paper where a hole is printed, try to avoid distorting the sphere. After some careful scraping you should be able to skewer/drill the pin into the model, this will allow the stick part of the Spike protein model produce in step 10.1 to be inserted. Push it the all the way in – superglue applied to the stick where the tetrahedron starts can be used to secure the part, however it shouldn't be necessary - it can also be applied to the base of the sphere.

## 11.1



## 11.2

The SARS-CoV-2 virion has 15-33 Spike proteins. For this model we recommend placing 17 paper Spike proteins; 2 green (double open Spike proteins), 10 dark blue (open Spike protein) and 5 lighter blue (closed Spike protein). 1 or 2 cocktail sticks can be used to model post-fusion Spikes. The supplied short strips can be folded to create "ears" that are slotted under the top faces of the tetrahedrons - these modelling the open/closed/double open nature of each Spike.

