# **Unfolding Organogenesis**

Organogenesis is the formation of organs and bodily tissues that occurs during the development of an organism. Like folding a sheet of paper into the shape of an organ, stem cells differentiate to form specialised organ cells during development. These differentiated cells arrange in the specific three-dimensional architecture of an organ, allowing it to perform its vital bodily functions. Researchers of developmental biology have long studied the mechanisms of organ design with the hope that a better understanding of these processes might increase medicine's ability to repair damaged tissues and intervene in devastating diseases.

Advances in stem cell science suggest that scientists might be able to replicate organogenesis in the laboratory to create bodily tissues and organs from stem cells. Using a technology called *induced pluripotency*, researchers restore the capacity of now specialised cells of patients to make different cells, tissues and organs. Like unravelling a sheet of paper from previous folds, induced pluripotency unfolds cells specially shaped for an organ by regulating their gene expression. This process enables researchers to repurpose cells from one organ to the next like the recycling of paper. Once the science is ready and clinical trials have been successful, this technology might find application to treat a wide range of health problems. A patient's cells, such as skin cells, could then be used to replace any other type of cell they might need.



Although the induced pluripotency technique might inform the development of medical treatments eventually, the folding, unfolding and refolding of stem cells today still faces a number of challenges in laboratory practice. In labour-intensive experiments, scientists need to tease out gene expression patterns for organogenesis that, like origami instructions, will tell them how organs are made. Like paper, cells retain 'creases' of previous foldings and these interfere with scientists' ability to form them anew, requiring research to study those traces. These and many more challenges need to be addressed before laboratory-grown organs can go into clinical trials and be safely applied in medical treatments.

Nonetheless, laboratory-produced organoids (organ-like structures) already provide useful three-dimensional models for studying diseases and screening drugs in the petri dish. To make organoids, scientists sometimes use scaffolds made from bio-compatible materials to support the formation of three-dimensional organ architecture. Unfolding organogenesis invites everyone to explore the incredible three-dimensional plasticity of cells, tissues and organs, to participate in a conversation with scientists, and to fold origami together.





### **Origami Organs: 3D Heart**



I. Start with a square, coloured side down. Crease in half horizontally and vertically. Pinch a mark one quarter of the way up the middle.



4. Fold the top corners to meet the crease mark.



5. Fold the bottom edges to the middle.



8. Fold in half.



10. Reverse fold the bottom left corner inwards.



14. Make 3D by pushing on the top and inflating from the bottom.



II. Turn over.



15. Complete. You might need to readjust the flaps to lock the heart.



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3. Fold in half.



6. Make creases along the folded edges. Unfold and open up to the square, coloured side down.



9. Reverse the corners in along existing creases.



13. Tuck the flaps inside. Adjust the flaps to lock the heart.









12. Reverse fold the

bottom left corner

inwards.

Origami for 'Unfolding Organogenesis'



7. Make the creases strong.





## **Origami Organs: The Cell**



I. Start with a square, coloured side up. Fold each diagonal of the square. Unfold back to the square after each fold.



2. Fold in half vertically and unfold. Then fold in half by bringing the top and bottom edges together.



3. Hold the the points labelled L and R with your left and right hands. As you bring the four corners of the square together, the front and back paper will form flaps like the ones that you are holding.



4. Continue collapsing the paper. Arrange the flaps so that you have two on the left and two on the right.



7. Fold the top left edges to the centre using the location marks show. Unfold.



5. Mark the midpoint of this smaller square by lifting the bottom corner, placing it on the top point, pinching the centre and then unfolding.



8. An optional fold that might help with the next step: fold the top point down to the quarter mark. Make the creases strong by unfolding and folding behind.



6. Fold the top left edges to the centre and unfold. Turn over.



9. Separate the layers at the top and spread the layers clockwise, when viewed from above.













## **Origami Organs: The Cell**



10. Spread the four corners so that they lie flat. Twist the central peak clockwise, spreading and flattening the centre. The peak will flatten on the creases made in step 8 and shown in the crease pattern below.



II. Fold the corners behind to round off the cell.



12. Complete. If you found the twist and collapse awkward, try again but use these extra steps below to help you.

#### Optional steps to ease the twist and collapse



8b. After making the crease in step 8, *sink* the top point. Do this by opening the paper and making the new crease mountain (convex) folds.



8c. Reform the shape with the top point pushed in.



8d. Continue with step 9. You will still twist the centre but will not need to flatten it as it is already flattened.

#### Analysis and variations



Opened up, the *crease pattern* shows the essential creases. The late Shuzo Fujimoto pioneered this technique of *twist folding*.

You can vary this single twist by changing the proportion of the folds in step 6 and 7. You can also use polygons other squares—or even a circle. If you use a regular hexagon or octagon, you can make a three dimensional nucleus by twisting two flaps together in step 9.



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## **Origami Organs: The Hand**



### **Origami Organs: The Beating Heart**











### **Origami Organs: Simple Heart**





I. Start with a square, coloured side down. Fold the vertical diagonal and unfold.

2. Fold the bottom corner to the top.

3. Fold the left and right corners to to the top.



4. Turn over vertically.



5. Fold the bottom upwards, but leave a gap (about 1.5 cm for a 15 cm square).



6. Fold the uppermost flap downwards.



7. Fold the flaps inside.



10. Fold the points inwards.





8. Squash the flaps



11. Turn over vertically.







9. Tuck the flaps inside.

12. Complete.

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## **Origami Organs: The Thymus**



I. Start with an A4 sheet, coloured side down. Crease into halves. Divide the long side into quarters.



4. Repeat steps 2 and 3 on the right edge.



2. Fold the left edge over to meet the three quarter line.



5. Fold the corners into the middle.



6. Unfold the corner flaps.



9. Tuck the flaps inside. 10. Lift the top flap.



3. Fold the flap back over

one quarter.

7. Fold in half.



II. Fold the flaps inside.



8. Squash the flaps.





15. Insert thumbs into the top pockets and spread apart.







13. Tuck the flap inside. Repeat behind.



16. Flatten the pockets.









14. Fold the larger flap into the pocket. Repeat behind.



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