# MITORIGAMI

## Instructions for how to make Mitochondria Origami

## Materials

- Din A4 sheets of different colors
- Pencil
- Cutter or scissors
- Ruler
- Mouse pad or a surface to cut
- Energy from your muscle mitochondria and a bit of patience

## Video

You can find a tutorial <u>here</u>.

In case you need some more guidance, here you have the detailed steps:

## Steps

#### 1. Re-sizing the DIN A4 sheet

- A. The horizontal side needs to be shortened. Place the Din A4 sheet on the table horizontally.
- B. Measure with the ruler 8mm from one of the vertical sides and make a small mark with the pencil.
- C. Repeat Step 2 on the other horizontal edge, so that it is parallel to the previous pencil mark.
- D. Draw a line with the pencil and the ruler to link the two pencil marks.
- E. Place the mouse pad underneath the paper and place the ruler next to the line you just draw.
- F. Use the cutter along the pencil line with the help of the ruler. Run it over the line until the 8mm excerpt is removed from the sheet. Now the paper is ready to be folded.



## 2. Crisping the grid

- A. VERTICAL AXIS: The vertical axis needs to be divided in 8 sections by folding and unfolding the paper; the lines separating the portions will not be cut, but will become the axis that will later on allow the proper folding of the paper. Start by folding the sheet in two, then in quarters and finally in eights. Make sure to be accurate with the measurements and to crisp the divisions thoroughly.
- B. HORIZONTAL AXIS: The following step is to mark eleven divisions on the horizontal axis by folding and unfolding the paper. Given that eleven is an uneven number, the sheet cannot be folded in multiples of 2. Hence, grab one of the corners of the paper and fold it over so that one of its sides is parallel to the opposite horizontal axis of the paper. Make a mark with the pencil. The larger length between this mark and the vertical edge constitutes a perfect square, and accordingly, it can be divided in multiples of 2.
- C. Fold the space between the pencil mark and the vertical edge in 8 pieces. Start by folding the vertical edge over the paper to match the pencil mark, which will give you halves, then fold again into quarters and finally divide the quarters in half.
- D. The remaining space in the sheet needs to be divided in 3. Fold the vertical edge of the unfolded side over the crisped line adjacent to the last mark, the one marked with pencil. Finally, repeat this last step but this time over this last crisp.



#### 3. Splitting the sheet

At this stage you should have a sheet divided in a grid that contains 8 sections on the vertical side and 11 sections on the horizontal side. In the following step, the paper needs to be cut in two pieces, one containing 6 of the horizontal divisions and the other one containing the remaining 5. Use the cutter or scissors to cut.



#### 4. Crisping the Outer Mitochondrial Membrane

A. Select the larger paper, the one having 6 horizontal divisions. Now, the horizontal edge has become the vertical one and vice versa. Tilt the paper to have it parallel to the edge of the table. With this orientation, mark in pencil the following pattern:



- B. Fold the paper following the lines you just draw on the previous steps. Make sure to crisp only those parts that are marked with pencil. Once crisped and marked, unfold the paper.
- C. Fold the dashed lines on the following pattern:



To do that, bend over the crisped line between rows 2 and 3 to form a  $90^{\circ}$  angle. Pull the crisped diagonal across B1 and C2 towards the crisped line between C and D. The excess of paper should face inwards. Once the two crisped lines are together, crisp the excess paper in half. Repeat the above mentioned procedure for all the pairs lines: diagonal F2-G1 and crisped line between E1/2 and F1/2; diagonal B6-C5 and the crisped line between C5/6 and D5/6; and diagonal F6-G5 and the crisped line between E5/6 and F5/6. At the end unfold.

D. Crisp rows 1 and 6 in half. Unfold.



#### 5. Folding of the Outer Mitochondrial Membrane

- A. Crisp again the line between rows 2 and 3 and fold it in a 90° degree. Place your thumb and index fingers over the vertical part and holding the paper on the line between columns C and D. Pull the diagonal B2-C3 towards your fingers, with the excess paper facing inwards.
- B. Repeat the same step on the other side with the diagonal F2-G1 while still pinching on the structure formed on the previous step.
- C. Pull your thumbs towards the upper part of your structure so that they are placed on top of the middle line traced in row 1, with the index finger on the other side. Bend over the paper to fold over the middle line of row 1. Pinch the edges to make sure the structure holds while you construct the other side.
- D. Repeat the same procedure on the opposite side of the paper. By now, you should have some kind of boat structure.



E. Choose one of the edges of the boat. Place one hand on each side, the thumbs on the inside of the structure and the rest on the opposite side outside. With your index fingers full the upper rhombus inside and down. Remove your index fingers and pull your thumbs together.



F. With one of your hands pinch together the middle edges of the rhombus. The rhombus is now a triangle. Place it in the middle. With the other hand, put your index finger inside the triangle and press on the upper side with your thumb. Press it against the wall.



G. Repeat these two last steps for the other side of the boat.

#### 6. Crisping the Inner Mitochondrial Membrane

A. Retrieve the other part of the paper, the one initially containing 5 horizontal sections. Place it horizontally in front of you. With this orientation the columns will be labelled from 1 to 5 and the rows from A to H. Draw the lines in the following pattern:



B. Crisp the diagonal lines traced. Try to only crisp the sections marked in pencil. Note that the pattern should look like a zig-zag line across columns B and D.

## 7. Folding the Inner Mitochondrial Membrane

- A. Fold columns A and E in the middle.
- B. Turn the paper over and make a 90° angle between rows 1/2 and the rest of the paper along the crisped line between rows 2 and 3. Make a 90° angle with column A and put the excess of paper (double triangle) facing outwards.



C. Bend the folded part towards the surface of the paper. Bend it to the other side, folding the paper like an accordion. Repeat until the paper is fully folded.



D. Make a 90° angle between rows 4/5 and the rest of the paper. Make a 90° angle with column A and this time, pull the excess paper inwards.



E. Repeat the accordion procedure in this side.



- F. Once the paper is fully folded, close the structure by putting each one of the edges under the lid of the other nearby end.
- G. Mold to adapt the structure to the shape of your liking.



- 8. Assembling the mitochondria
  - A. Now both parts of the mitochondria are ready. Place the inner membrane inside the outer membrane.
  - B. Mold the structures to adapt to each other.
  - C. If you would like to have a more colorful mitochondria for aesthetic purposes, you can use more than one DINA4 sheet of paper or interchange it with a friend.
  - D. Now you can decorate the mitochondria.

