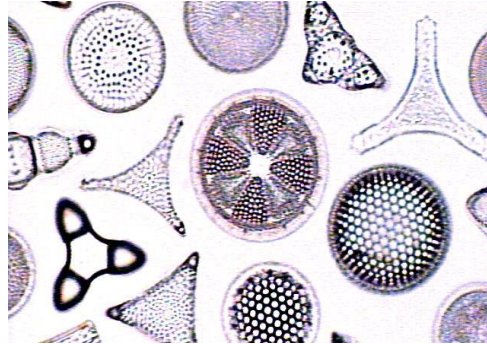


# Euler Cycles for “Life”



LEFT: Seashells, RIGHT: Diatoms

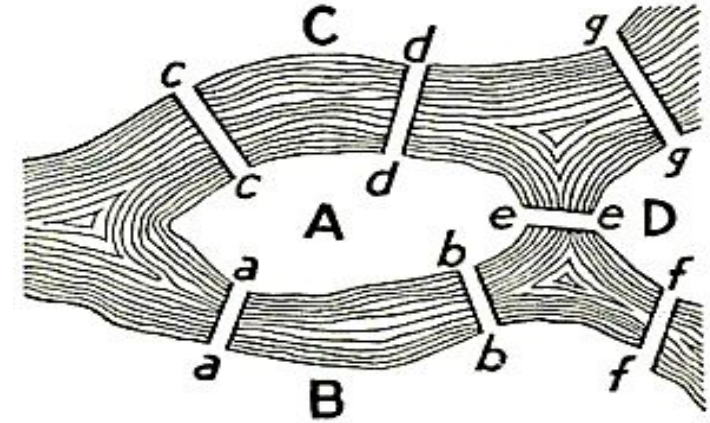
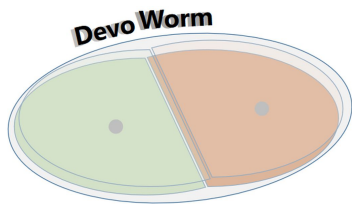
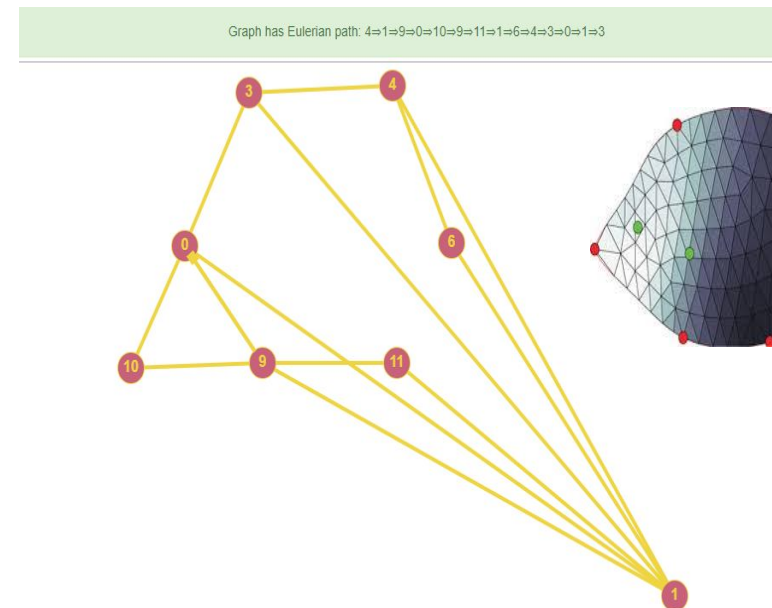


FIGURE 98. Geographic Map:  
The Königsberg Bridges.

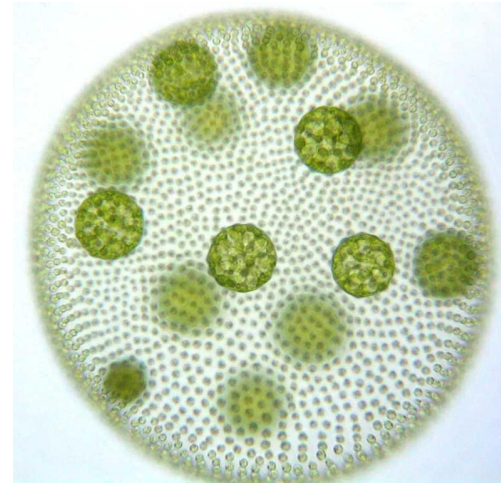
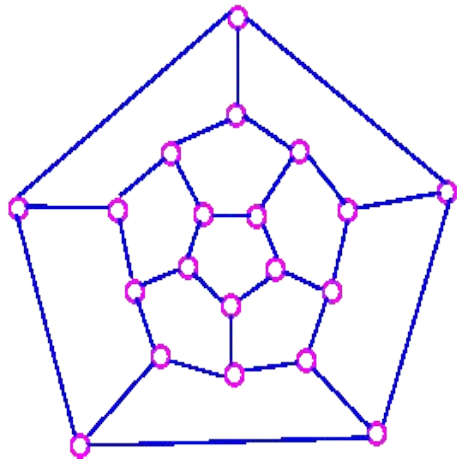
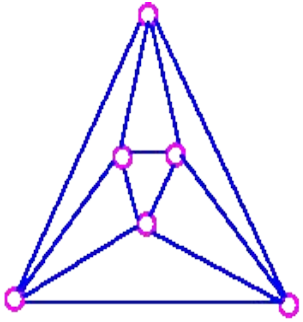
<http://mathworld.wolfram.com/KoenigsbergBridgeProblem.html>



Bradly Alicea   
@balicea1



# Euler Paths



*Volvox* colony

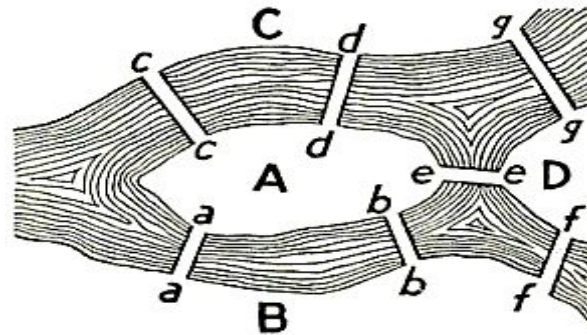
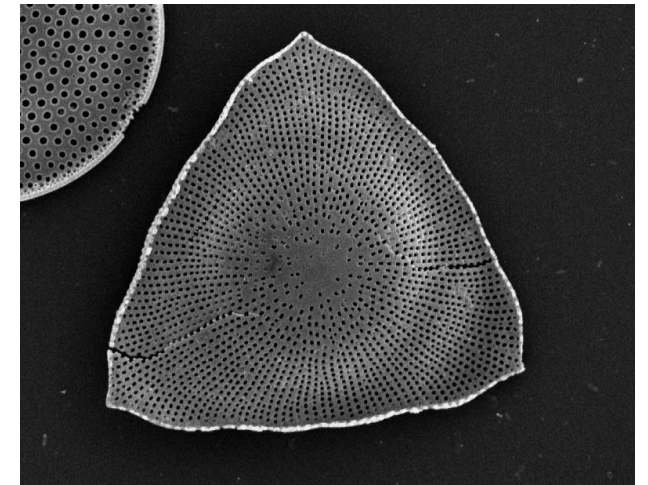
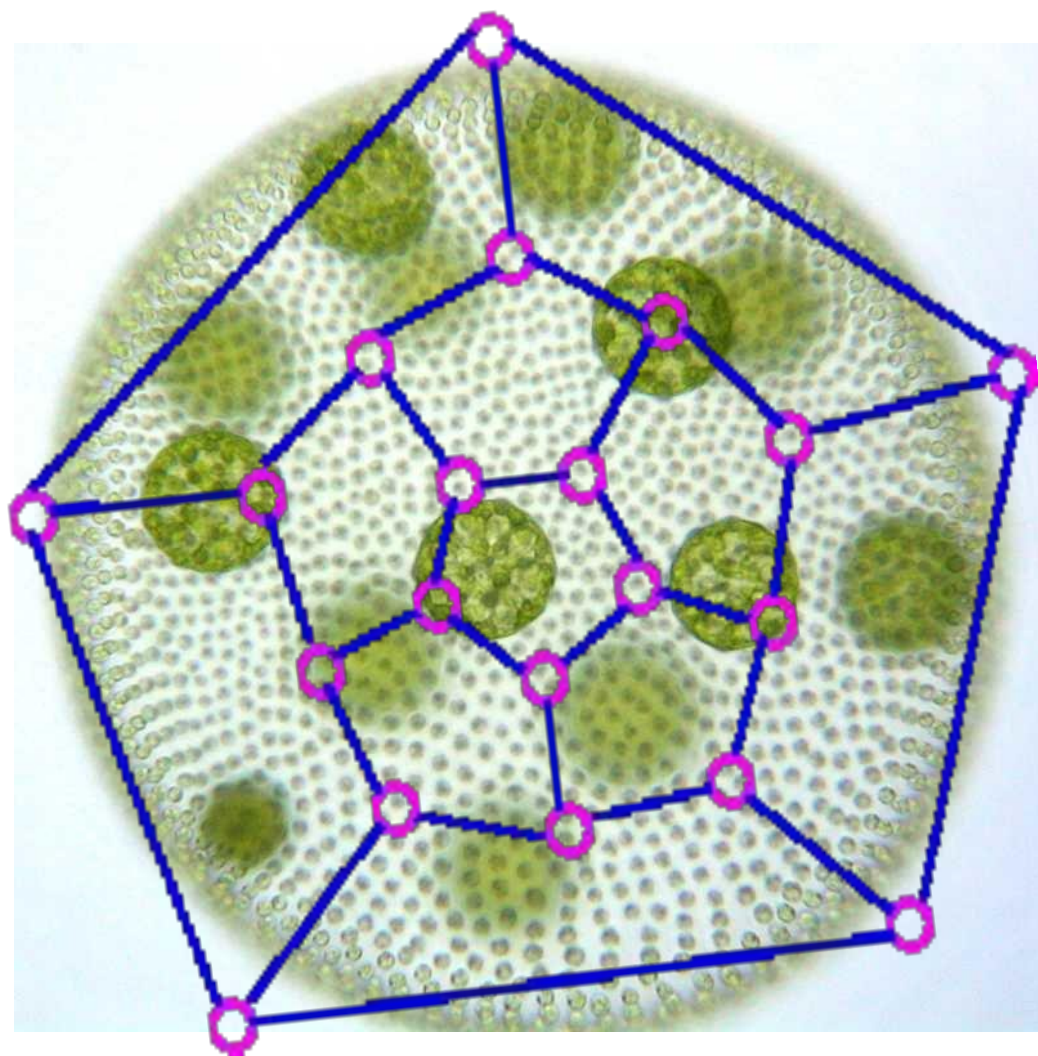
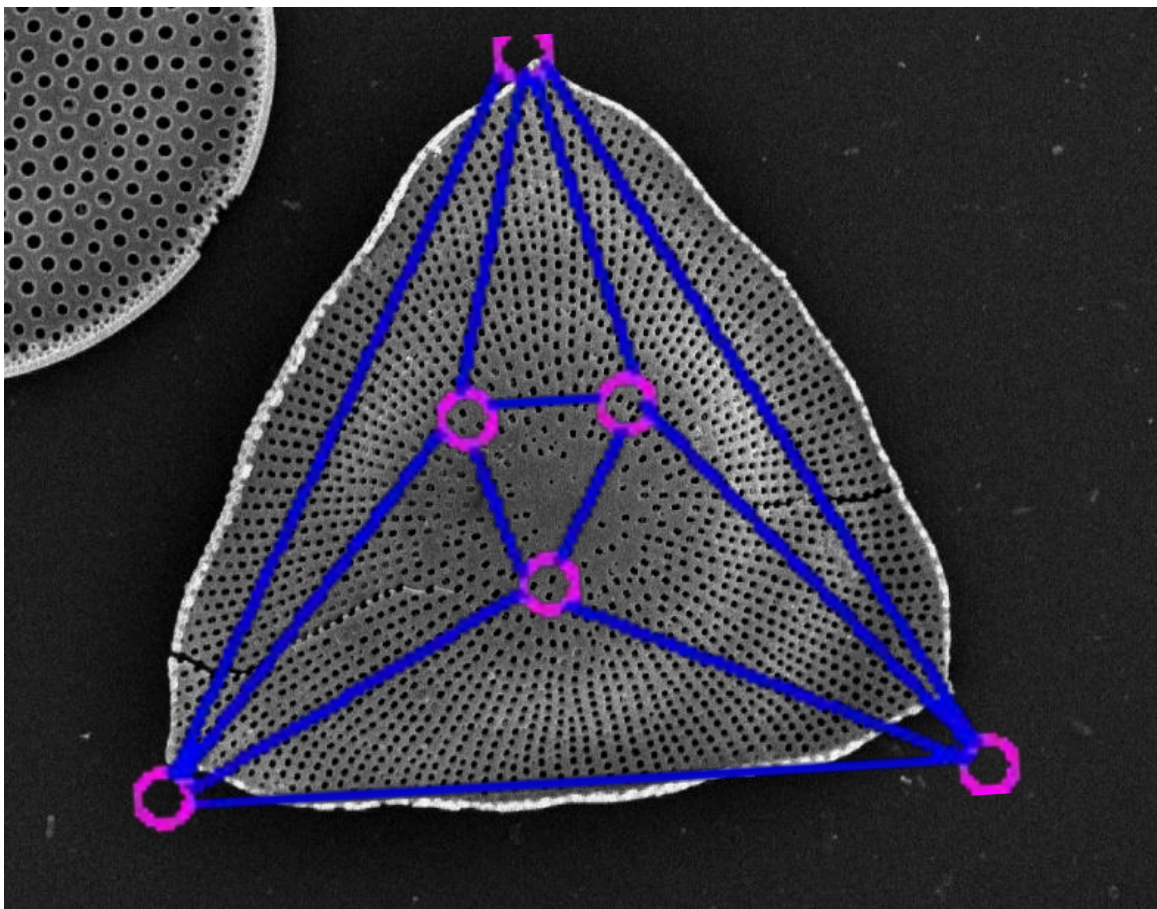


FIGURE 98. Geographic Map:  
*The Königsberg Bridges.*

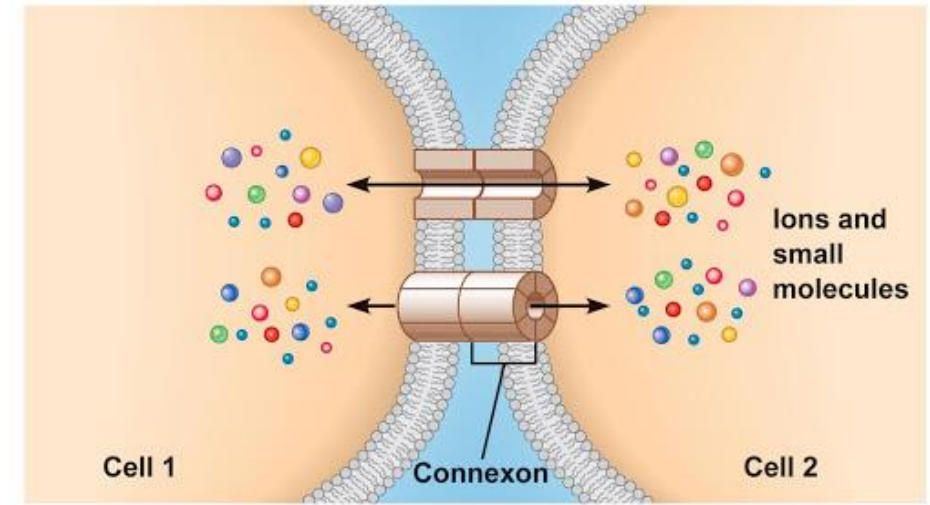
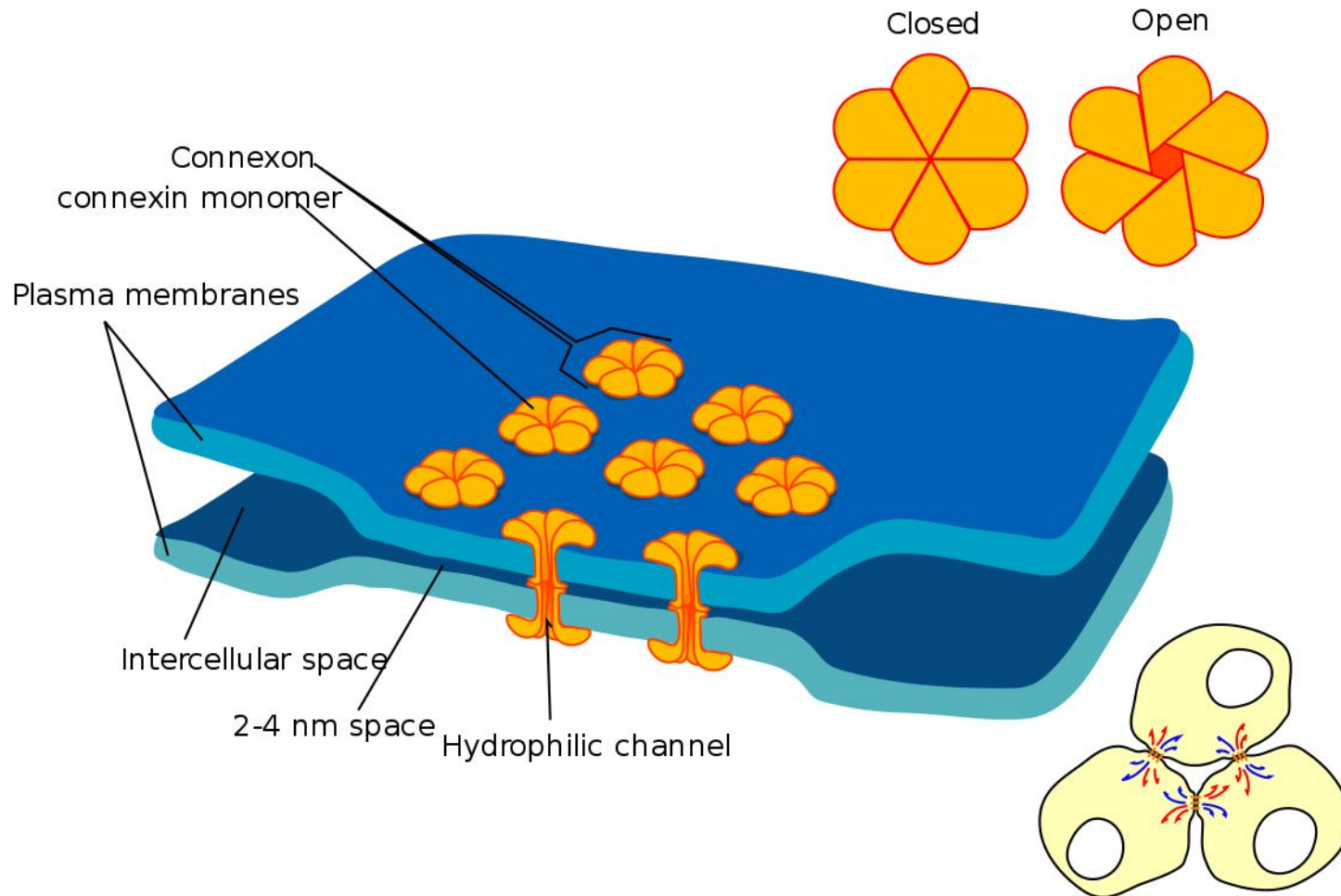


Diatom cell



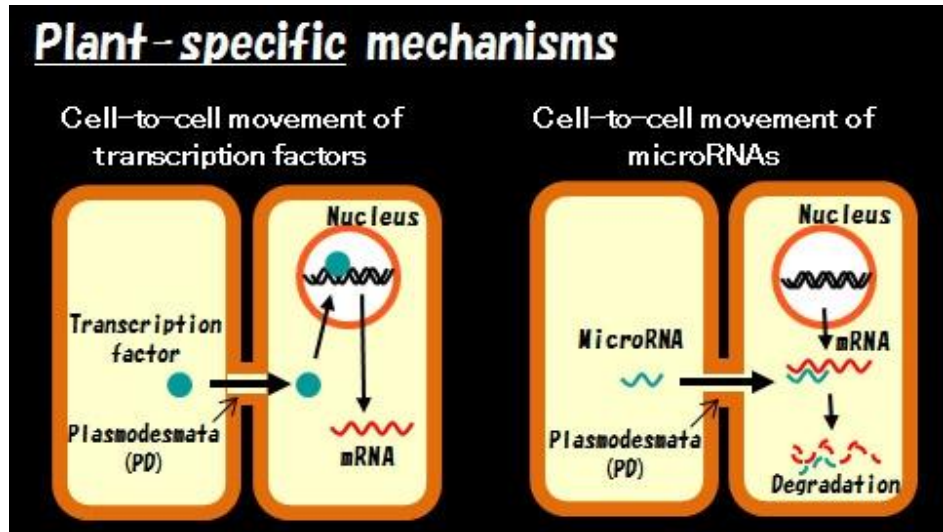


# Why are cell boundaries important?



(a) Direct communication through gap junctions

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# Euler Circuits (EC)

- 1) attempt to cross every independent edge in multicell network.
- 2) Every edge crossed once and only once.
- 3) number of sides of motif and copies of motif determine  $EC = 0$ .
  - even-sided shape (squares, rectangles, hexagons) arrayed in an even number of copies (or even and odd for hexagons) result in  $EC = 0$ .

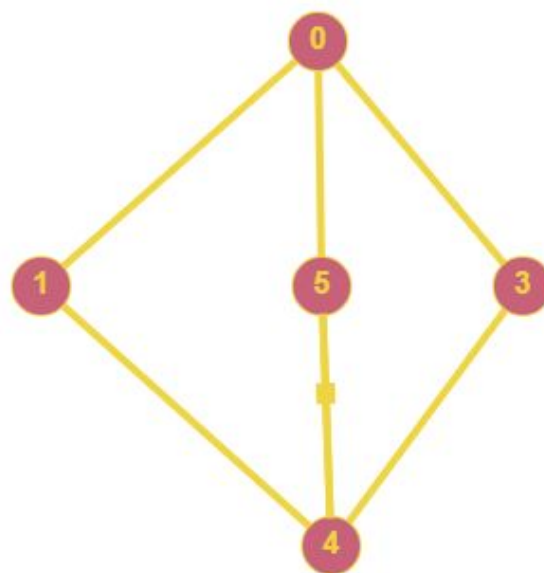


## Find shortest path

Create graph and find the shortest path. On the Help page you [will find tutorial video](#).

[⚙ Graph ▾](#)[🔍 View ▾](#)[🔄 Default m](#)[+ Add vertex v](#)[A Connect vertexes e](#)[⚙ Algorithms ▾](#)[✖ Remove object r](#)[⚙ Settings ▾](#)

Graph has Eulerian path:  $4 \Rightarrow 1 \Rightarrow 0 \Rightarrow 3 \Rightarrow 4 \Rightarrow 5 \Rightarrow 0$



## Find shortest path

Create graph and find the shortest path. On the Help page you will find [tutorial video](#).

⚙ Graph ▾

🔍 View ▾

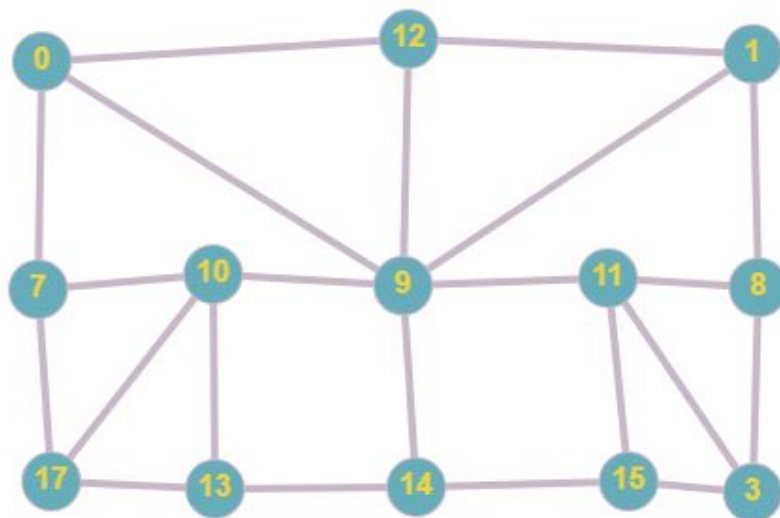
🔄 Default m✚ Add vertex v📐 Connect vertexes e

⚙ Algorithms ▾

✕ Remove object r

⚙ Settings ▾

Graph has not Eulerian path

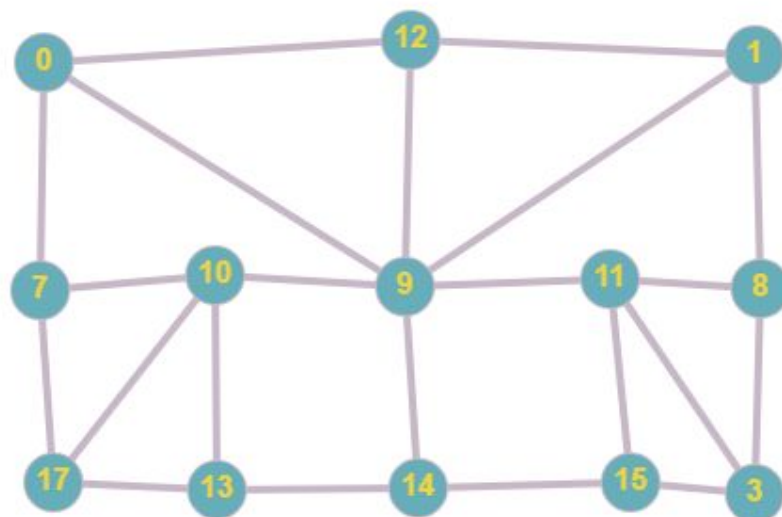


## Find shortest path

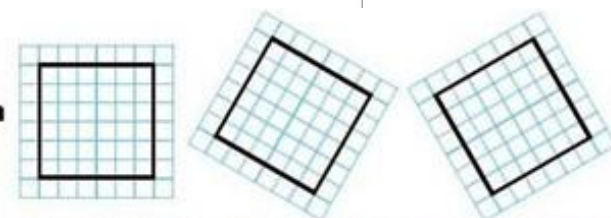
Create graph and find the shortest path. On the Help page you will find [tutorial video](#).

[⚙ Graph ▾](#)
[🔍 View ▾](#)
[🔄 Default m](#)
[+ Add vertex v](#)
[A Connect vertexes e](#)
[⚙ Algorithms ▾](#)
[✕ Remove object r](#)
[⚙ Settings ▾](#)

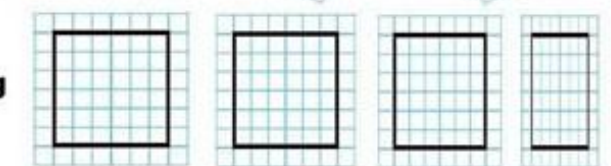
Graph has not Eulerian path



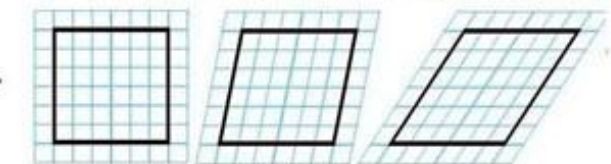
rotation



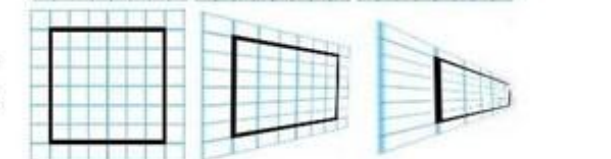
scaling



shear

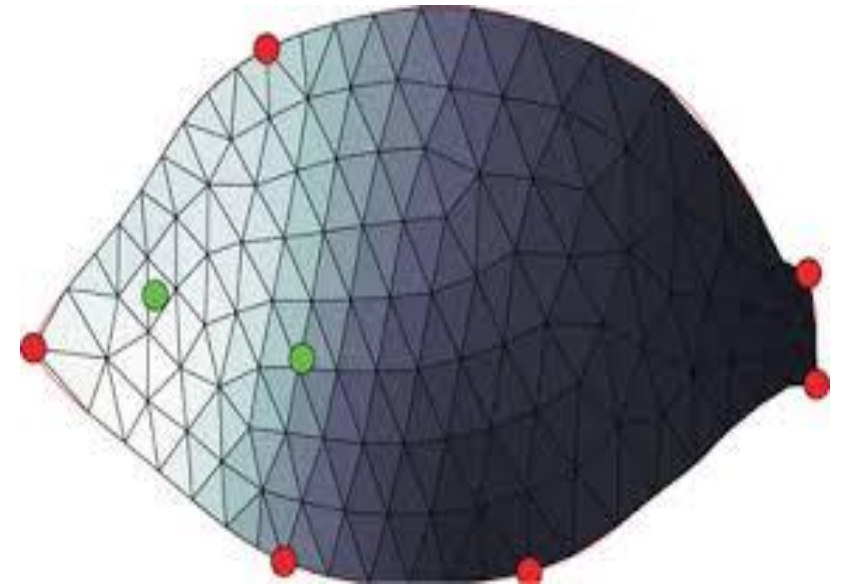
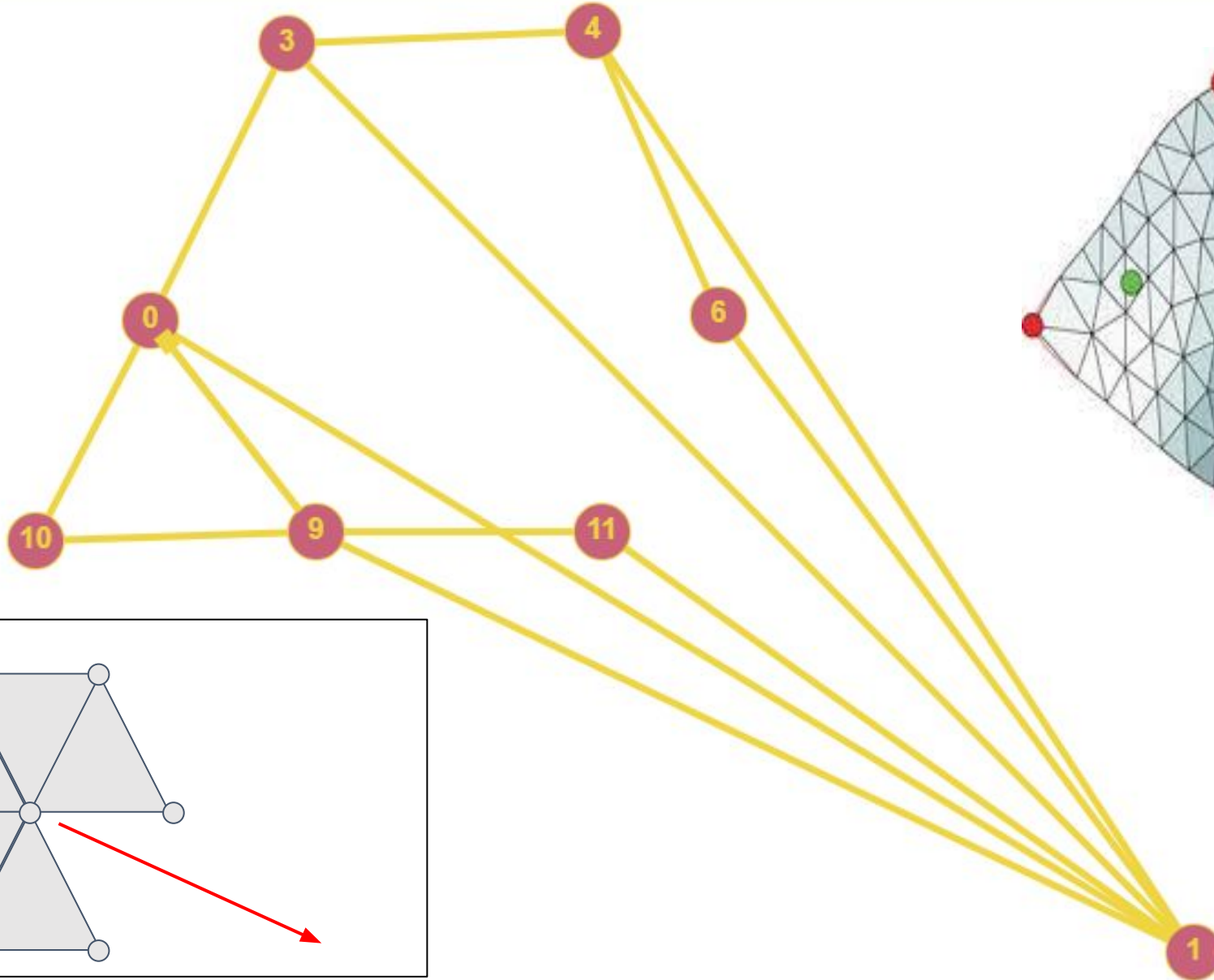


persp-  
ective

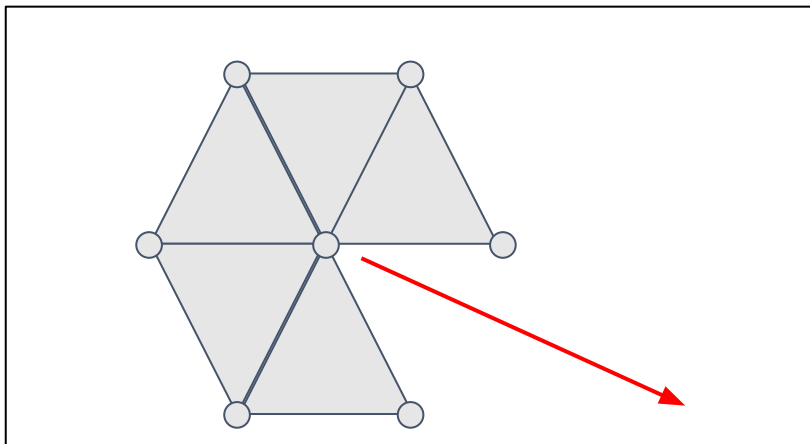




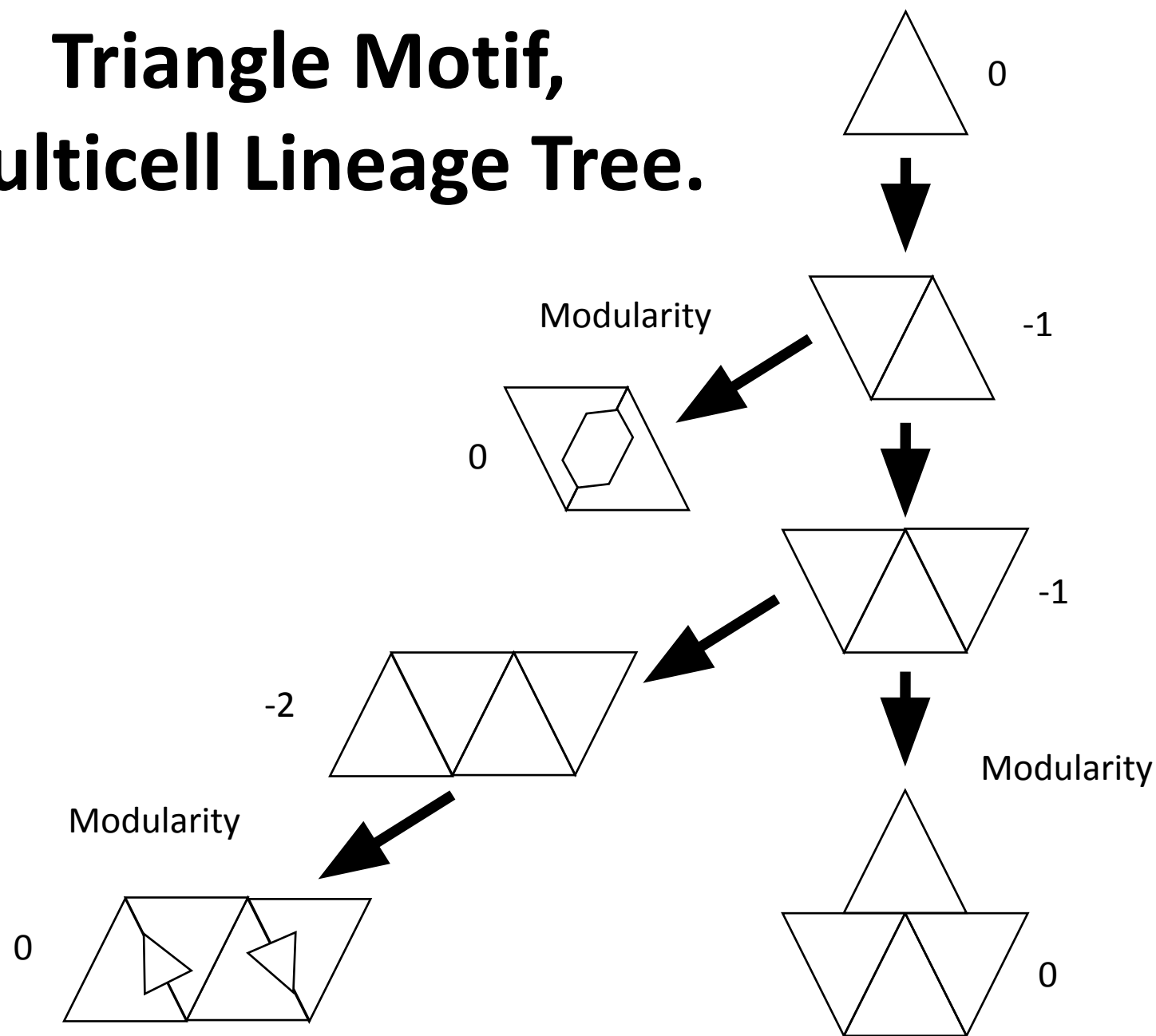
Graph has Eulerian path:  $4 \Rightarrow 1 \Rightarrow 9 \Rightarrow 0 \Rightarrow 10 \Rightarrow 9 \Rightarrow 11 \Rightarrow 1 \Rightarrow 6 \Rightarrow 4 \Rightarrow 3 \Rightarrow 0 \Rightarrow 1 \Rightarrow 3$



Conformal Mappings



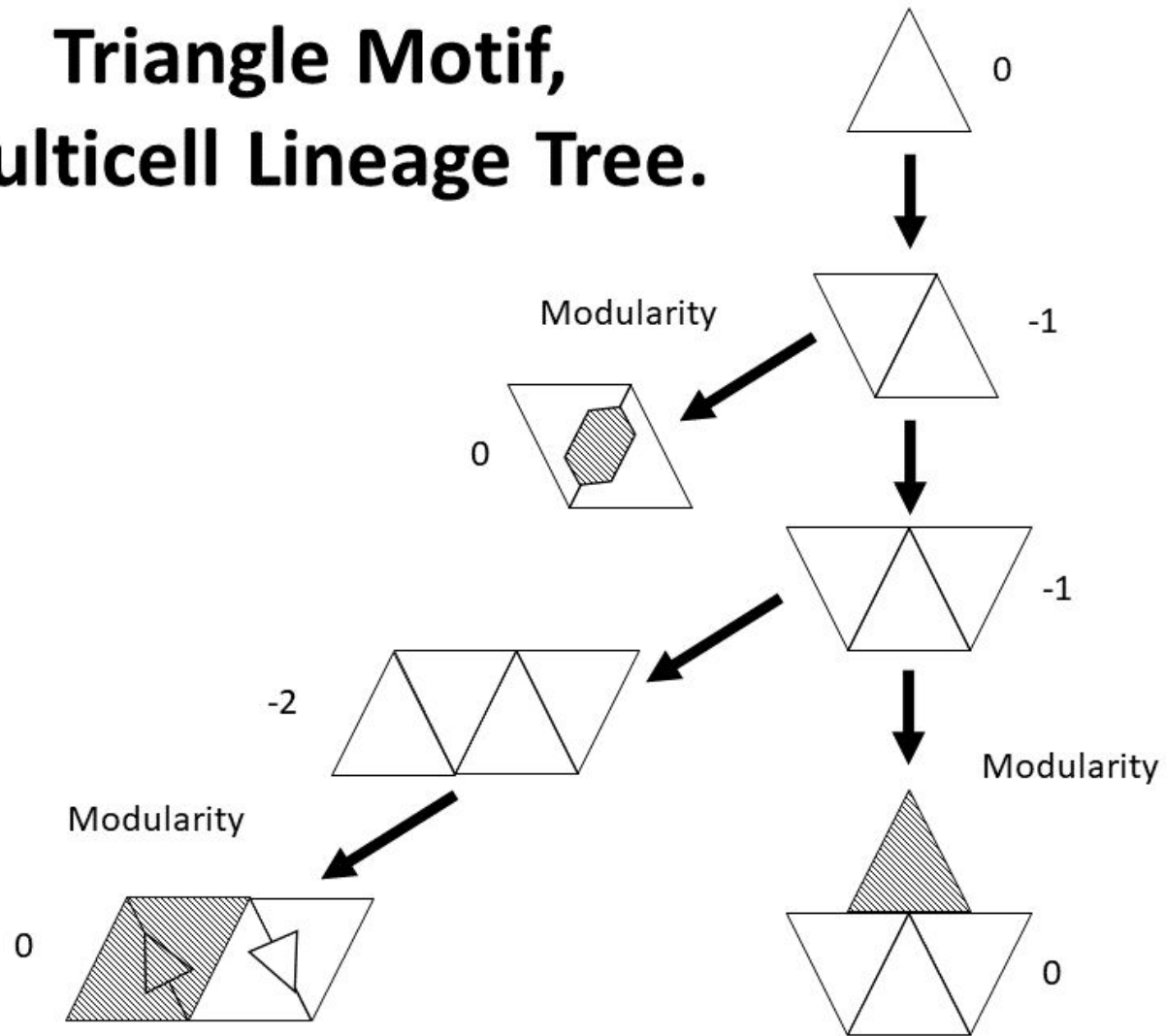
# Triangle Motif, Multicell Lineage Tree.



Numbers represent number of steps from Euler Circuit Completeness\*

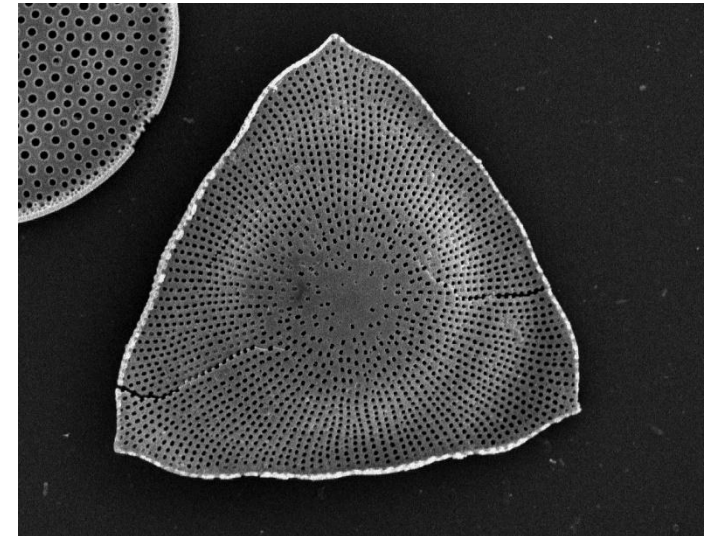
\* every edge crossed only once, no trajectory self-crossings.

# Triangle Motif, Multicell Lineage Tree.



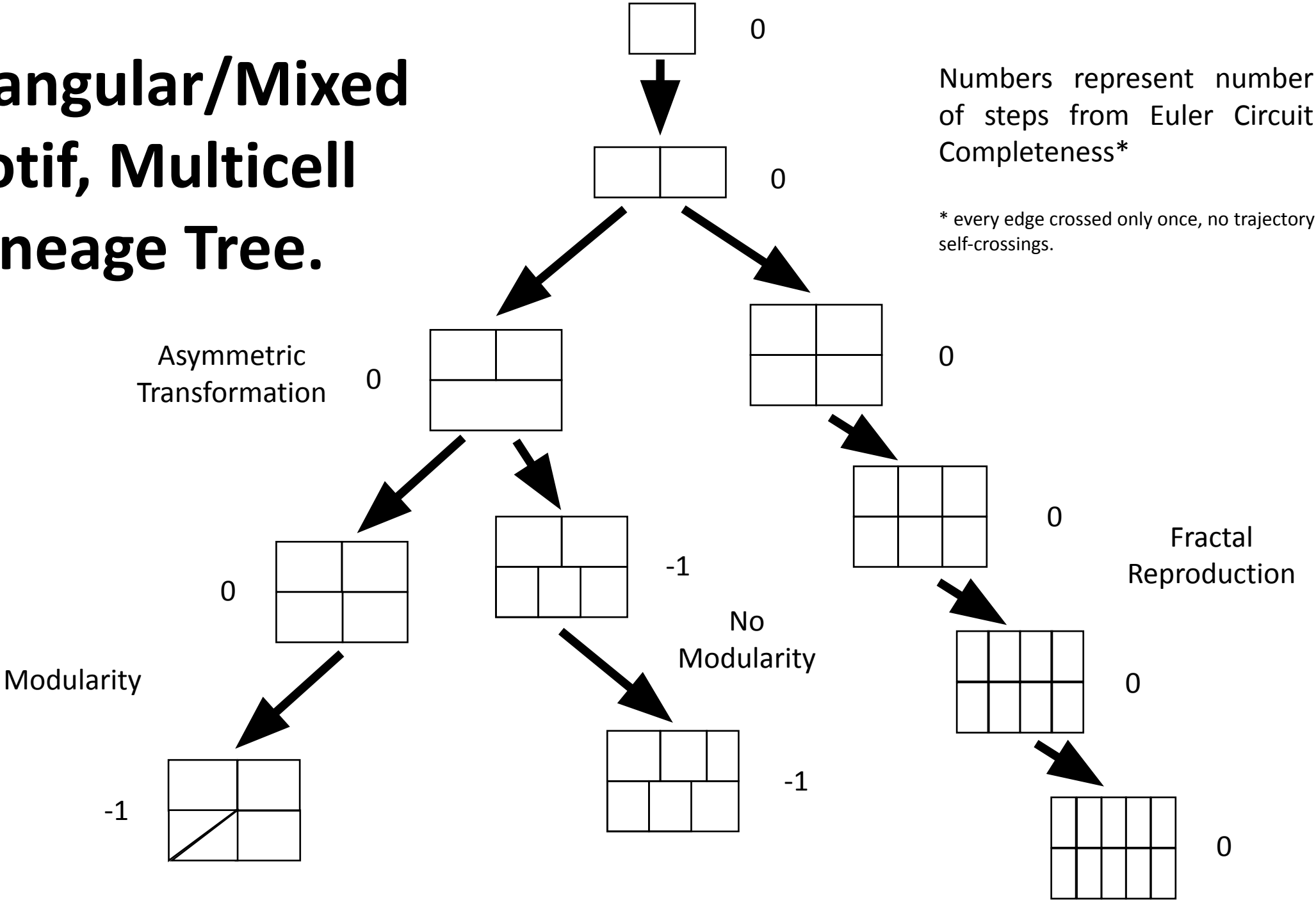
Numbers represent number of steps from Euler Circuit Completeness\*

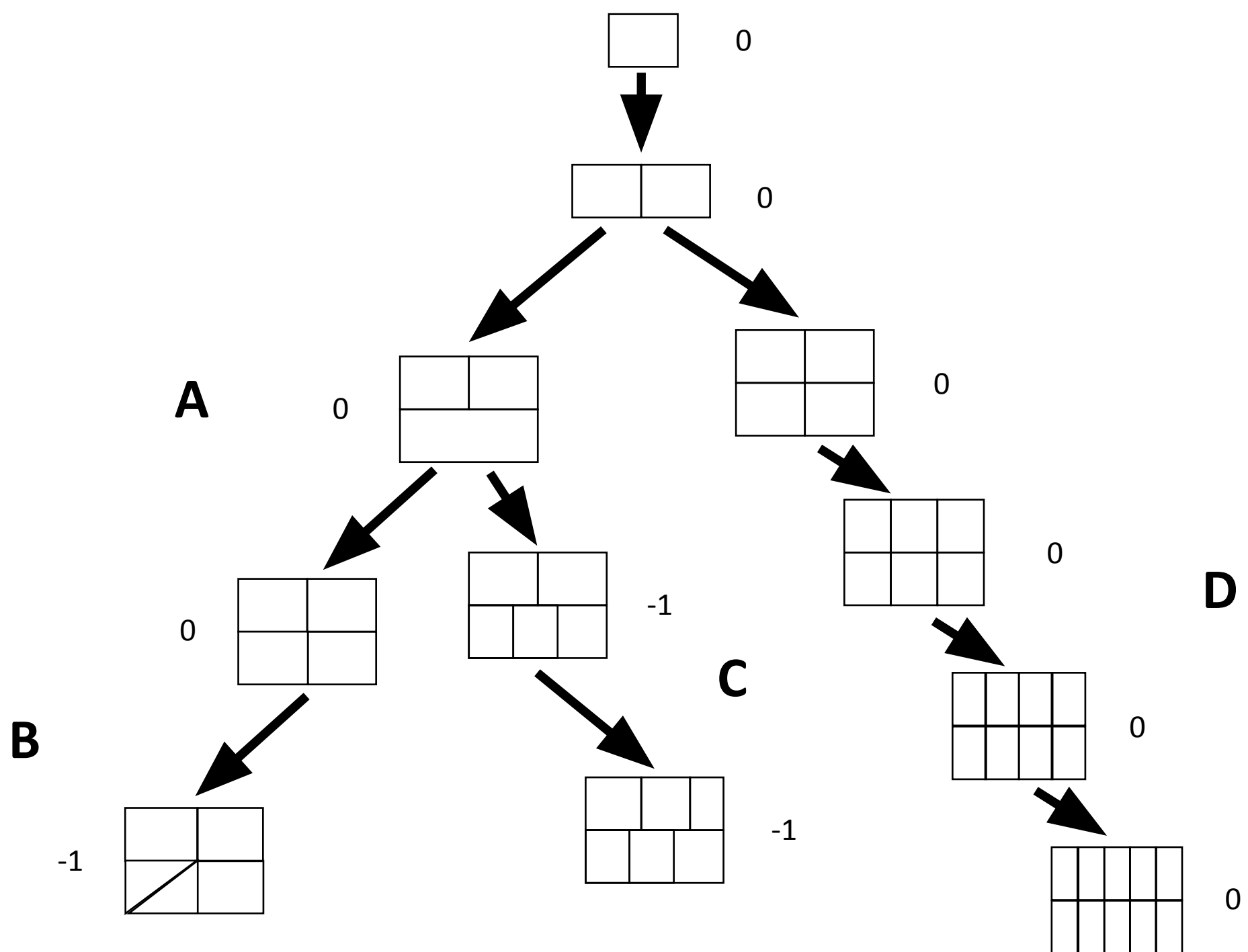
\* every edge crossed only once, no trajectory self-crossings.



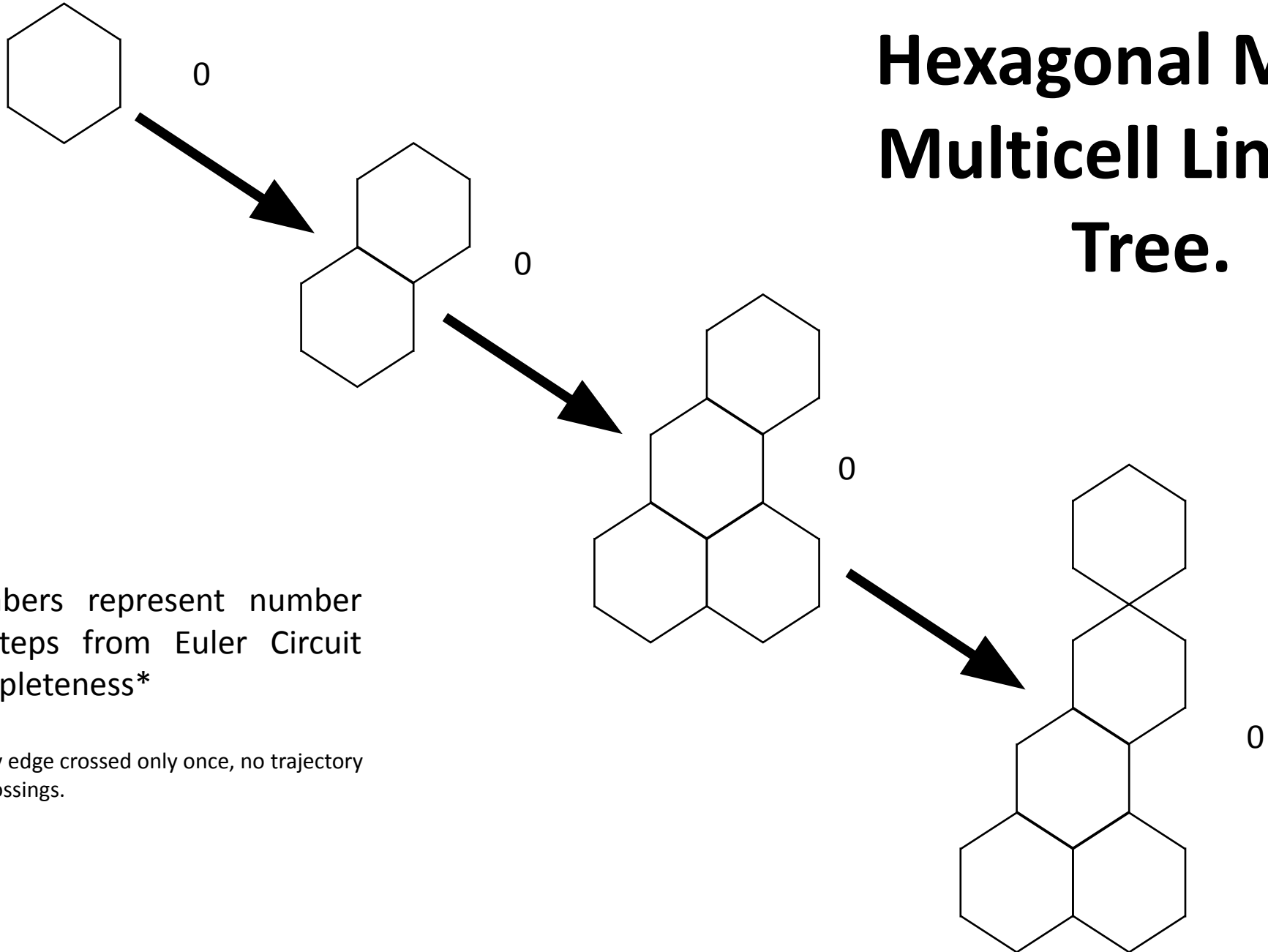


# Rectangular/Mixed Motif, Multicell Lineage Tree.





# Hexagonal Motif, Multicell Lineage Tree.



Numbers represent number  
of steps from Euler Circuit  
Completeness\*

\* every edge crossed only once, no trajectory  
self-crossings.





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100th anniversary conference:

754 THE EQUIANGULAR SPIRAL

recognised by Descartes, and discussed in the year 1638 in his letters to Mersenne\*. Starting with the conception of a growing curve which should cut each radius vector at a constant angle—just as a circle does—Descartes shewed how it would necessarily follow that the radii at equal angles to one another at the pole would be in continued proportion; that the same is therefore true of the part cut off from a common radius vector by successive whorls or convolutions of the spire; and furthermore, that distances measured along the curve from its origin, and intercepted by any radii, as at *B, C*, are proportional to the lengths of these radii, *OB, OC*. It follows that

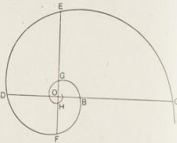
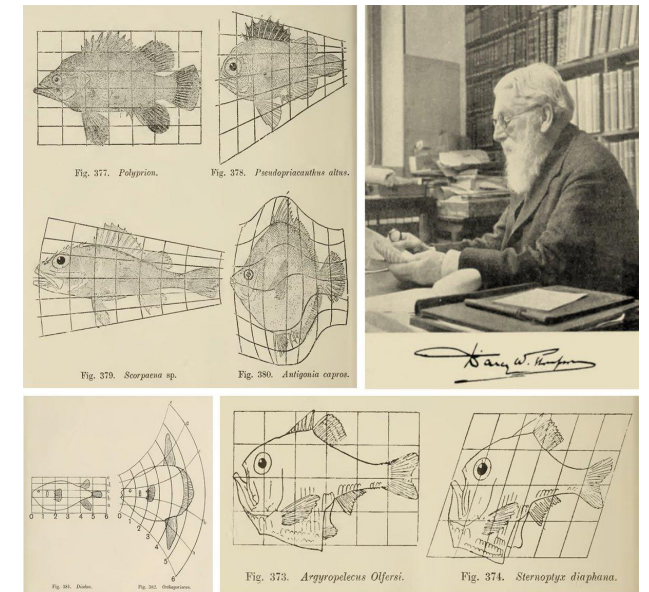
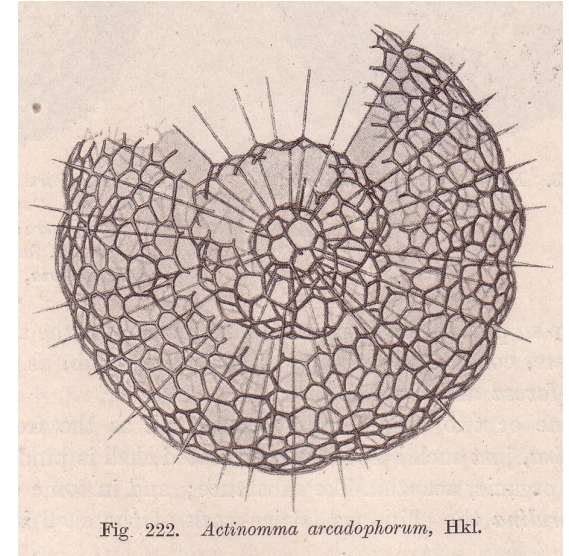




Fig. 356. The equiangular spiral.

the sectors cut off by successive radii, at equal vectorial angles, are similar to one another in every respect; and it further follows that the figure may be conceived as growing continuously without ever changing its shape the while.

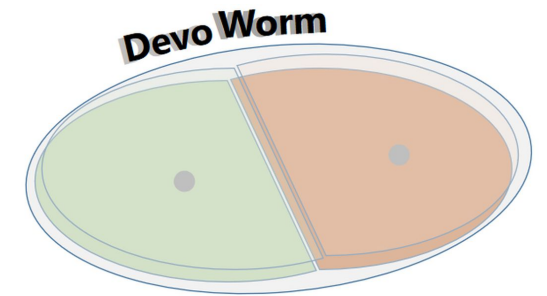
If the whorls increase very slowly, the equiangular spiral will come to look like a spiral of Archimedes. The Nummulus is a case in point. Then we have a large number of whorls, very narrow, very close together, and apparently of equal breadth, which give rise to an appearance similar to that of our usual rope. And, in a case of this kind, we might actually find that the whorls were of equal breadth, being produced (as is apparently the case in the Nummulus) not by any very slow and gradual growth in thickness of a continuous tube, but by a succession of similar cells or chambers laid on, equal and round, determined as to their size by constant surface-tension coefficient and therefore of unvarying dimensions. The Nummulus must always have a central core, or initial coil, around which the coil is not only wrapp'd, but out of which it springs; and this initial chamber corresponds to our *c* in the expression  $r=a'e^{a\theta \cot \alpha}$ .

\* *Quares*, ed. Adam et Tannery, Paris, 1898, p. 260.





# Thanks for your Attention!



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