

TUBES II

**Generation of novelty in a discrete time system
with an unique starting element**

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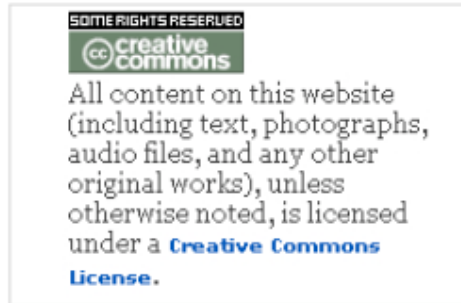
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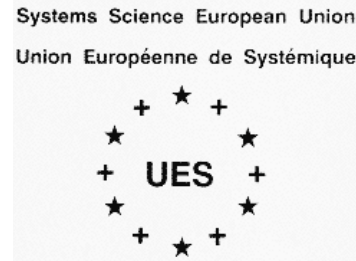
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Structure, Material, Operators, Time

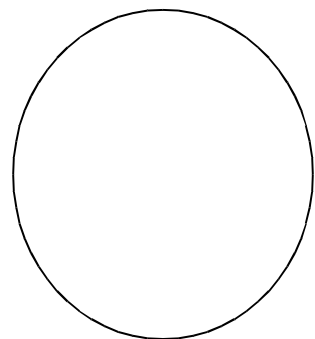
- The initial structure is a TUBE (I) – an empty cylinder
- The material is called « hyper-elast » - a material which shrinks to minimize its surface, volume, and edges. It is a very thin foil.
- The operators used are « cut (K) » and « paste (C) »; other pairs of operators might be used: fold/unfold, pierce/cork, twist-l/twist-r,....
- Time is discrete, materialized by clock ticks

CUT (K)

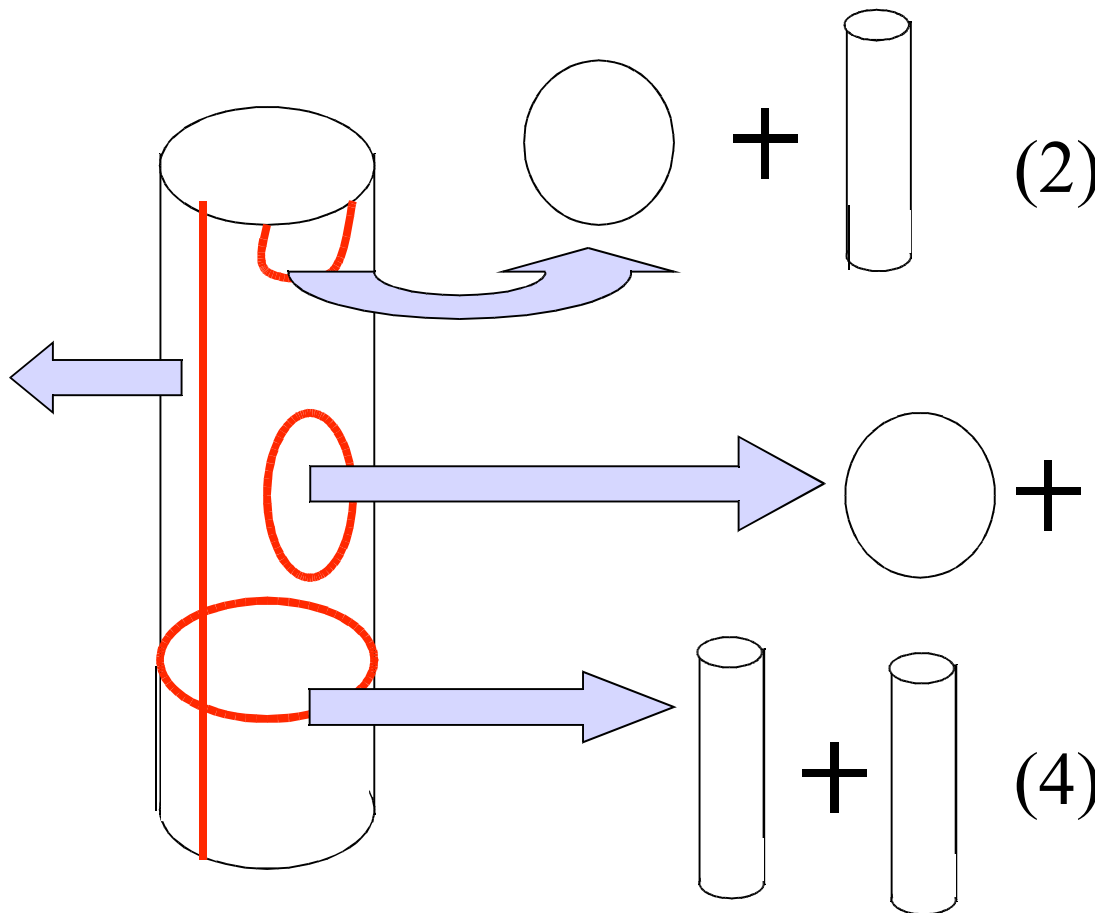
- By applying the operator once, it performs a single cut on a single object, cut which either starts at one edge to join another, or starts at a point to join it again after having done a curve without crossing another edge
- At the clock tick, the operator might be applied just once.

CUT (K)

Disk



(1)



Tube
with
1 hole

(3)

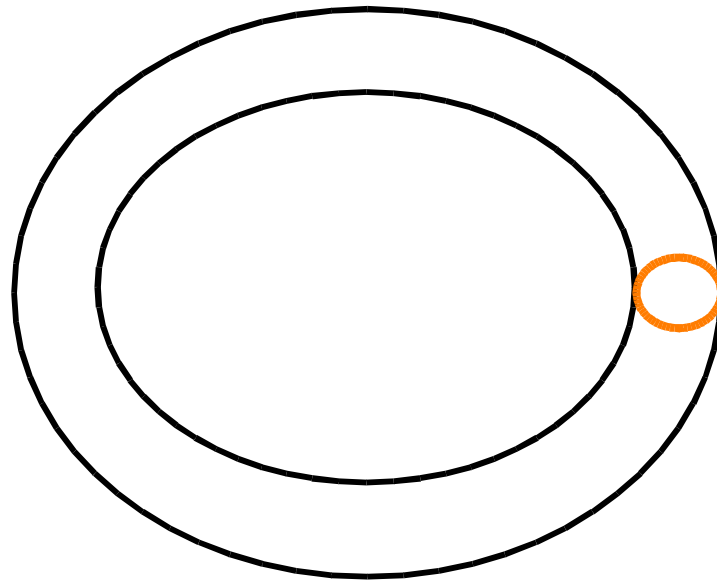
$$/K/I = \mathbf{D} \text{ or } [\mathbf{D}, \mathbf{I}] \text{ or } [\mathbf{D}, \mathbf{I}_1] \text{ or } [\mathbf{I}, \mathbf{I}]$$

PASTE (C)

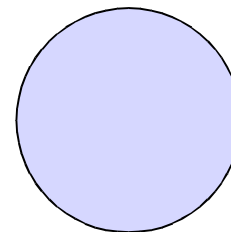
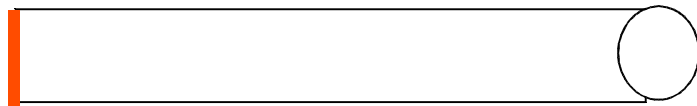
- By applying the operator once, it could stick together edges ; any edge on itself or on another edge.
- At the clock tick, the operator might be applied just once.

PASTE (C)

Torus (T)



Disk (D)



$/C/I \Rightarrow D \text{ or } T$

Operation on D and T

***/C/* T = T** ("paste" on a torus is inoperant: it is edgeless)

***/C/* D = S** (sphere)

***/C/* [I,I] = [D,I] or [T,I]**

***/C/* [D,I] = [S,I] or [D,T] or [D,D]**

***/C/* [D,I₁] = [S,I₁] or [D,T₁]** (I₁ – tube with a hole/ T₁ – torus with a hole)

***/K/* D = [D,D] or [D,I]**

Novelty generation only

$G_0 \rightarrow I$

$G_1 \rightarrow D, T, [D, I_1], \dots$

$G_2 \rightarrow [S, I], [D, T_1], [D, D, I_2], \dots$

and extract from such selected groups novelty only :

$G_0 \rightarrow I$

$G_1 \rightarrow D, T, I_1$

$G_2 \rightarrow S, T_1, I_2$

Novelty generation only

G3 -> T₂, I₃

G4 -> 2L*, T₃, I₄

G5 -> T₄, I₅, 2L₁

G6 -> T₅, I₆, 2L₂

G7 -> T₆, I₇, 2L₃, 3L**

***2L**, a « pair of glasses »(a torus with two empties)

- by application of /C/ on T₂

****3L**, a torus with three empties)

- by application of /C/ on 2L₂

General observations

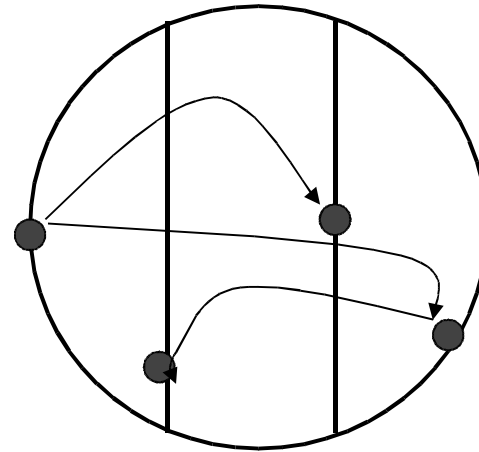
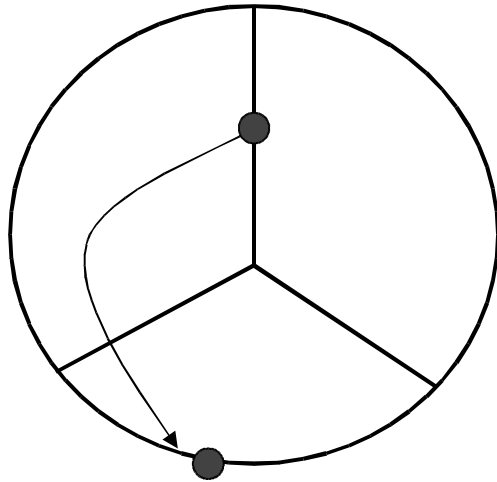
- Applying $/C/$ on close structures is inoperant
- The same structure might show-up at different generations from different operation sequences
- From a certain point on, a third dimension is required
- $/K/S$ or $/K/D = [D,D] \gg$ indeterminacy in knowledge of the past

Complexity appears by applying just two operators on one initial structure, after a few generations

General observations

- Novelty is rather rare
- Novelty might be obtained by associating objects coming from different groups at the same generation :
 - $/K/T=[D,T_1]$ or ...
 - $/C/[D,I_1]=[D,T_1]$ or
 - $/C/(T_1,T_1)=2L$
- S,D and I, as roots, are « equivalent » as far as novelty generation is concerned
 - $/K/S=[D,D]$
 - $/K/D=[D,I]$ or $[D,D]$
 - $/C/D=S$

The third dimension (1)



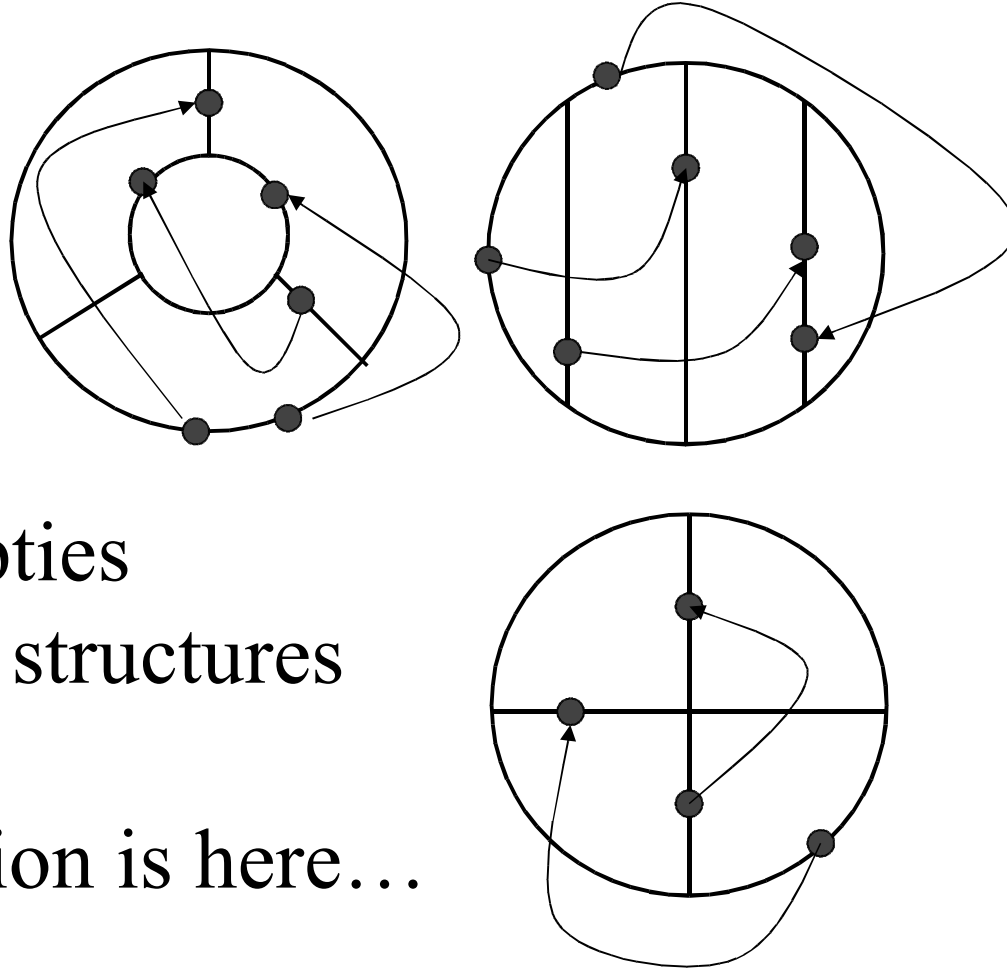
If $/C/$ is applied on figures with non adjacent regions,

A third dimension is mandatory to express the result

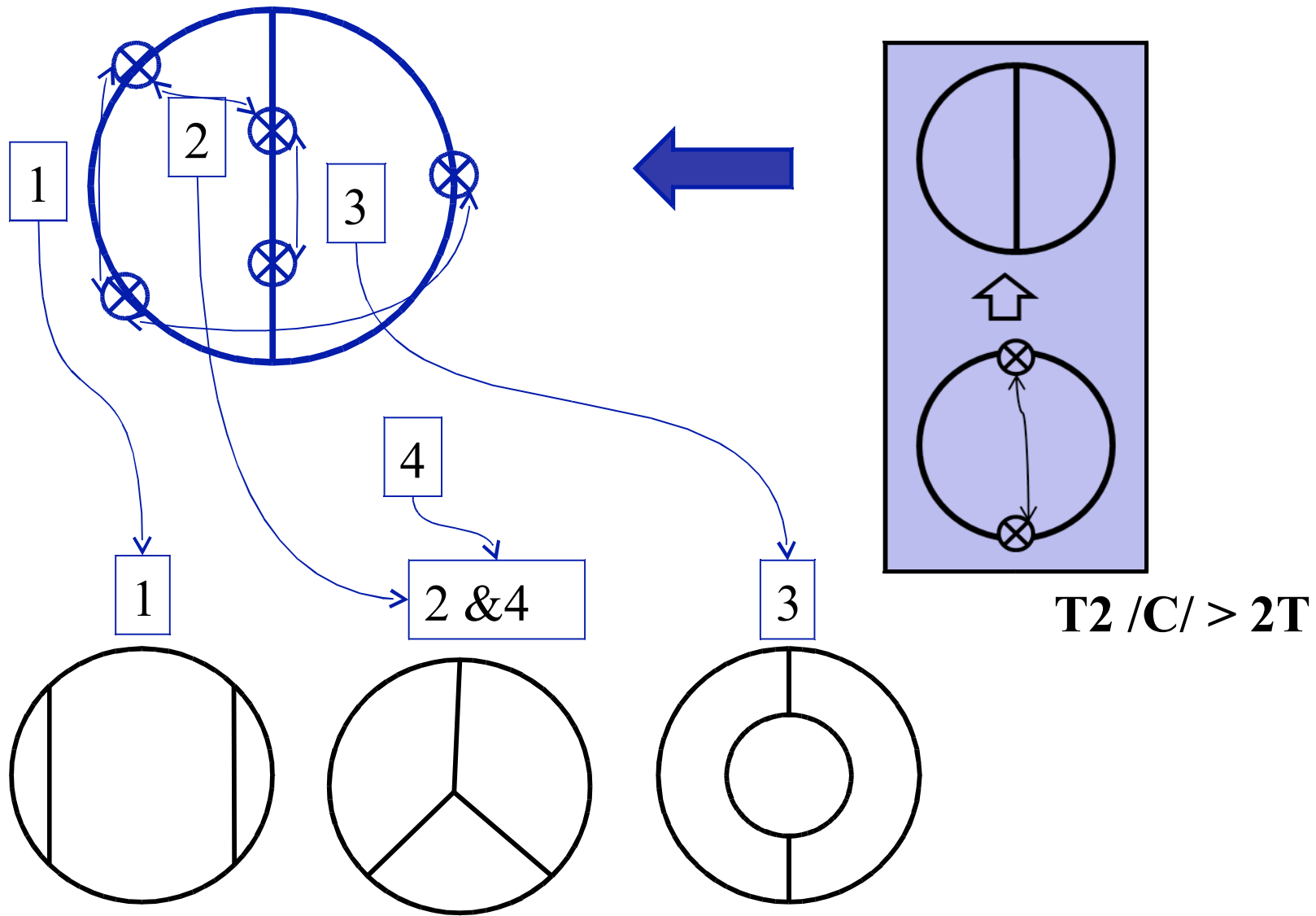
The third dimension (2)

In case of 4 empties,
more possibilities for
a 3D shape appear.

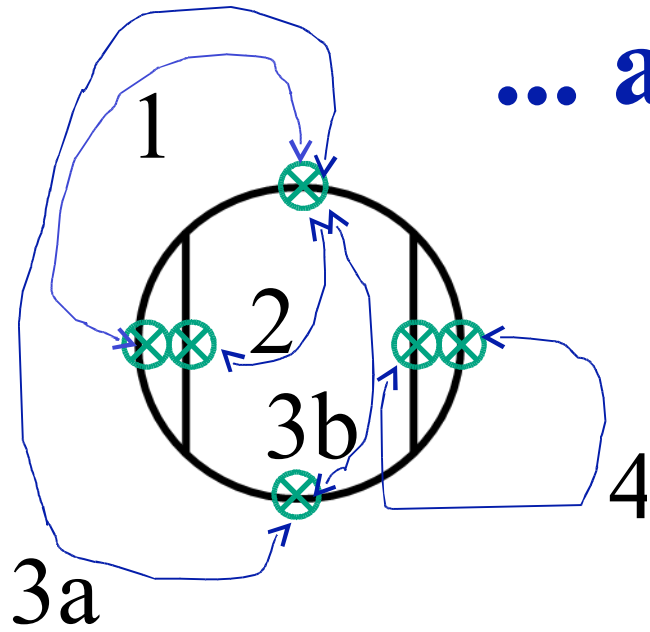
As the number of empties
grows, more complex structures
will show up, and the
Combinatorial explosion is here...



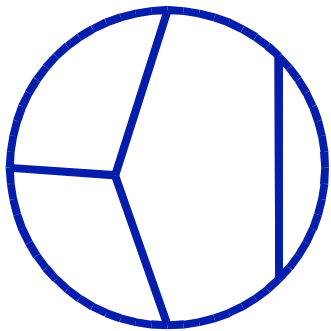
Remaining in 2D...



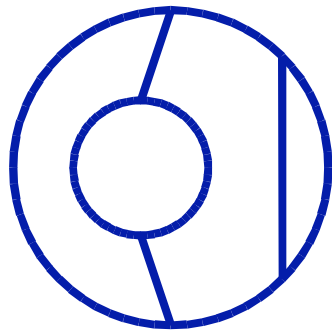
... and continuing (1)



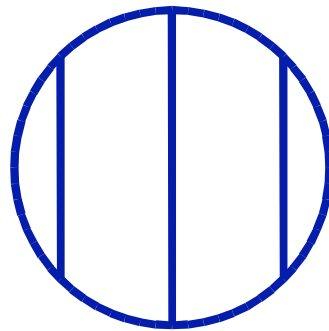
1&2



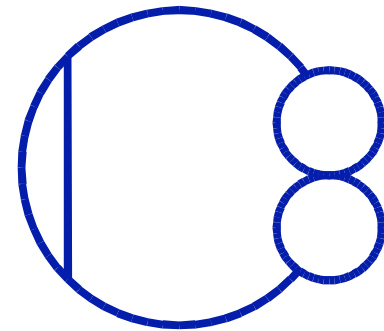
3a



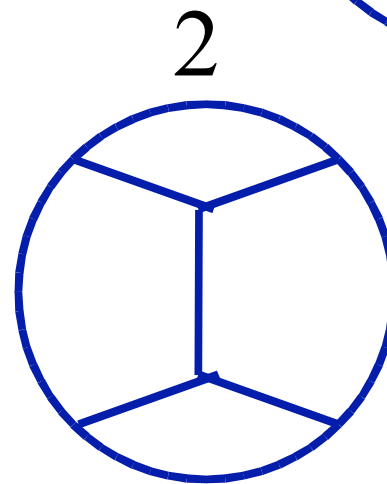
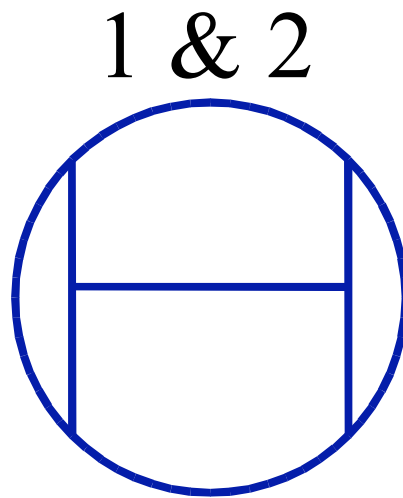
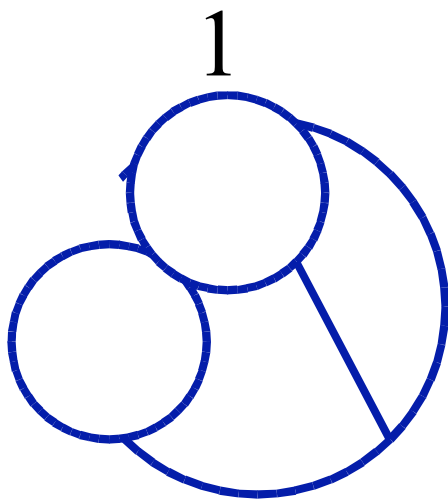
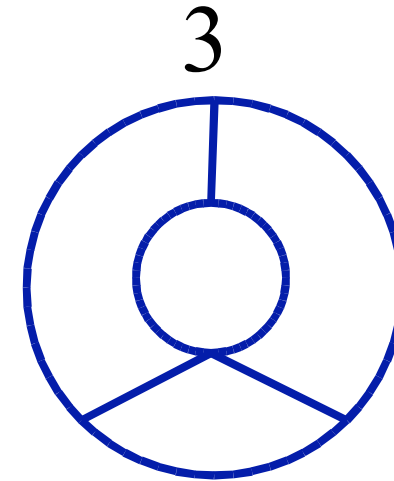
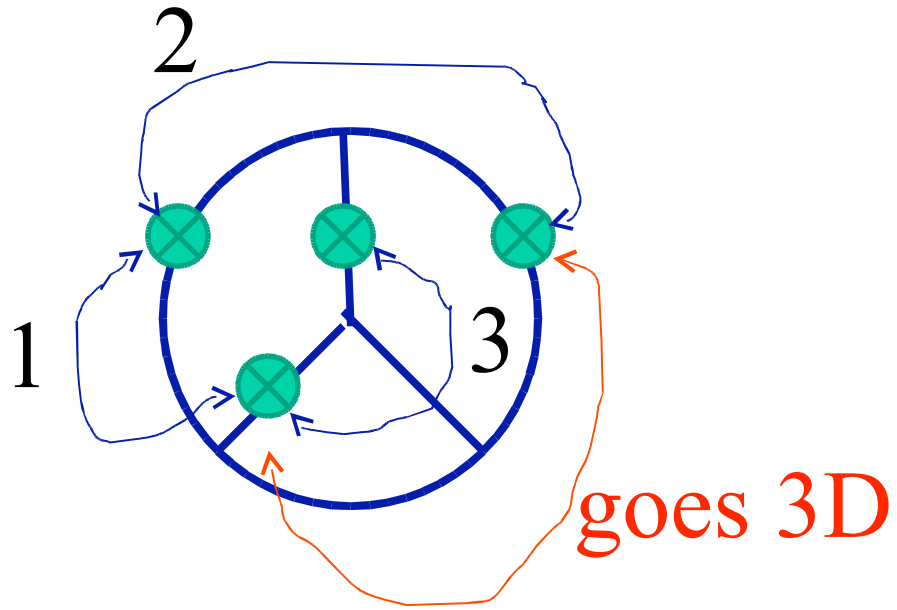
3b



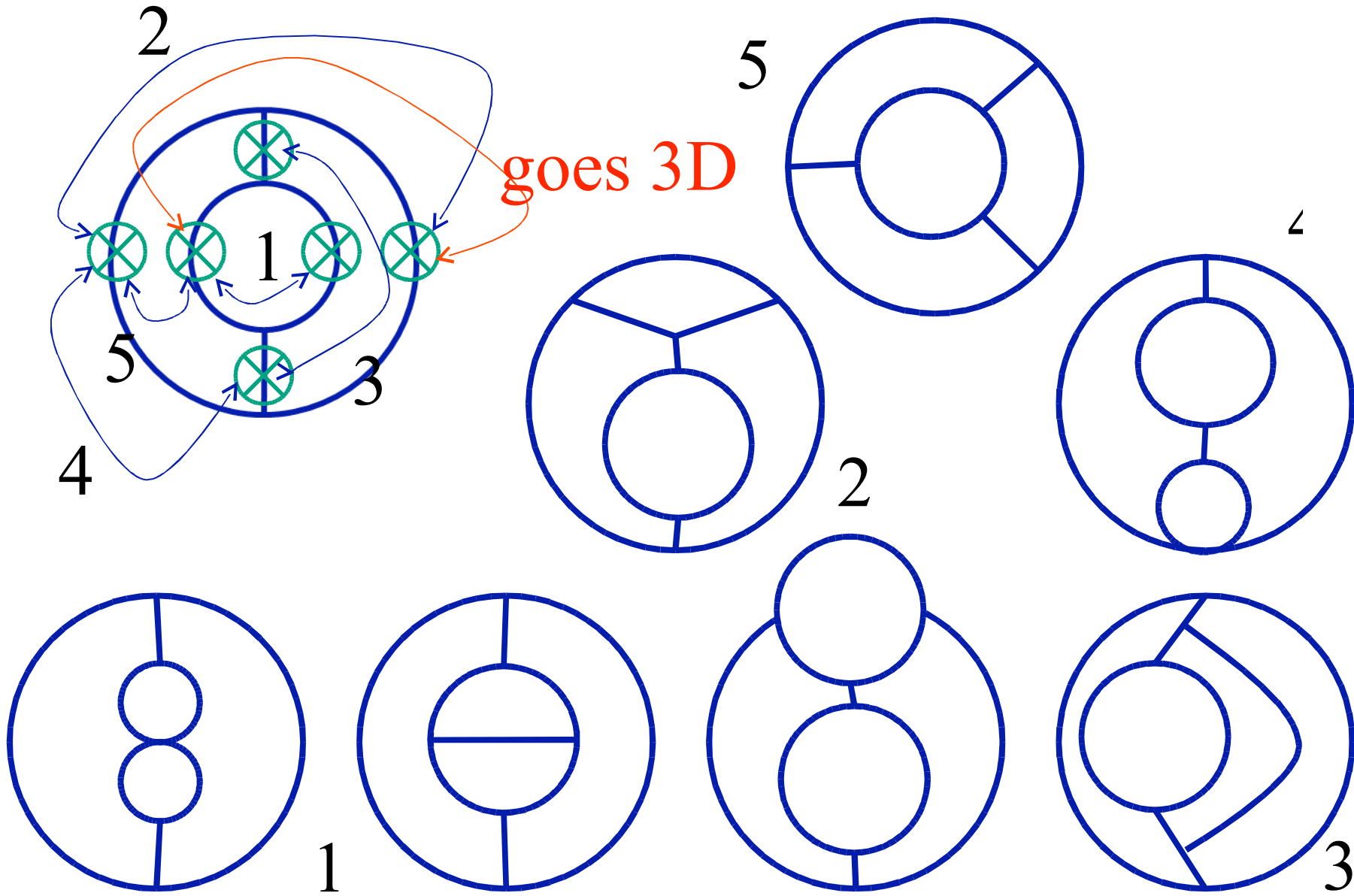
4



... and continuing (2)



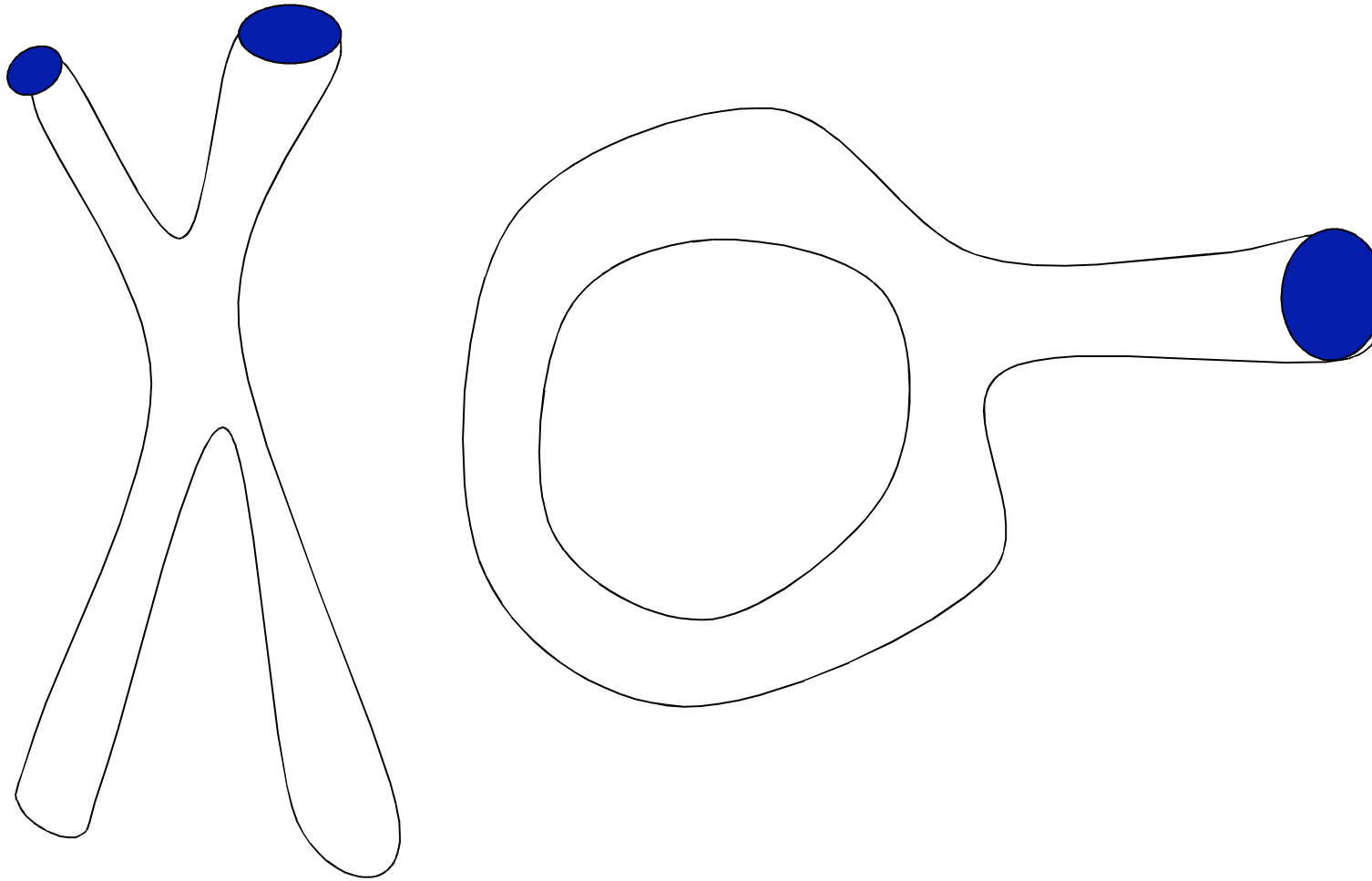
... and continuing (3)



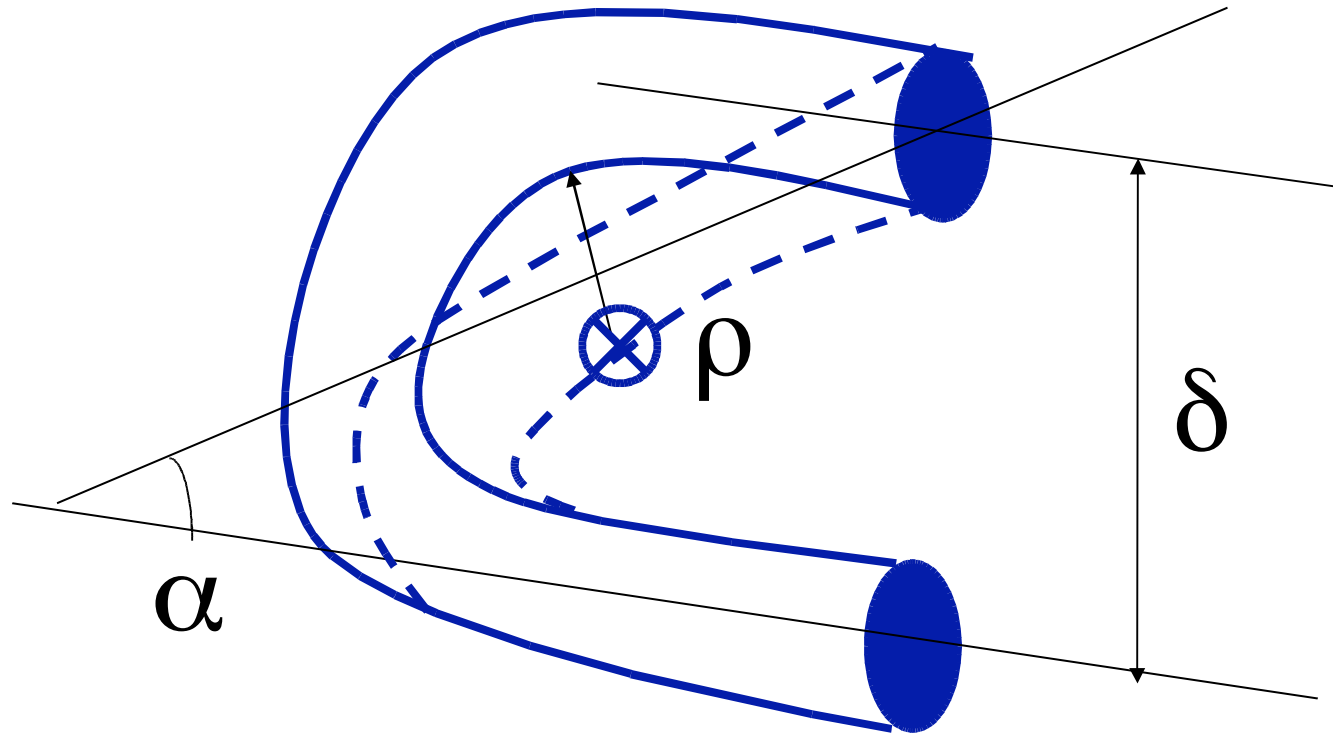
A few directions for further research

- **Use of more operators (fold/unfold being the most interesting, but poses the angles and dimensionality problems)**
- **Relax the material properties (ie. extensibility) and the operators application rules (ie; general paste)**
- **Produce a program to express the results in litteral and graphics (the « forecast problem)**
- **Examine the relation to knots**
- **Do an AL program (at least litteral)**
- **Do a classification exercise to aggregate shapes with the same properties and genesis.**

Examples of shapes obtained by relaxation of the material properties



Folding/Unfolding

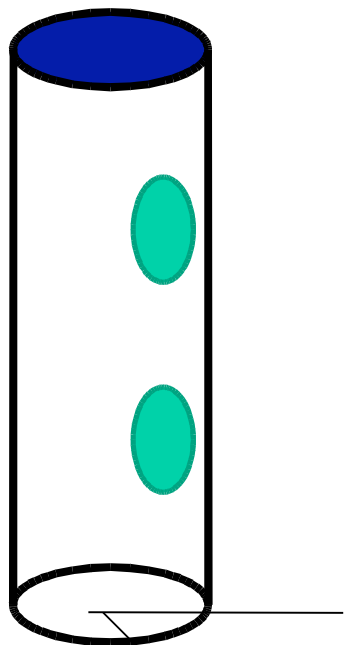


Angle α and distance δ from 0 to...

A curvature radius ρ from 0 to...

...all this means « dimension »

Twisting

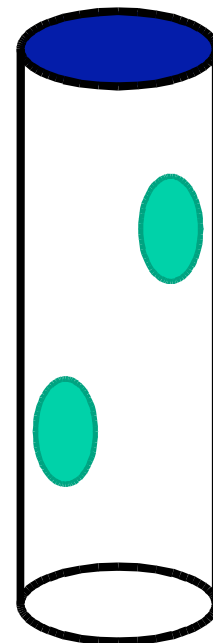


α

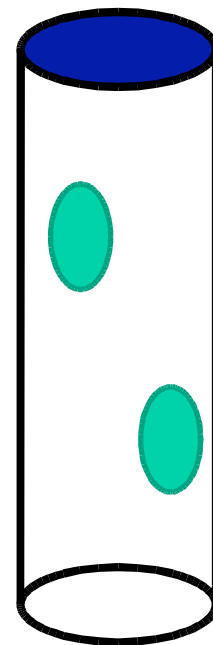
The angle $\alpha > 0$



Twist-l



Twist-r



A first conclusion

- **This research continues to be at its beginnings.**
- **The complexity which appears after a few generations allows to further inquire into the complexity subject as such.**
- **The « vicinity » with knots, some chemical molecules behavior, allows to expect interesting results in terms of modelling.**
- **This research is a very interesting tool for Systemics teaching, to better grasp complexity.**
- **This research shows the power of qualitative models using simple operators**