TUBES II

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

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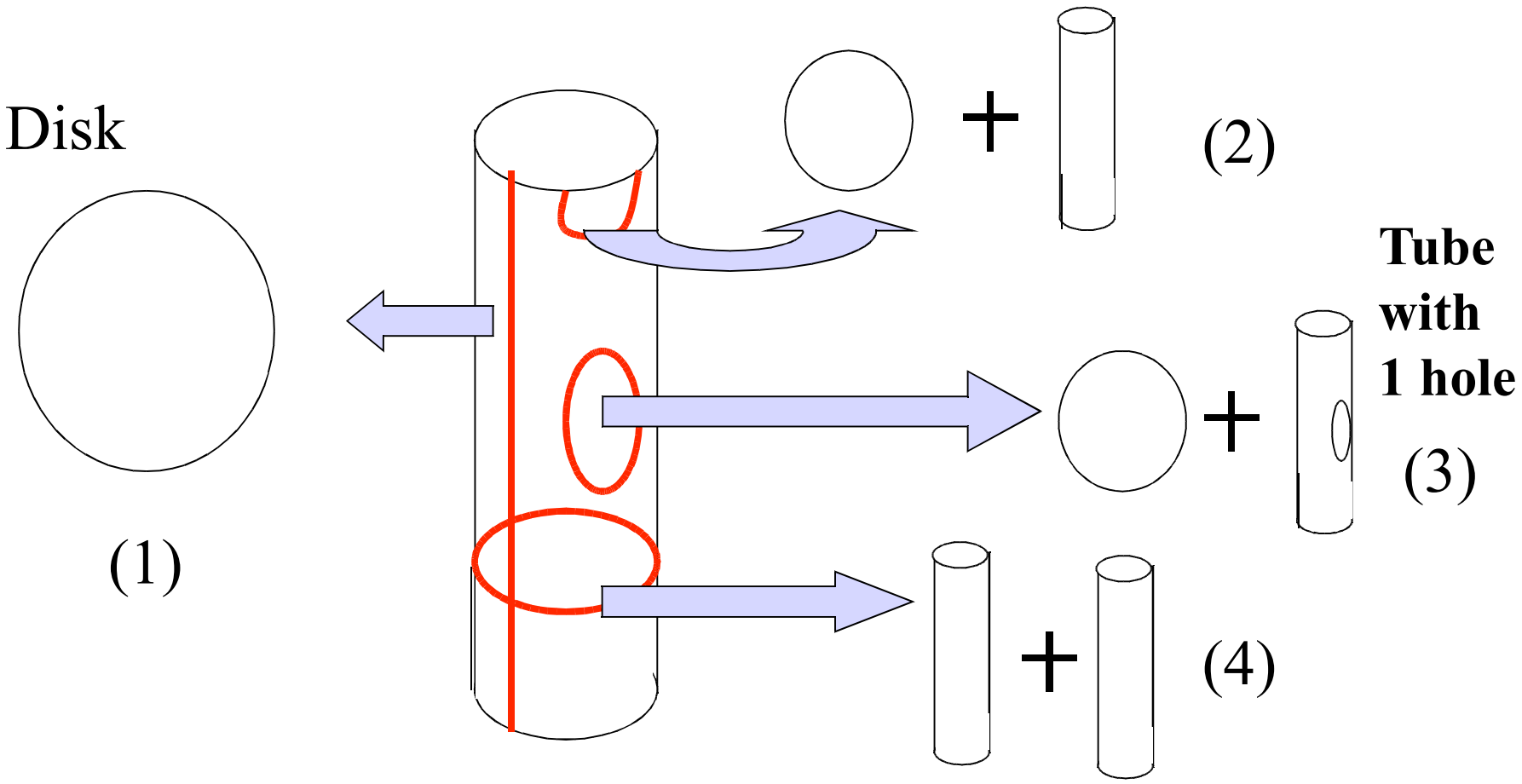
Structure, Material, Operators, Time

- 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*)



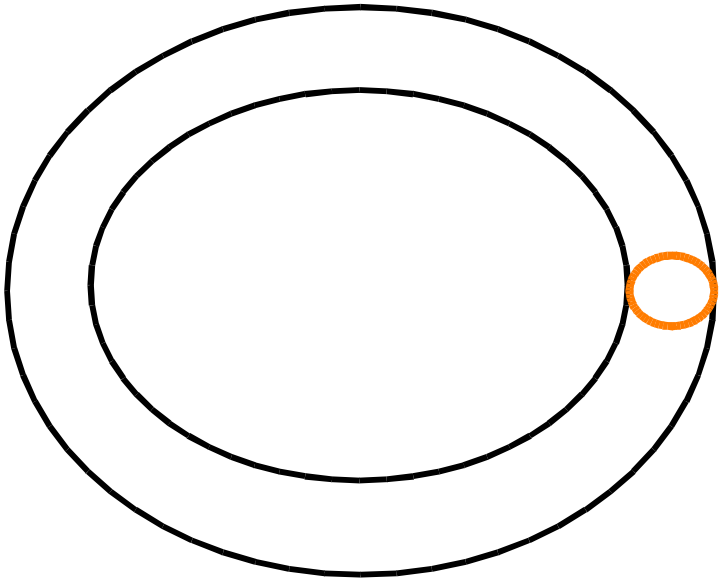
/*K*/I = D or [D,I] or [D,I$_1$] or [I,I]

PASTE (*C*)

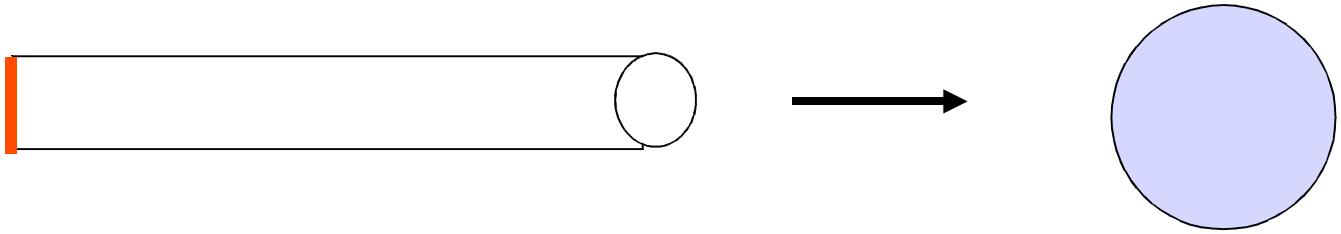
- By applying the operator once, it could stick together edges ; any edge on itself or on another edge.
- At the clock tick, the operator might be applied just once.

PASTE (*C*)

Torus (T)



Disk (D)



/*C*/I => D 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,I_1] = [S,I_1] or [D,T_1] (I_1 – tube with a hole/ T_1 – torus with a hole)

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

Novelty generation only

G_0 -> I

G_1 -> D, T, [D,I_1],…

G_2-> [S,I], [D,T1], [D,D,I2],…

and extract from such selected groups novelty only :

G_0 ->I

G_1 -> D, T, I_1

G_2 -> S, T1, I_2

Novelty generation only

G_3 -> T_2, I_3

G_4 -> 2L*, T_3, I_4

G_5 -> T_4, I_5, $2L_1$

G_6 -> T_5, I_6, $2L_2$

G_7 -> T_6, I_7, $2L_3$, 3L**

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

- by application of /***C***/ on **T_2**

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

- by application of /***C***/ on **$2L_2$**

General observations

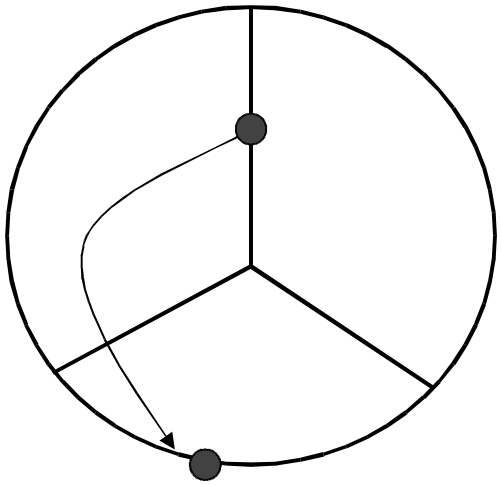
- Applying /***C***/ on close structures is inoperant
- The same structure might show-up at different generations from different operation sequences
- From a certain point on, a third dimension is required
- /***K***/S or /***K***/D = [D,D] >> indeterminacy in knowledge of the past

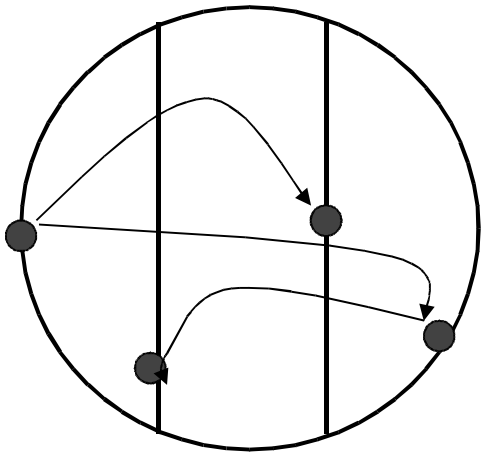
Complexity appears by applying just two operators on one initial structure, after a few generations

General observations

- Novelty is rather rare
- Novelty might be obtained by associating objects comming 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)

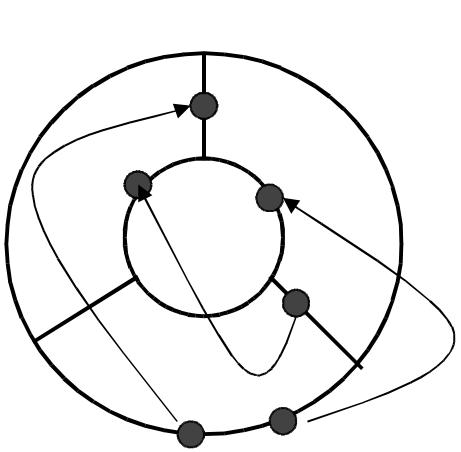


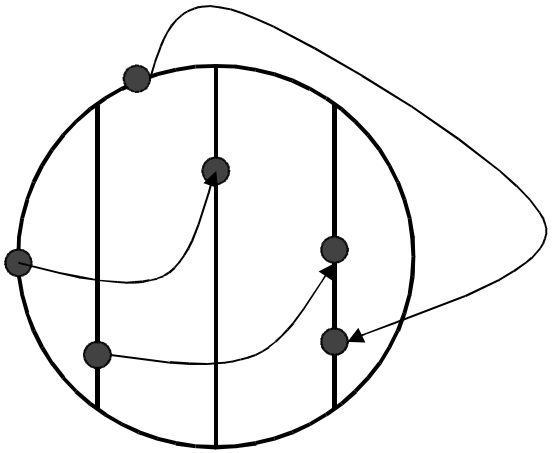


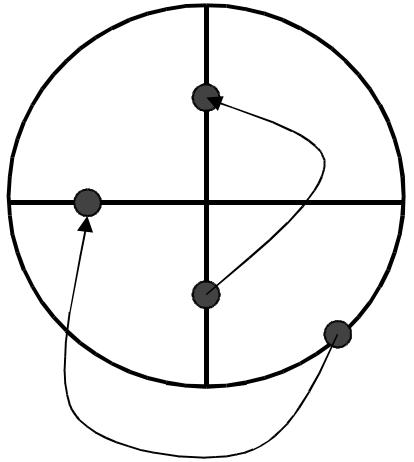
If /***C***/ is applied on figures with non adjacent regions,
A third dimension is mandatory to express the result

The third dimension (2)

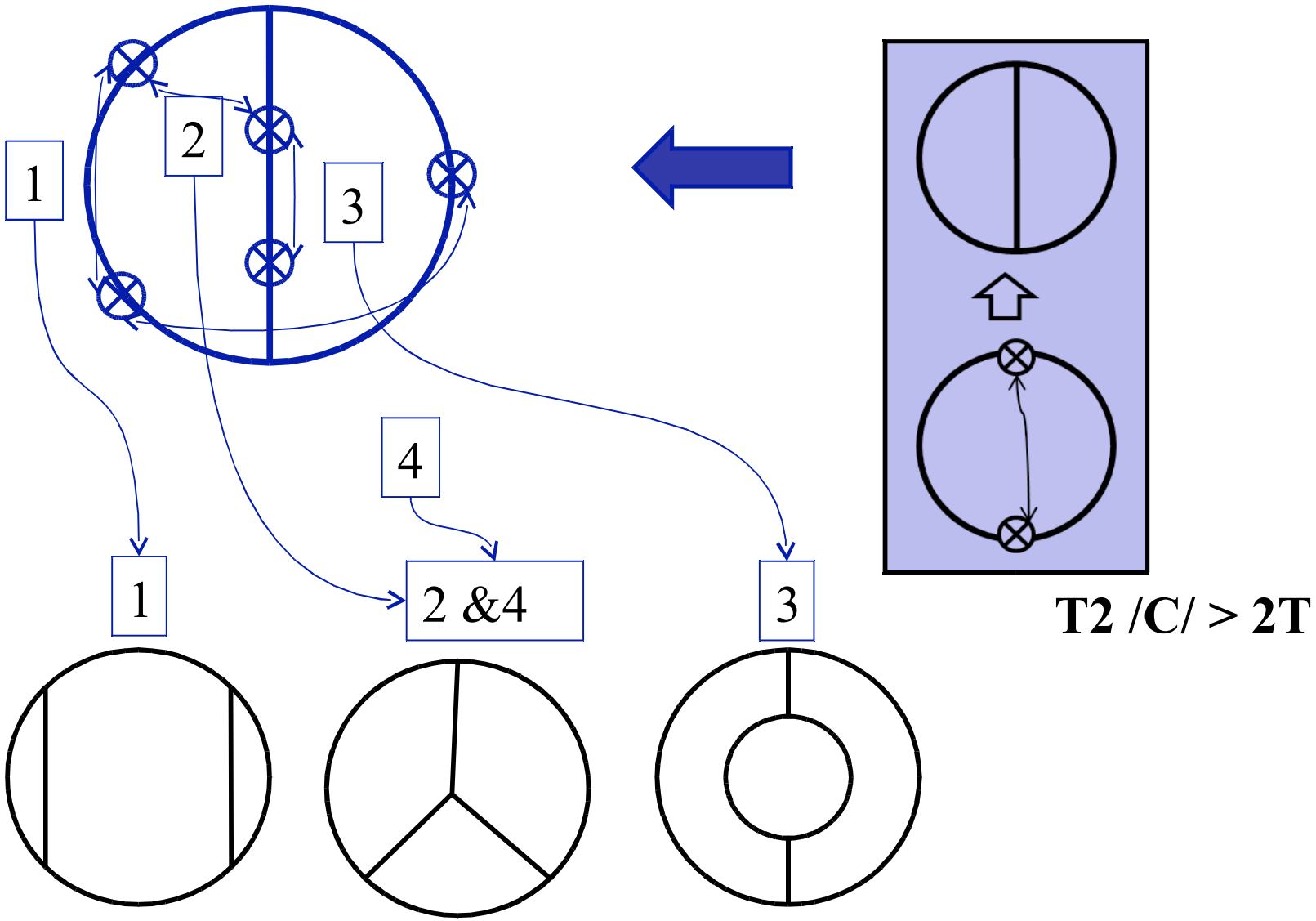
In case of 4 empties, more possibilities for a 3D shape appear.
As the number of empties grows, more complex structures will show up, and the Combinatorial explosion is here…





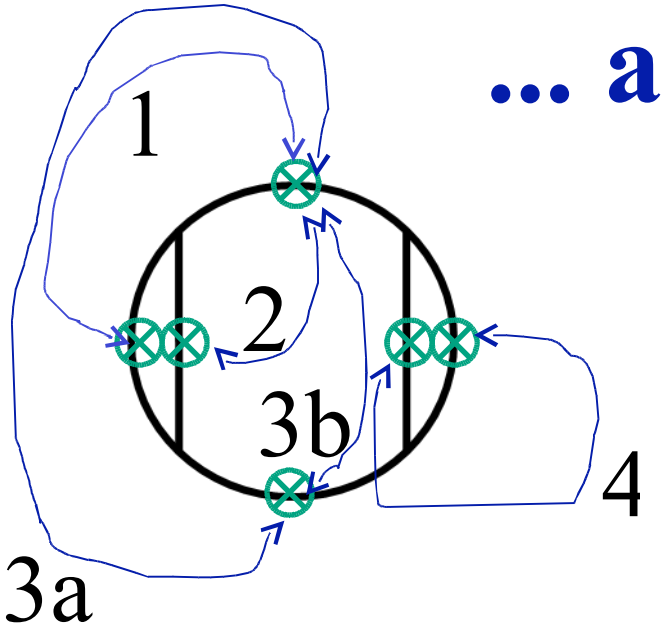


Remaining in 2D...

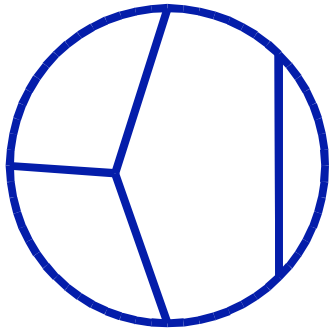


T2 /C/ > 2T

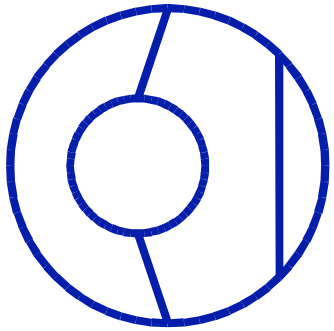
... and continuing (1)



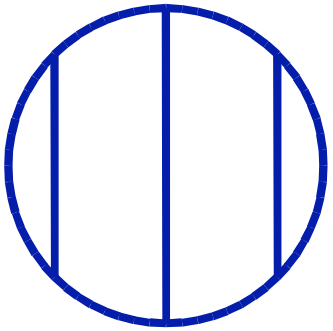
1&2



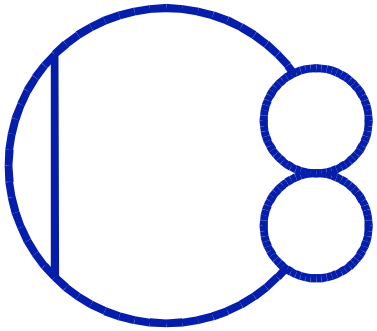
3a



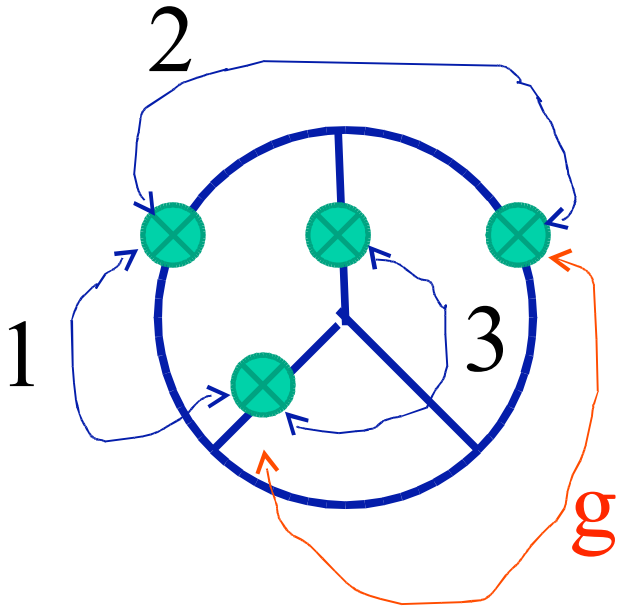
3b



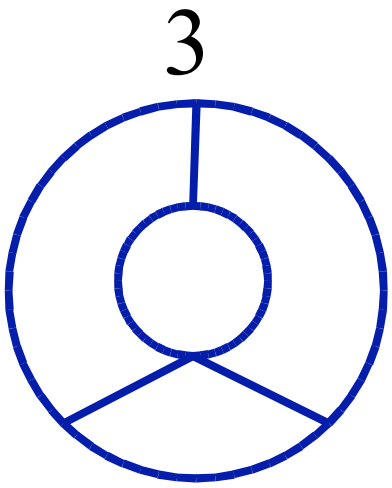
4

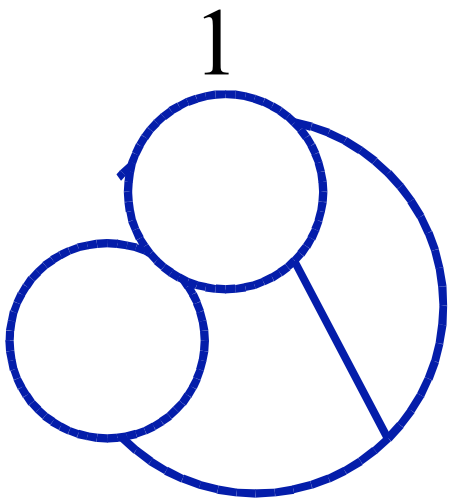


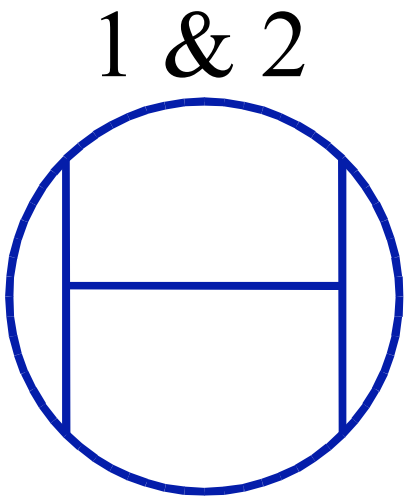
... and continuing (2)

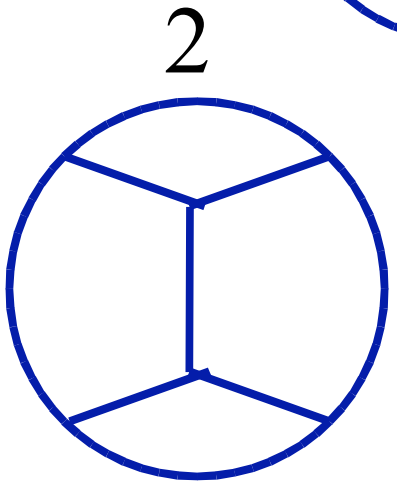


goes 3D

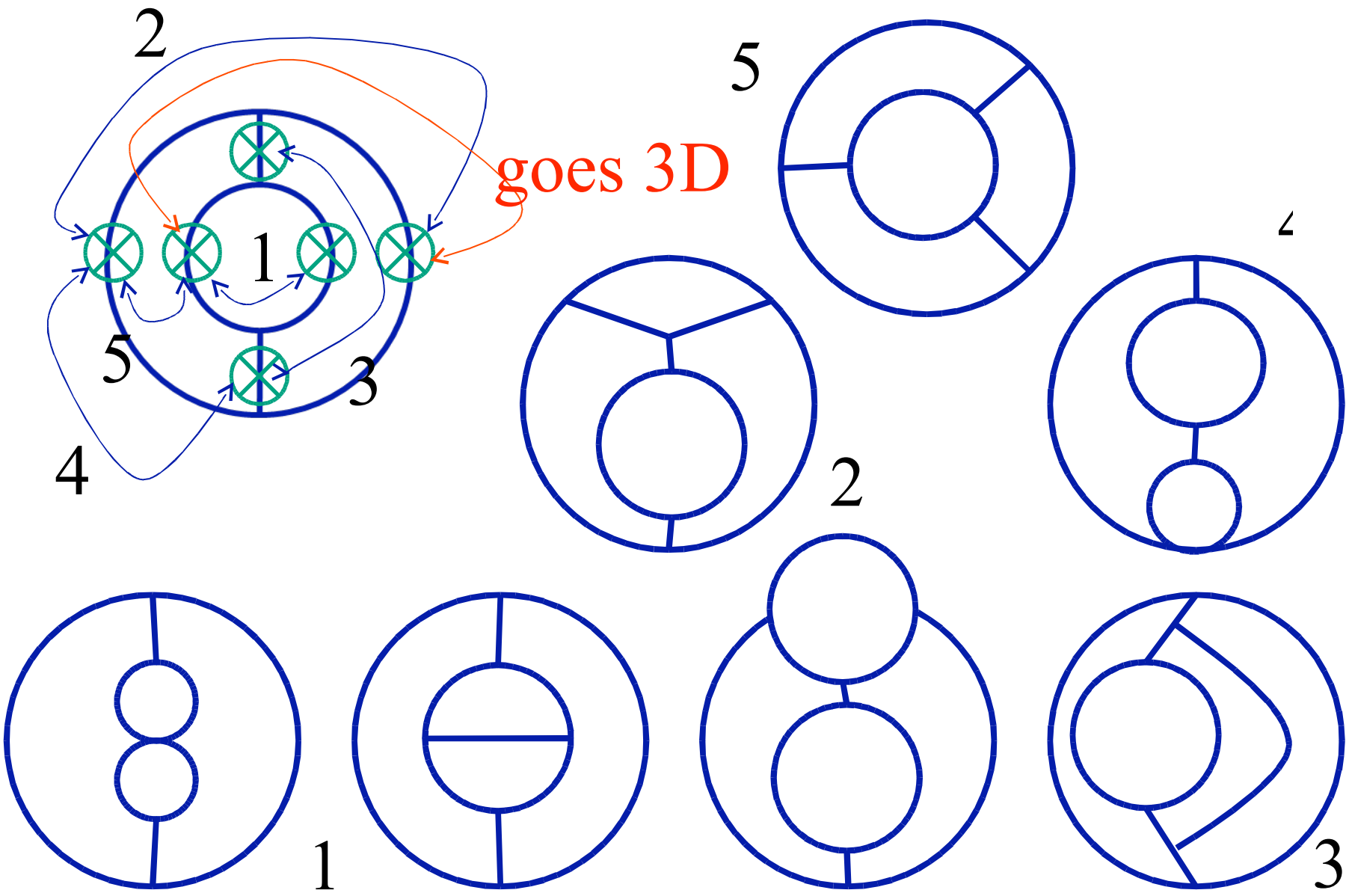








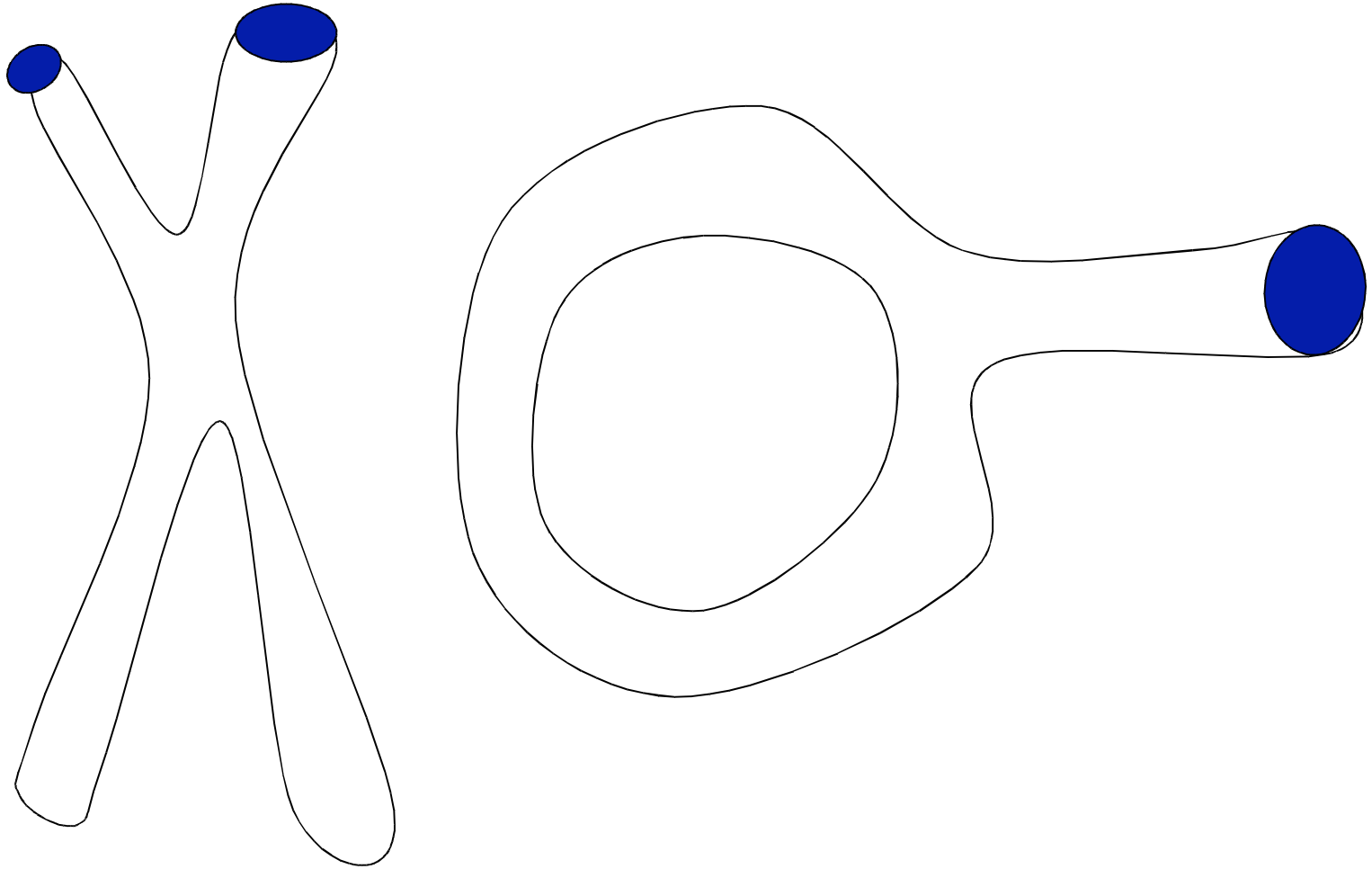
... and continuing (3)



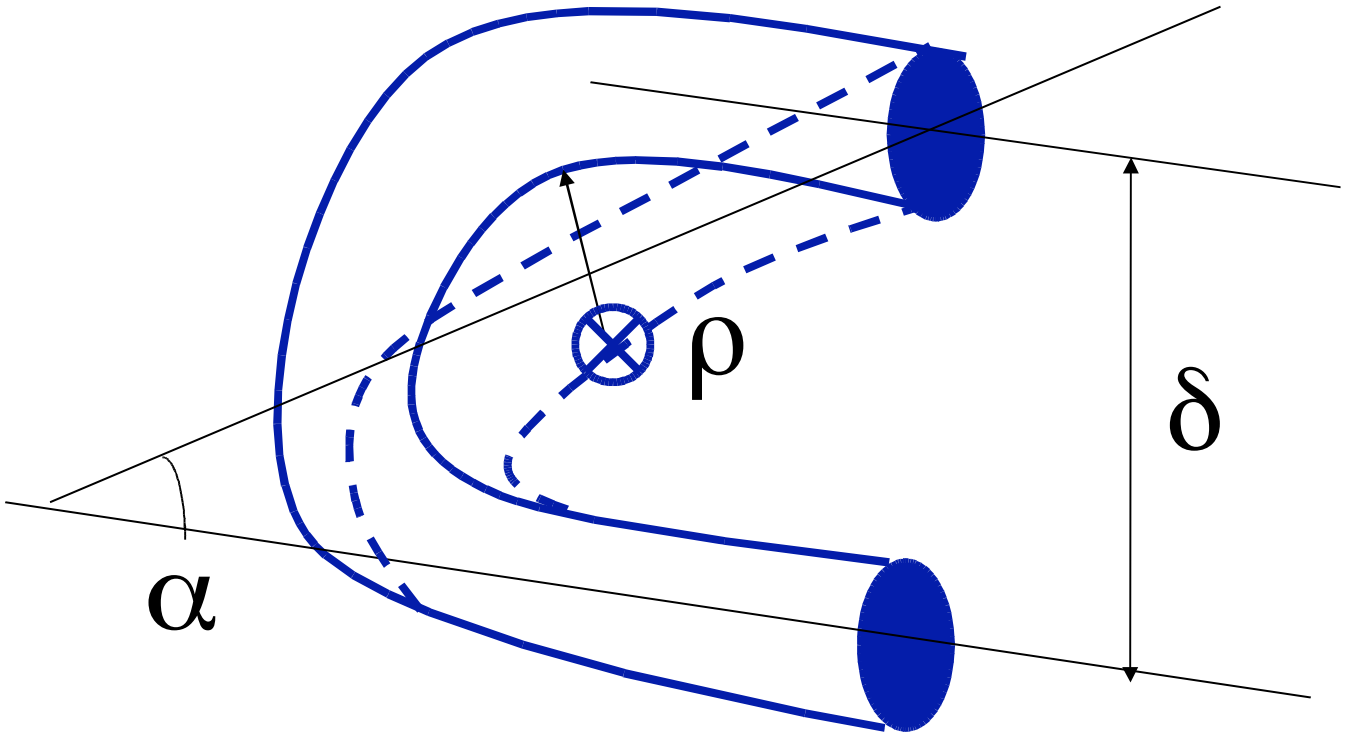
A few directions for further research

- **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

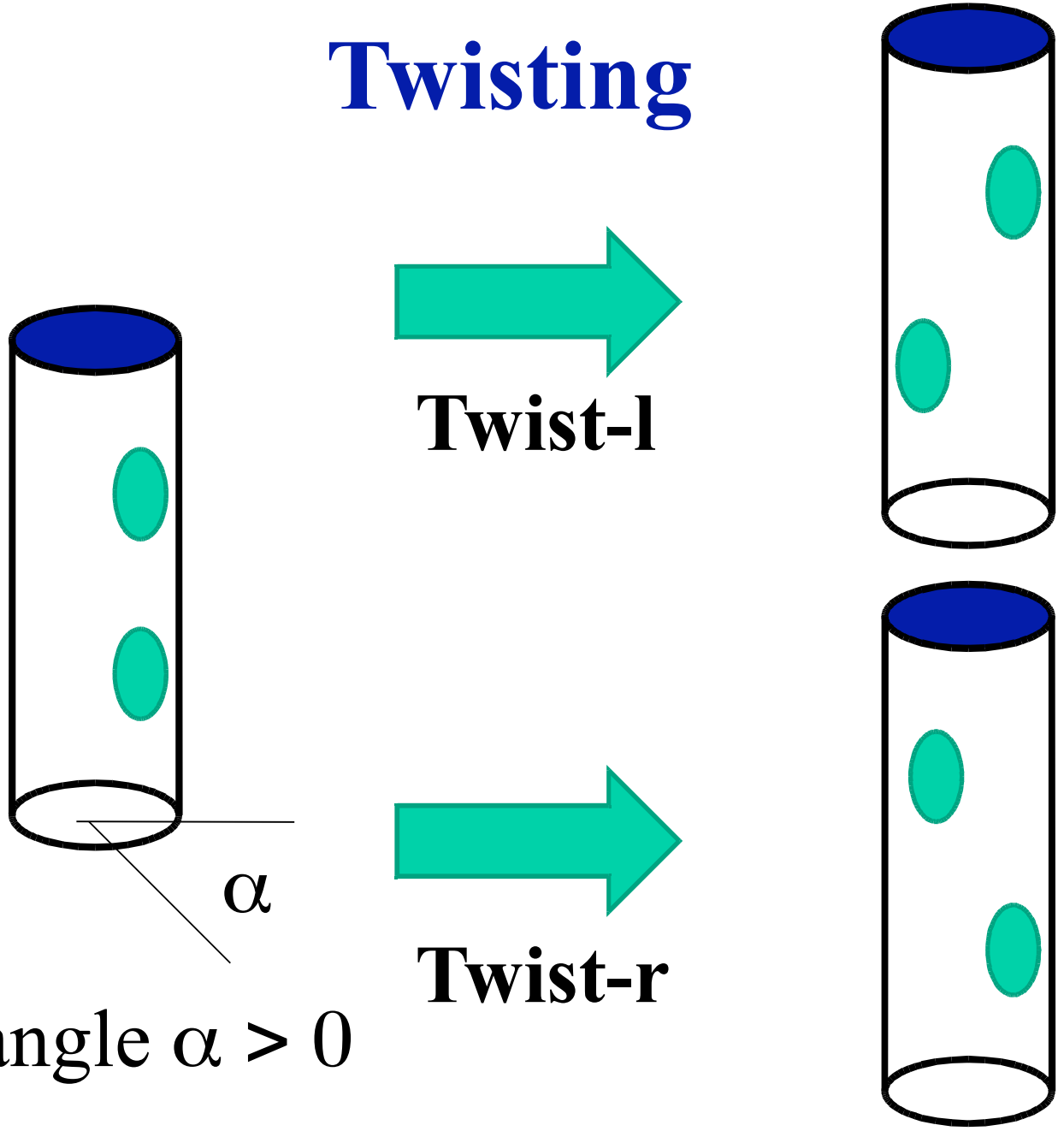


Angle α and distance δ from 0 to…

A curvature radius ρ from 0 to…

…all this means « dimension »

Twisting



The angle $\alpha > 0$

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 compexity 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**