

# Emergence

E. Bonabeau  
JI Dessalles

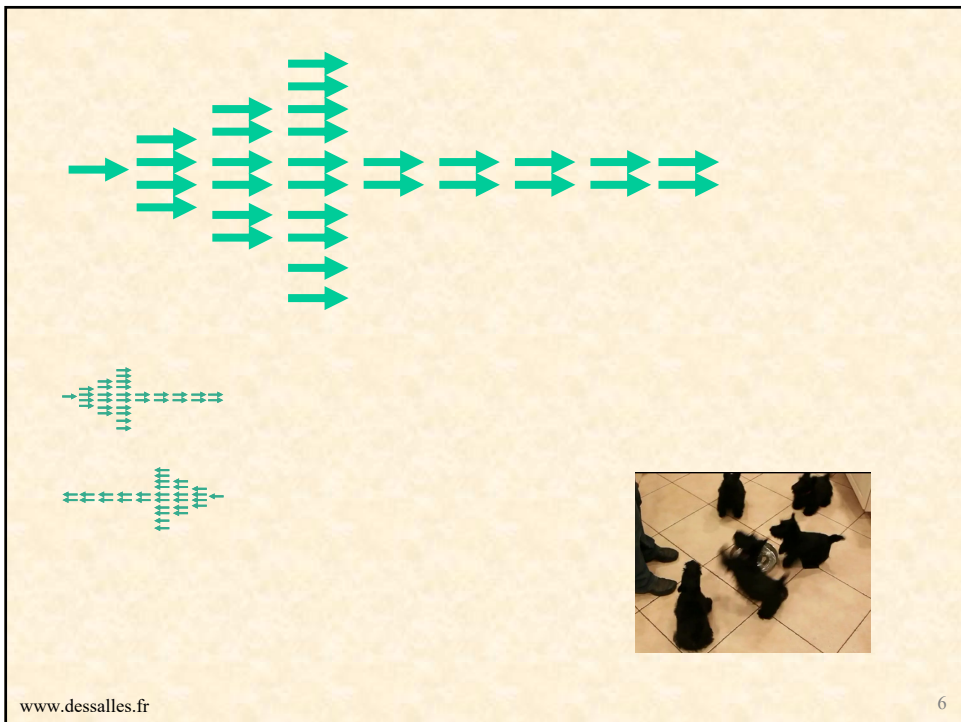
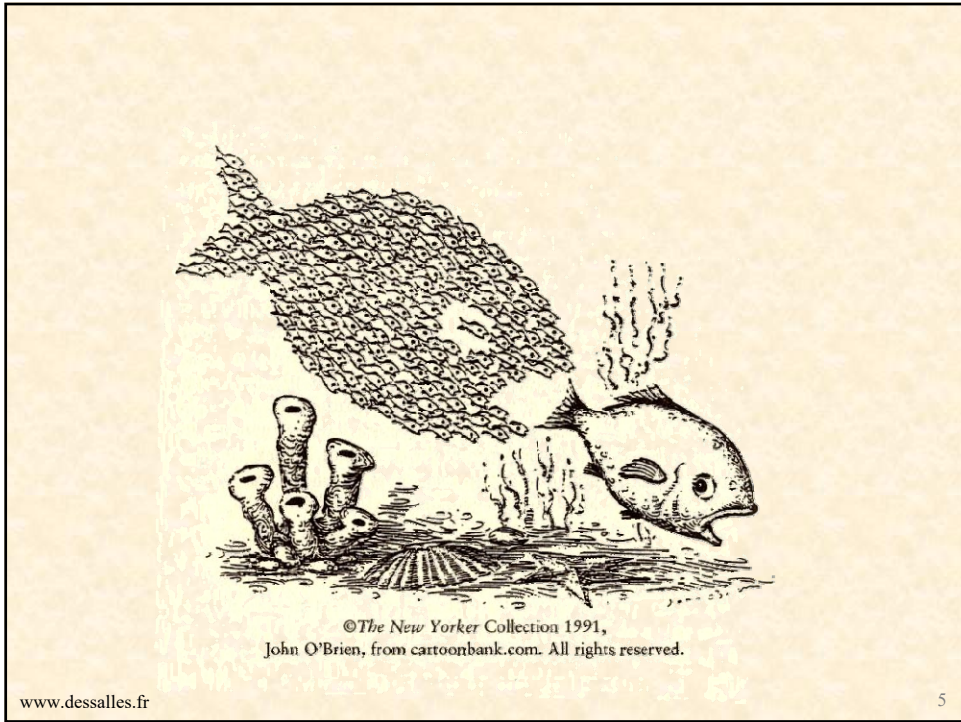
[www.dessalles.fr](http://www.dessalles.fr)



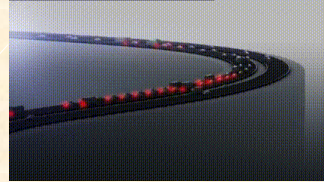
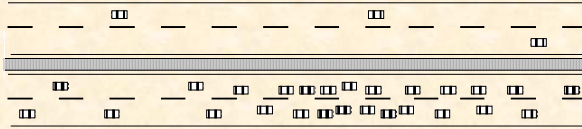
Telecom Paris – Nov-23







## Examples



Spirales old

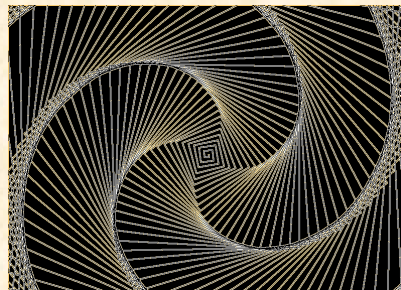
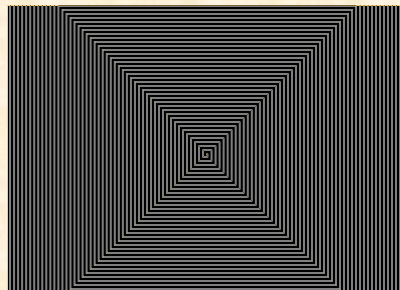
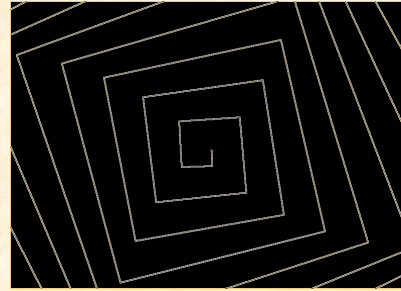
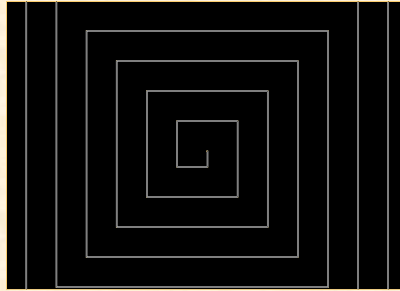
spirales

marienbad

example	emerging object	component	new property
spiral	4 arms spiral	straight segments	rounded
traffic jam	vehicle gathering	car	moving back
temperature	group of molecules	molecule	hot
H <sub>2</sub> S	molecule	atoms	smell
particule	quantic particle	plane wave	localization
word	english word	phonem	reference
<b>run for 20</b>	complex rule	elementary rule	generality

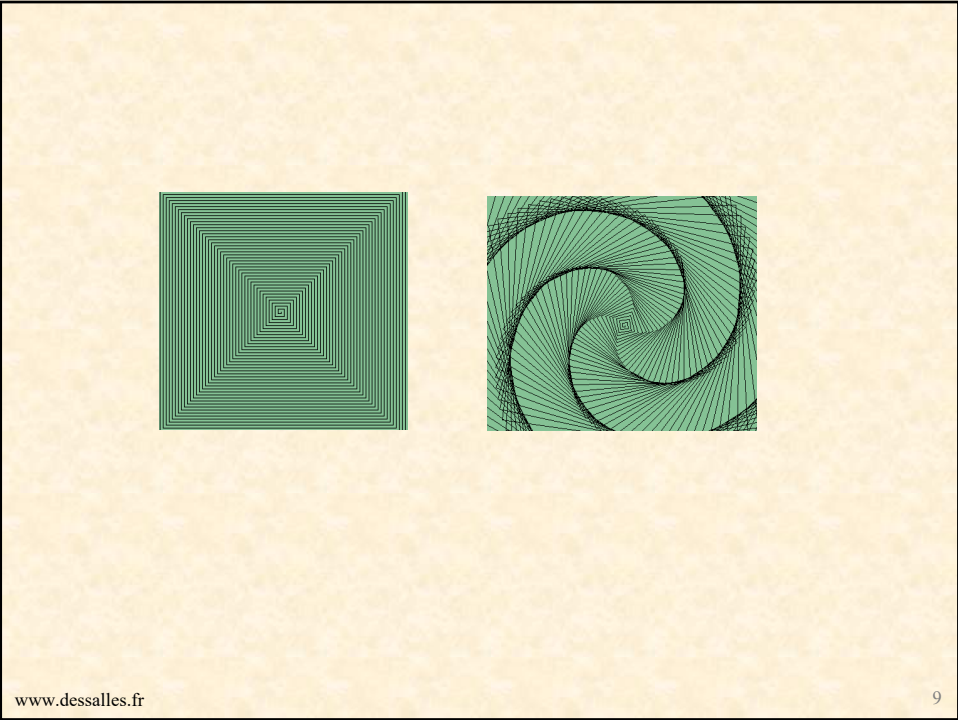
www.dessalles.fr

7



www.dessalles.fr

8



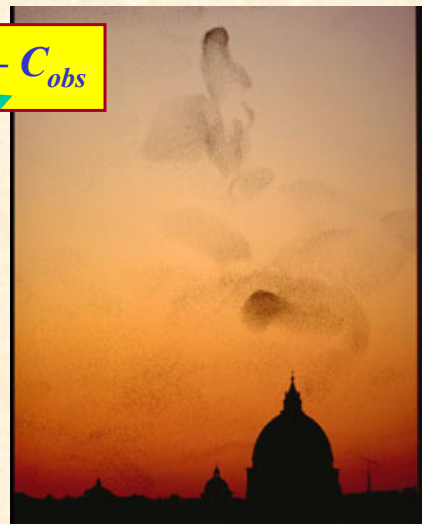
☀ **Which sentence characterizes "emergence" best?**

- A. The whole is less than the sum of its parts
- B. The whole is more than the sum of its parts

**Emergence as complexity drop**

$$E = C_{exp} - C_{obs}$$

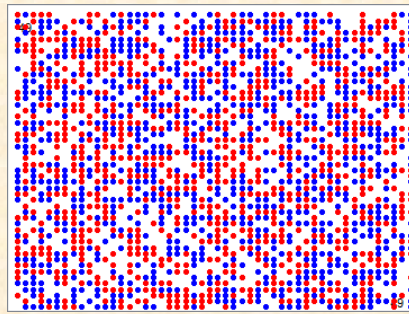
Kolmogorov complexity



## Emergence as complexity drop

$$E = C_{exp} - C_{obs}$$

Kolmogorov  
complexity



Thomas Schelling (1971)

## Emergence as complexity drop

$$E = C_{exp} - C_{obs}$$

Kolmogorov  
complexity



$$C_{exp}(s) = N \times C(a_i)$$

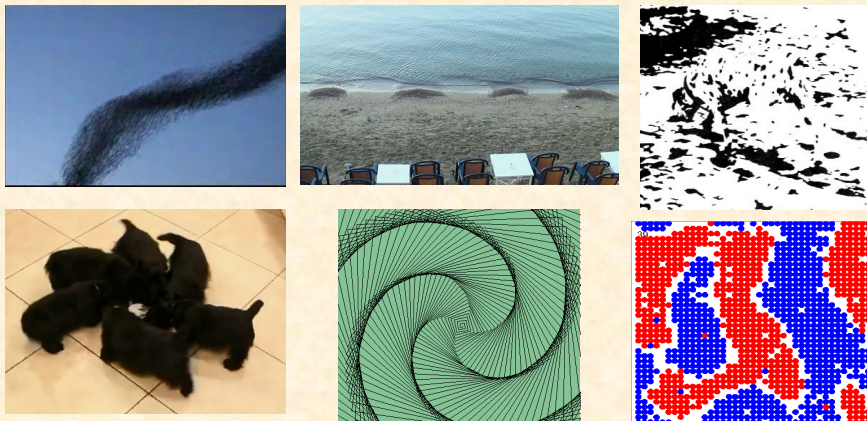
$$C_{obs}(s) = C(S) + N \times C(a_i|S)$$

The whole is more than the sum of its parts

The whole is *less* than the sum of its parts

## Emergence as complexity drop

$$E = C_{exp} - C_{obs}$$



www.dessalles.fr

15

## Emergence as complexity drop

$$E = C_{exp} - C_{obs}$$

$$C_{exp}(s) = \sum_j C(d_j) + C(s|\{d_i\})$$

$$C_{obs} = C(D) + \sum_j C(d_j|D) + C(s|D \& \{d_i\})$$

www.dessalles.fr

16