Pattern formation in biological systems

- Patterns characterizing individuals
  - Giraffe coat
  - Zebra
  - Leopard
  - Vermiculated rabbitfish
  - Cone shells
  - Finger prints
  - Moral
  - Metamerisation
  - Occular dominance stripes

- Most of those patterns are in fact fixed states of reactions that have occurred long time ago… … or process is still running.

Mechanisms?

**Activation-inhibition mechanism**

Inspired by equations of reaction-diffusion (Turing 1949)

The activator autocatalyzes its own production, and also activates the inhibitor. The inhibitor disrupts the autocatalytic process. Meanwhile, the two substances diffuse through the system at different rates, with the inhibitor migrating faster. The result: local activation and self-organization share a common mechanism

- Starting point: a homogeneous substrate (lacking pattern)
- Positive feedback (short-range activation, autocatalyzes)
- Negative feedback (long-range inhibition)
Self-Organization in Natural Systems

- Definitions
- Pattern formation in living and non-living systems
- Social systems (Sociality and gregarism)
- Cellular systems (Cells build animals)
- Properties of self-organized systems

Pattern formation in colonies activity

- Patterns resulting from the activity of a society of...
  - social insects
    - Ant
    - Bees
    - Wasps
    - Termites
  - Mammalians
    - African Mole-rats
    - Humans

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- Several orders of size magnitude difference
- Those patterns result of the permanent activity of society’s elements...

**Causality and mechanisms**

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**Pattern formation in colonies activity**

- Environmental constraints
  - Openness
  - Heterogeneity...
- Template
  - Gradients
  - Grids...
- Stigmergy [Grassé 1959]
  - Indirect interactions between animals
    - Local environmental changes (pheromones, mud pellets...)

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**Pattern formation in biological systems**

- Patterns occurring during collective movement
  - Microorganisms
  - Insects and Crustaceans
  - Social insects
  - Fishes
  - Birds
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