

「差異・パターン形成と拡散方程式の現在」

パネルディスカッション

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1. 形やダイナミクスが似ていればモデルは本質をとらえているのか？
2. チューリングモデルの成功と限界：チューリングモデルは超えられるか？
3. 形態形成現象において美しくかつ解かれていない問題のリスト
4. 生命現象において現在の数学・物理では十分に捉えきれない問題は何か？

1. 形やダイナミクスが似ていればモデルは本質をとらえているのか？

Self-replicating Patternの例

分裂するベシクル

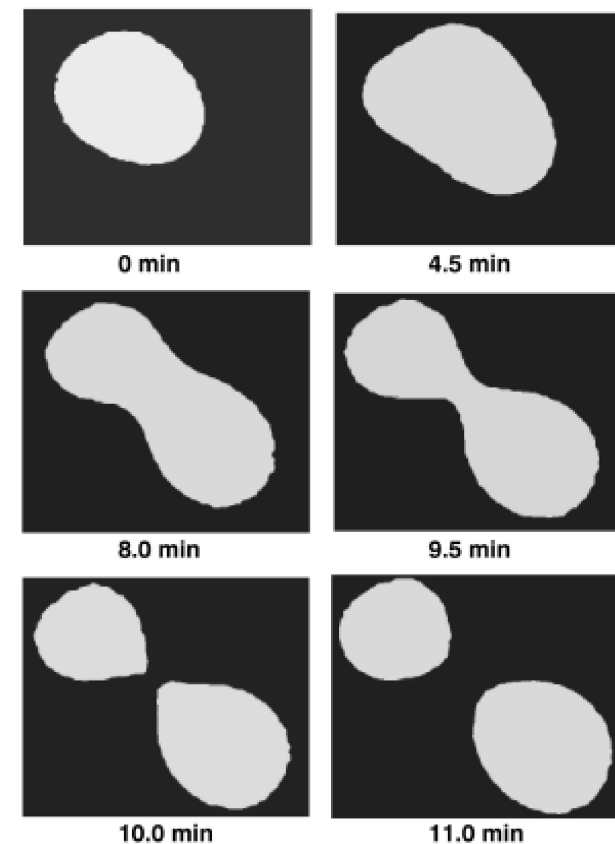
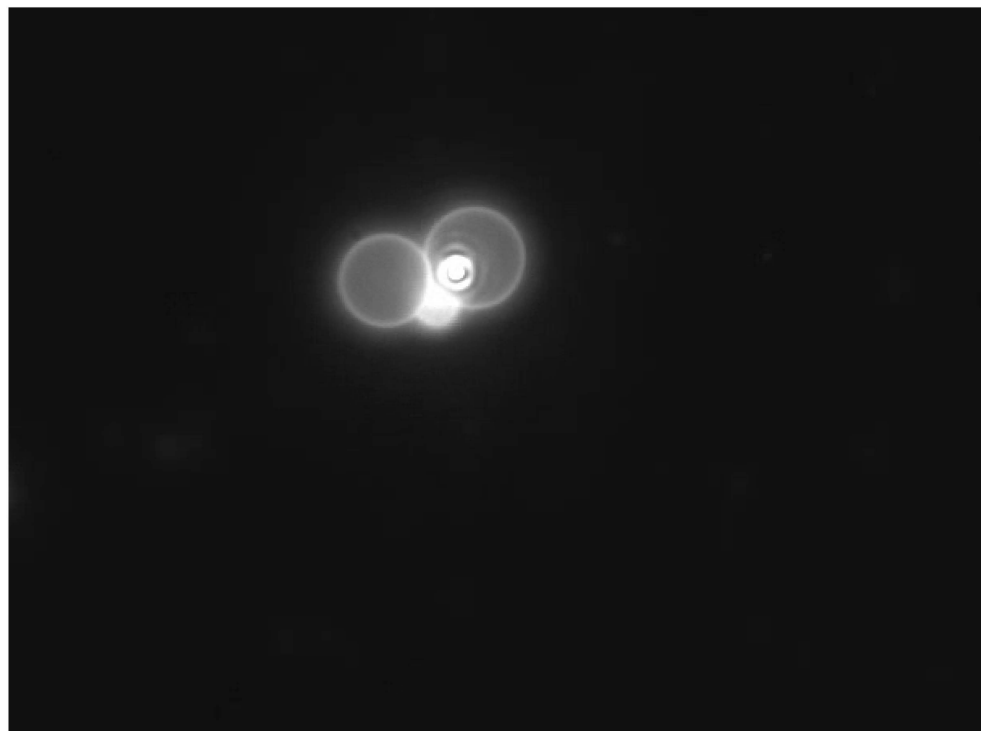
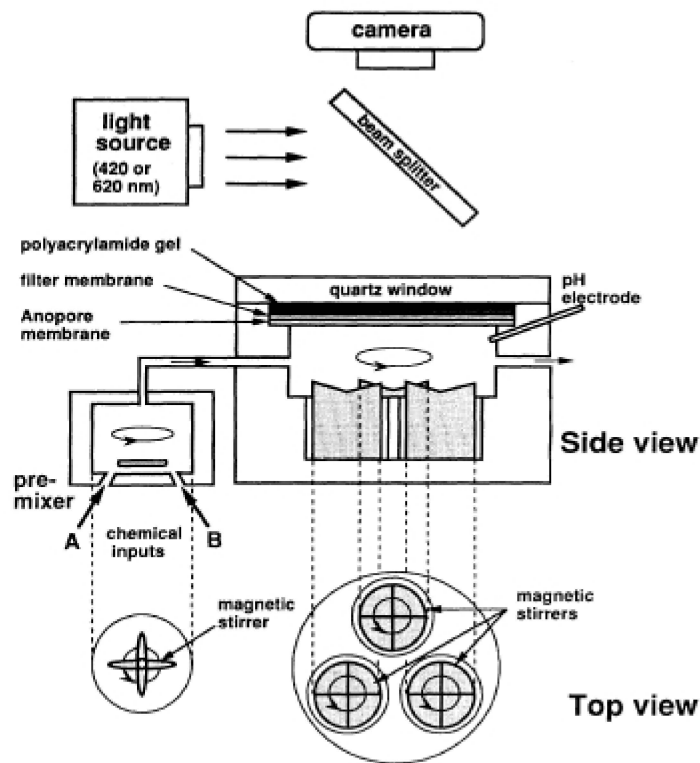


FIG. 10. Self-replication of a spot. The flow rate is 148 m/h and the gel is 0.2 mm thick [as in Fig. 1(d)]. Each frame is $3.9 \times 3.5 \text{ mm}^2$.

Lee & Swinney, PRE (1995)

Self-replicating Pattern I

FIS (ferrocyanide-iodate-sulfite) reaction: A bistable system of high (white) and low (black) pH.



Lee & Swinney, PRE (1995)

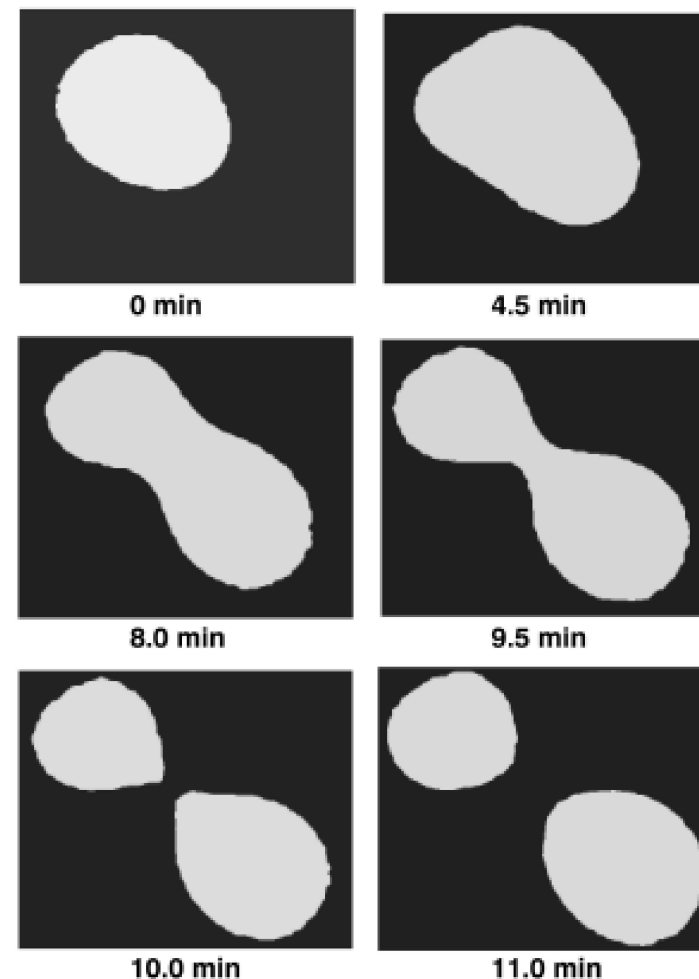
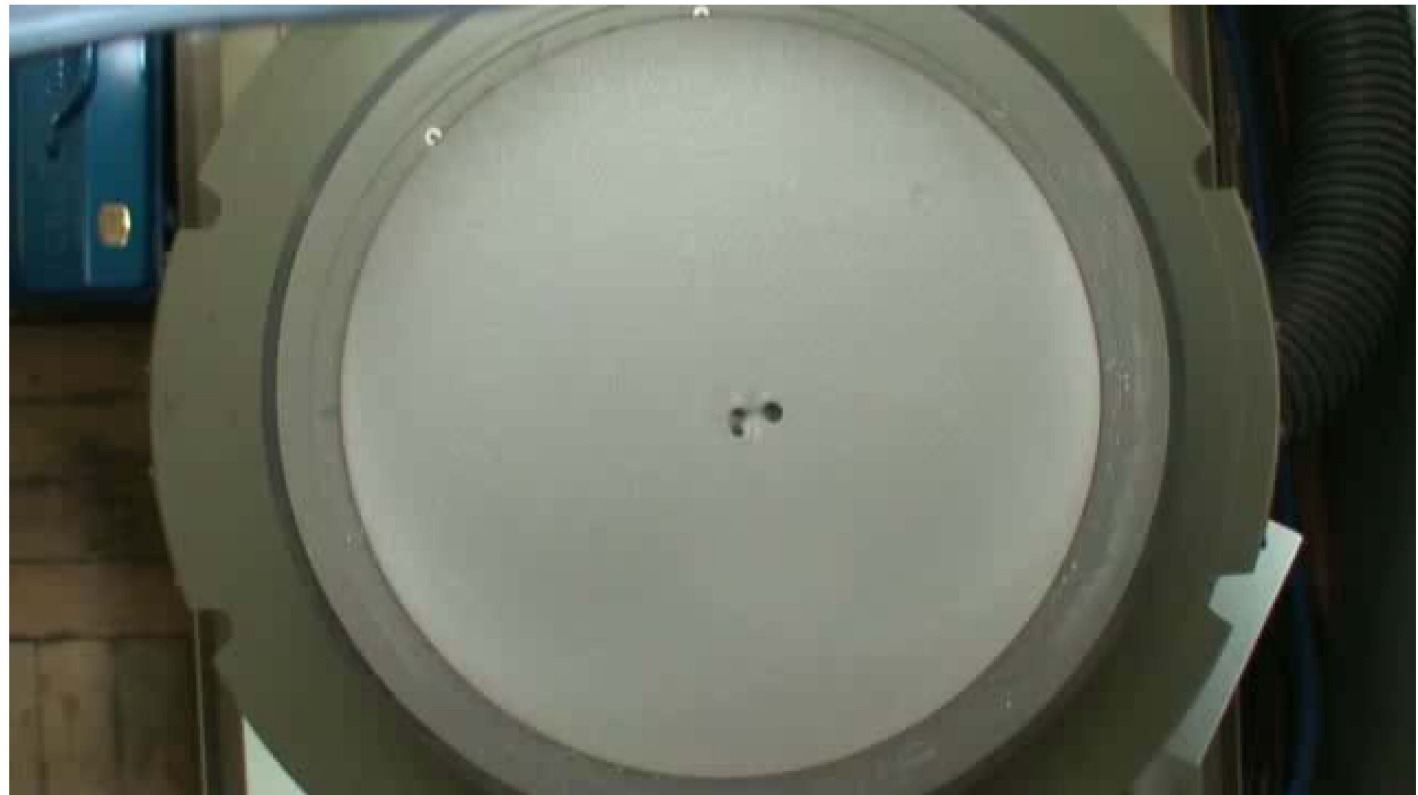
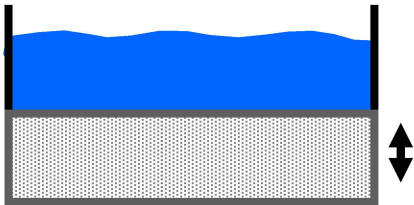


FIG. 10. Self-replication of a spot. The flow rate is 148 $\mu\text{m}/\text{h}$ and the gel is 0.2 mm thick [as in Fig. 1(d)]. Each frame is $3.9 \times 3.5 \text{ mm}^2$.

Self-replicating Pattern II

Farady surface waves
(stripes and squares)



粘弾性体 (ポテスターチ) の垂直振動 (Ebata & Sano)

Self-replicating patternの反応拡散モデル

FitzHugh-Nagumo (FHN) model:

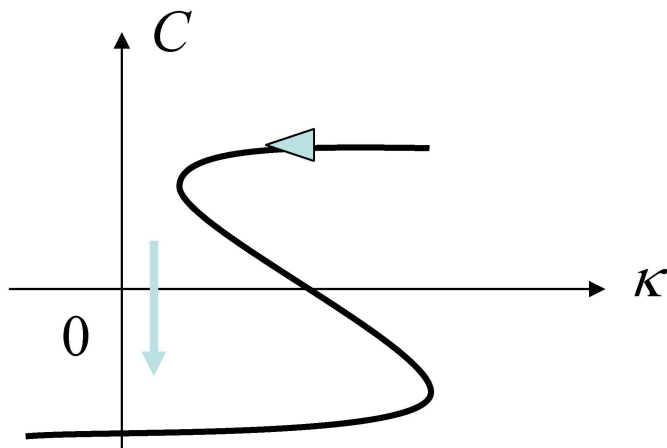
$$u_t = u - u^3 - v + \nabla^2 u$$

$$v_t = \varepsilon(u - a_1 v - a_0) + \delta \nabla^2 v$$

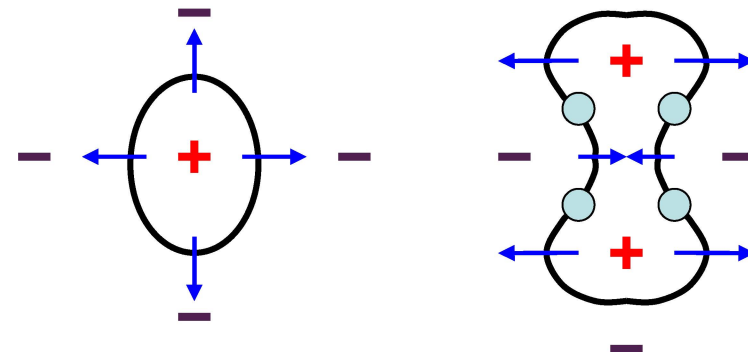
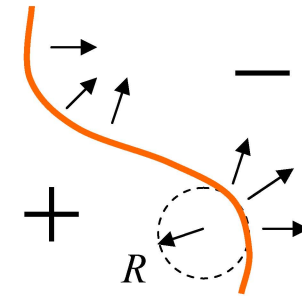
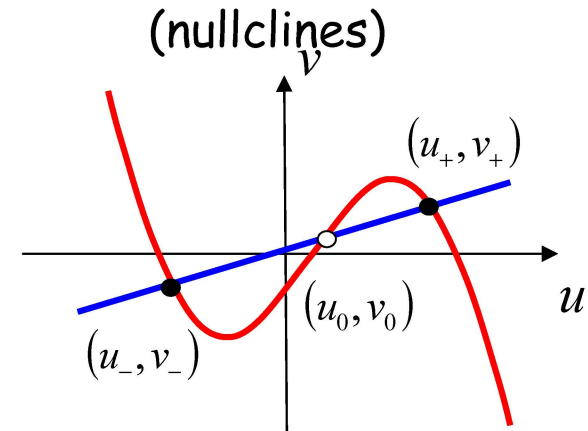
u : activator, v : inhibitor $\rightarrow$ Bistability

Front Dynamics

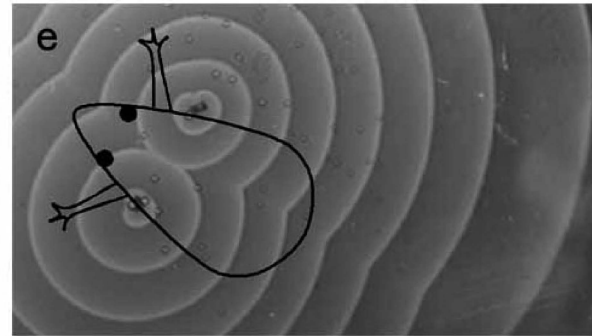
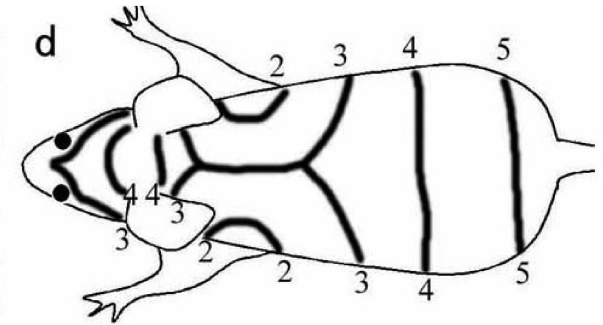
front velocity C : $C = C(\kappa)$ $\kappa = 1/R$



E. Meron et al.

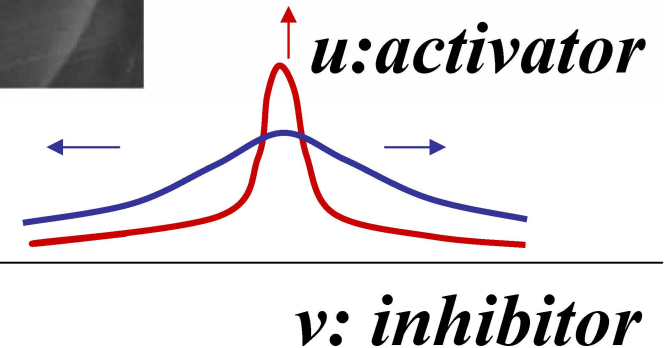


2. チューリングモデルは超えられるか？



Local Activation +
Long Range Inhibition

S. Kondo

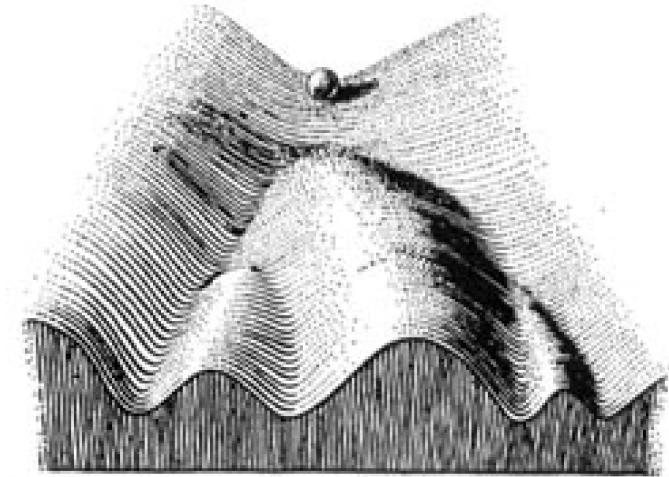
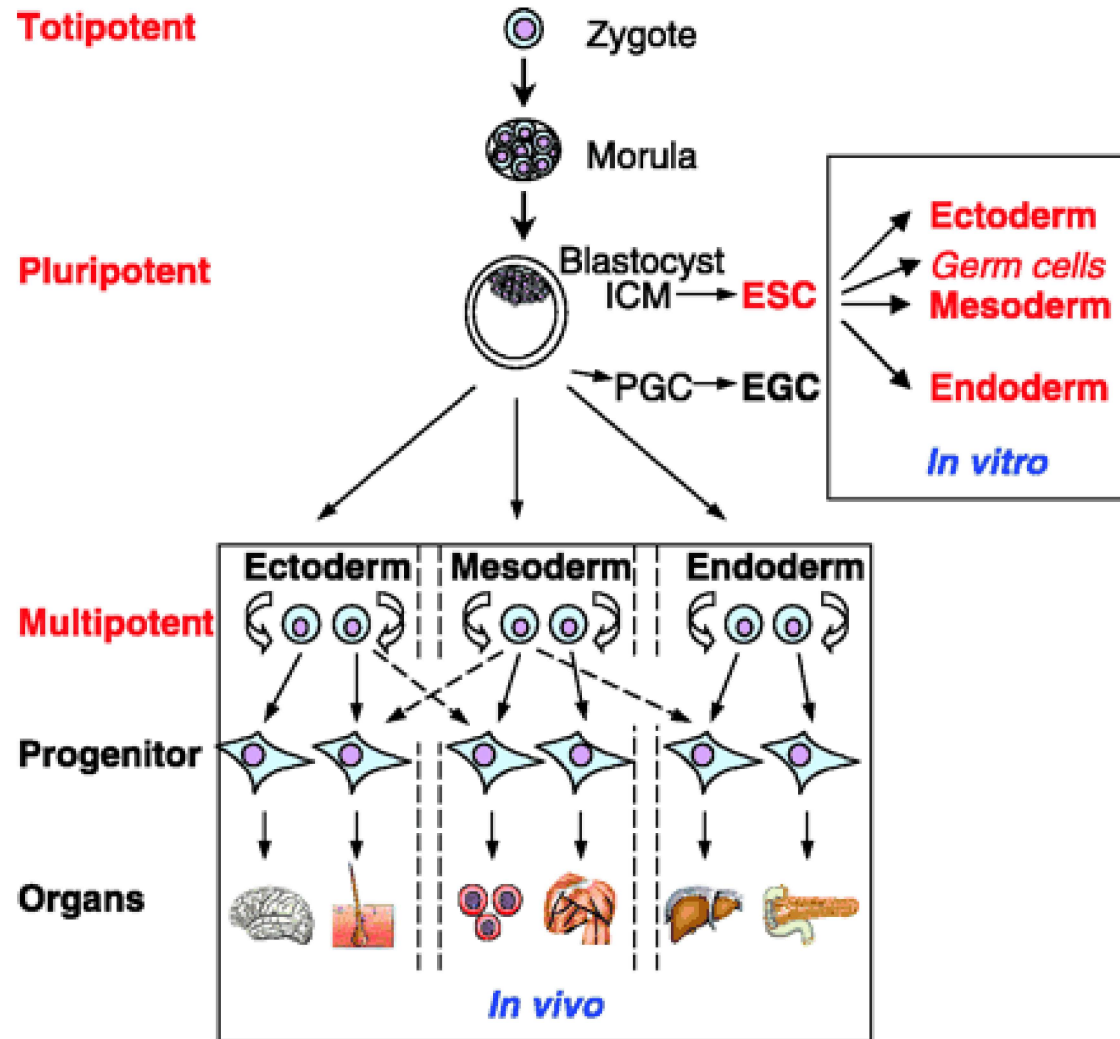


自発的対称性の破れ: 空間並進対称性

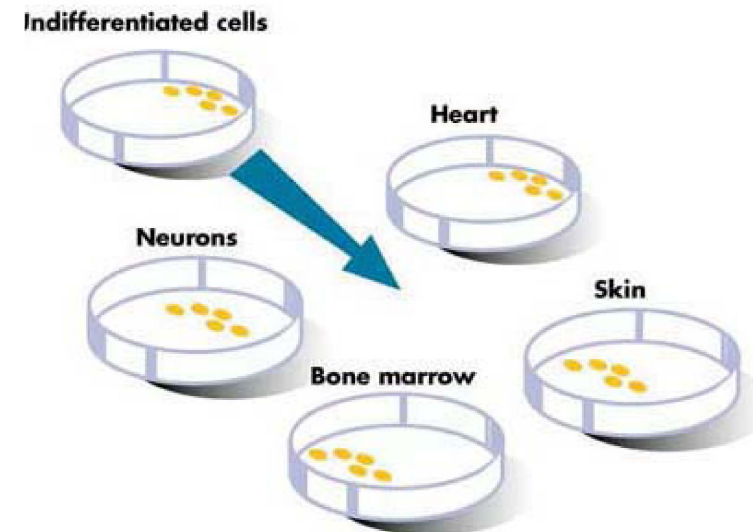
$$\dot{u} = au - bv + D_u \nabla^2 u, \quad (a, b, c, d > 0)$$

$$\dot{v} = cu - dv + D_v \nabla^2 v, \quad D_u \ll D_v$$

3. 解かれていない問題の例：発生・分化 Development of Cell is Irreversible



Waddington's Epigenetic Landscape



--Why iPS (induced pluripotent cells) cells become pluripotent by adding only three genes --

- 30,000 genes can be activated by 3 genes
- 3 is enough to create infinite complexity

Examples:

- 3 variables are enough to create Chaos!
- Period 3 implies Chaos
 - ⇒ However, Chaos is not robust in general !

Two Major Possibilities: #1

- Network structure

3 genes control
downstream genes,
downstream genes
control further down,,,
cascade

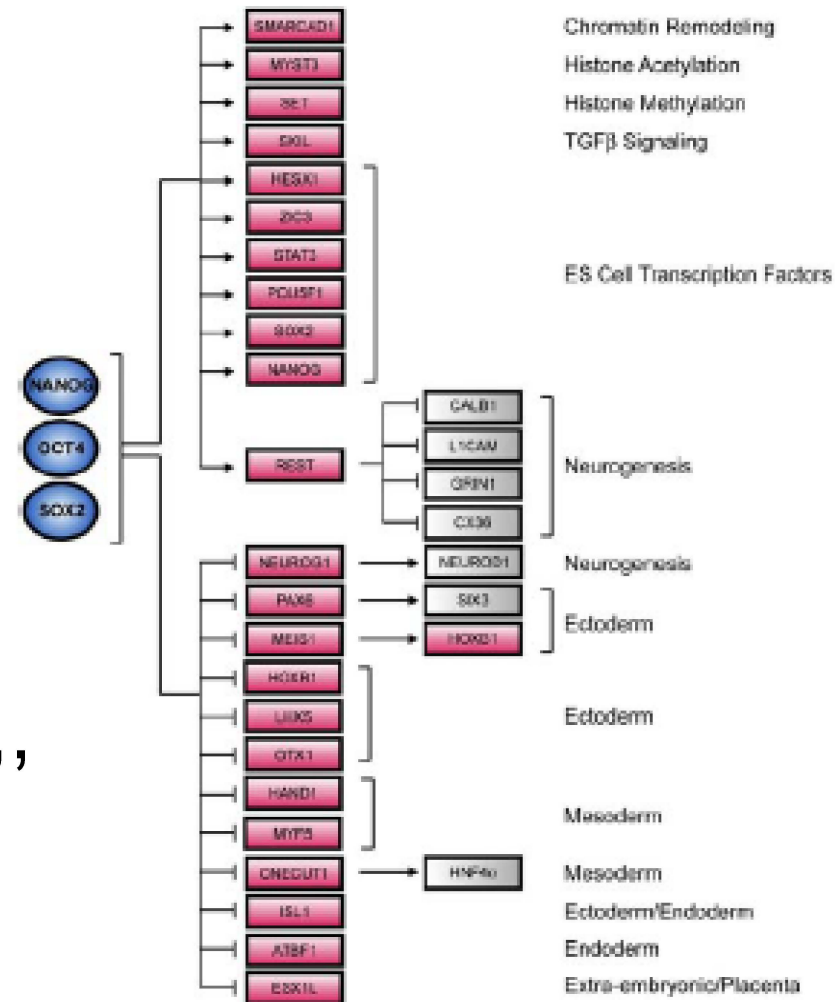


Figure 5. Core Transcriptional Regulatory Network in Human ES Cells

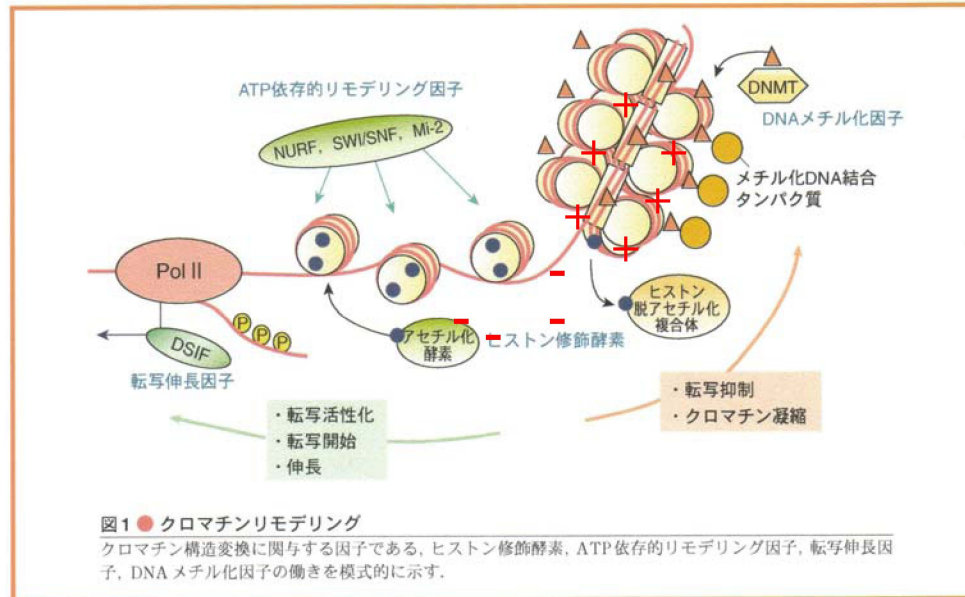
Two Major Possibilities: #2

DNA methylation and chromatin remodeling

DNAの情報が読まれるか否か (Transcription Activity)

DNAのみではダイナミックレンジ10倍

クロマチン構造により>2000倍のレンジで制御される。

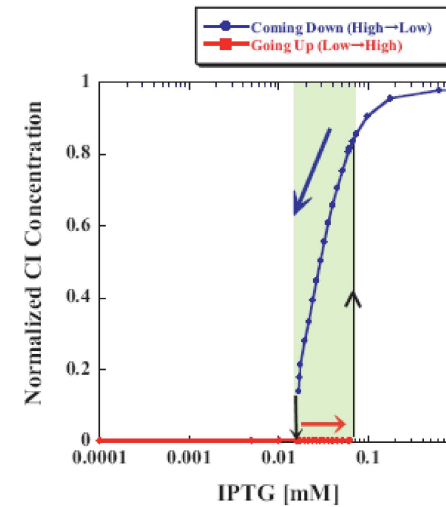
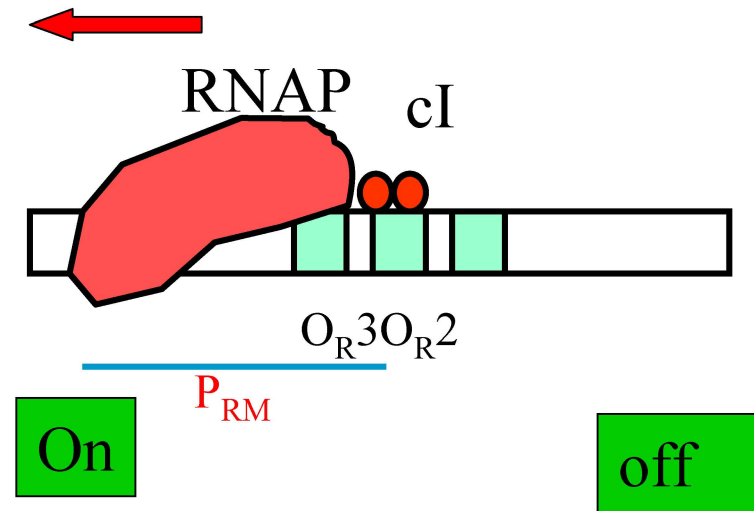
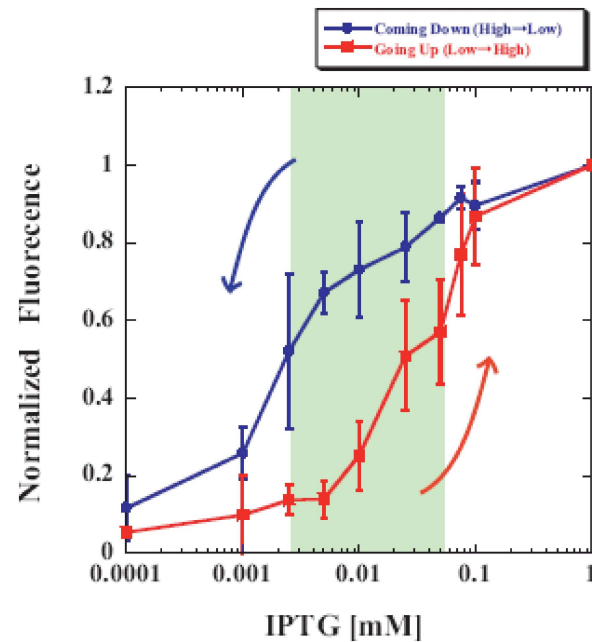
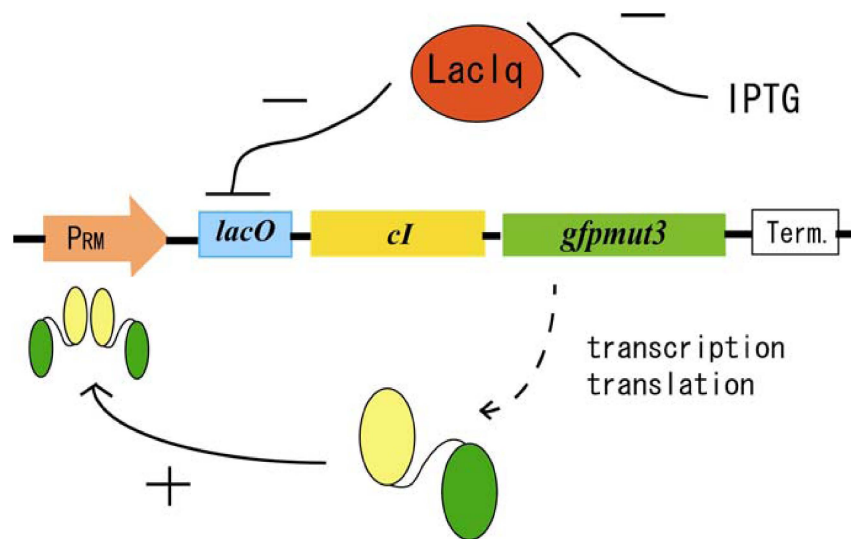


アセチル化によりヒストンの正電荷が減少

周辺を活性化する

メカニズムの本質は分かっていない

遺伝子ネットワークだけではゆらぎが大きい



Y. Maeda, M. Sano, JMB (2006)