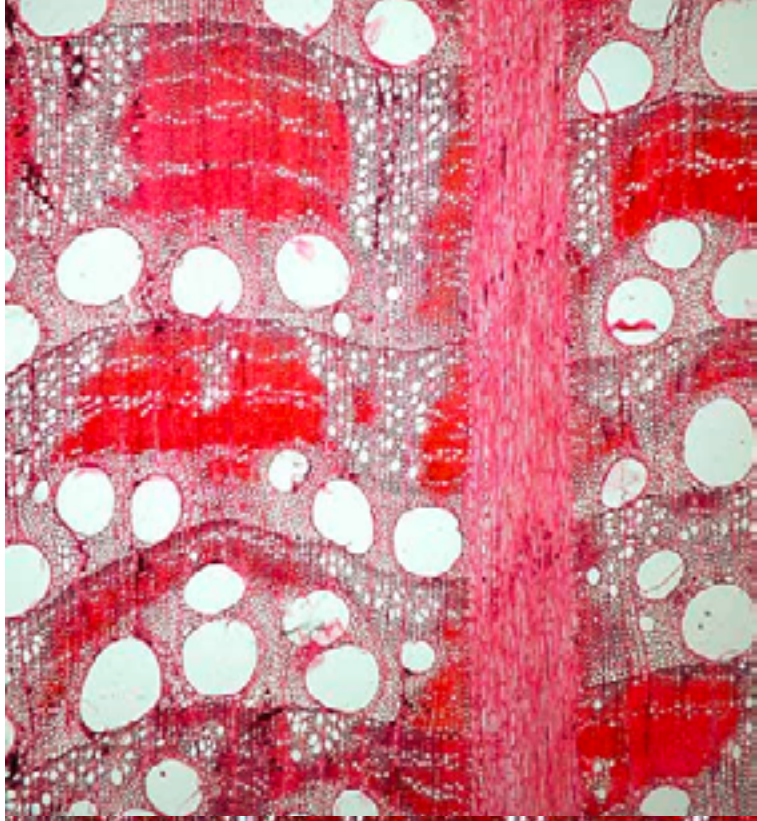


DIFFERENTIATION

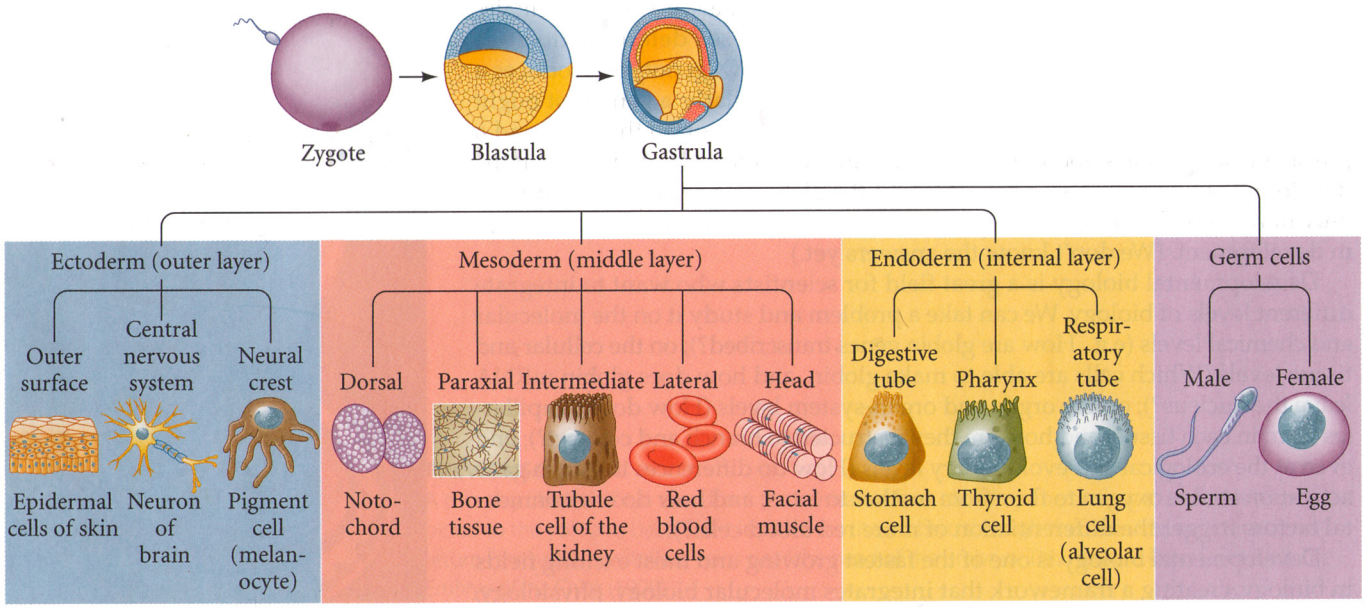
HOW CAN AN IDENTICAL SET OF GENETIC INSTRUCTIONS PRODUCE DIFFERENT TYPES OF CELLS?

MORPHOGENESIS

HOW CAN CELLS FORM ORDERED STRUCTURES?

GROWTH

HOW DO OUR CELLS KNOW WHEN TO STOP DIVIDING AND WHEN TO DIE?



DIFFERENTIATION

DIFFERENTIAL GENE TRANSCRIPTION

regulates which genes are allowed to be transcribed into RNA

SELECTIVE NUCLEAR RNA PROCESSING

regulates which RNAs are allowed to enter the cytoplasm

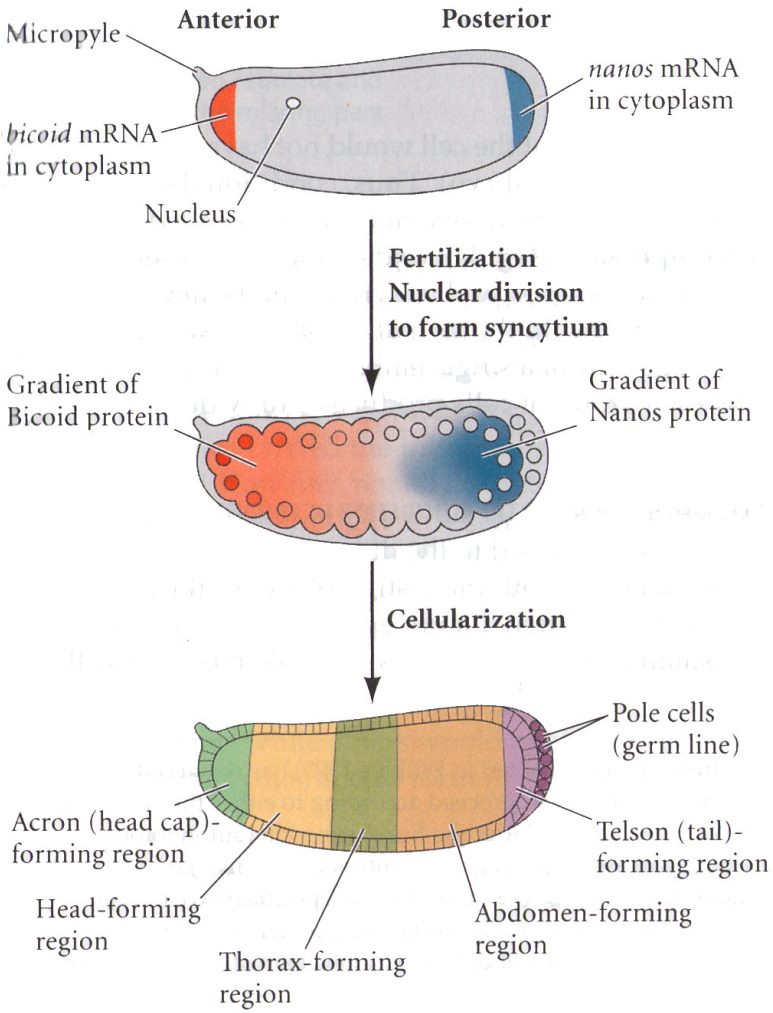
SELECTIVE MESSENGER RNA TRANSLATION

regulates which mRNAs in the cytoplasm are translated into proteins

DIFFERENTIAL PROTEIN MODIFICATION

regulates which proteins are allowed to remain and function in the cell

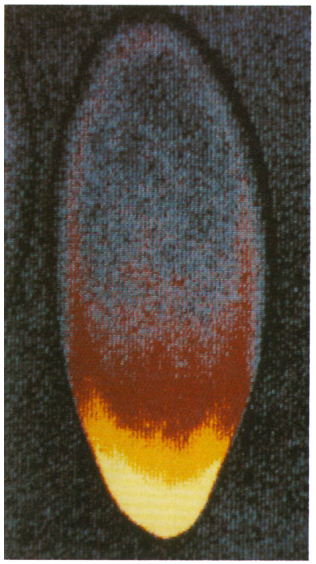
nervous system

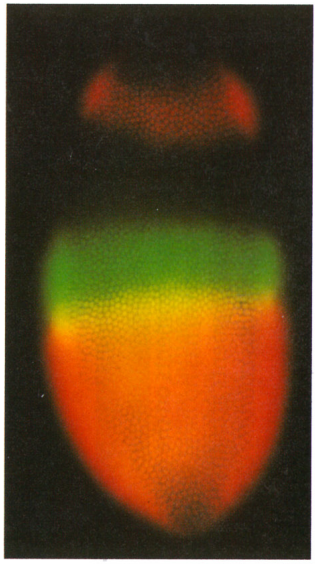


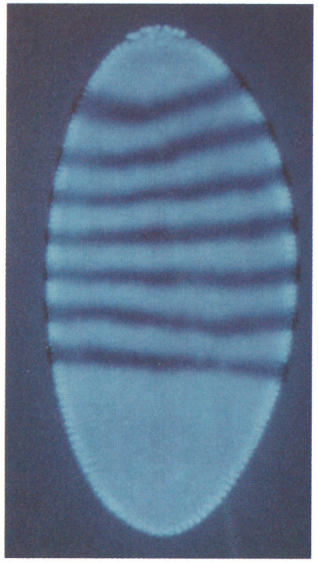
protein gradients

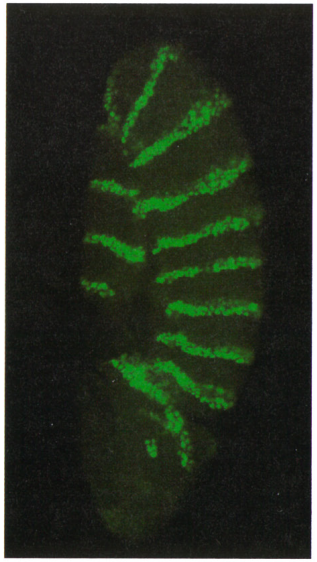
the ratio of Bicoid to Nanos forms a coordinate system that distinguishes each position along the axis from any other position. when division occurs the amount of each protein present differentially activates transcription of various genes that specify the segmental identities of the fly

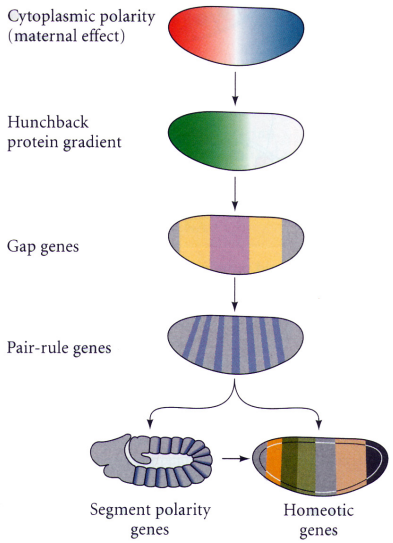
nervous system











morphegenetic fields

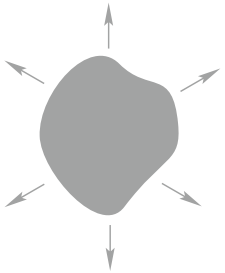
"FIELDS OF ORGANIZATION"
"CELLULAR ECOSYSTEMS"

a group of cells able to respond to discrete, localized biochemical signals leading to the development of specific morphological structures or organs. The spatial and temporal extent of the embryonic fields are dynamic, and within the field is a collection of interacting cells out of which a particular organ is formed. As a group, the cells within a given morphogenetic field are constrained — i.e. cells in a limb field will become a limb tissue, those in a cardiac field will become heart tissue. However, the specific cellular programming of individual cells in a field is flexible: an individual cell in a cardiac field can be redirected via cell-to-cell signaling to replace specific damaged or missing cells.

nervous system

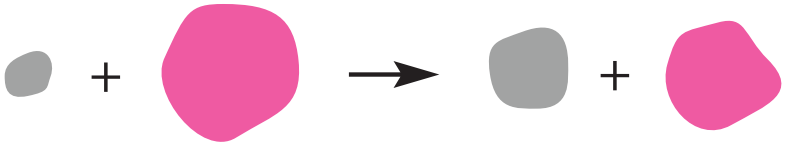
REACTION-DIFFUSION

Diffusion



Molecules naturally spread to areas of less density

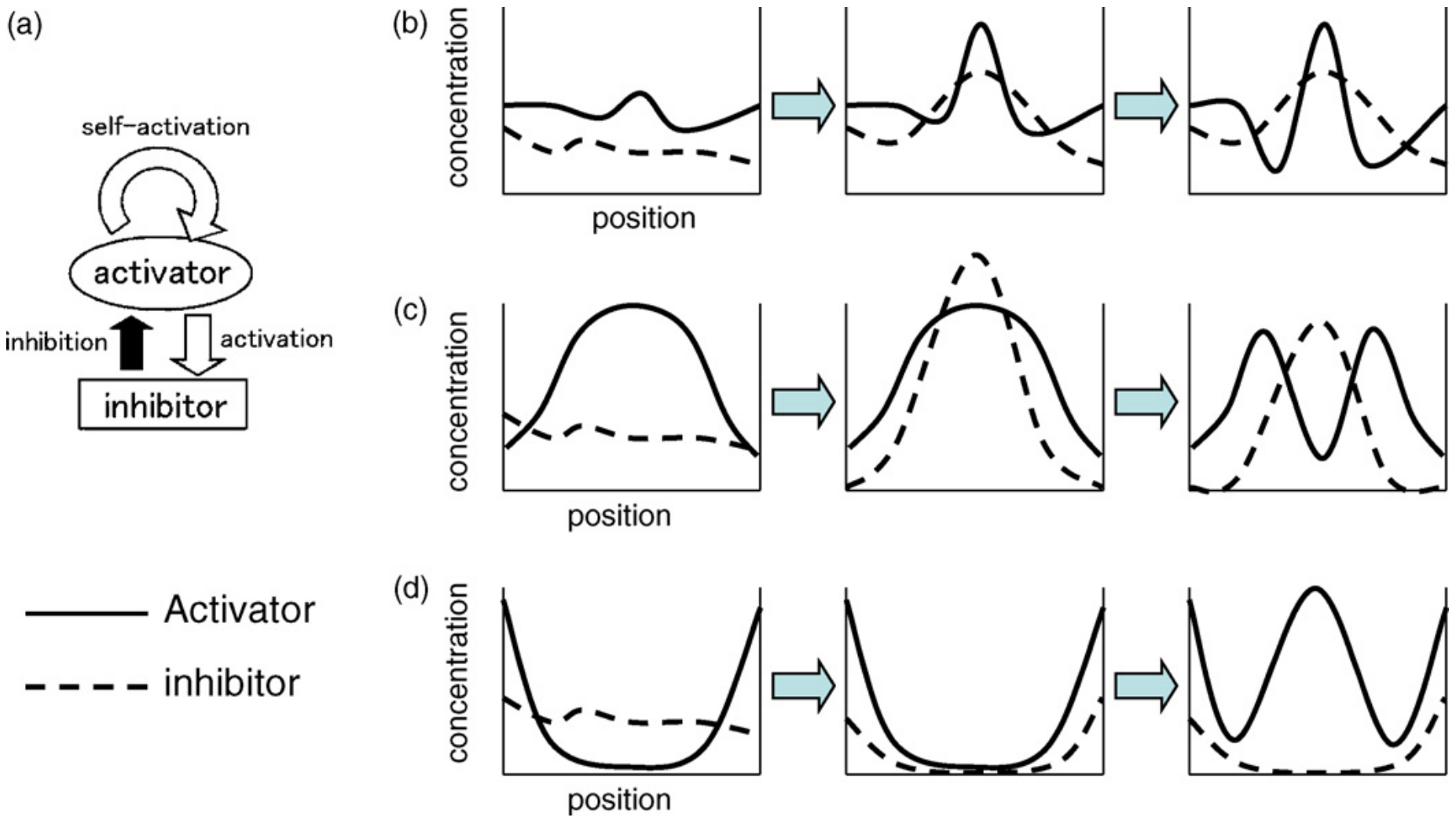
Reaction



Chemicals recombine, sythesize, degrade changing quantities

Reaction Diffusion

Combining these processes patterns emerge and stabilize

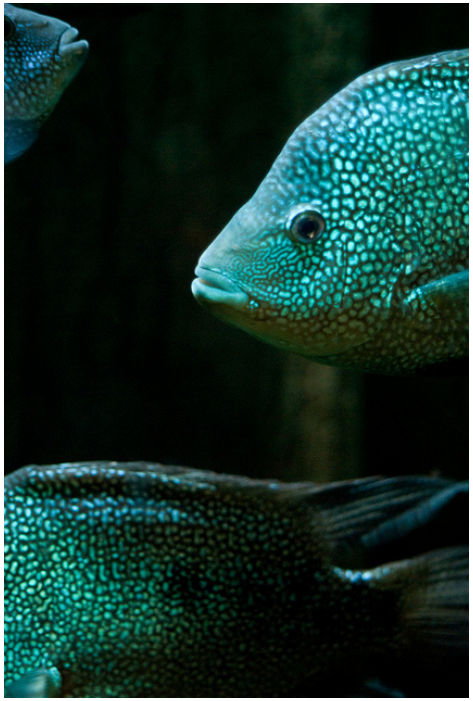
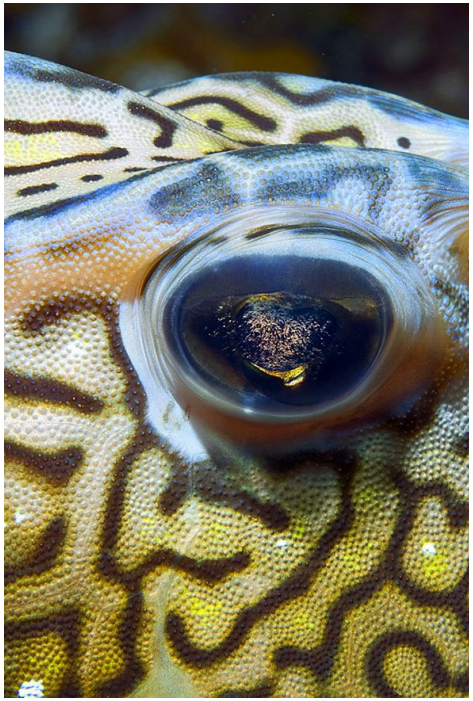
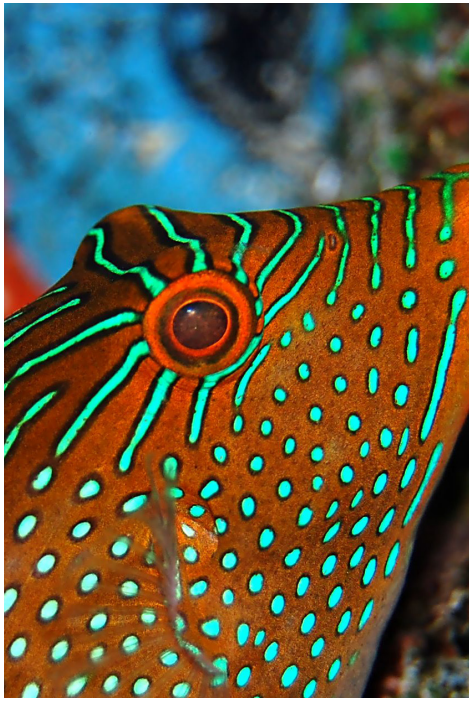
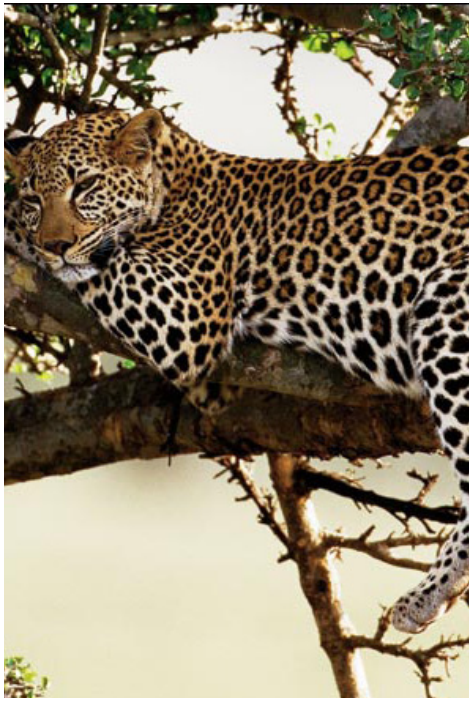


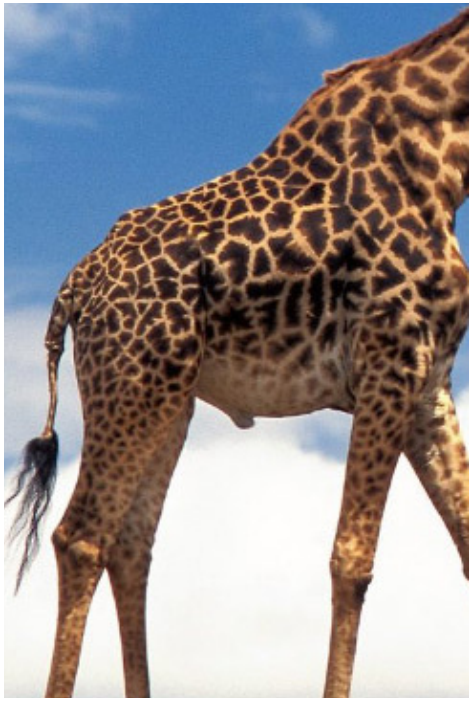
local amplification
lateral inhibition

inhibitor diffuses more quickly than activator

nervous system





nervous system

Equations:

$$\frac{\partial u}{\partial t} = r_u \nabla^2 u - uv^2 + f(1-u)$$
$$\frac{\partial v}{\partial t} = r_v \nabla^2 v + uv^2 - (f+k)v$$

Chemical Reaction:

$$U + 2V \rightarrow 3V$$
$$V \rightarrow P$$

U and V and P are chemical species.

u and v represent their concentrations.

ru and rv are their diffusion rates.

k represents the rate of conversion of V to P.

f represents the rate of the process that feeds U and drains U,V and P.

gray-scott reaction-diffusion

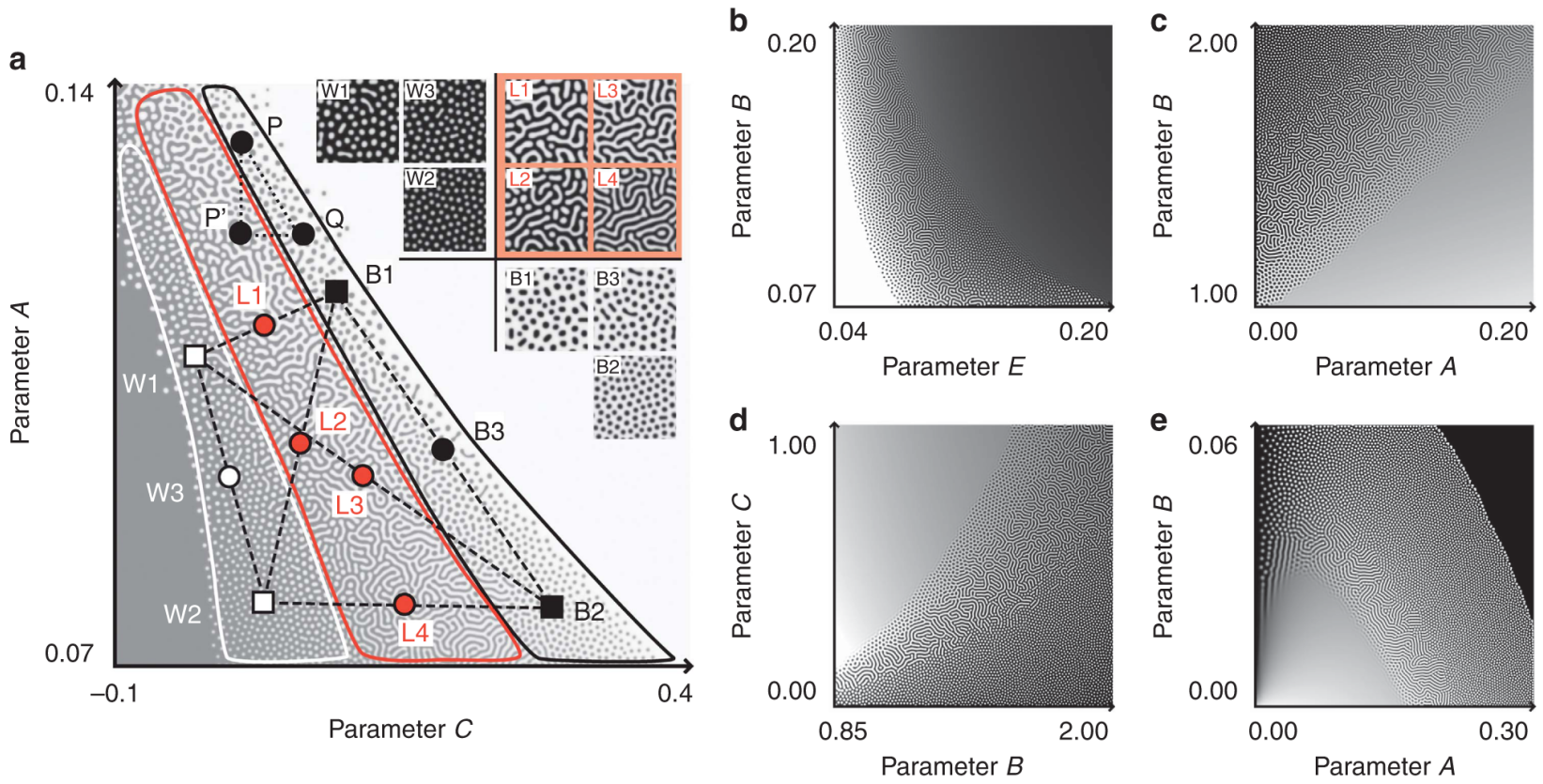


Figure 3 | '*In silico* hybridization' in the two-dimensional parameter space. (**a**) Pattern dynamics in the linear model RD system. Each point (x, y) represents a parameter set ($C = x$, $A = y$) for the model equations. The labyrinthine pattern zone (outlined by the red border) lies between the white spot zone (white bordered) and the black spot zone (black bordered). Broken line segments joining the coloured squares (W1–2 and B1–2) denote '*in silico* hybridization' between distinct parameter sets ('genotypes'). The midpoints of these segments (coloured circles; W3, B3 and L1–4) correspond to the 'hybrids'. The colour patterns calculated using the parameter sets of the indicated points are shown in the insets. (**b**–**e**) Pattern dynamics with various parameter sets and models. (**b**) Linear model, (**c**, **d**) the Gierer–Meinhardt model and (**e**) the Gray–Scott model.

nature communications 7 Sep 2010
Blending of animal colour patterns by hybridization
Seita Miyazawa, Michitoshi Okamoto & Shigeru Kondo

nervous system

hybrid fish experiments

White-spotted Charr (S. leucomaenis) X Masu Salmon (O. masou masou)
Peculiar labyrinthine patterns are seen in all the hybrids.

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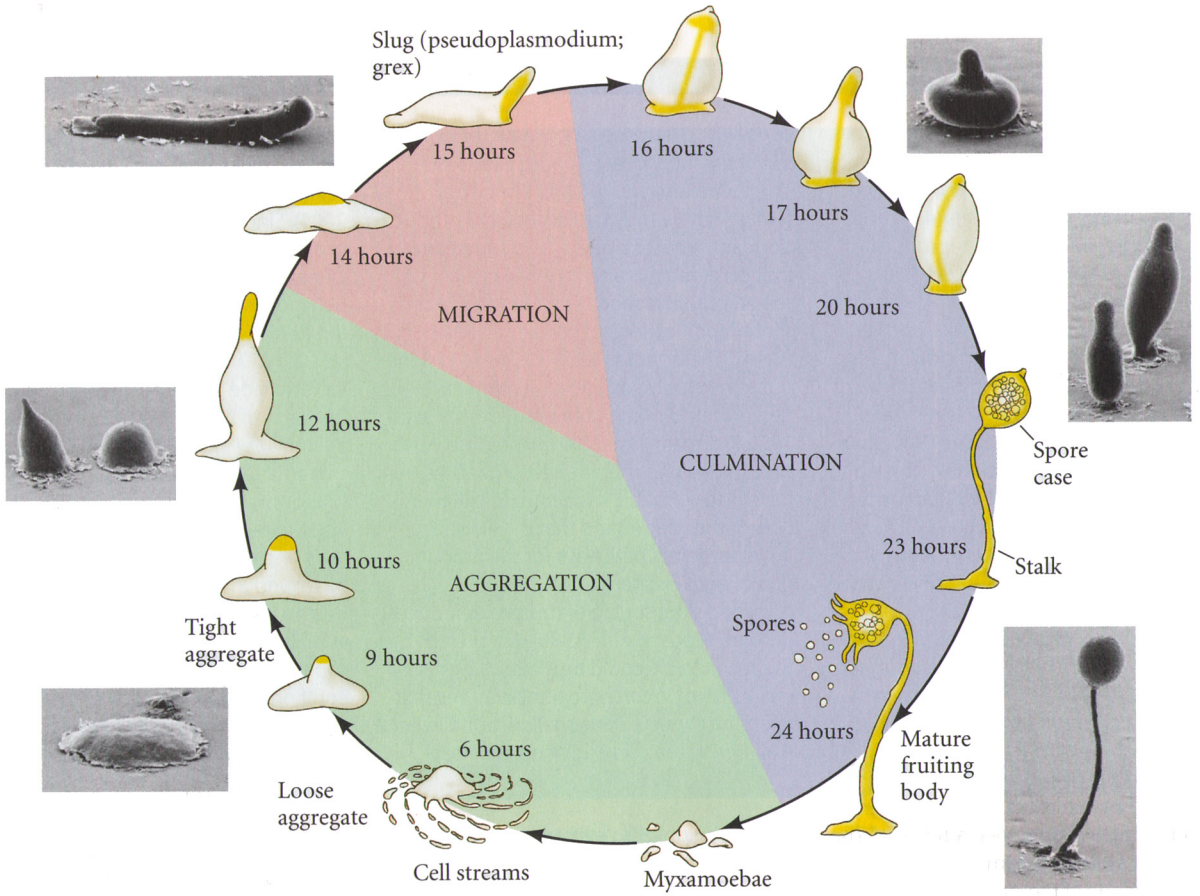


the social amoeba

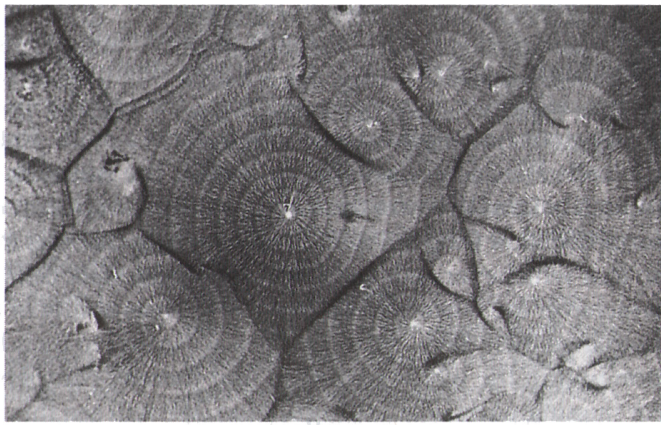
INDIVIDUAL SLIME MOLD CELLS CAN ACT TOGETHER TO FORM MACROSCOPIC STRUCTURES USING REACTION-DIFFUSION

When food is readily available they are individual amoebae, which feed and divide normally. However when the food supply is exhausted, they aggregate to form a multicellular assembly, called a pseudoplasmodium or slug. The slug has a definite anterior and posterior, responds to light and temperature gradients, and has the ability to migrate. Under the correct circumstances the slug matures forming a fruiting body with a stalk supporting one or more balls of spores. These spores are inactive cells protected by resistant cell walls, and become new amoebae once food is available.

nervous system

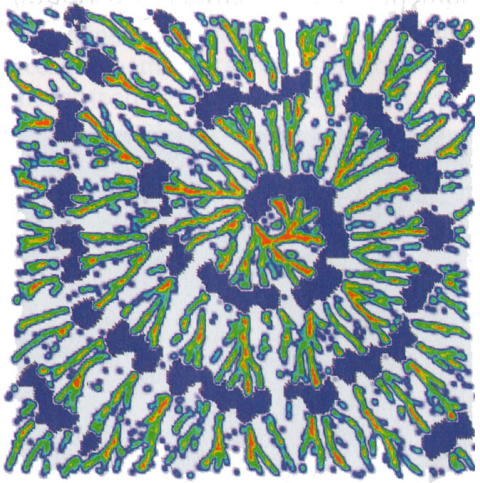
cAMP waves produced by aggregating Dictyostelium as seen on filter paper tagged with radioactive cAMP

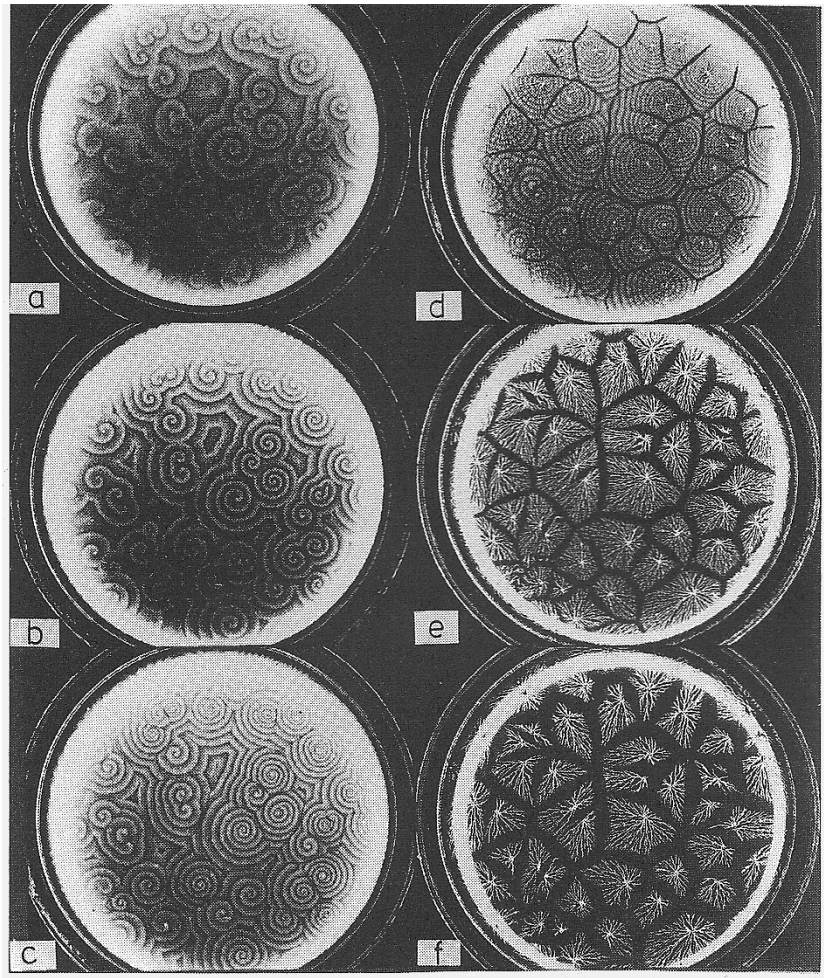
(B)



computer simulation modeling reception and release of cAMP and changes in cell density due to cell movement

(D)



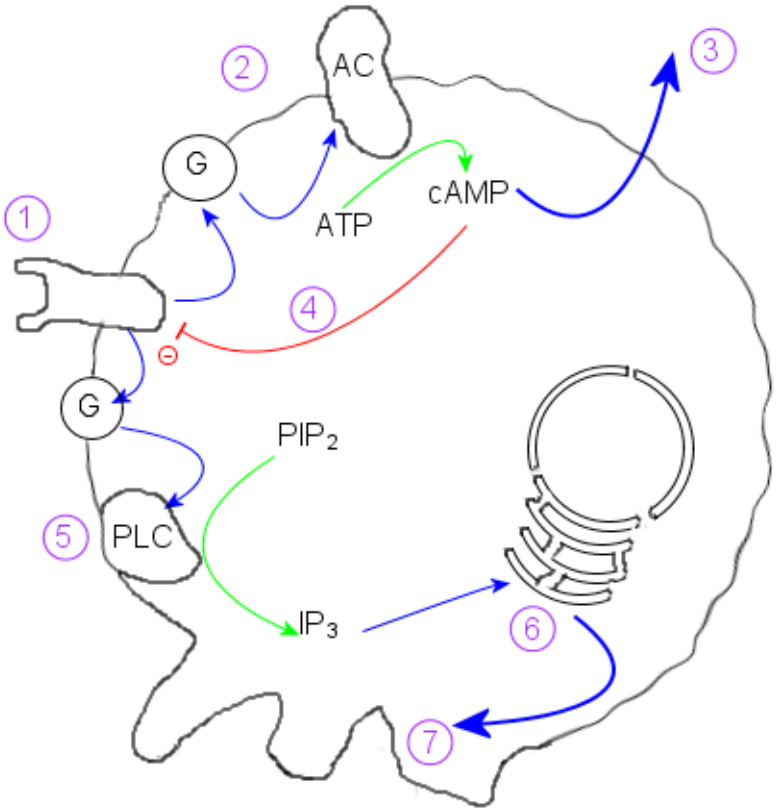


photos taken 10 min apart of 5 x 10^7 aggregating Dictyostelium discoideum. Cells appear bright when moving and dark when stationary

Dictyostelium aggregation

aggregation is initiated as each of the slime molds begin to synthesize cAMP. There are no dominant cells that begin the secretion of control the others. Instead the sites of aggregation are determined by the distribution of Dictyostelium. The cells respond to cAMP by initiating movement toward the cAMP pulse for about 1 minute and they release cAMP of their own. The cAMP also causes a change in cytoskeletal polarity which leads to the movement of the cell. After this the cell is unresponsive to further cAMP pulses for several minutes.

nervous system



Dictyostelium aggregation

1. cAMP reception at the cell membrane activates a G-protein
2. G protein stimulates Adenylate cyclase
3. cAMP diffuses out of cell into medium
4. Internal cAMP inactivates the external cAMP receptor.
5. A different g-protein stimulates Phospholipase C
6. IP3 induces calcium ion release
7. Calcium ions act on the cytoskeleton to induce the extension of pseudopodia.

Cell signaling/spiral waves in Dictyostelium
http://www.youtube.com/watch?v=OX5Yiz38fgY

John Bonner's slime mold movies
http://www.youtube.com/watch?v=bkVhLJLG7ug

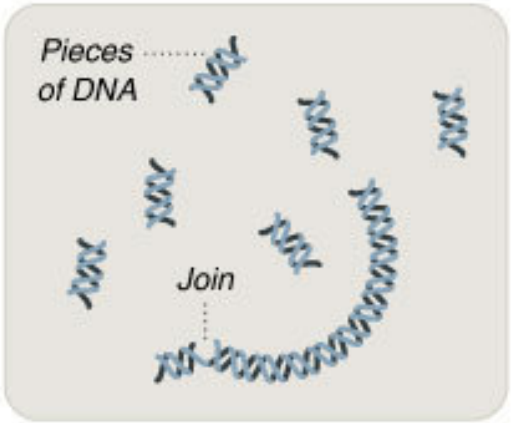
Slime Mold Waltz
http://www.youtube.com/watch?v=wvRxoiiGCWY

nervous system

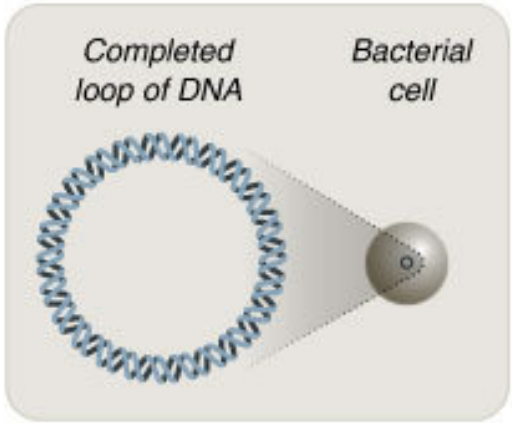
May 2010 - the Venter Institute created the first "synthetic" lifeform
Mycoplasma laboratorium

Synthesizing a Functional Genome

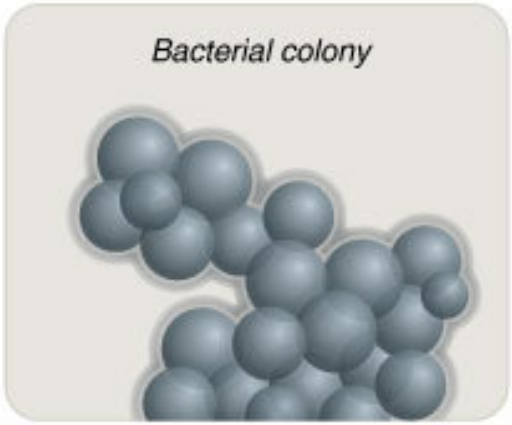
A team led by J. Craig Venter has succeeded in creating a synthetic bacterial genome and using it to control a cell.



ASSEMBLY The team began with small pieces of laboratory-made DNA, then used a new technique to join them together into the largest piece of DNA synthesized so far, a loop one million units in length.



INSERTION The loop of DNA was designed to closely replicate the genetic sequence of a species of bacterium. To test the DNA, the team inserted it into an empty cell of a different species of bacterium.



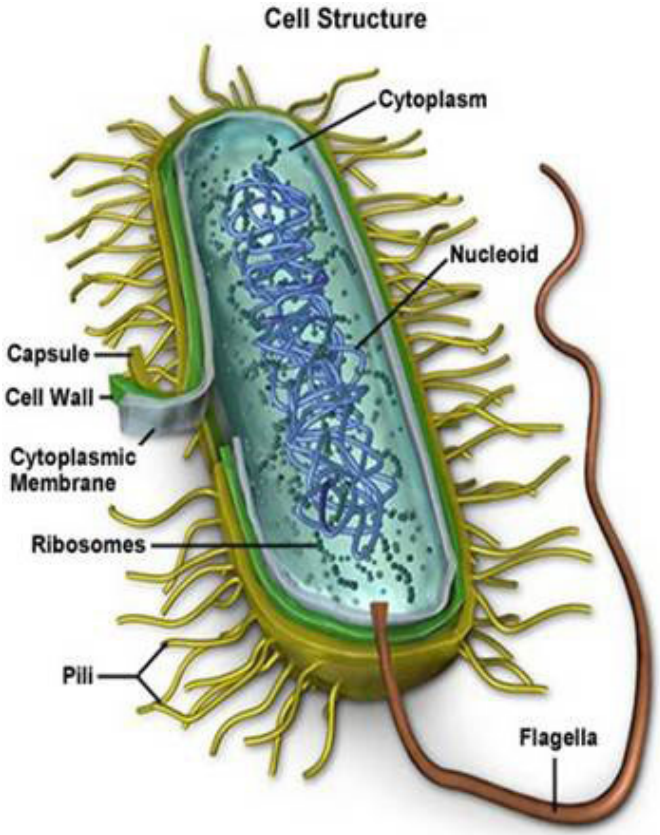
SELF-REPLICATION The synthetic DNA proved accurate enough to take over the bacterial cell and substitute for the cell's own DNA. The "synthetic cell" then replicated itself to form a bacterial colony.

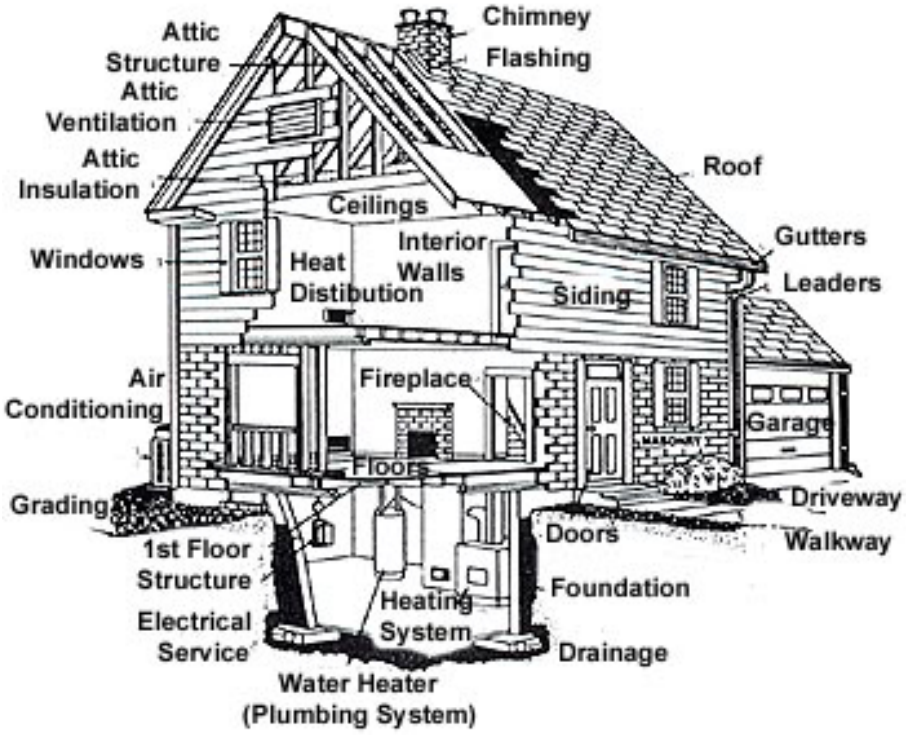
Source: Science

THE NEW YORK TIMES

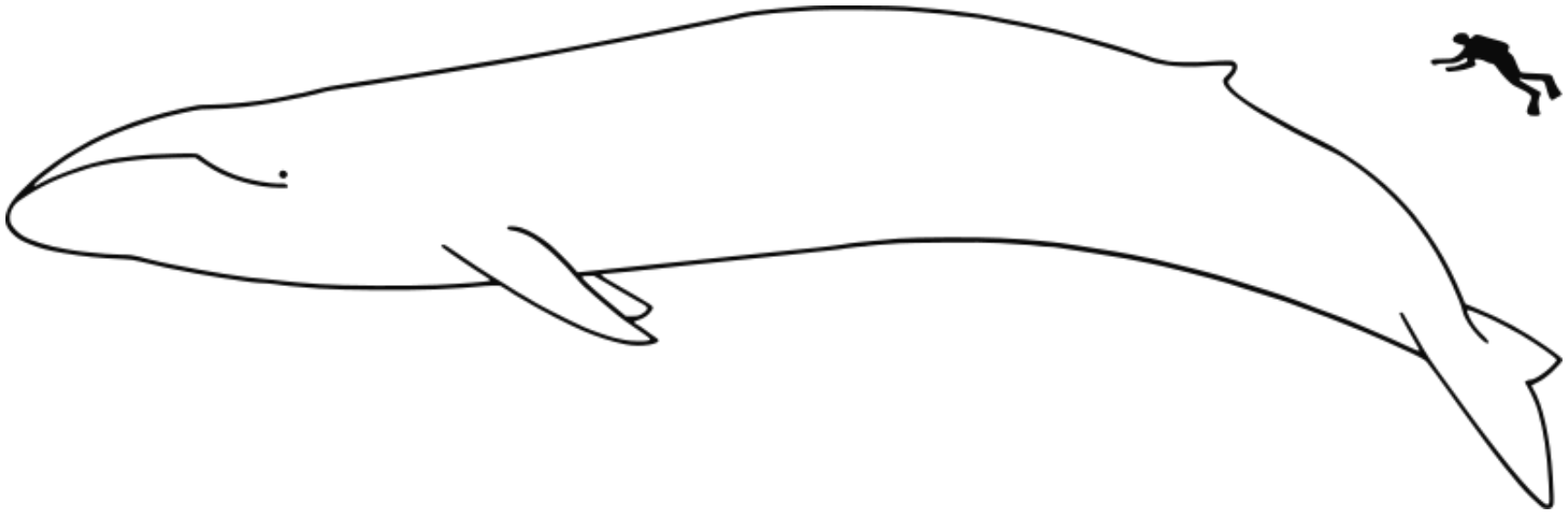
now what?

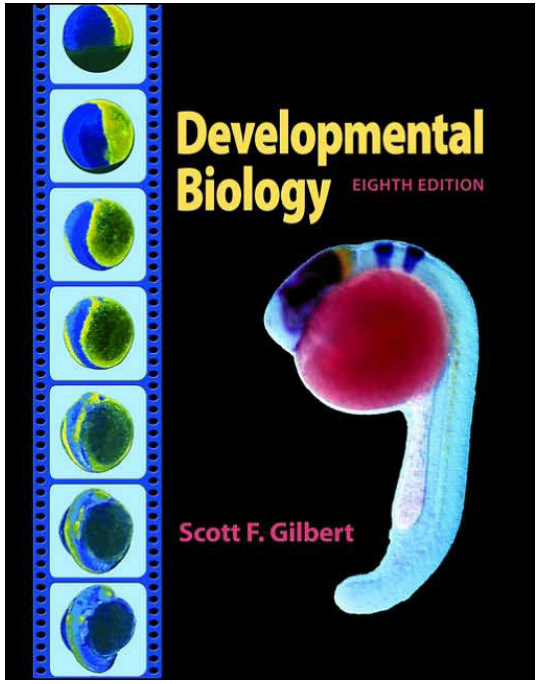
nervous system

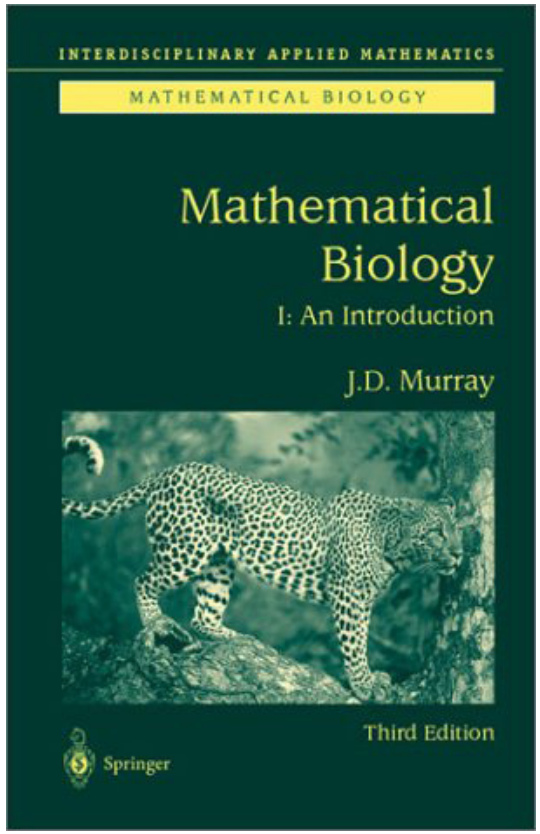




nervous system







http://dictybase.org/

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nervous system