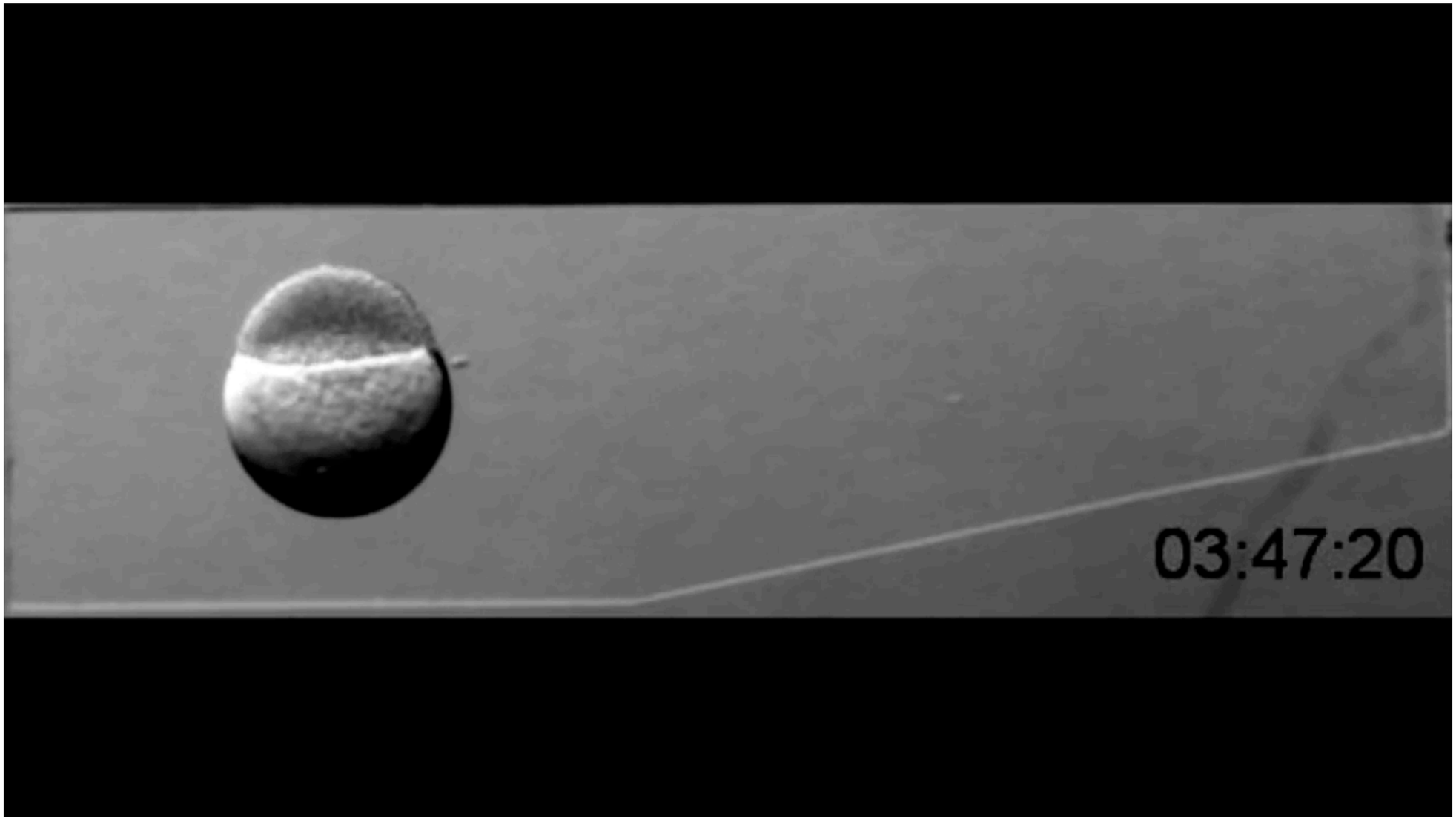
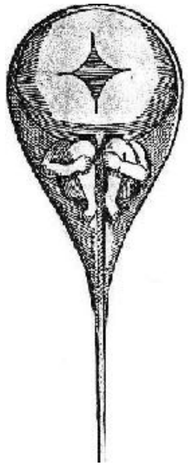
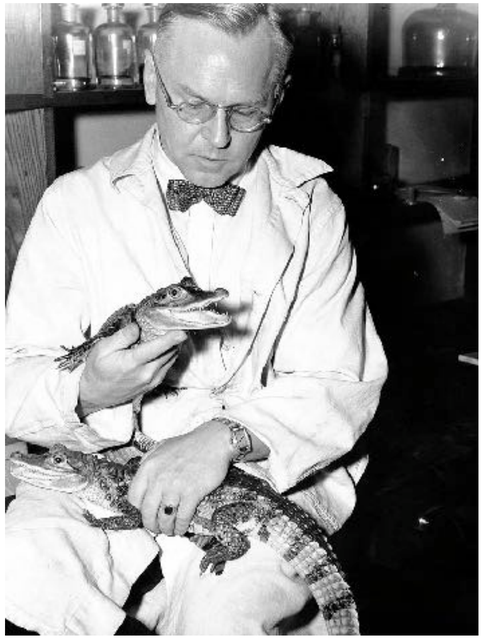
Morphogenesis



Instruction versus self-organization





Johannes Holtfreter

"selective affinity" 1955

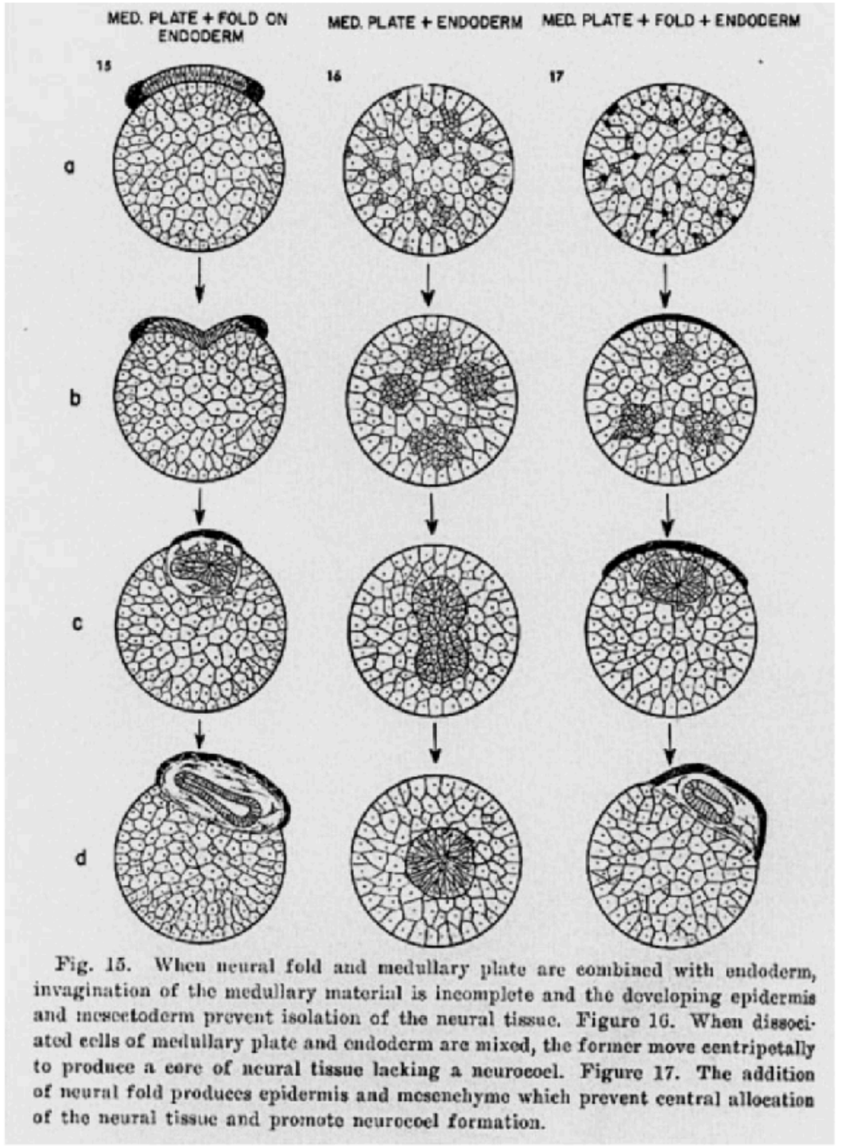
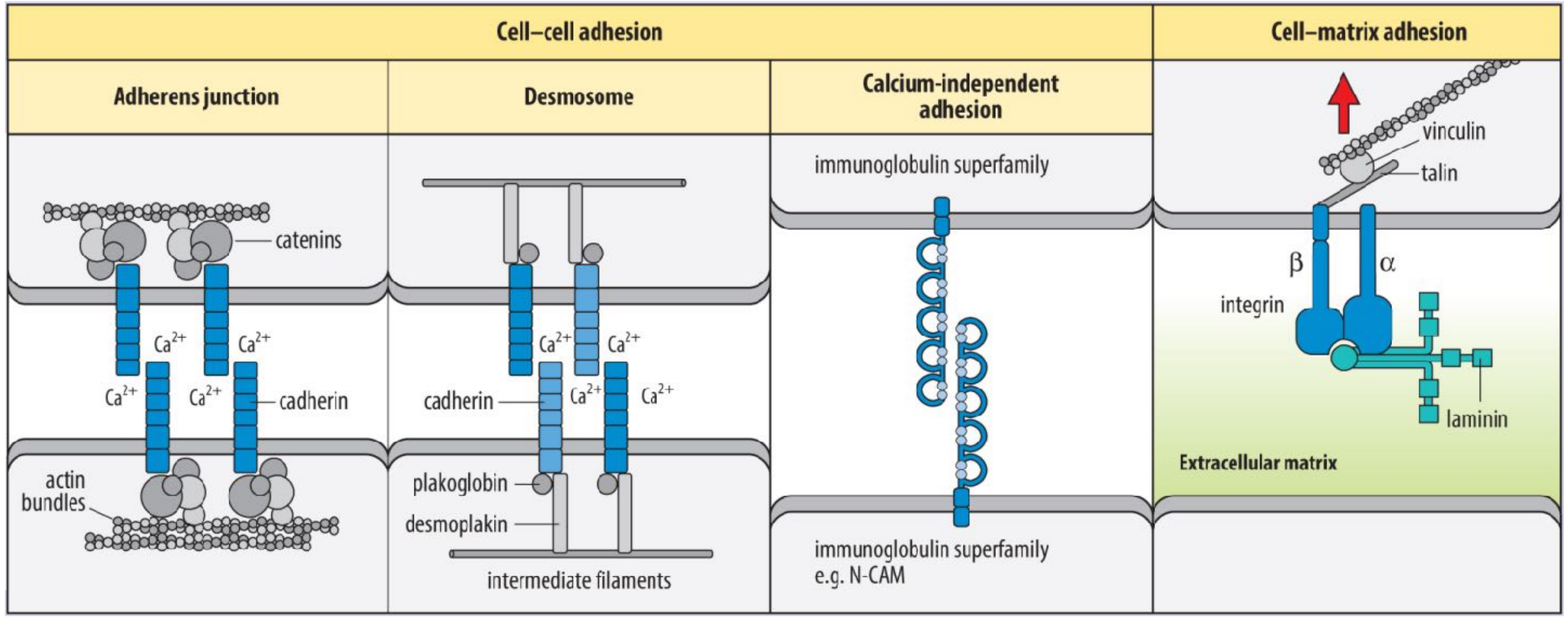


Fig. 15. When neural fold and medullary plate are combined with endoderm, invagination of the medullary material is incomplete and the developing epidermis and mesectoderm prevent isolation of the neural tissue. Figure 16. When dissociated cells of medullary plate and endoderm are mixed, the former move centripetally to produce a core of neural tissue lacking a neurocoel. Figure 17. The addition of neural fold produces epidermis and mesenchyme which prevent central allocation of the neural tissue and promote neurocoel formation.

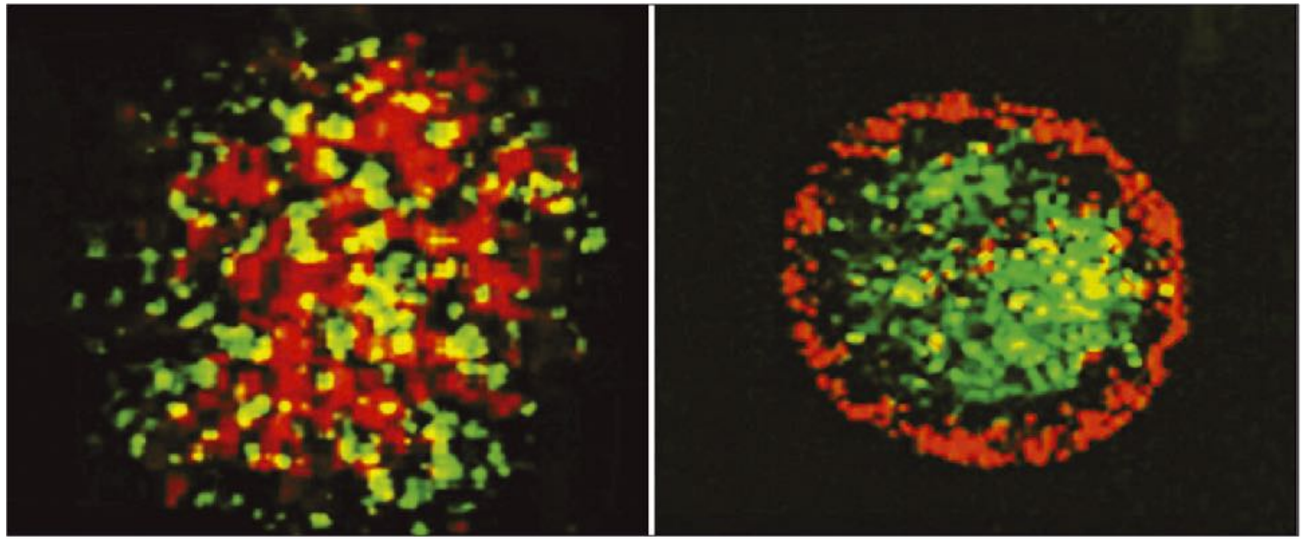
Cell-cell and cell-matrix adhesion systems



These adhesion systems in animal cells make contact onto the cytoskeleton - adhesion can alter cortical tension

Cadherin *level* and *type* can drive cell-sorting

Experiment: mix together cells expressing different levels of a fluorecently-labelled cell adhesion molecule



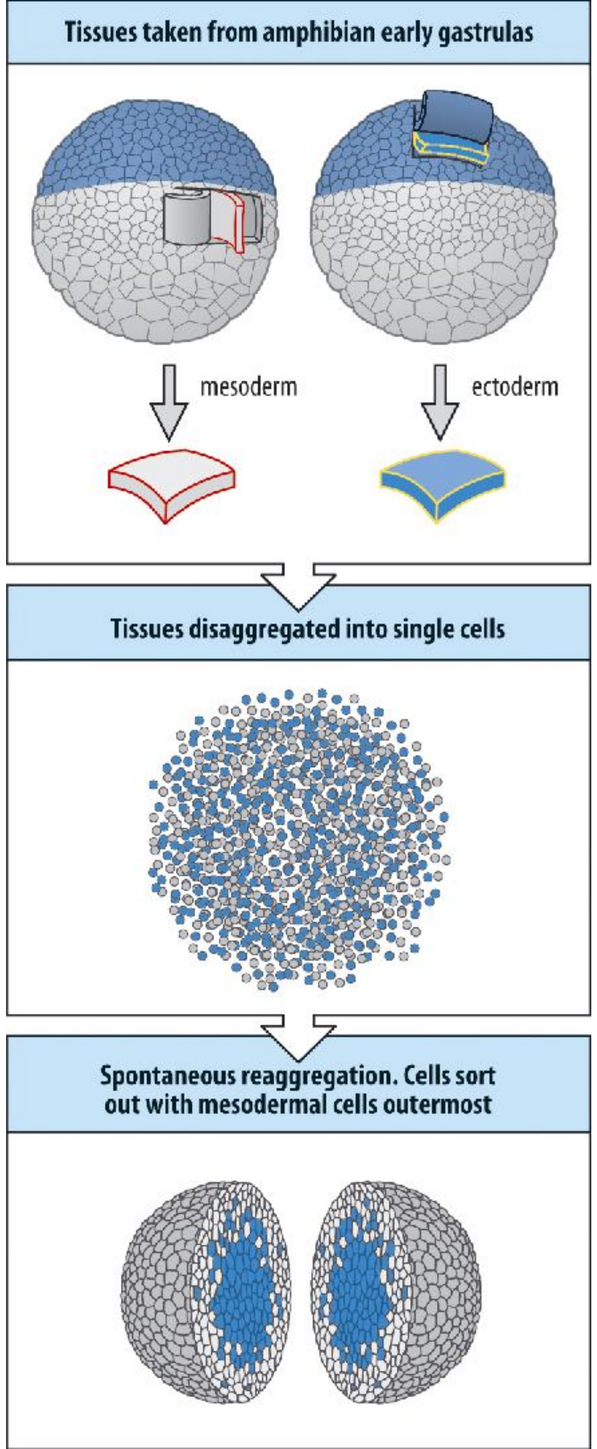
Early → **Late**

High N-cadherin

Low N-cadherin

Malcolm Steinberg

"differential adhesion hypothesis" 1964



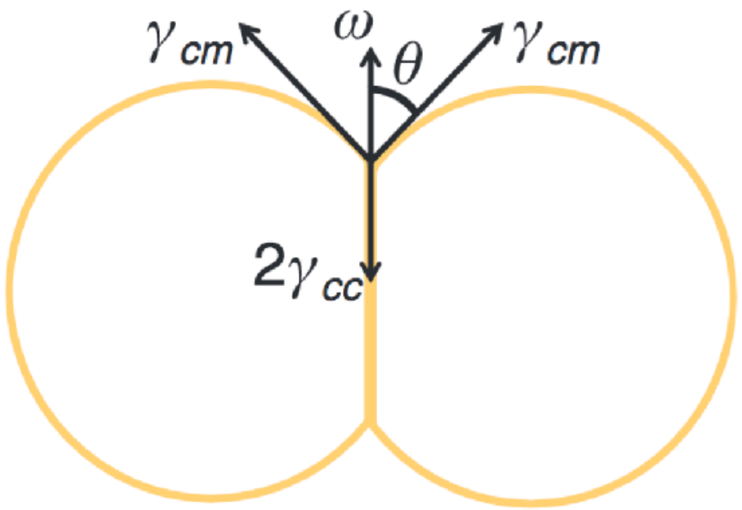
Cell sorting driven by differential surface tension and differential adhesion

N-cadherin

E-cadherin

- Surface tension: oil-water
- Surface tension modified by adhesion
- Cells with strongest interactions form inner layer

Balance of forces at contact point



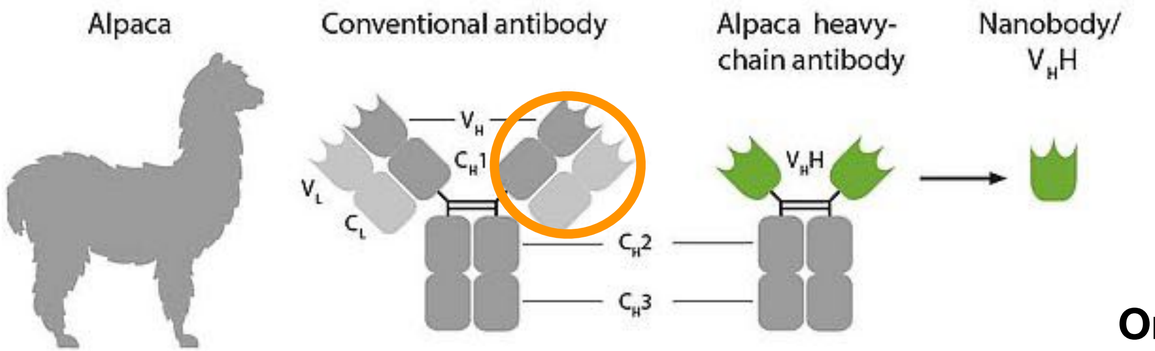
$$\cos\theta = \frac{2\gamma_{cc} - \omega}{2\gamma_{cm}}$$

- Tension from cortex contact with medium (γ_{cm})
- Tension from cortex contact with cell (γ_{cc})
- Tension from adhesion between cells (ω)

Difficult in practice to distinguish the effects on tension from the contributions of adhesion and from the cell cortex - can we determine what differential adhesion can do by itself?

Maitre et al,. 2012

Single chain antibodies - Nanobody



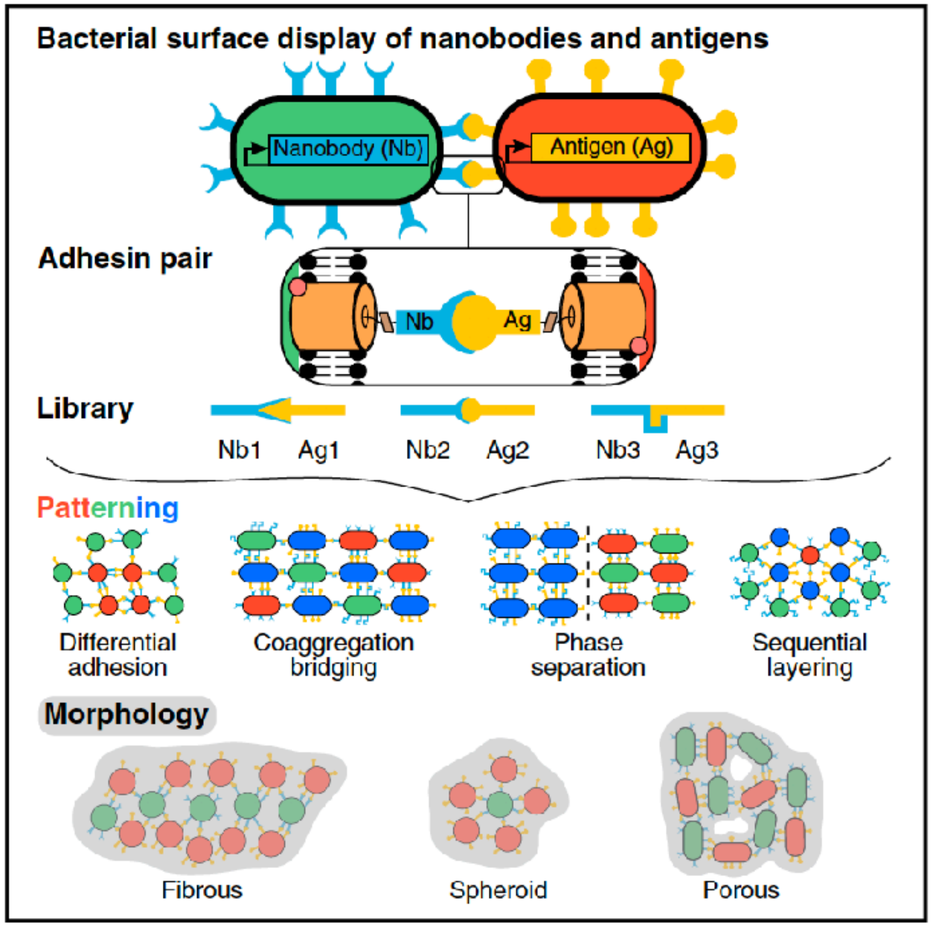
One gene, 12-15 KDa peptide, simple production

Two genes, complex peptide folding and secretion 150-160 KDa

Fab - 50 Kda

A Synthetic Bacterial Cell-Cell Adhesion Toolbox for Programming Multicellular Morphologies and Patterns

Graphical Abstract



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In Brief

The development of a genetically encoded toolkit of surface-bound nanobodies and antigens in *E. coli* allows for precise manipulation of cell-cell adhesion and rational design of diverse self-assembled multicellular patterns and morphologies.