

Zelforganiserende Schoonheid

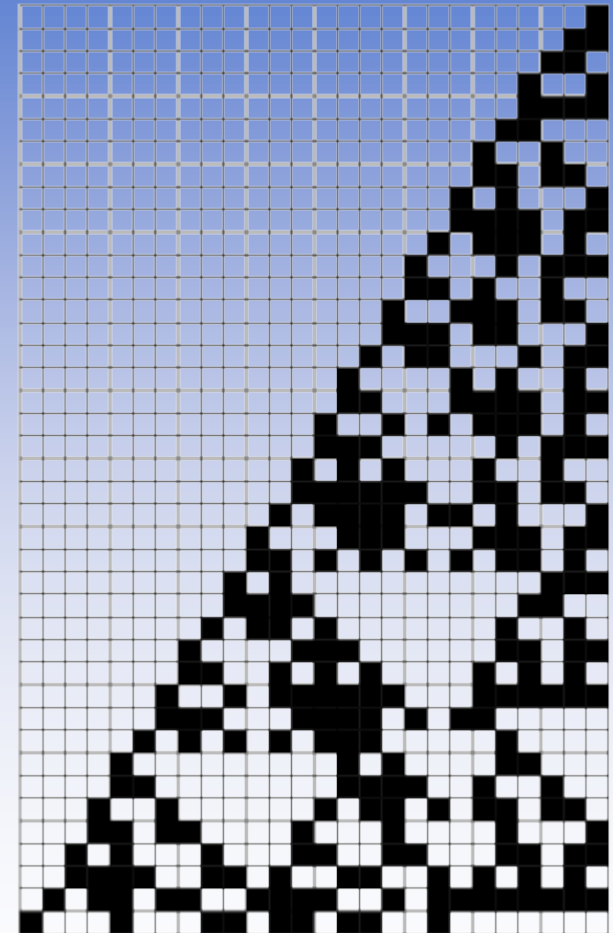
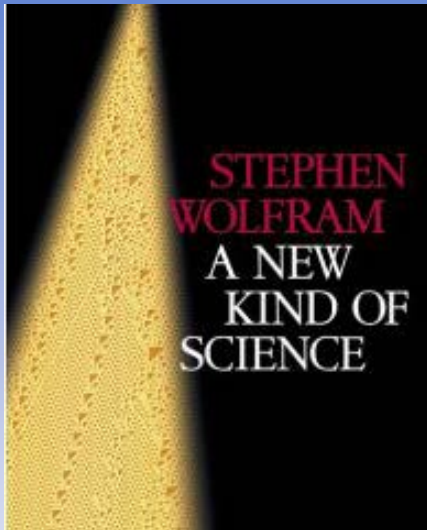


Introductie: regels voor zelfconstructie

- **Simpele regels geven complexe patronen**



Simpele regels en feedback geven complexe patronen

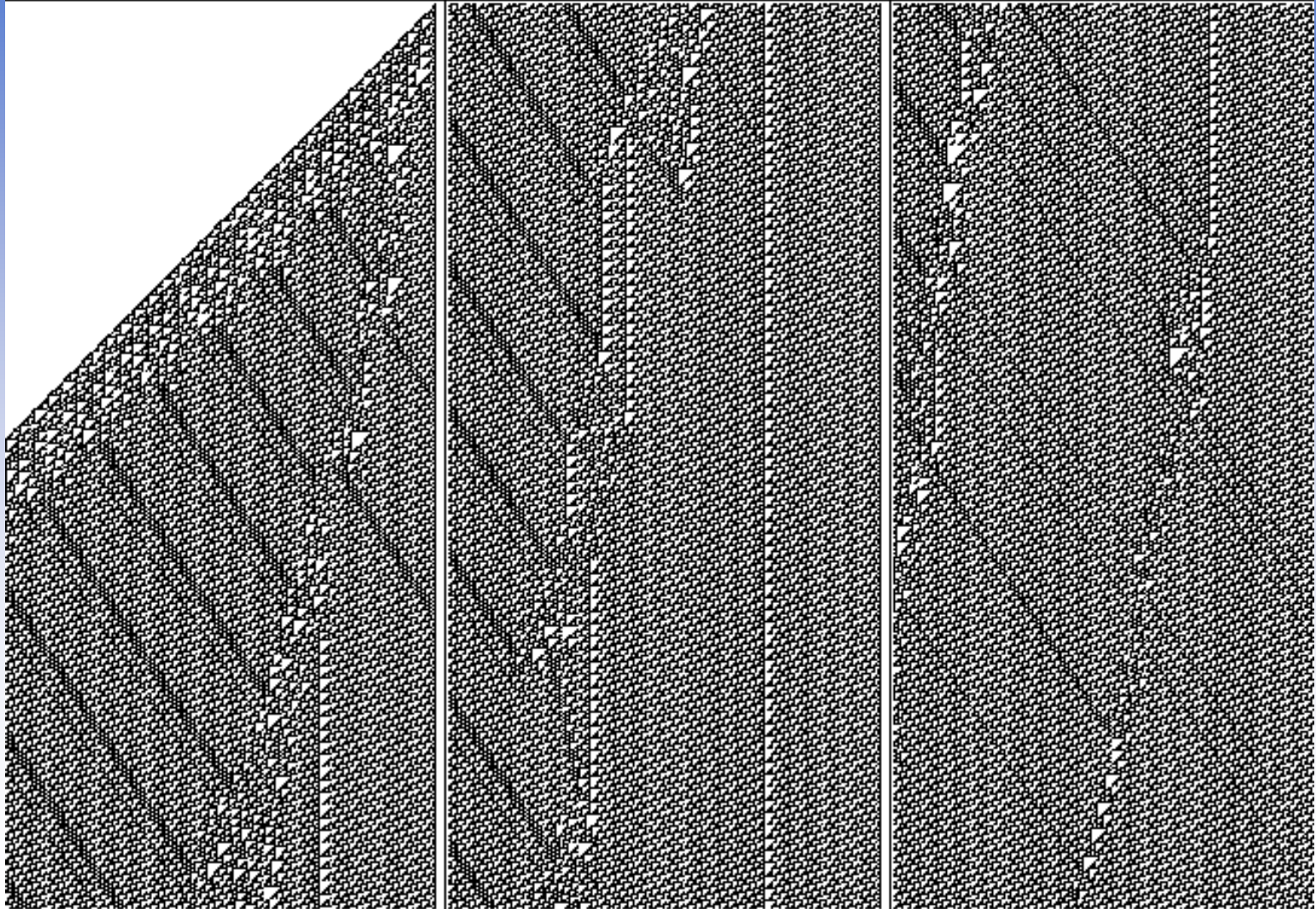


Rule 30 cellular automaton

current pattern	111	110	101	100	011	010	001	000
new state for center cell	0	0	0	1	1	1	1	0

Makkelijk te illustreren in cellulaire automaten

Simpele regels geven 'macro- patronen

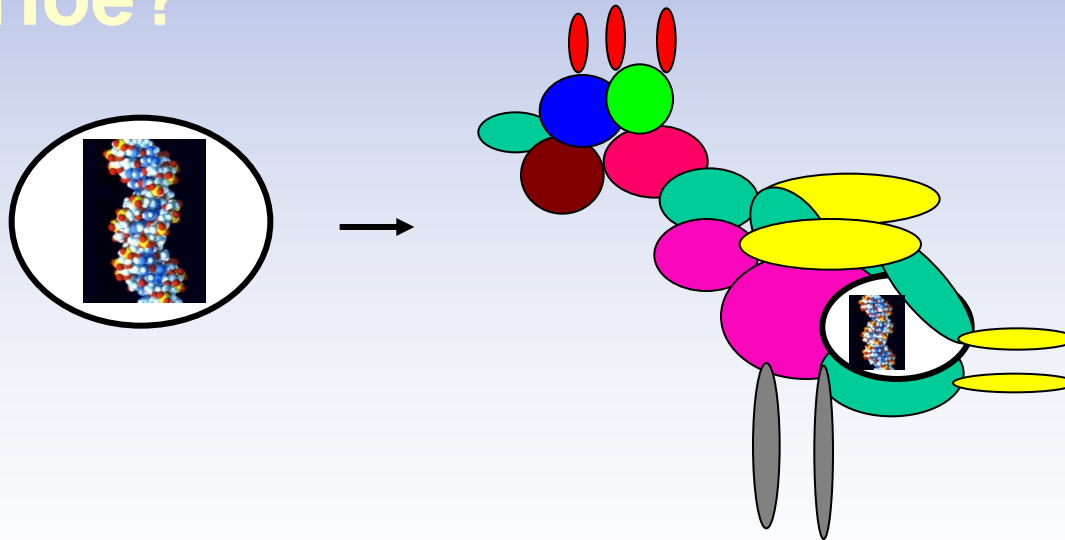


Zelforganiserende schoonheid

- **DNA en informatie netwerken**
 - **Feedback en verstrengeling**
- **Voorbeelden**
 - **Biologische klok**
 - **Kleurpatronen op vleugels**
 - **Architectuur van de plant**
- **Finale**

Architectuur in de Biologie:

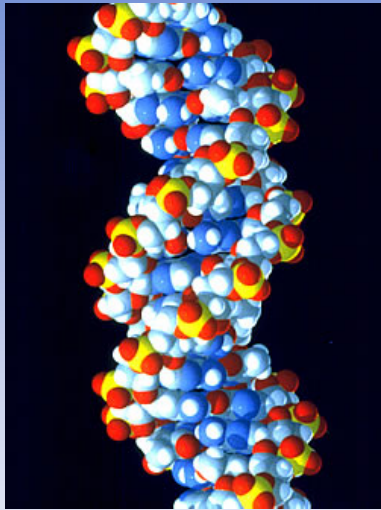
- **Bouwplan start vanuit enkele cel**
- **Informatie opgeslagen in coderende moleculen: DNA**
- **Hoe?**



Mens: ~ 60 miljoen miljard cellen

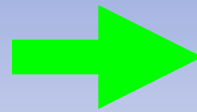
Biologische informatie

- Klassiek 'dogma'

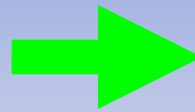


DNA

Code: ..ACGTAAT..



..ACGUAAU..

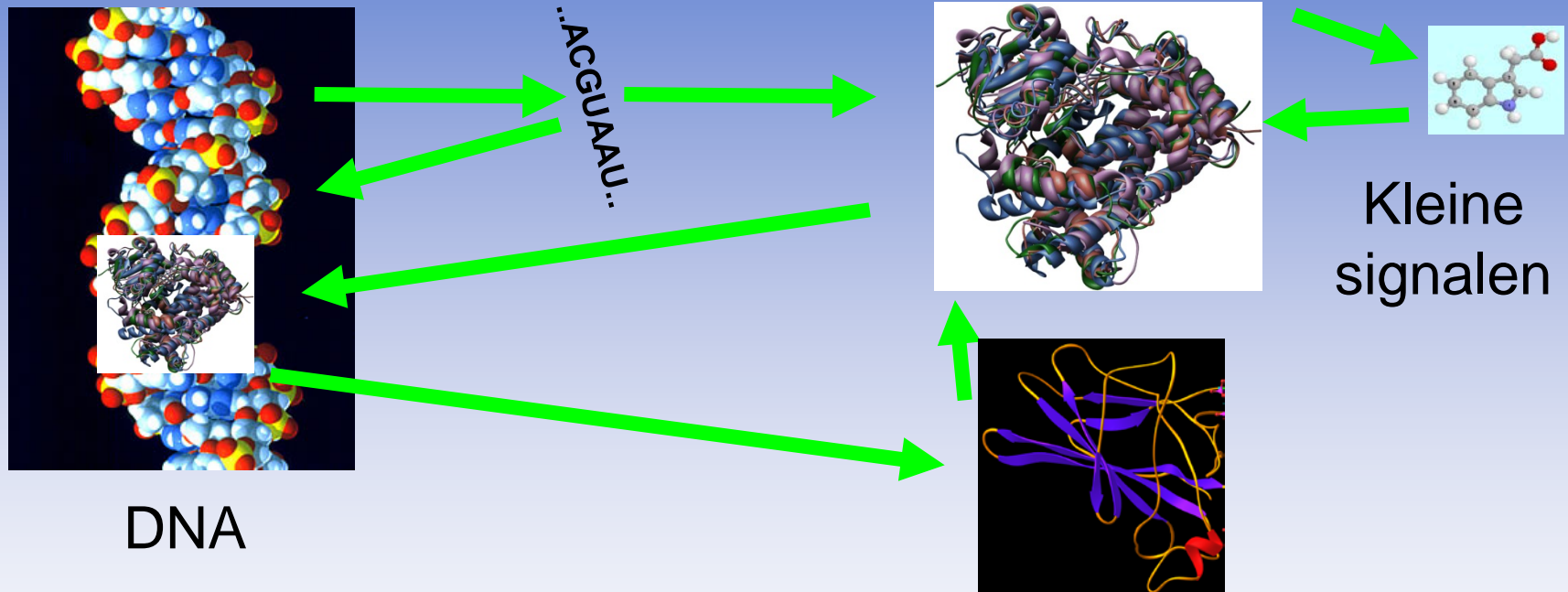


Eiwitten

Vertaalde code: ..QPLIV..

Biologisch informatie netwerk

- Informatie 'verspreid' over hierarchieën: DNA, eiwit, signalen, structuur...

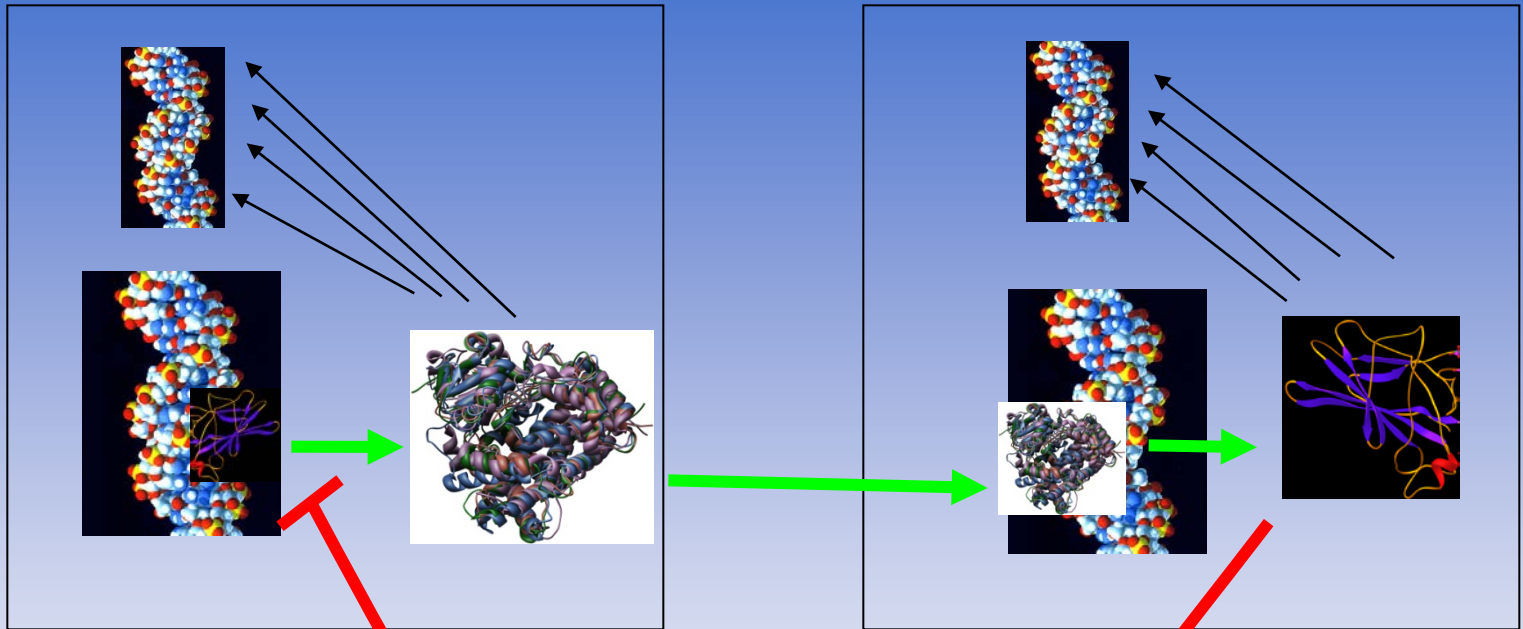


~1000 'Regel-Eiwitten':
Transcriptiefactoren (TFs)
~25000 gewone eiwitten

Zelforganiserende schoonheid

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 - Architectuur van de plant
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Emergente eigenschap van netwerkje



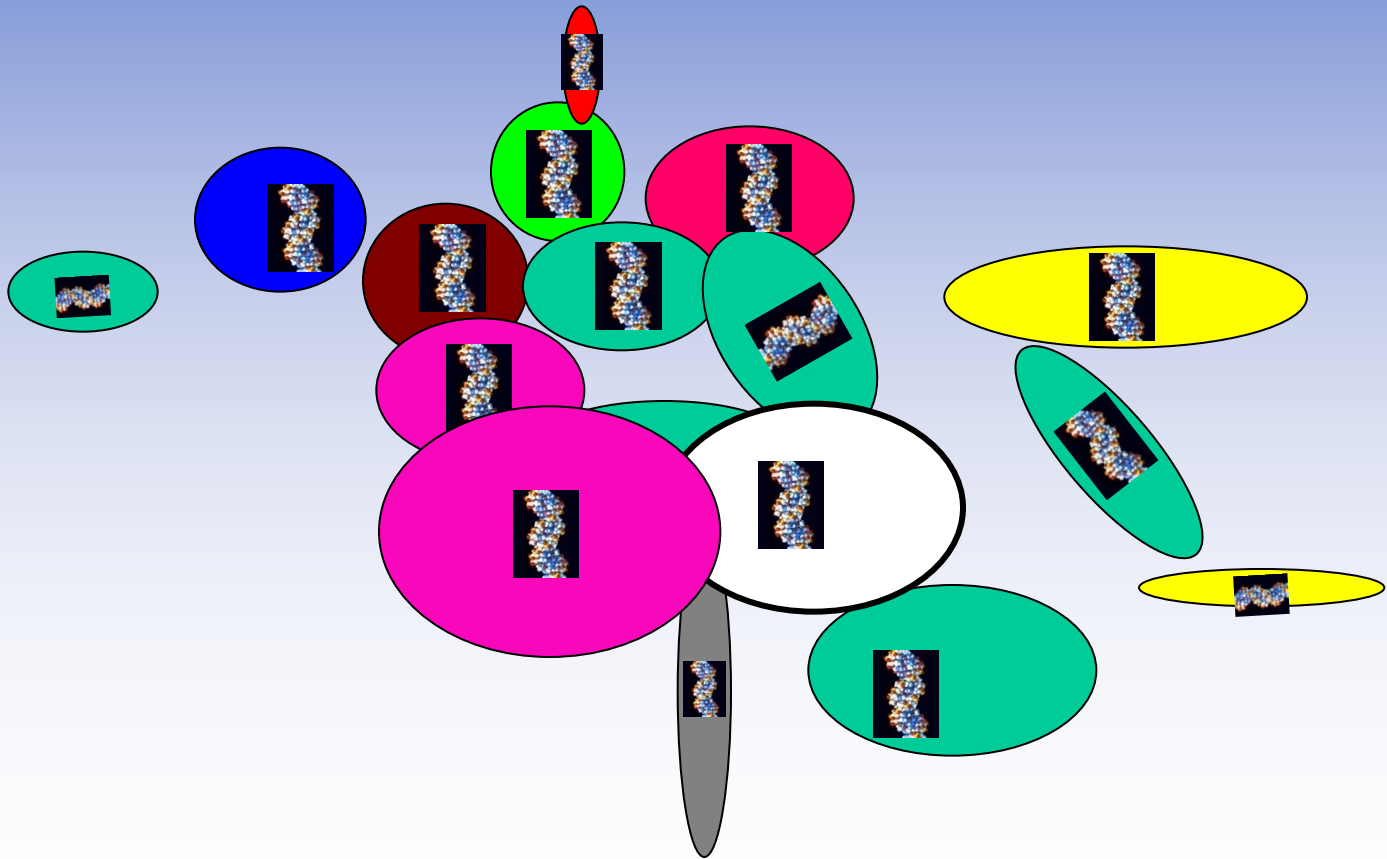
Centrale
oscillator

Biologische klok!

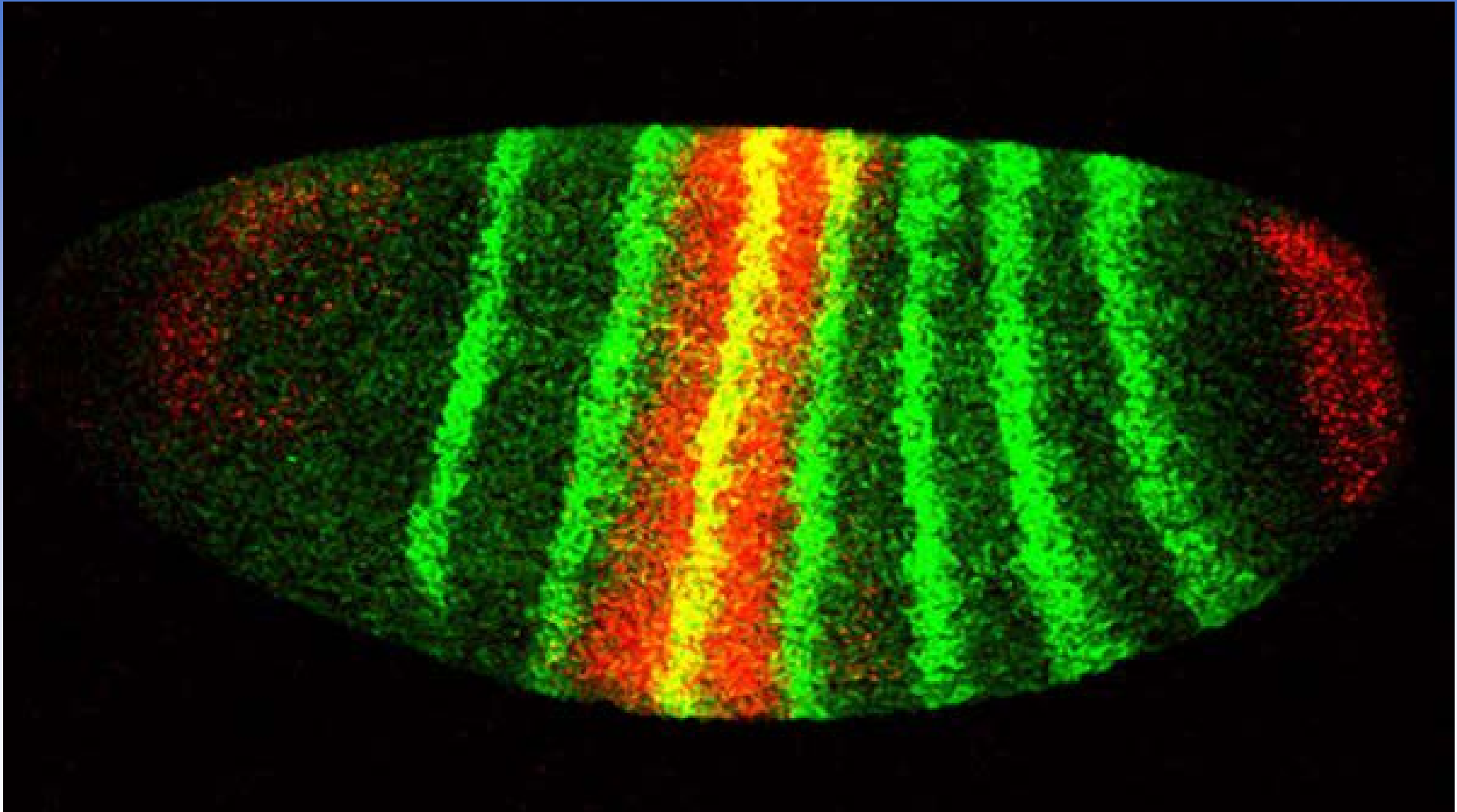


Ontwikkeling: de kip en het ei

- Verschillende gespecialiseerde cellen gebruiken andere delen van de DNA code

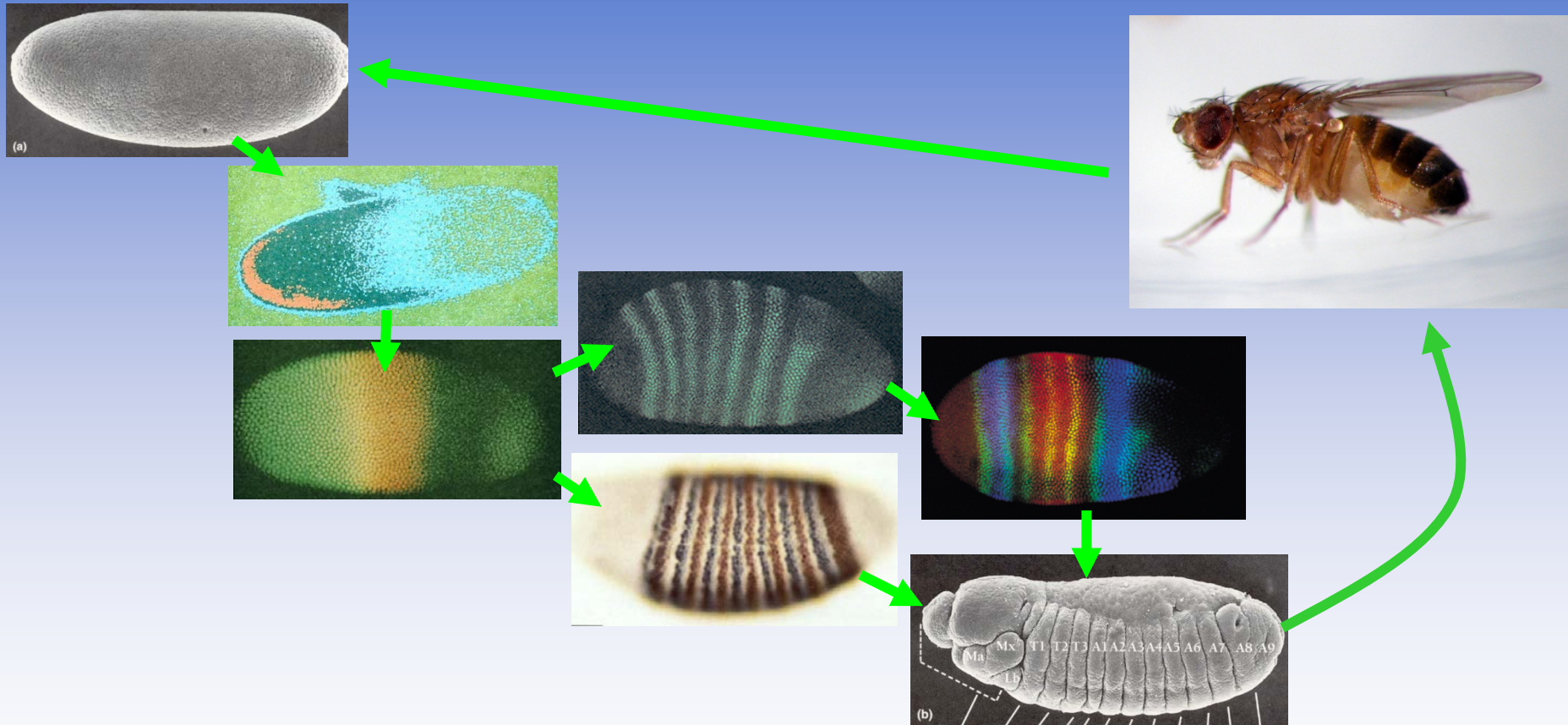


Een 'ei' transcriptiefactor netwerk



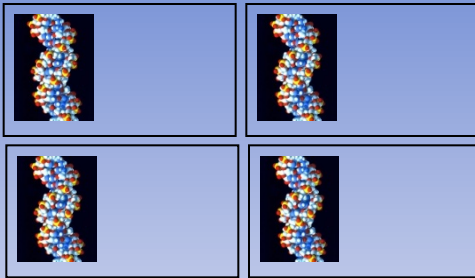
Complexiteit ontvouwt zich geleidelijk

Van ei naar 'kip'....en van 'kip' naar ei



Transcriptiefactor netwerk vormt 1 geheel

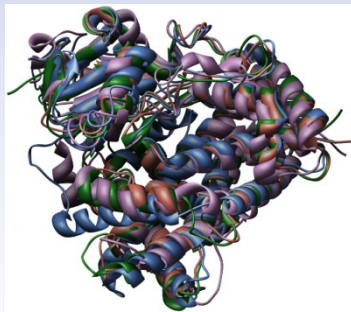
Patronen op vleugels



Meerdere cellen

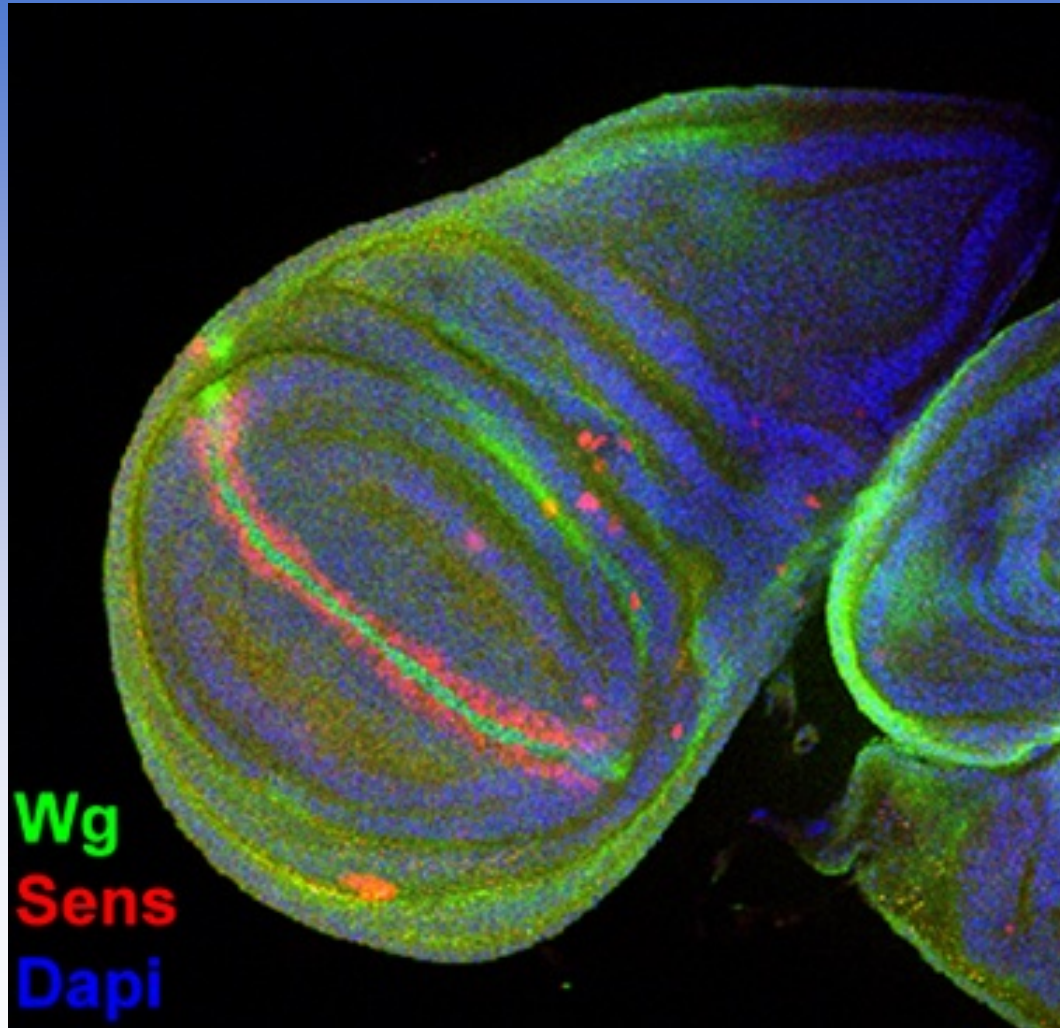


Signaal-eiwit:
wingless

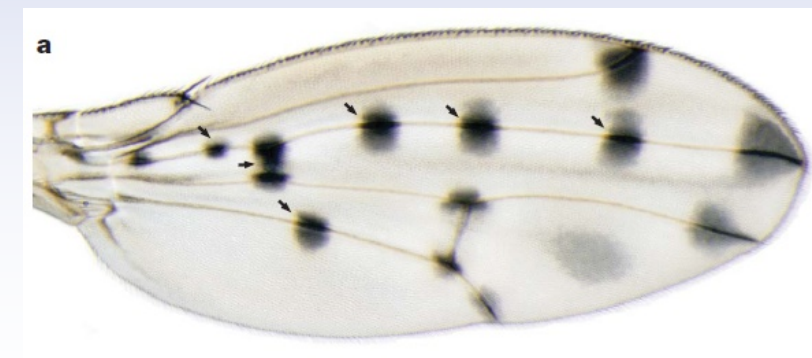
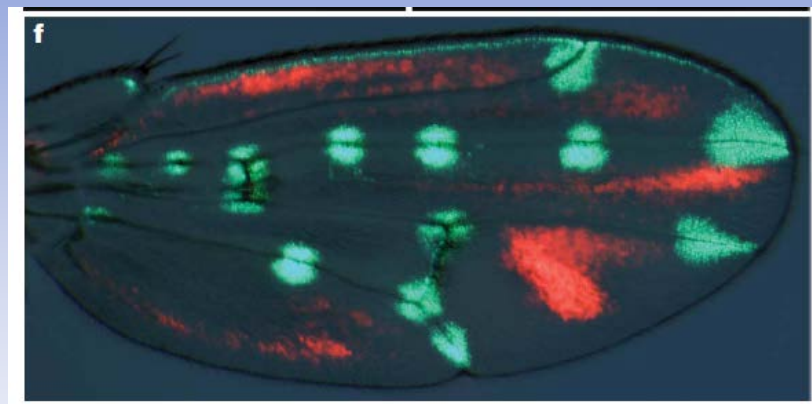
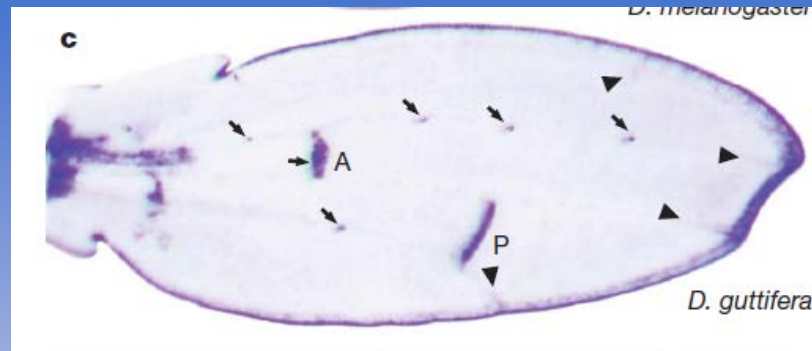


Transcriptie-factoren (TF)
Voor: (1) cel-identiteit
(2) pigment-eiwitten

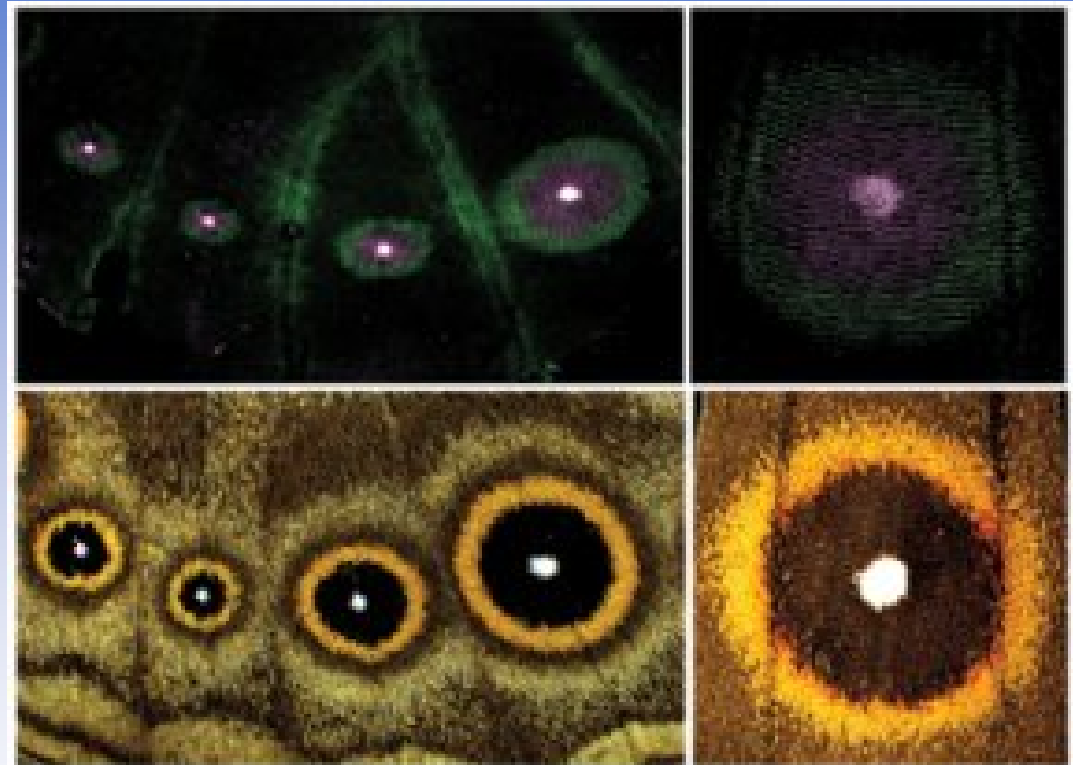
Bouwplan vleugel opzetten...



...inkleuren...

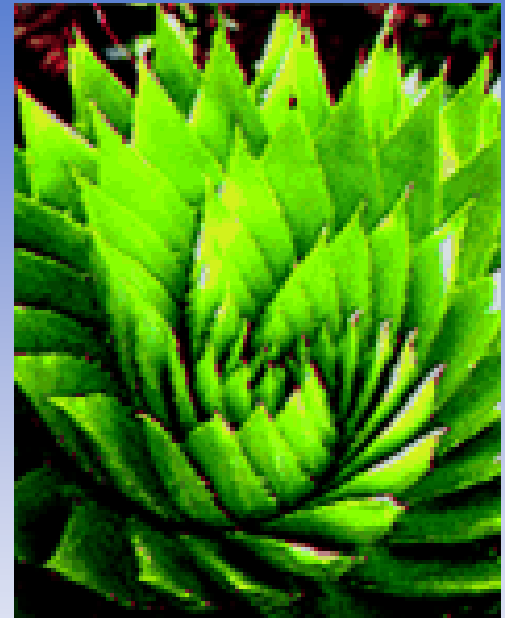
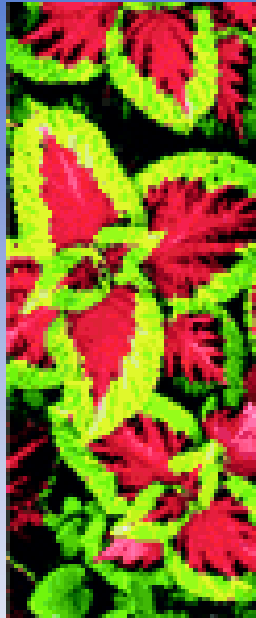


...: zelfgeprogrammeerde schoonheid

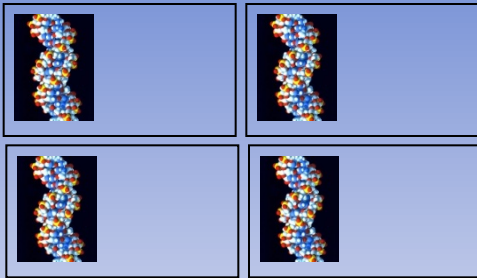


Signaalmolecuul gebruiken

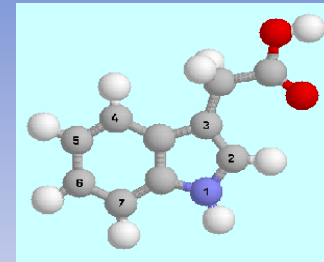
Plant architectuur netwerken



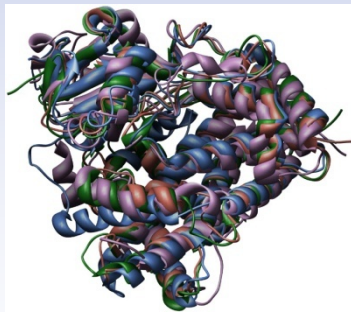
Groeipunt netwerk componenten



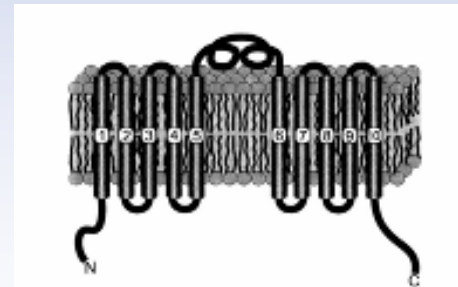
Meerdere cellen



Signaalmolecuul:
auxine

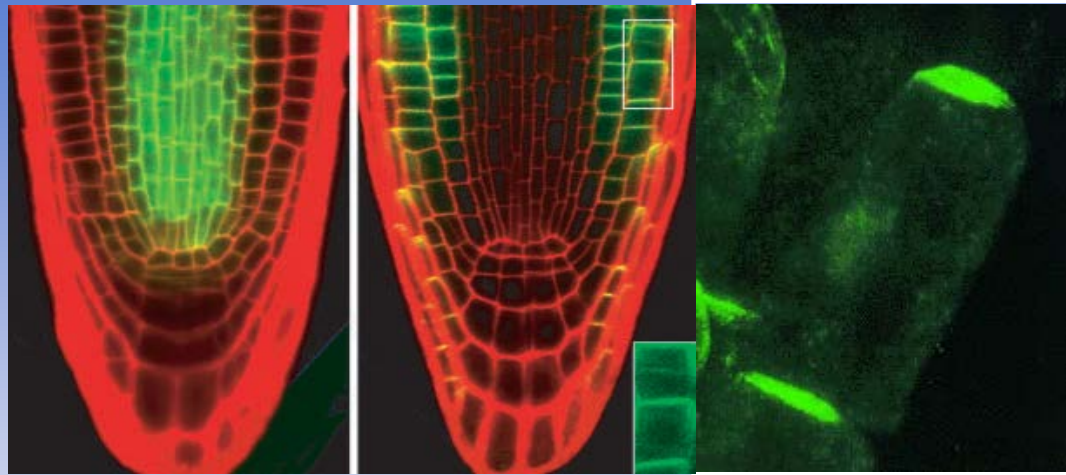


Transcriptie-factor (TF)
voor cel-deling

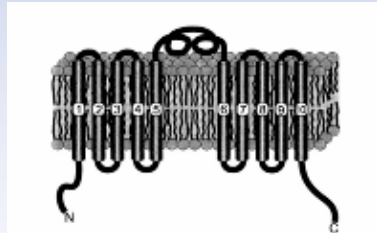


Transport eiwit
pompt auxine
naar buiten

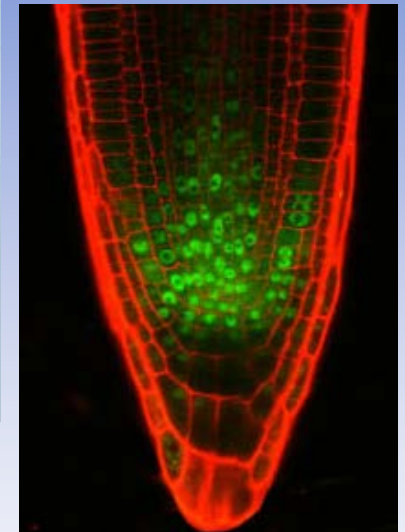
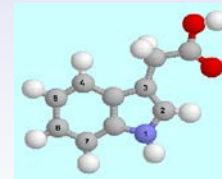
Netwerk componenten in het echt



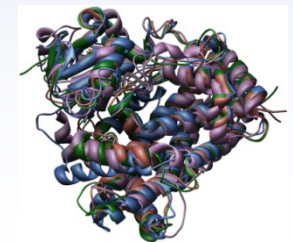
Auxine pompen



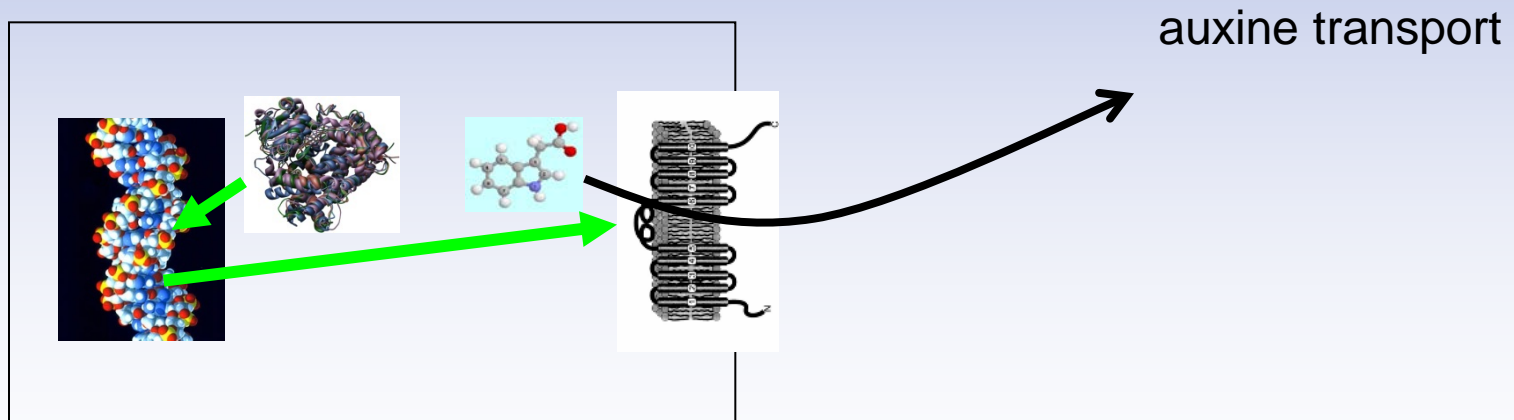
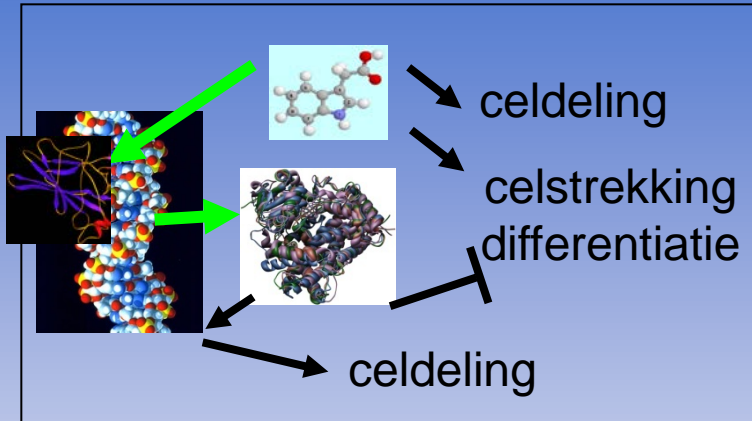
Auxine



Delings TF



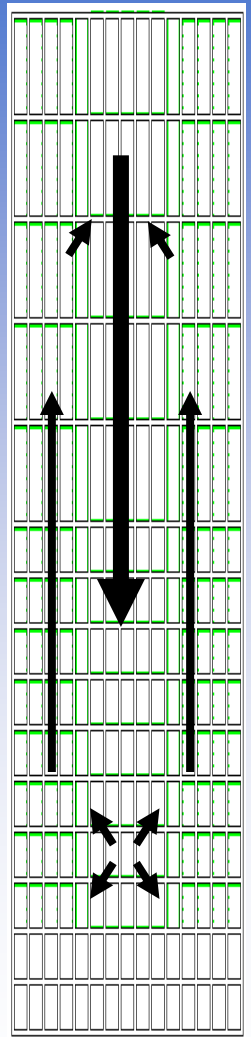
Netwerk regels



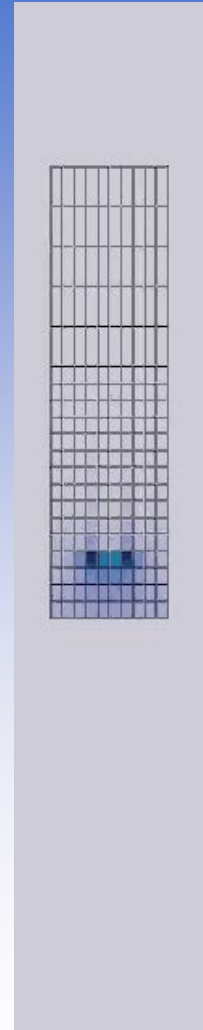
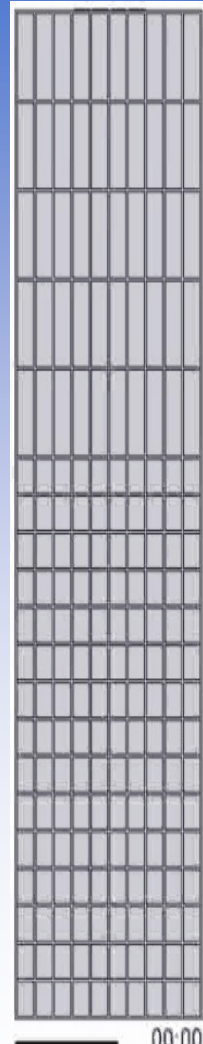
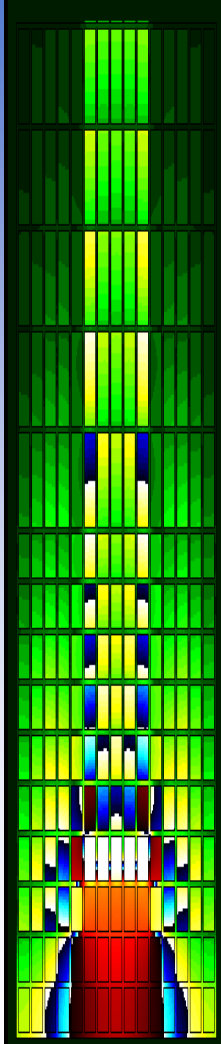
Emergente eigenschappen?

De digitale wortel

pompen



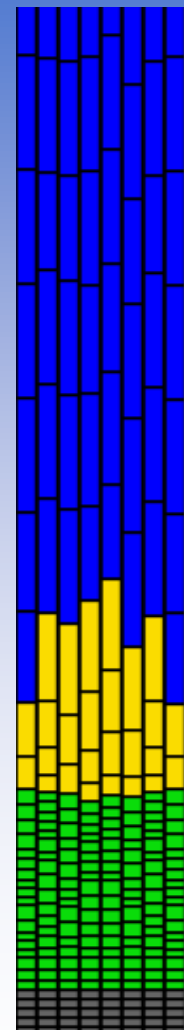
auxine



TF

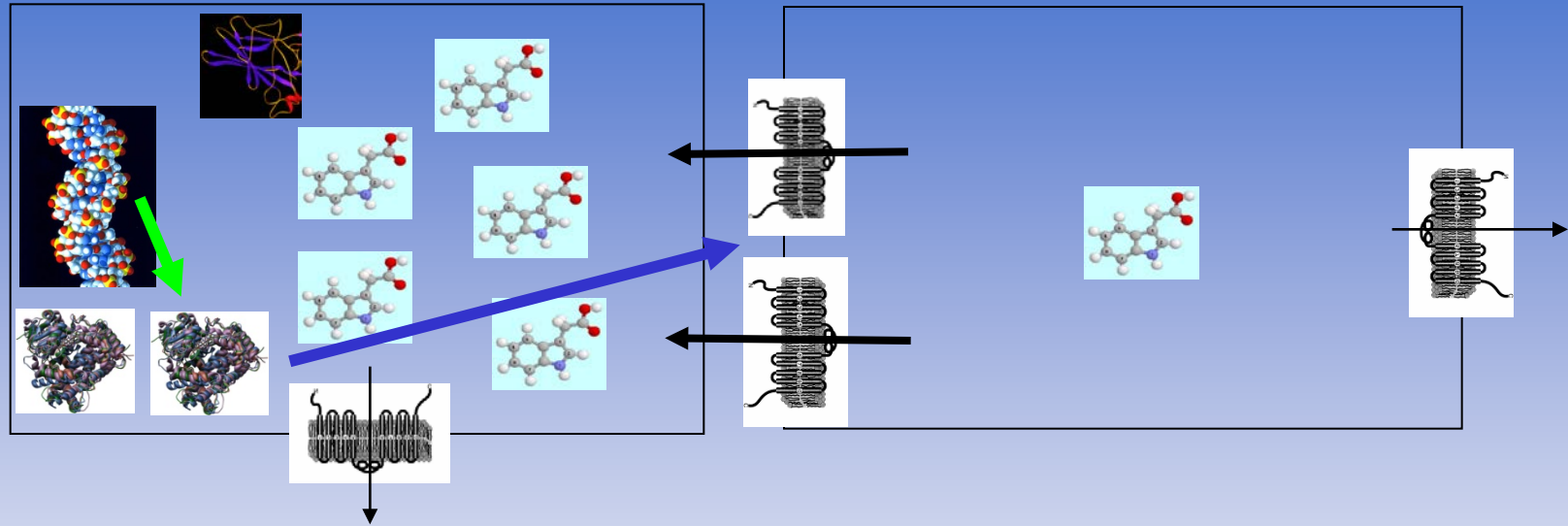


actie



'simpel' netwerk → complexe uitkomst

1 extra netwerk regel...



auxine beïnvloedt hoeveelheid en richting
transportmoleculen

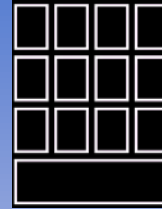
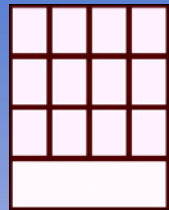
Emergente eigenschappen?

...geeft zelforganisatie

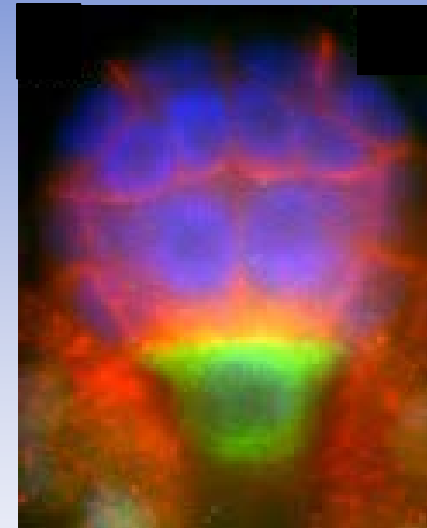
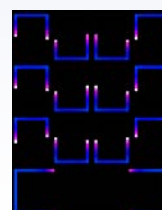
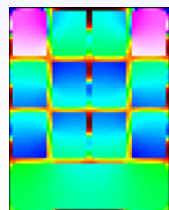
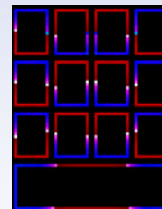
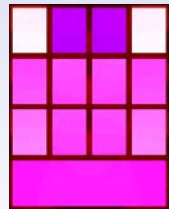
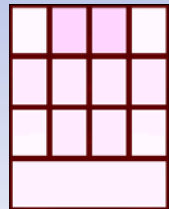
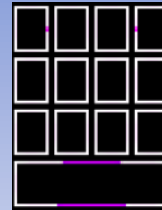
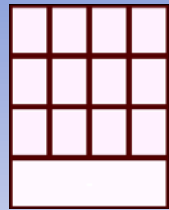
Digitale en echte
embryo's:

auxine

pompen



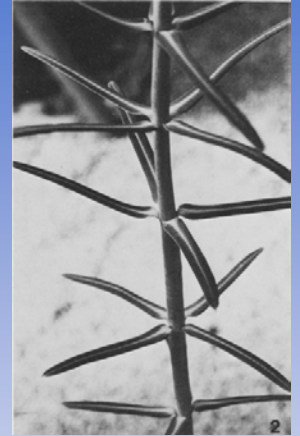
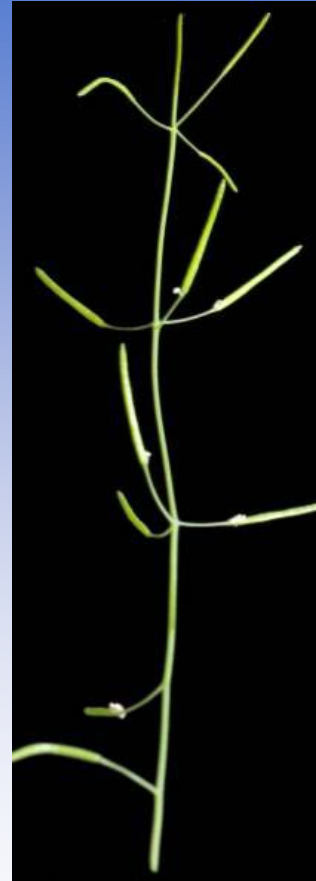
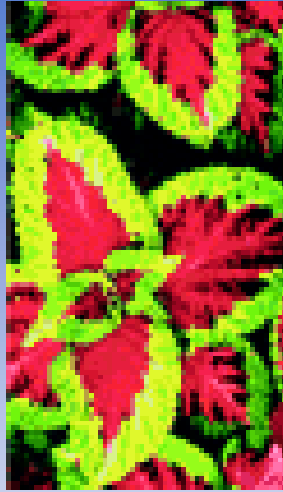
tijd
↓



pompen

auxine

Scheut architectuur



Verklaring groeipatronen scheut



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- DNA en informatie netwerken
 - Feedback en verstrengeling
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Evolutie en zelf-organisatie

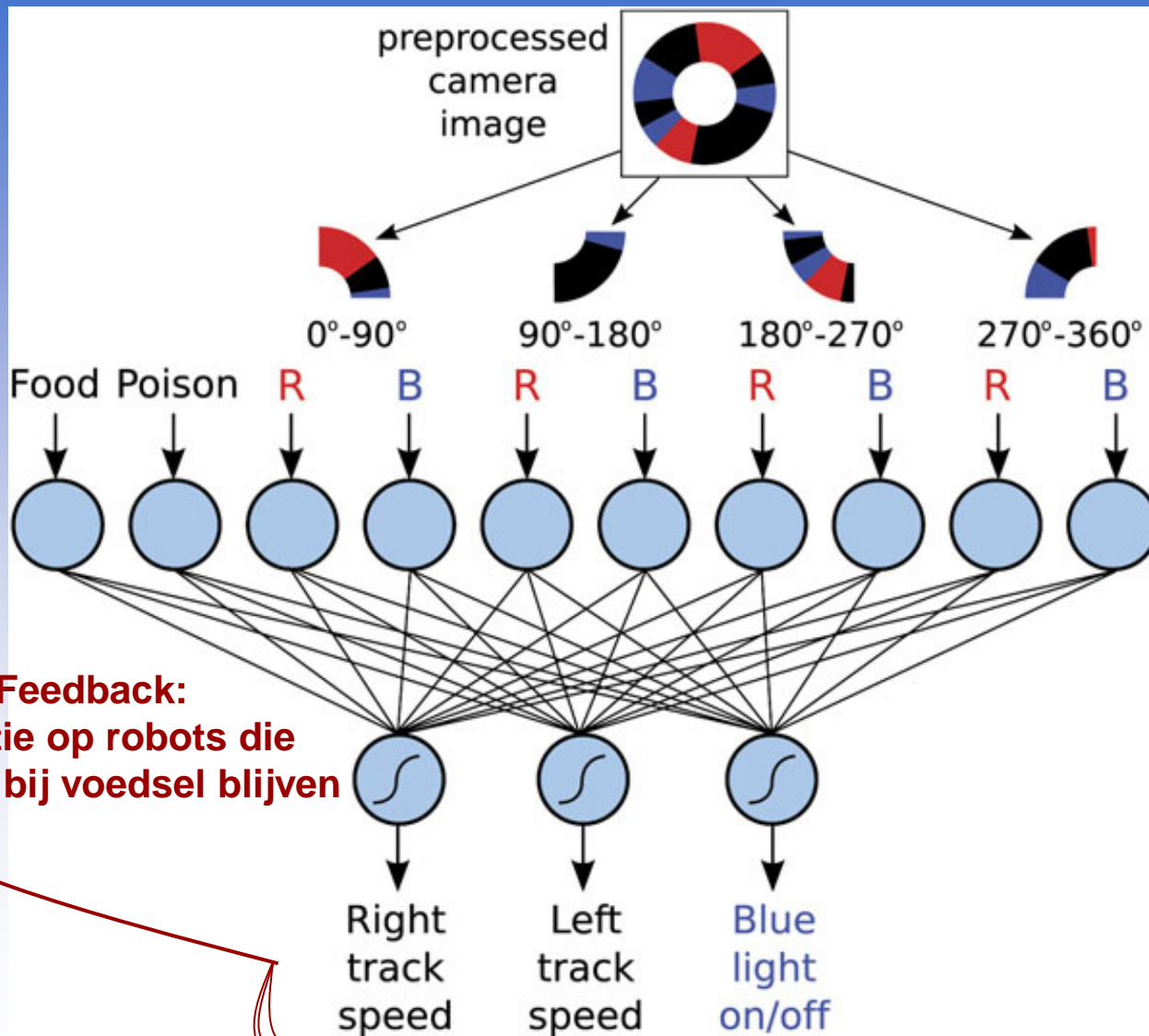


*mutatie, replicatie en selectie →
evolutie*

Evolutie van Gedrag...



...in simpel neuraal netwerk



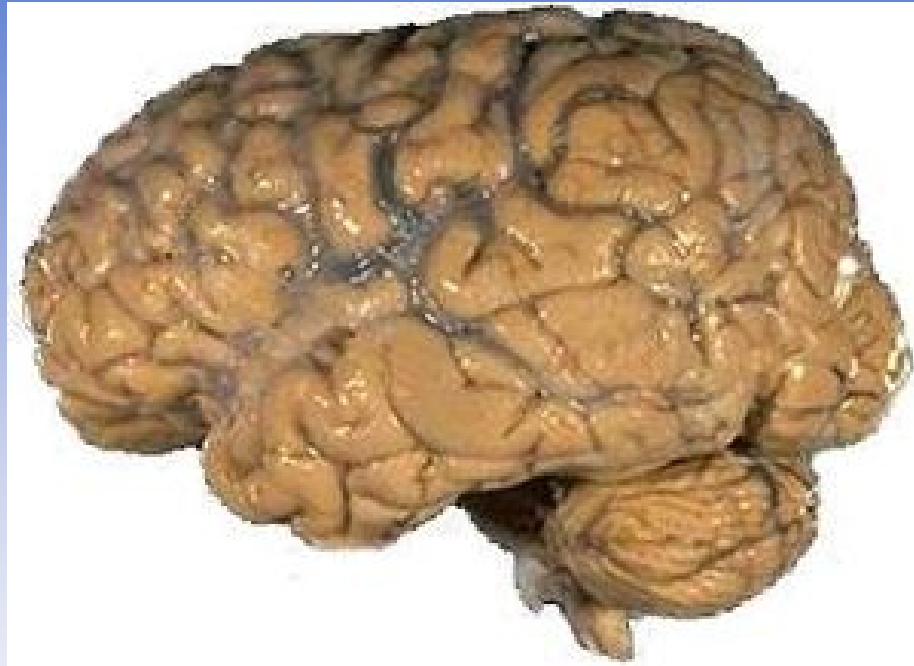
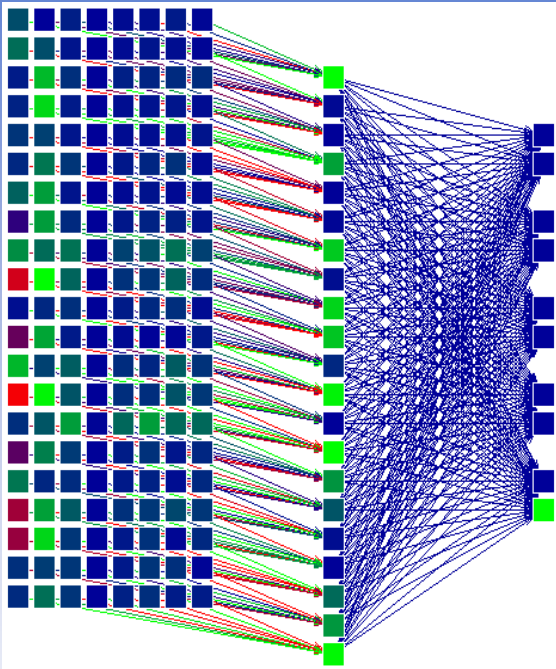
Feedback:
Selectie op robots die
effectief bij voedsel blijven

Right
track
speed

Left
track
speed

Blue
light
on/off

Een experiment in netwerk evolutie



Hoeveel 'zelforganisatie' kan worden begrepen...

- Door een mens?
- Door een computer?
- Door de mensheid?

Conclusies

- **Zelf-organisatie - *niet* chaos - is de kern van de biologie**
- **Met wiskunde/informatica naar een nieuwe 'netwerk-biologie'**
- **Het biologisch ontwerp kent zijn eigen schoonheid : U2!**



