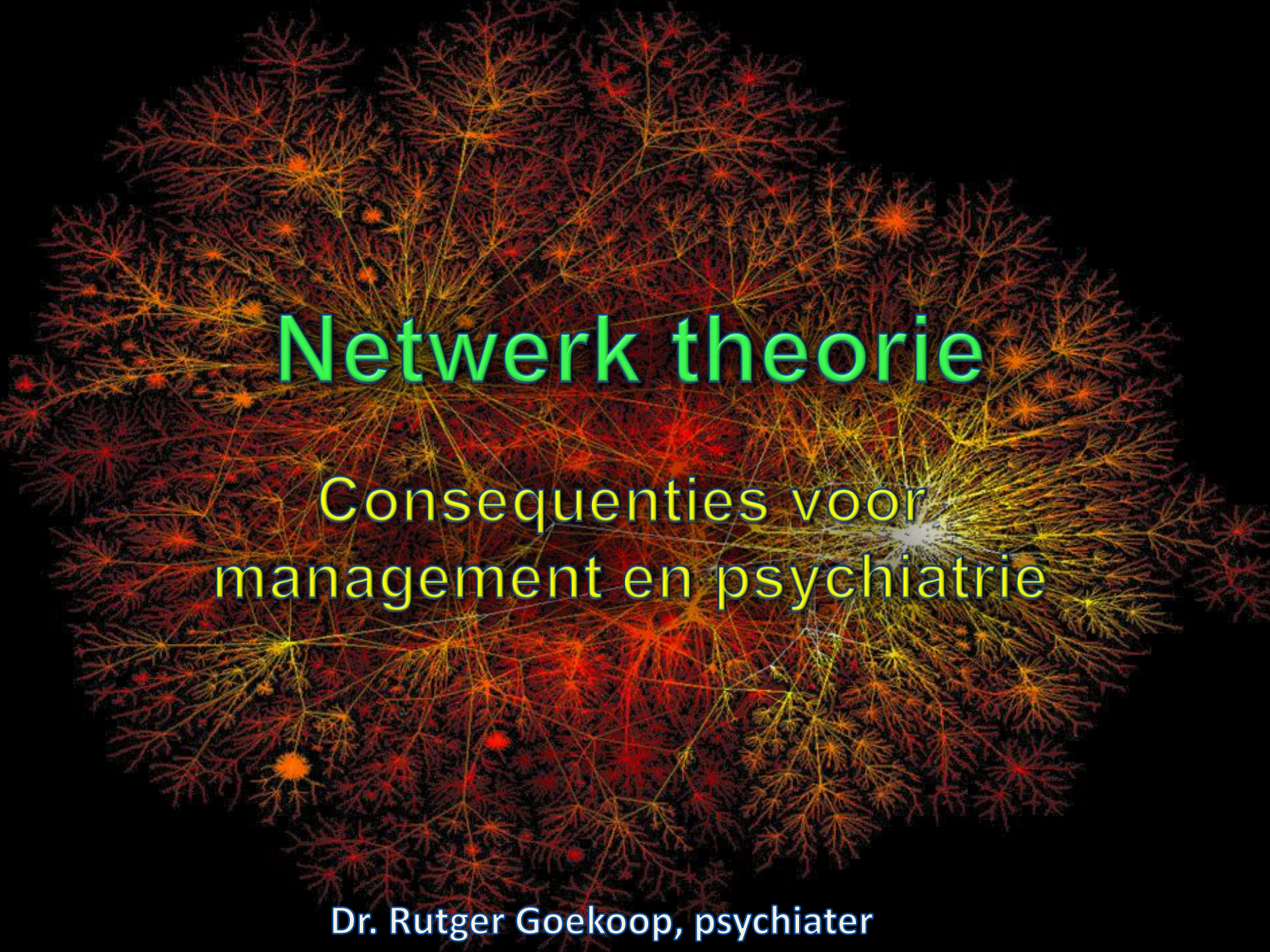


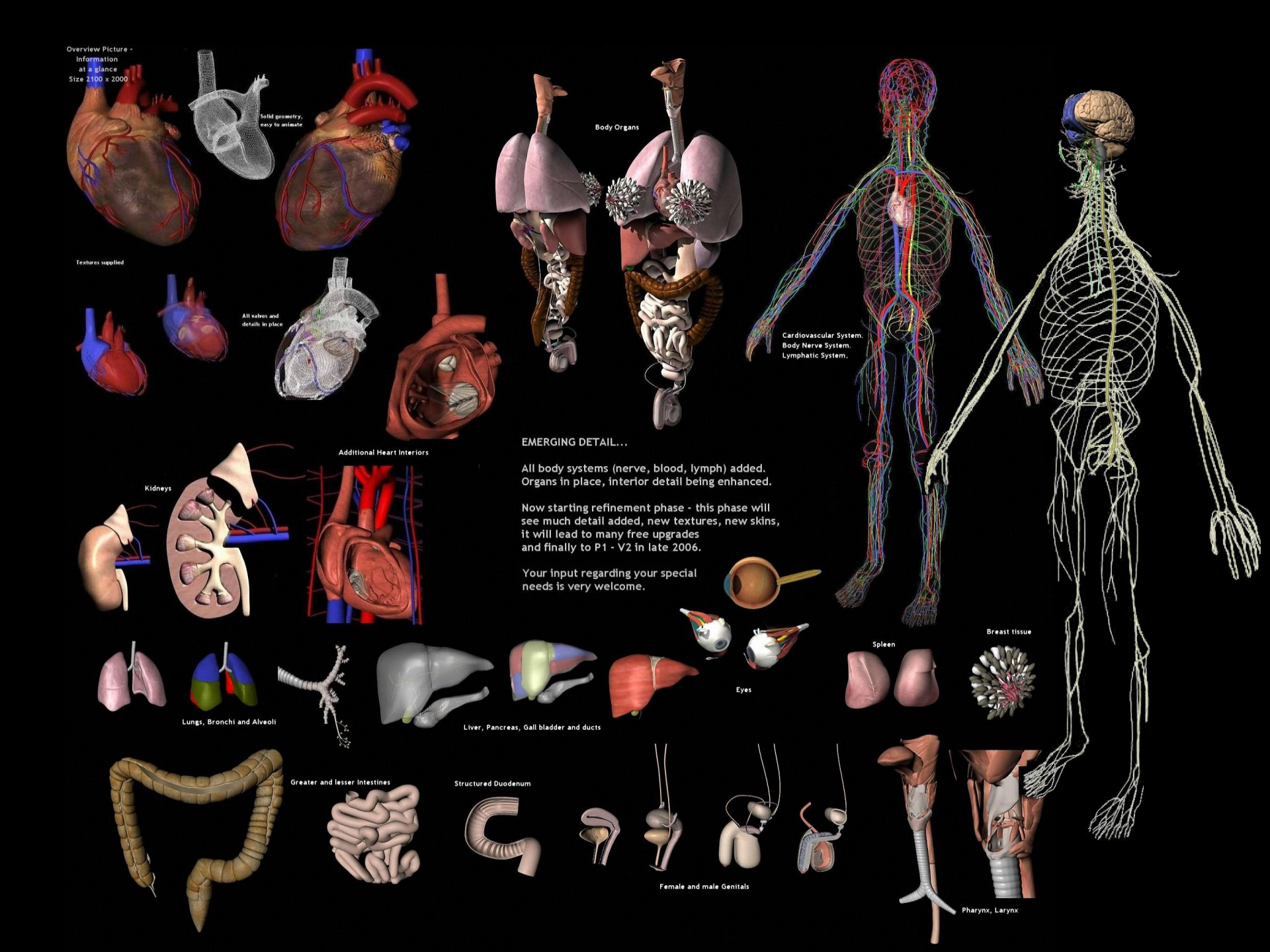
Netwerk theorie

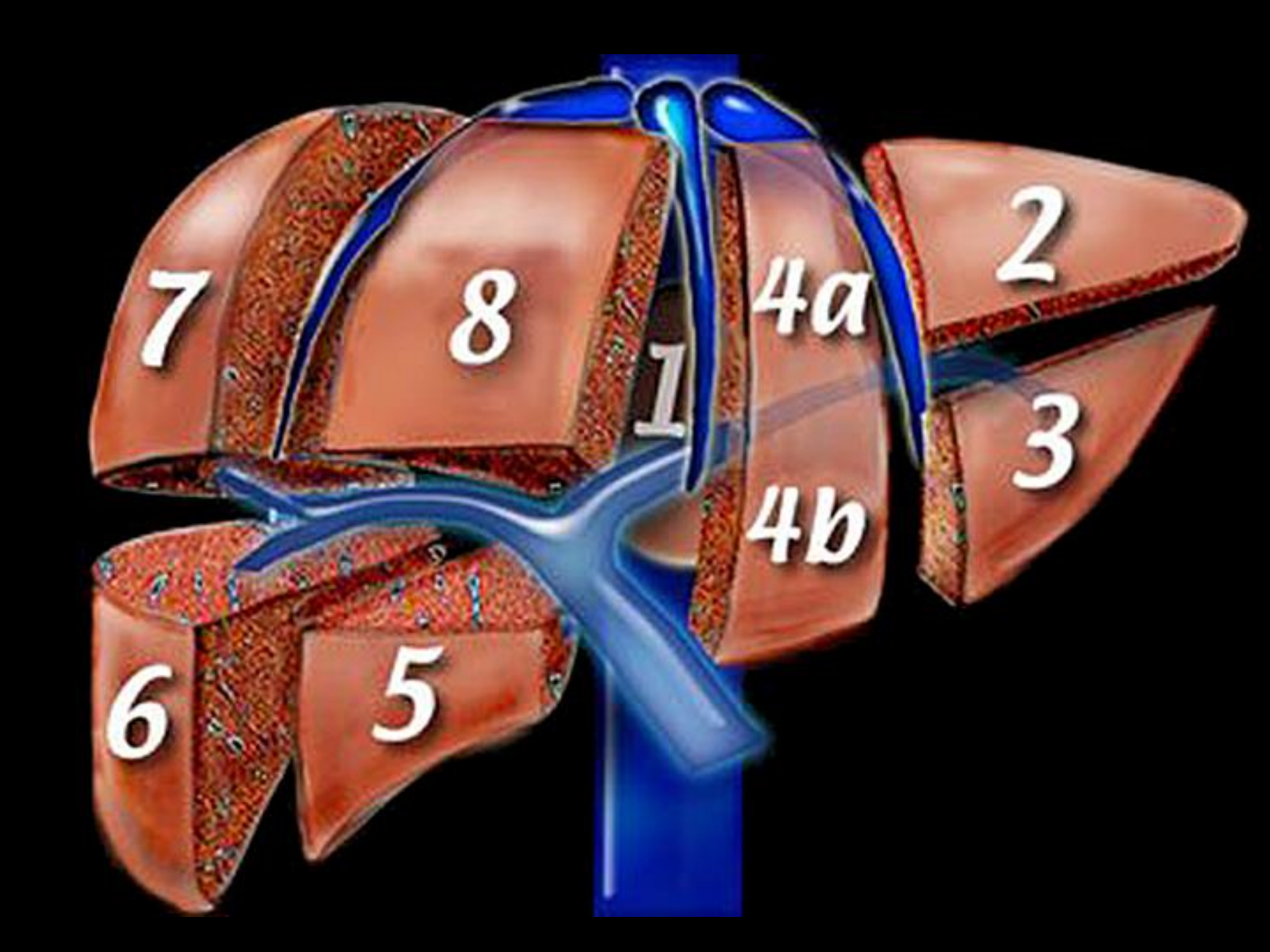
Consequenties voor management en psychiatrie

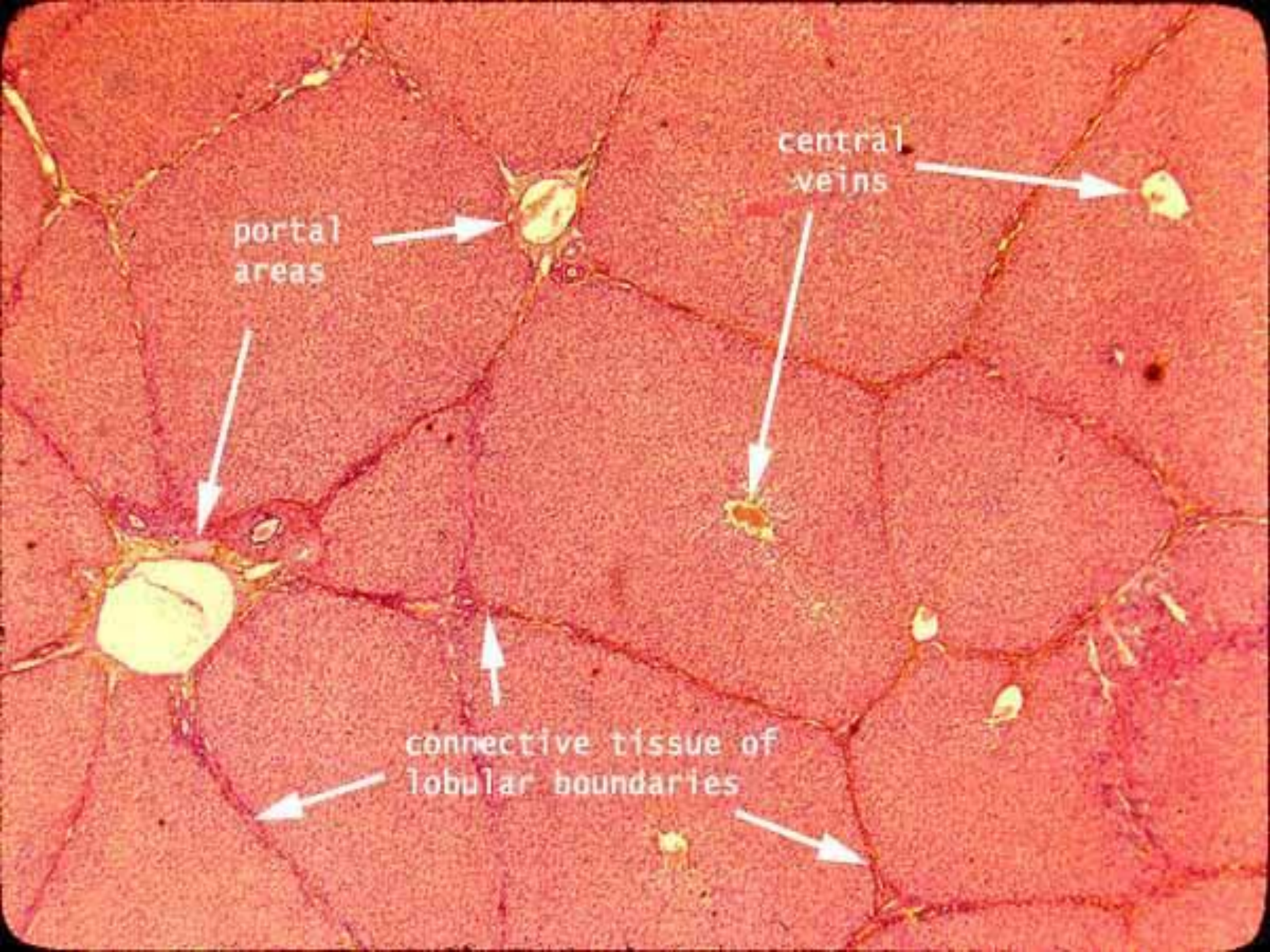
Dr. Rutger Goekoop, psychiater

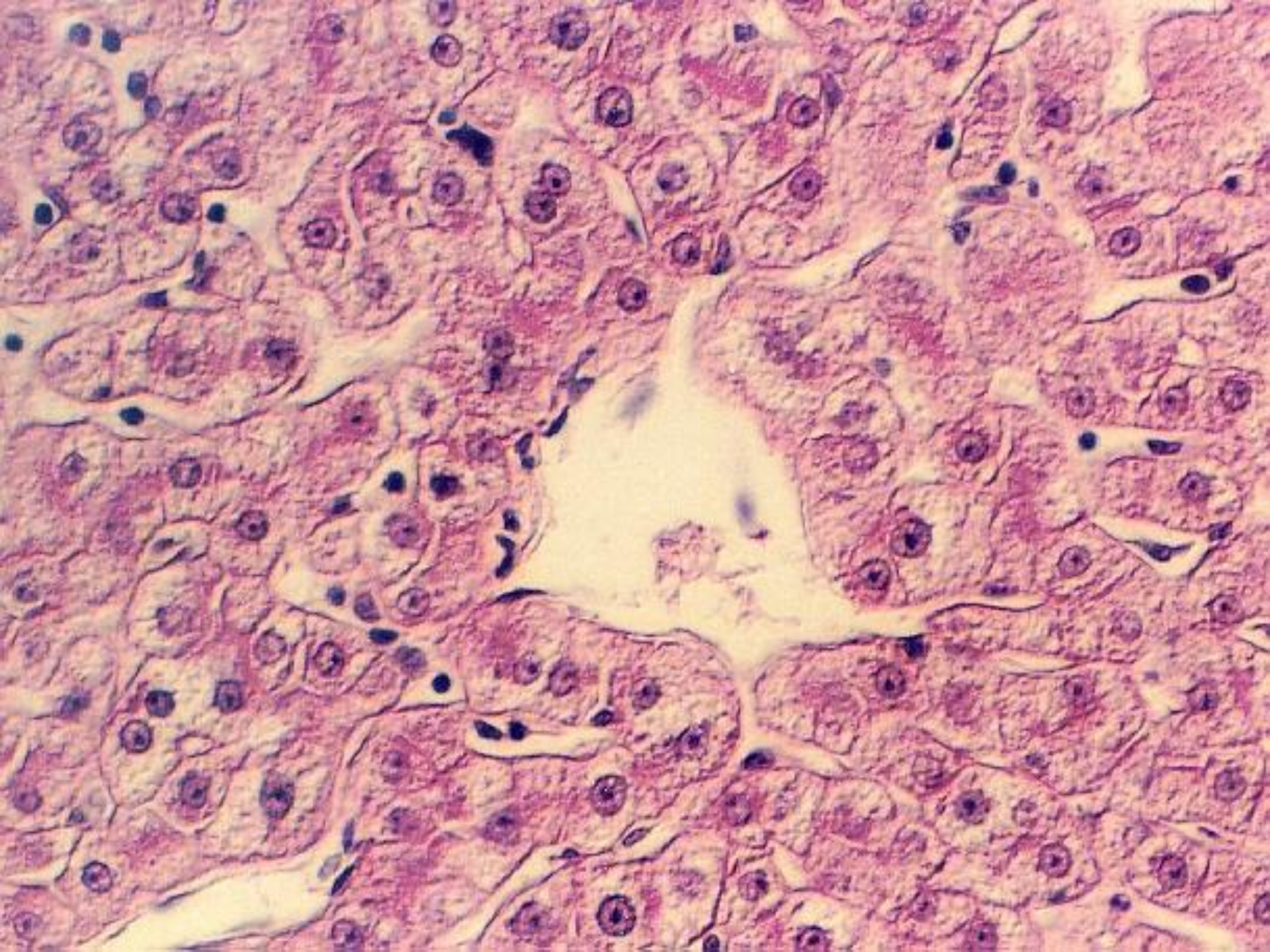

JUSTIN GILLIGAN

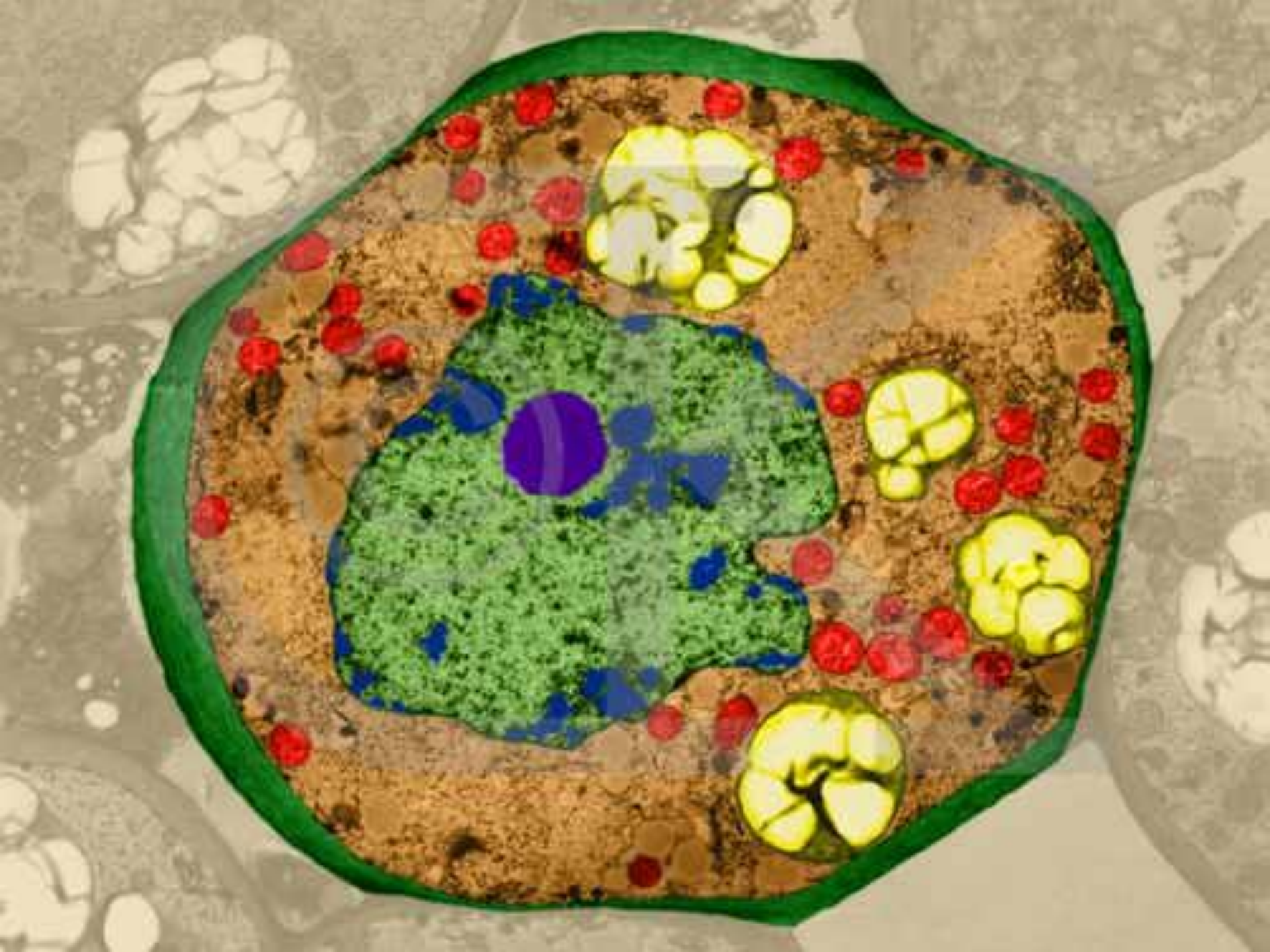

PEPSI
BUFFALOES

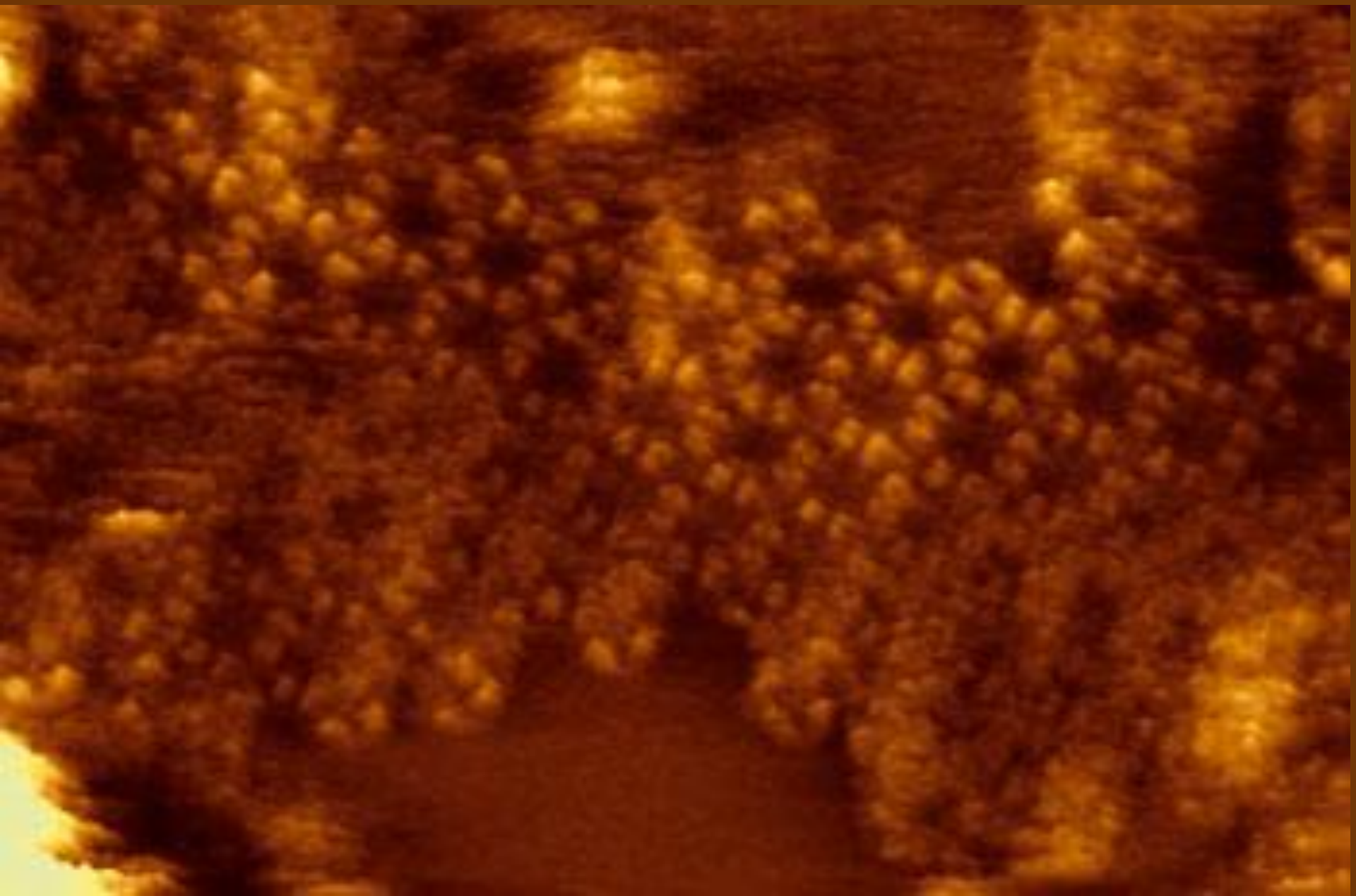

Overview Picture - Information at a glance
Size 2100 x 2000
Solid geometry, easy to animate
Textures supplied
All valves and details in place
Body Organs
Cardiovascular System.
Body Nerve System.
Lymphatic System.
Additional Heart Interiors
Kidneys
EMERGING DETAIL...
All body systems (nerve, blood, lymph) added.
Organs in place, interior detail being enhanced.
Now starting refinement phase - this phase will see much detail added, new textures, new skins, it will lead to many free upgrades and finally to P1 - V2 in late 2006.
Your input regarding your special needs is very welcome.
Eyes
Spleen
Breast tissue
Lungs, Bronchi and Alveoli
Liver, Pancreas, Gall bladder and ducts
Greater and lesser Intestines
Structured Duodenum
Female and male Genitals
Pharynx, Larynx

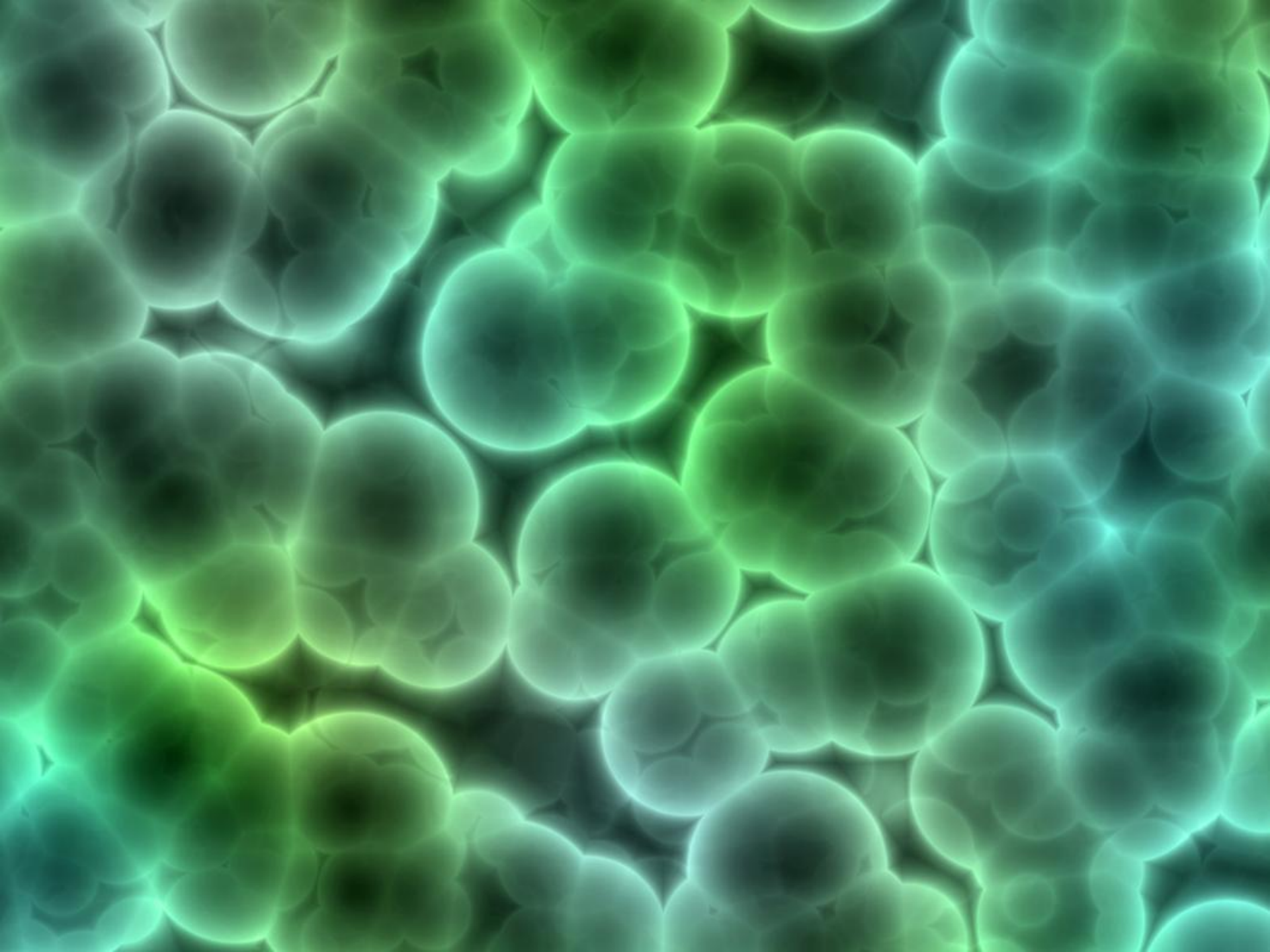

7
8
1
4a
2
3
4b
6
5

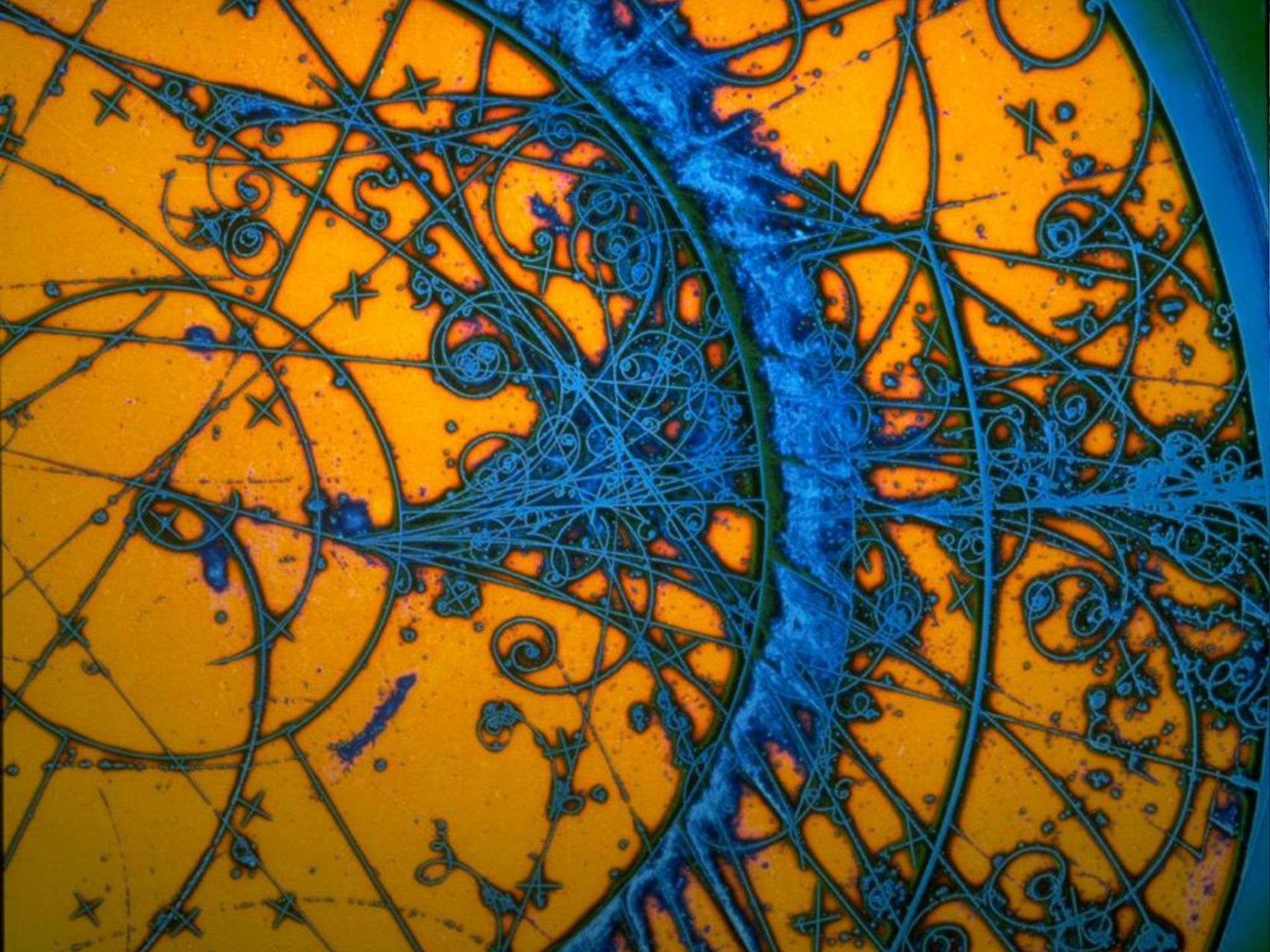

central
veins
portal
areas
connective tissue of
lobular boundaries











‘Consilience’

- "Scientists have ***broken down*** many kinds of systems. They think they know most of the elements and forces."
- "The next task is to ***reassemble*** them, at least in mathematical models that capture the key properties of the entire ensembles.”
- “The greatest challenge today (...) in all of science, is the accurate and complete ***description*** of complex systems.“ (E. O. Wilson, *Consilience* Knopf, New York, 1998).

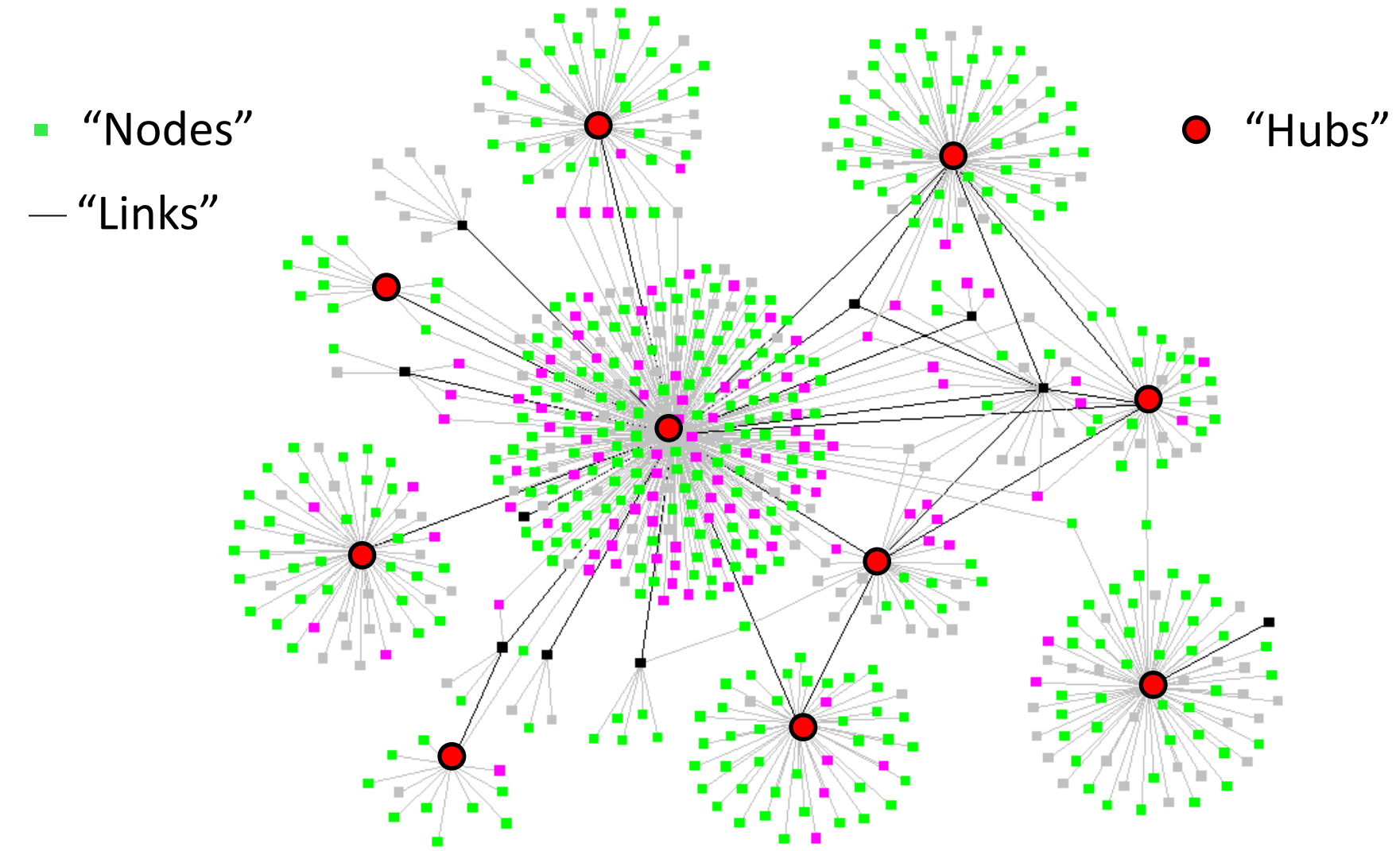
Modern Network Theory

- A. Einstein: *"Everything can be described in terms of events (states) that travel in space and time".*
- Derived from systems theory (1940-1950): Wiener, von Bertalanffy, Ashby, von Foerster, Paul Erdös.
- Recent breakthrough in mathematics and physics (1999 – 2009): Watson and Strogatz, Barabasi.
- *"The biological world consists of networks".*
- These have "Small World" characteristics.
- **By ignoring within-level details, general rules** can be found that apply to all levels of organization.

“Degrees of separation”

- How many handshakes separated from the Pope?
- How many co-**ac**torships separated from Kevin Bacon?
- Co-**au**thorships between scientists?
- Sexual contacts between people?
- Connections between brain cells en brain areas?
- Chemical reactions between genes, proteins, metabolites?

“Small-world” netwerk



Gene-gene interactions

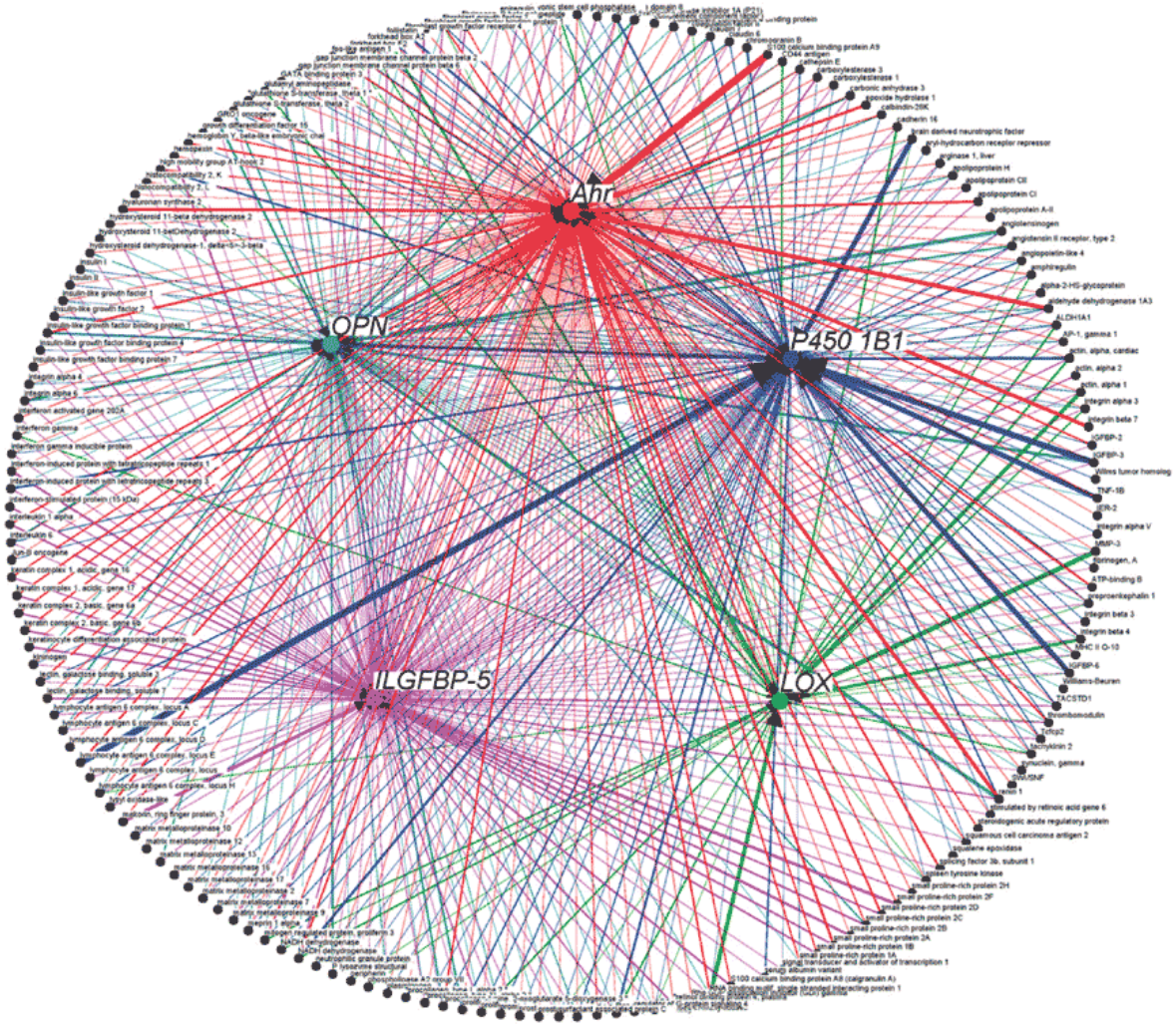
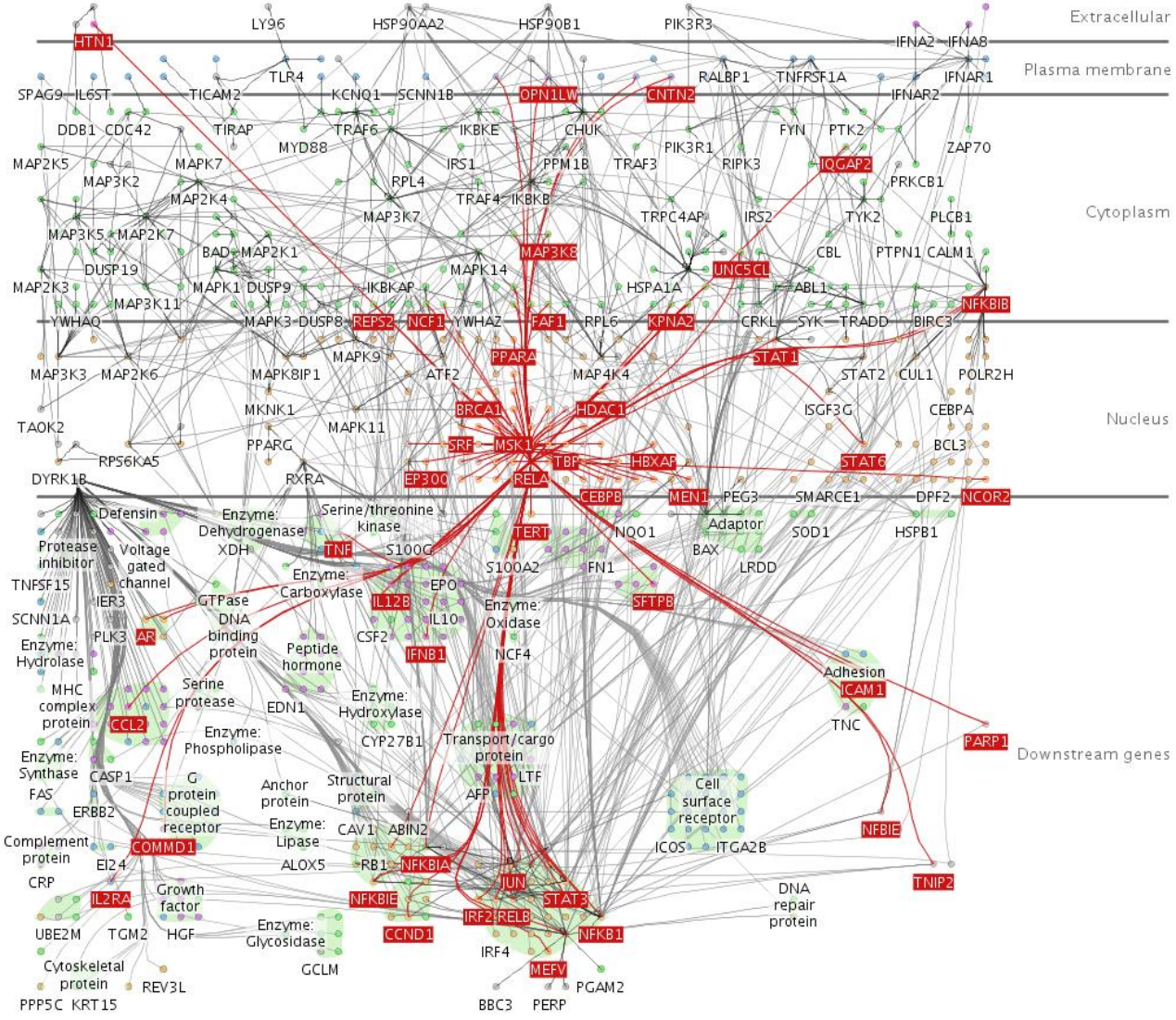
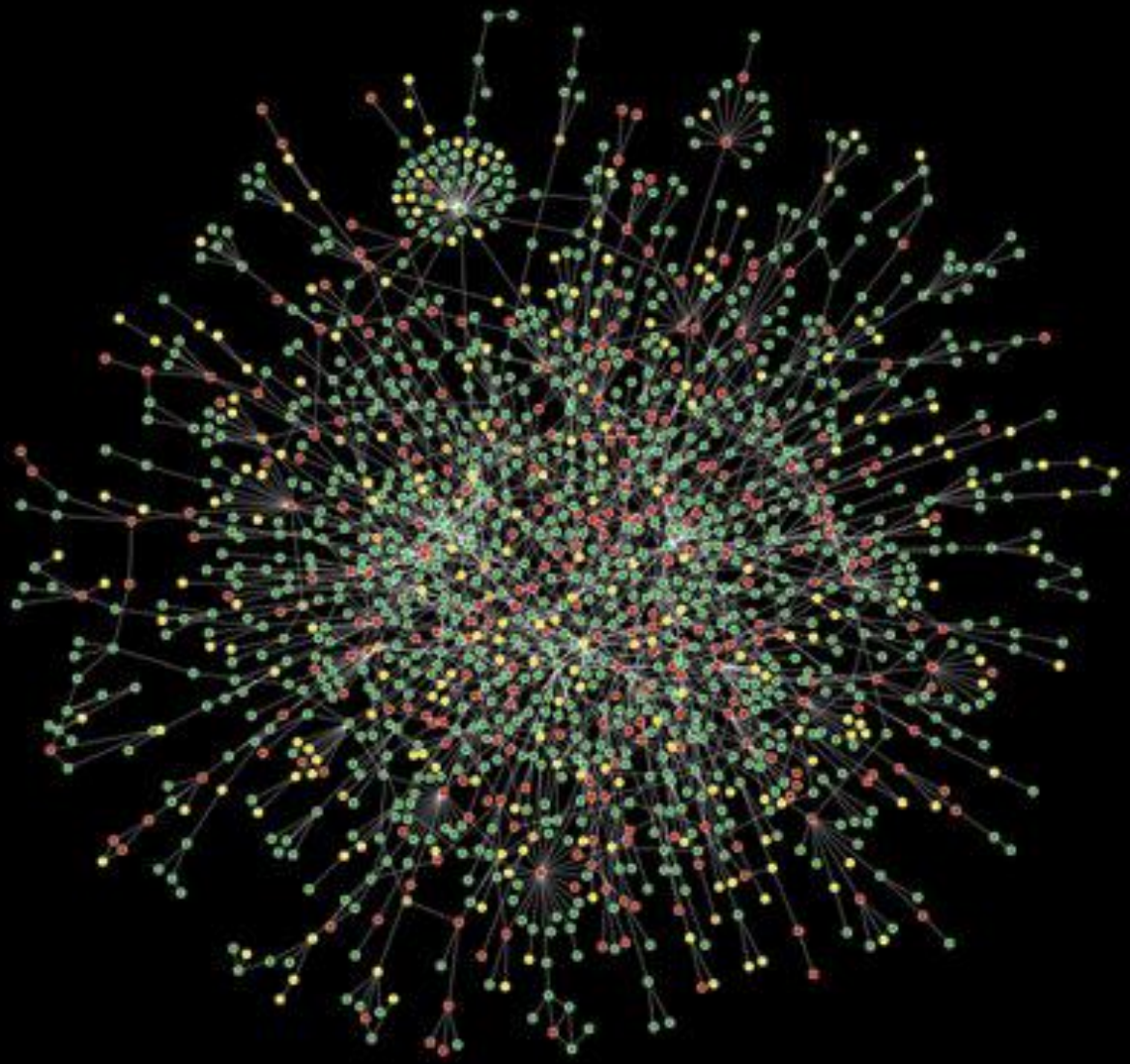


Figure 2. Gene–gene interaction networks activated by ligands of the *Ahr*. All three gene combinations for each target that met the cutoff of COD > 0.9 and error < 0.5 were individually plotted using a program developed by Breitkreutz et al. (2003). The thickness of the line denotes the selection frequency for individual gene for each target.

Gene-protein interactions



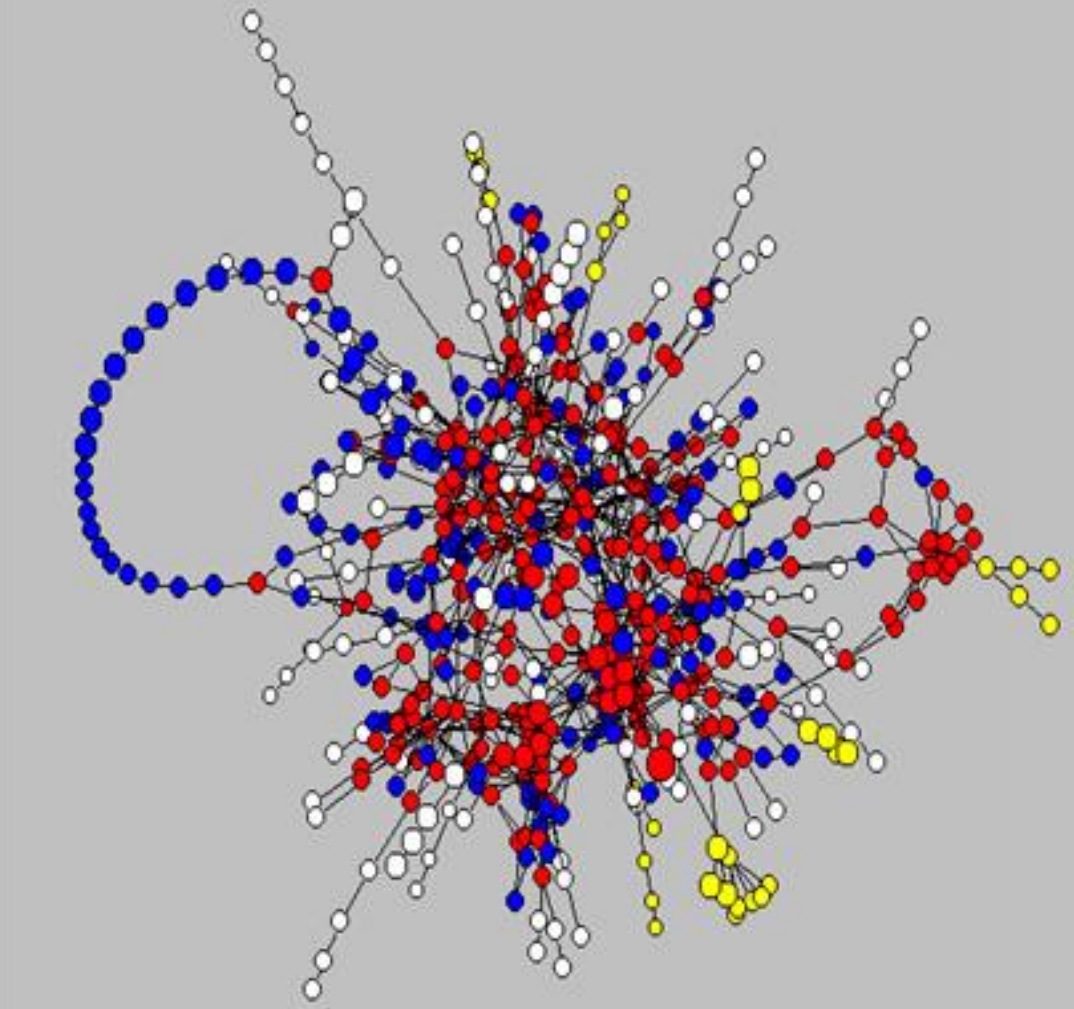
Protein-protein interactions



Yeast

Science 2002; **298**, 763-764.

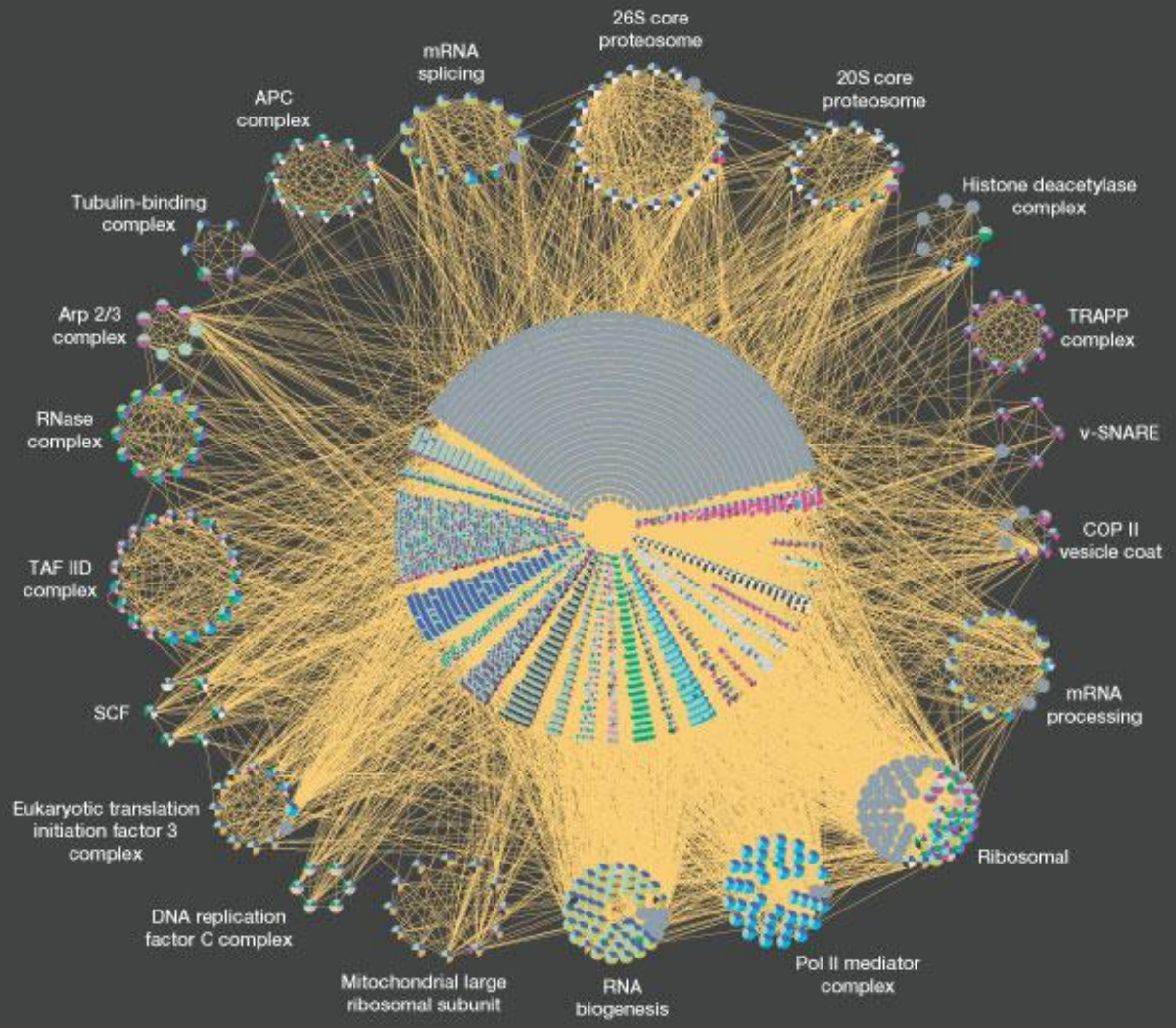
Metabolite-metabolite-interactions



E. Coli

Science 2002, 297: 1551-1555

Organelle-organelle interactions



Nature **422**, 193-197 (13 March 2003)

Cell-cell interactions

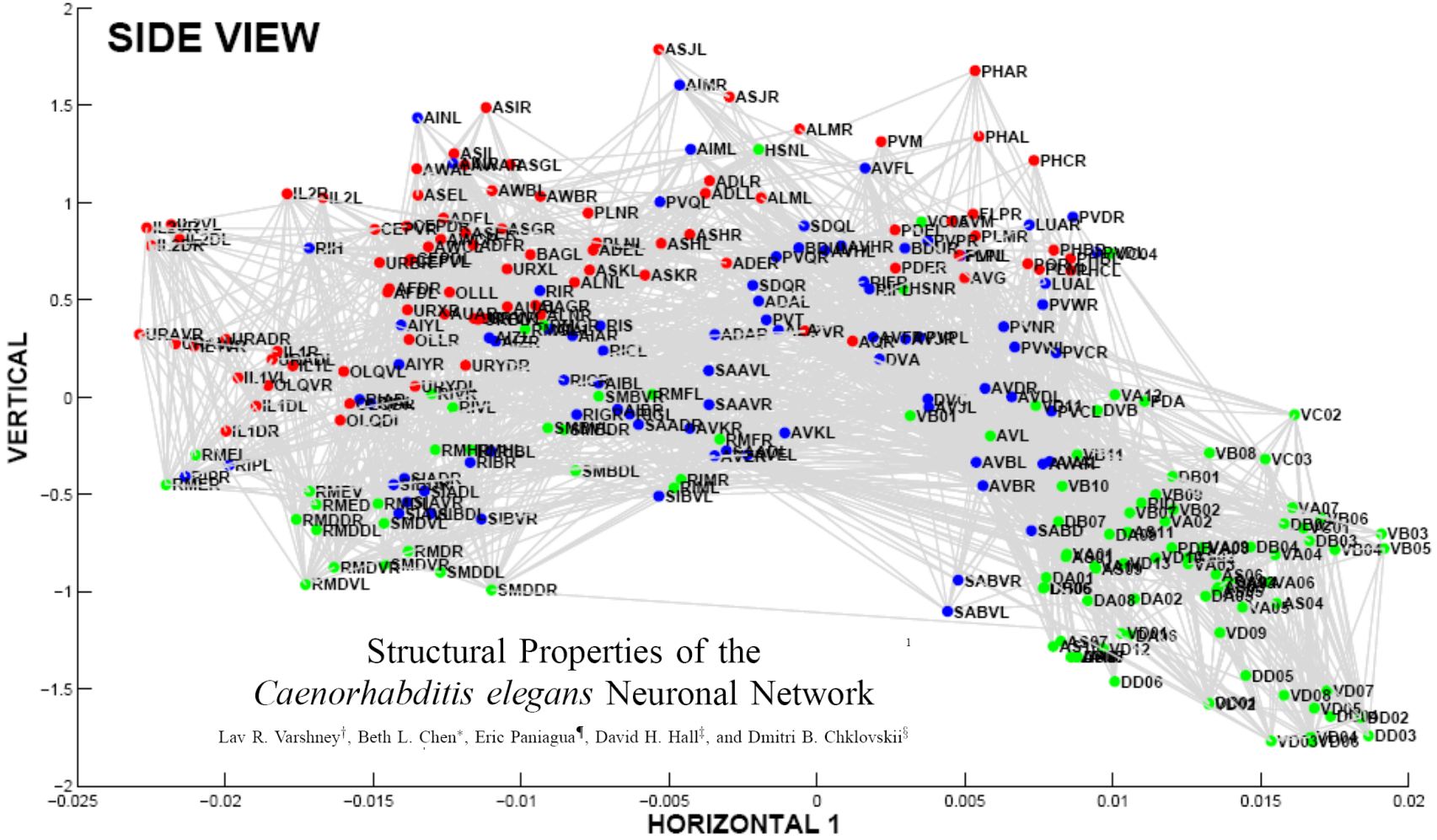
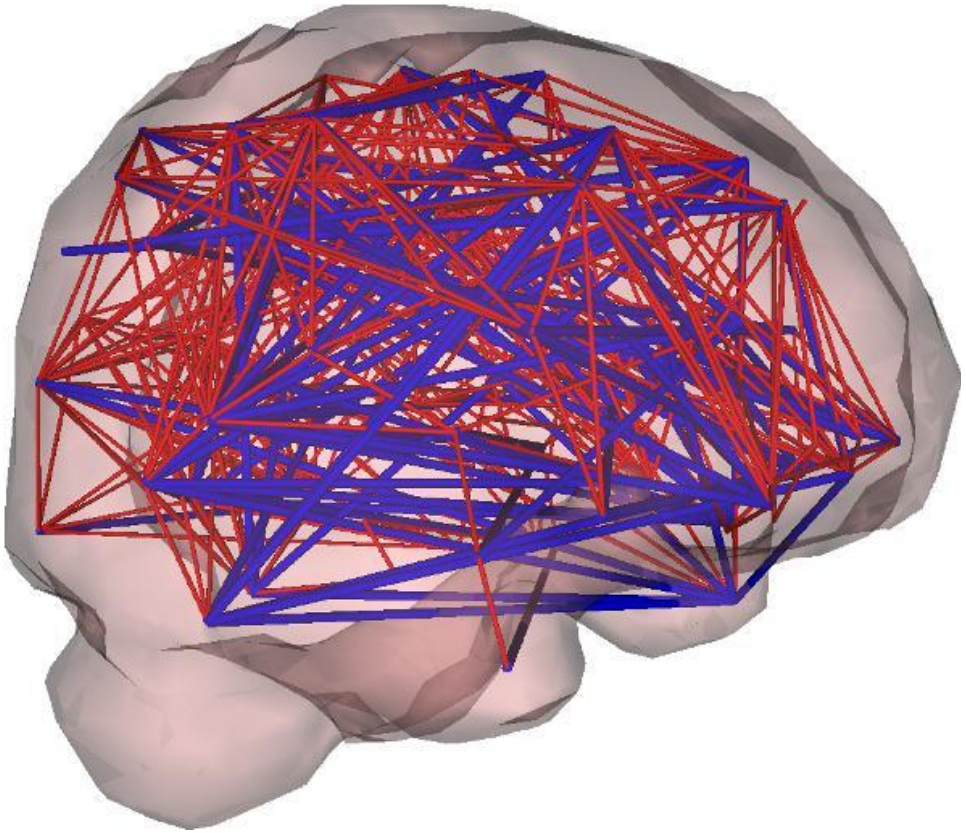
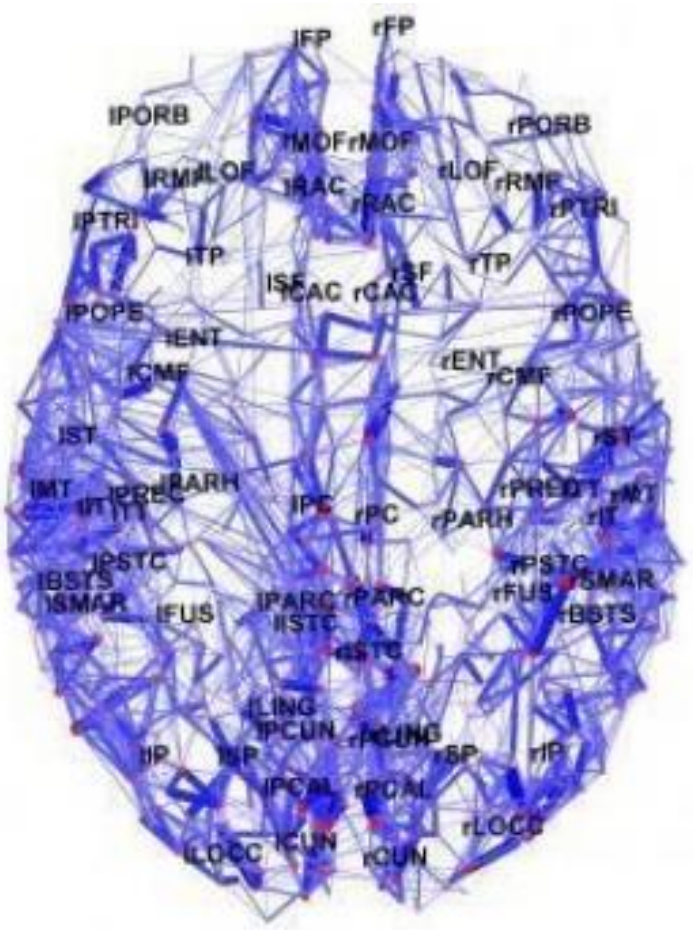


Fig. 2. The *C. elegans* wiring diagram is a network of identifiable, labeled neurons connected by chemical and electrical synapses. Red, sensory neurons; blue, interneurons; green, motorneurons. (a). Side view shows neurons arranged so that the direction of information flow is mostly downward. (b). Top view shows structure in the horizontal plane reflecting adjacency of neurons in the network. http://arxiv.org/abs/0907.2373v2

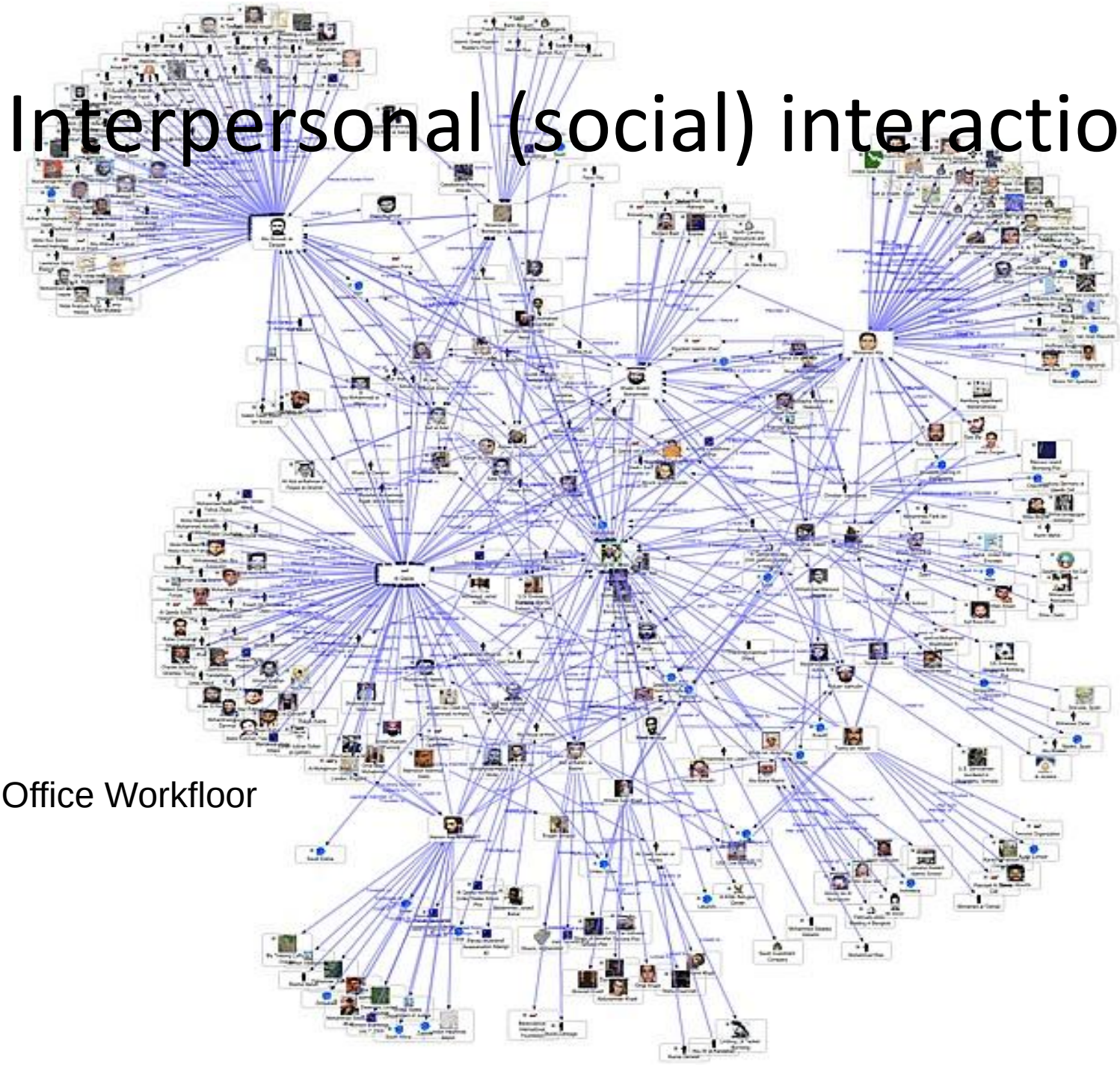
Interregional interactions





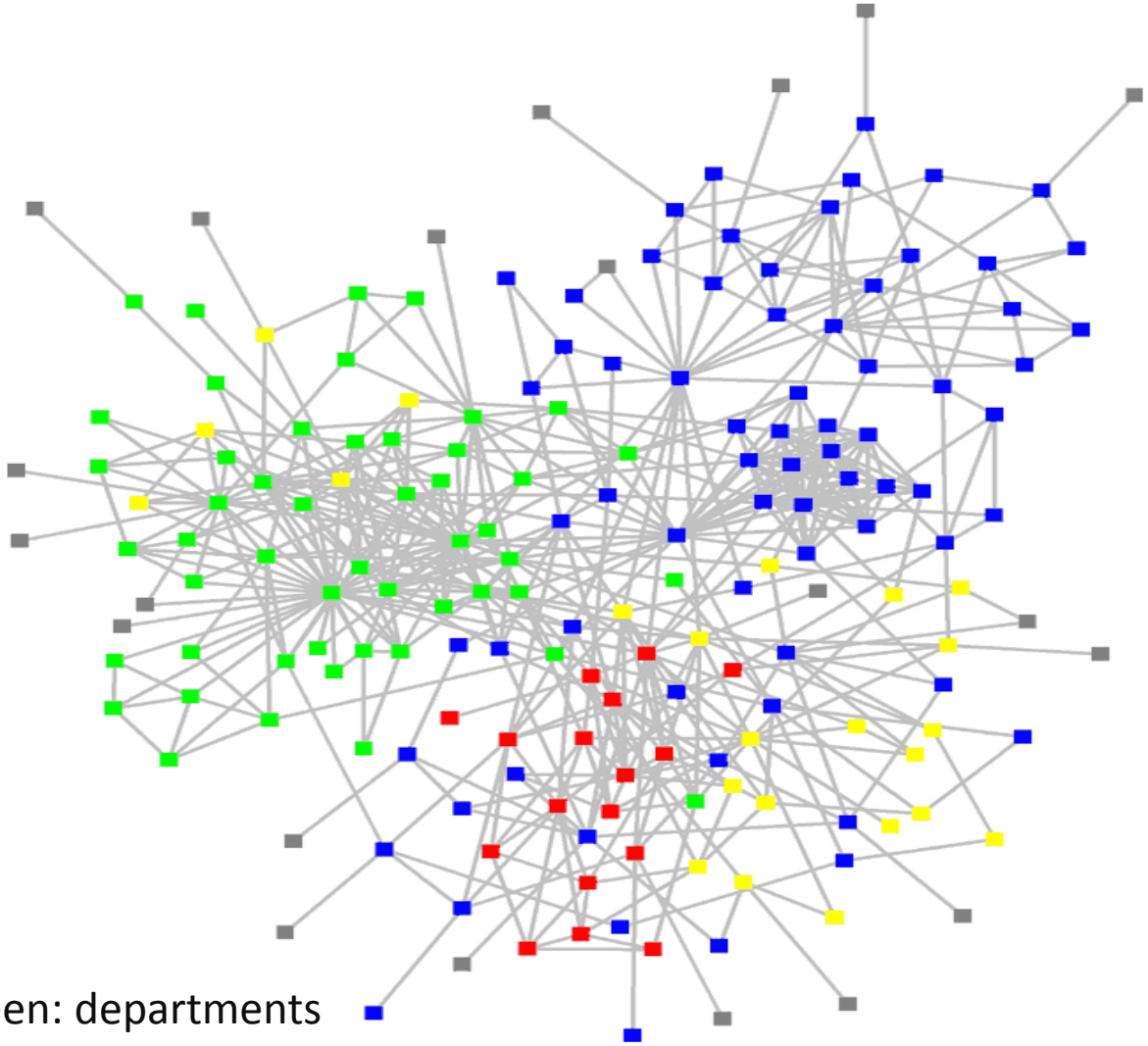
Bullmore e.a., Nat Rev Neurosc 2009

Interpersonal (social) interactions



The Office Workfloor

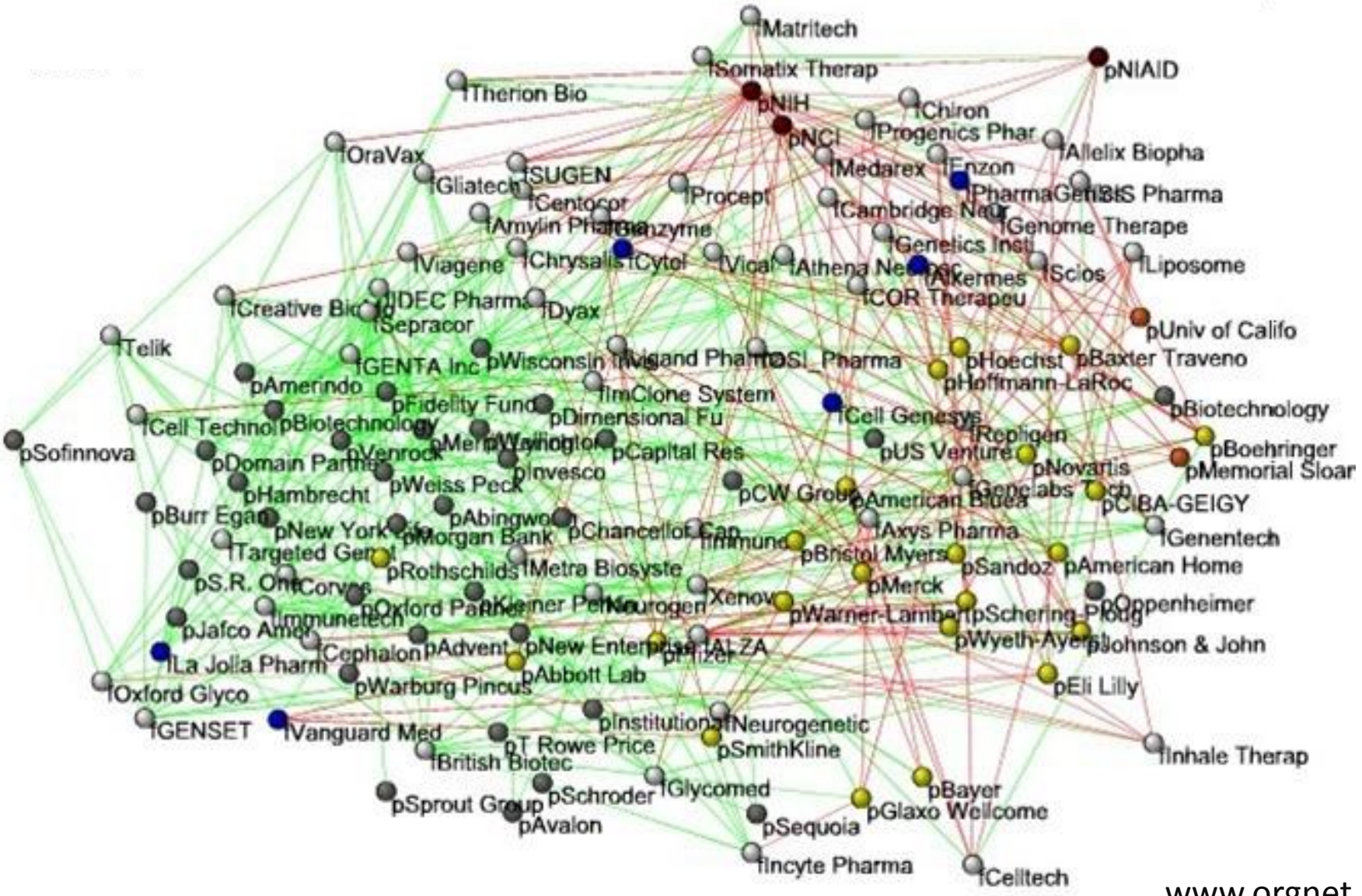
Inter-department interactions



Red, blue, or green: departments
Yellow: consultants
Grey: external experts

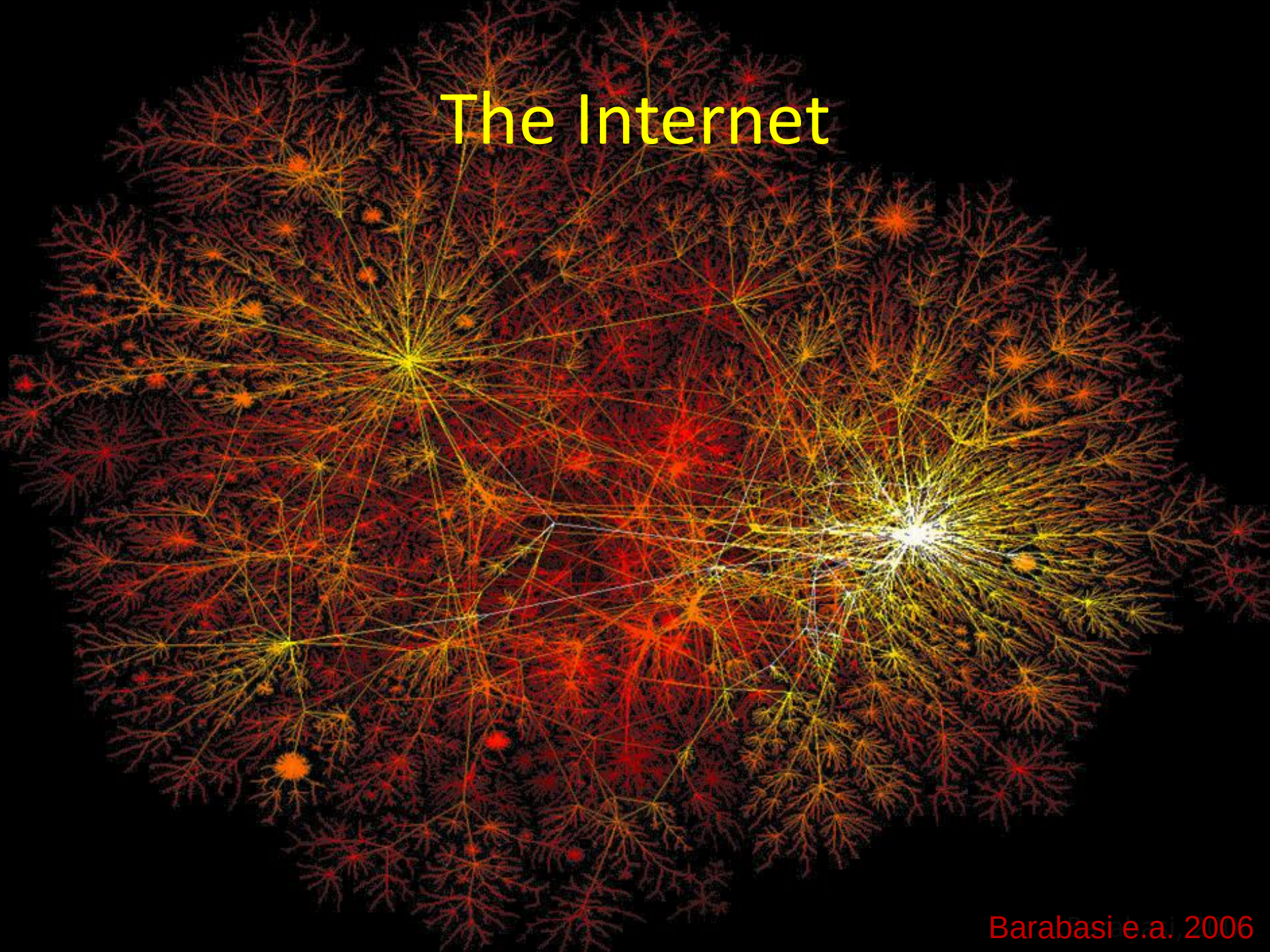
www.orgnet.com

Interactions between companies



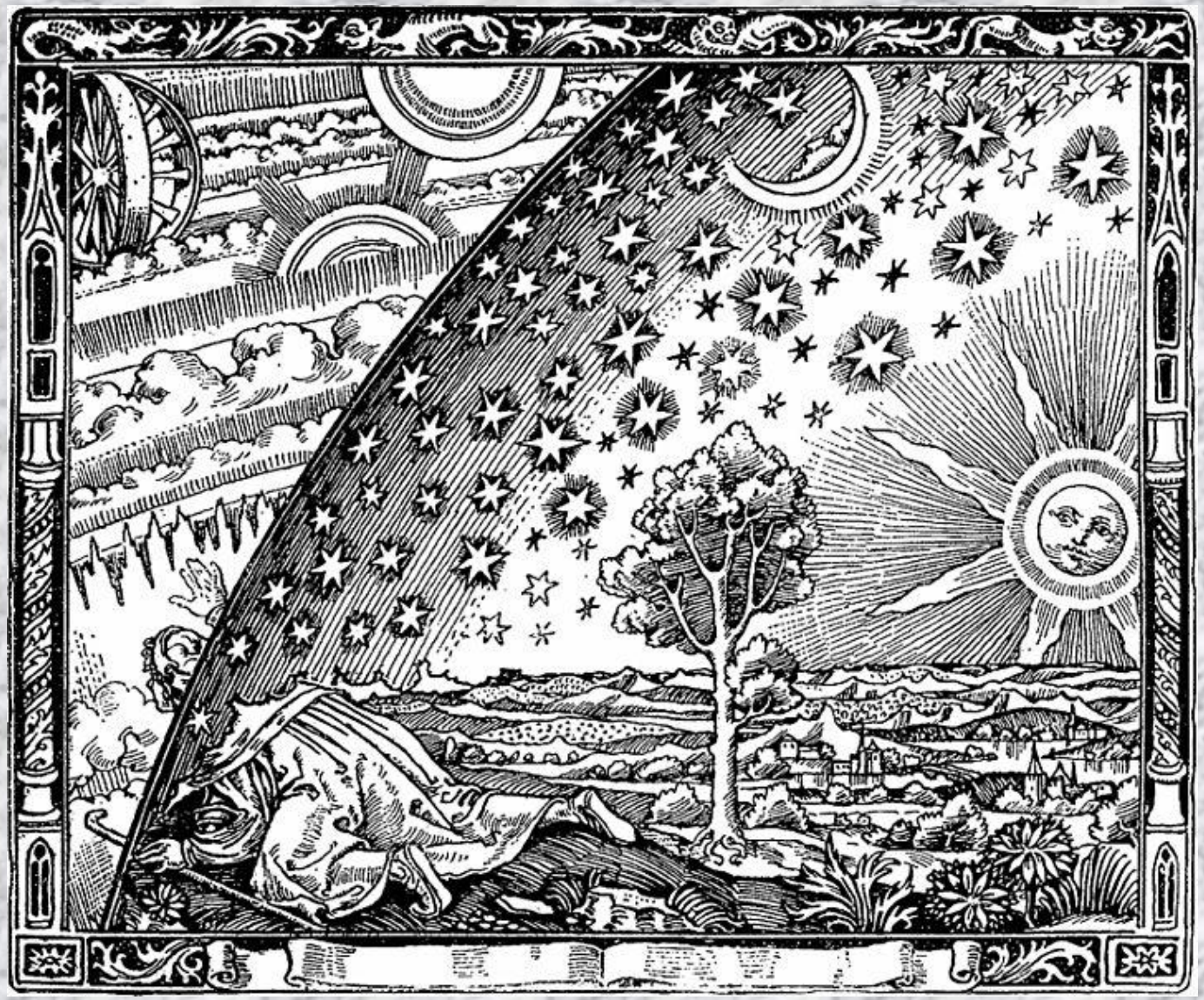
www.orgnet.com

The Internet



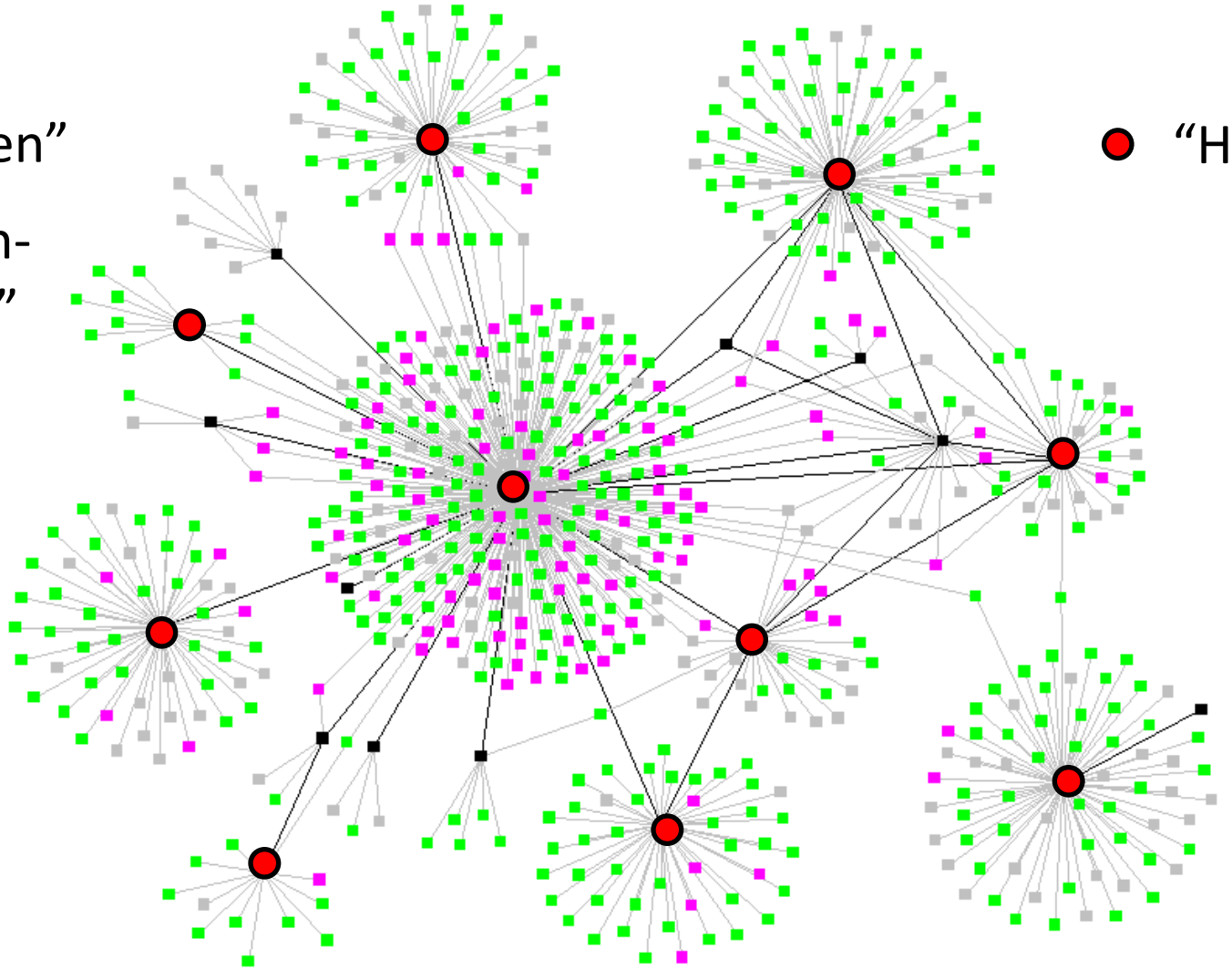
Barabasi e.a. 2006

Ontdekkingen



I. “Small-World” structuur

- “Knopen”
- “Verbin-dingen”

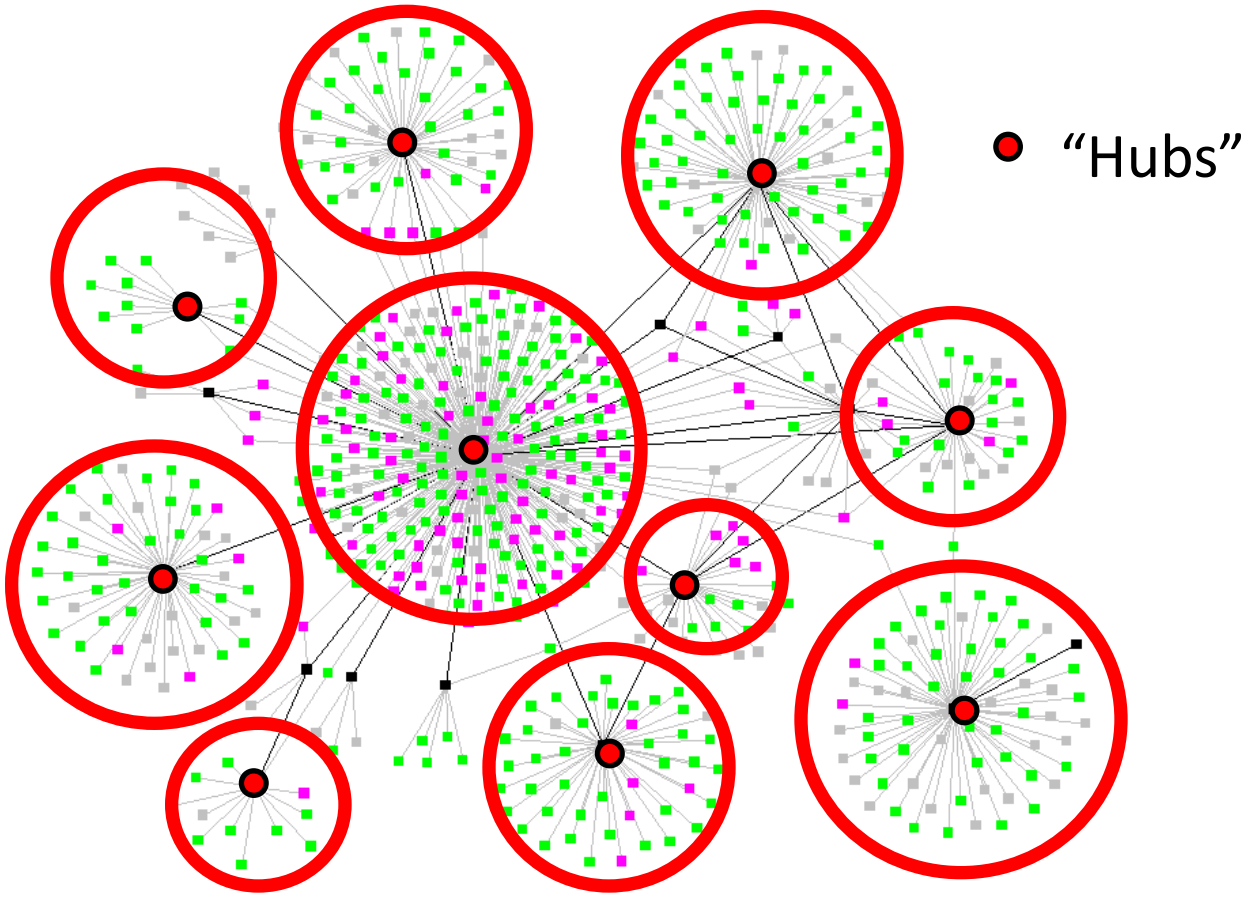


- “Hubs”

I. Functie

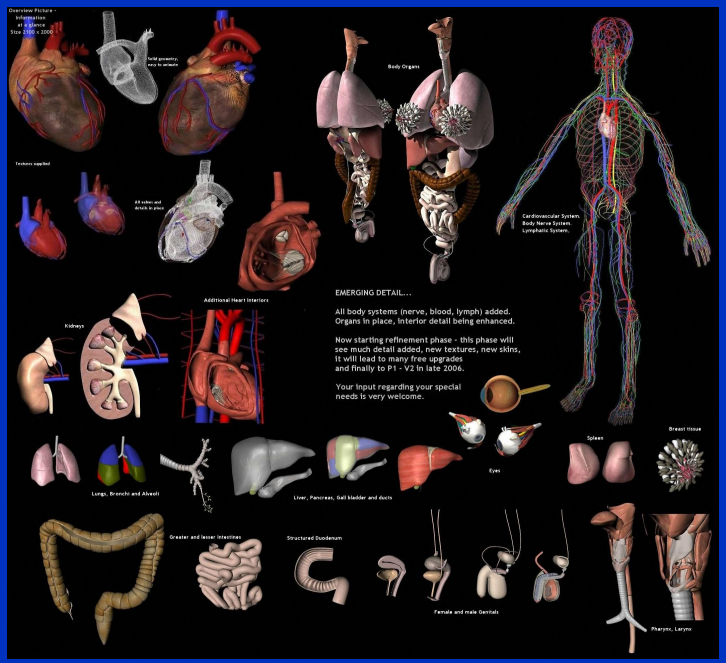
- Snelle & efficiente informatie uitwisseling
  - Informatie komt snel op alle plekken.
- Minimale “kosten” (connecties).
  - Met minimale middelen (verbindingen) maximale functie.
- Zeer goede “aanvals-tolerantie”
  - Goed bestand tegen random schade.
  - Slecht bestand tegen gerichte schade (hubs).

II. Vorming van modules

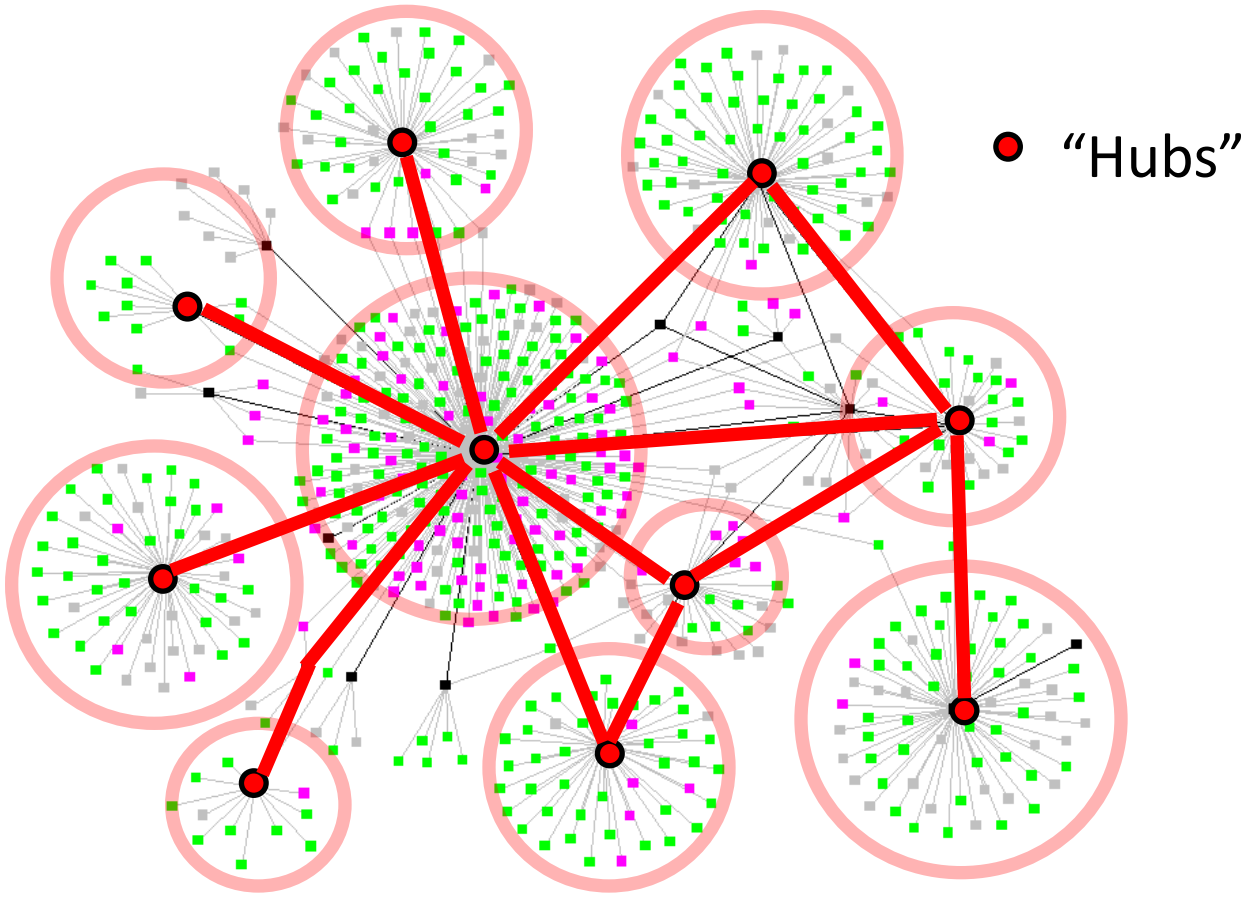


II. Functie

- Functionele segregatie (“Specialisatie”).
  - Taakverdeling: probleem oplossend vermogen.
  - Parallele informatieverwerking: snelheid.

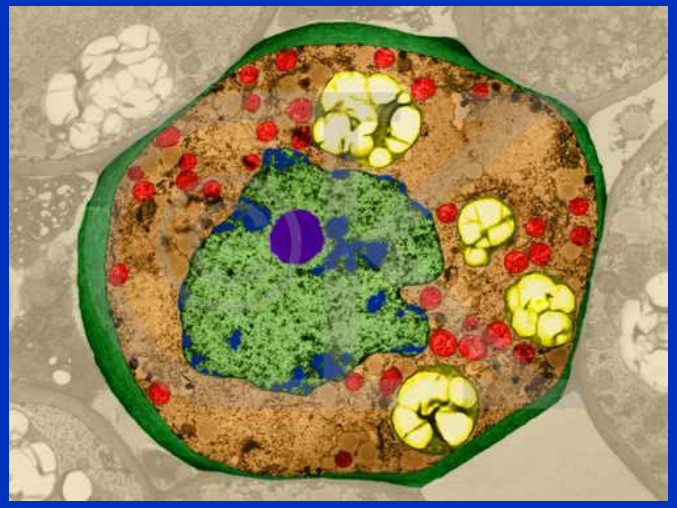


III. Verbonden zijn van modules



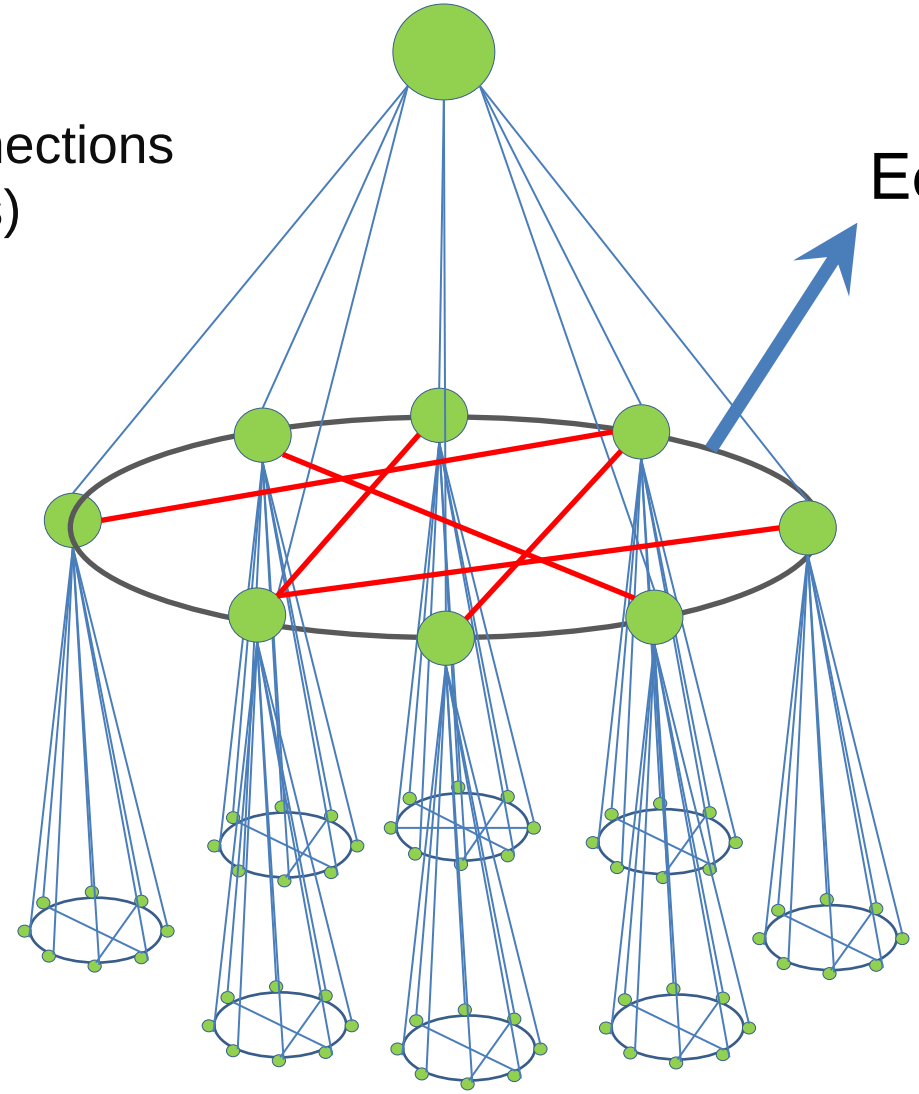
III. Functie

- Functionele integratie (“Cooperatie”).
  - Complex problem solving.
  - Recombineren van modules: creativiteit.



IV. Vorming van “Hiërarchiën”

Convergent connections
(onto hubs)



Een “Rich Club”

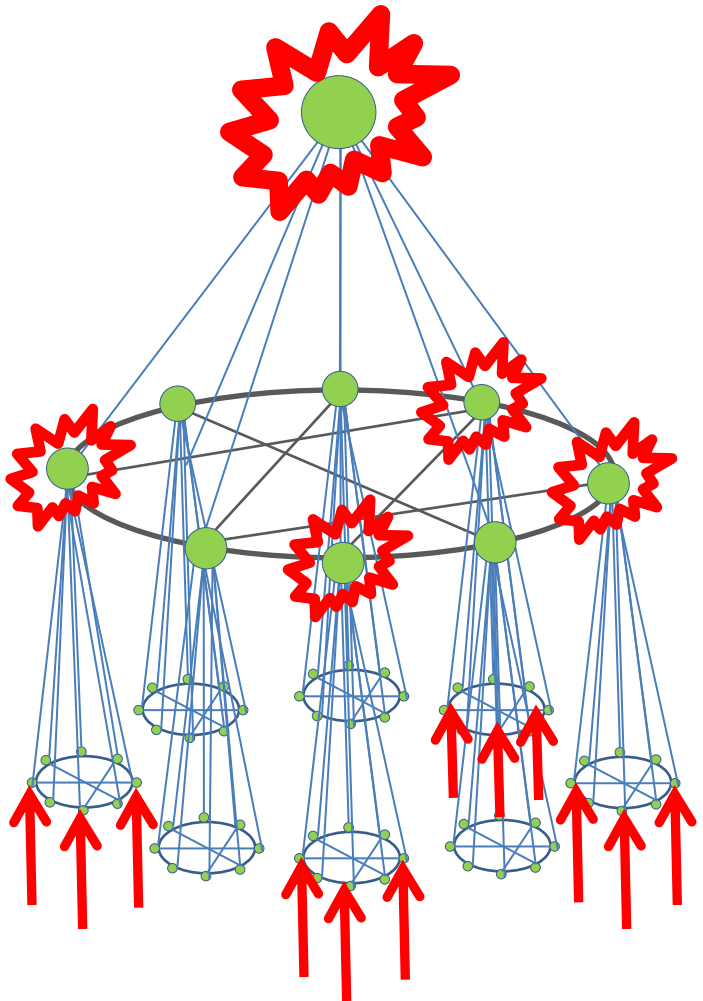
IV. Functie

- “Ruisreductie”, “Globale beeldvorming”

Global representation (Multimodal)
Hogere associatie cortex

Global representation (Unimodal)
Primaire associatie cortex

Distributed representation (Unimodal)
Primaire sensore cortex



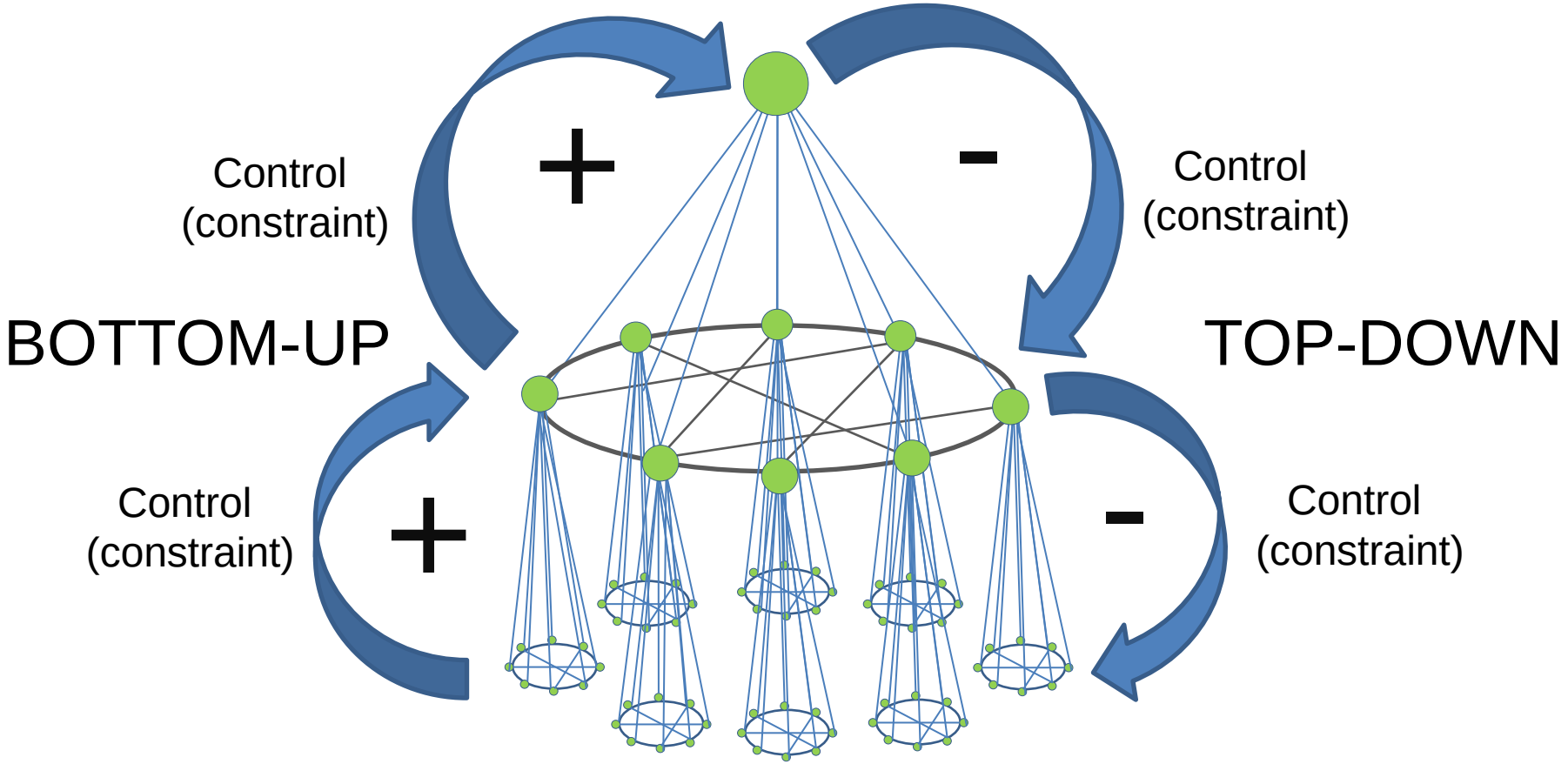
Managers (Generalisten)

Staf

Werknemers (SPVs, psychologen, psychiaters)

IV. Functie

- “Controle”, “Coordinatie”, “Finetuning”.

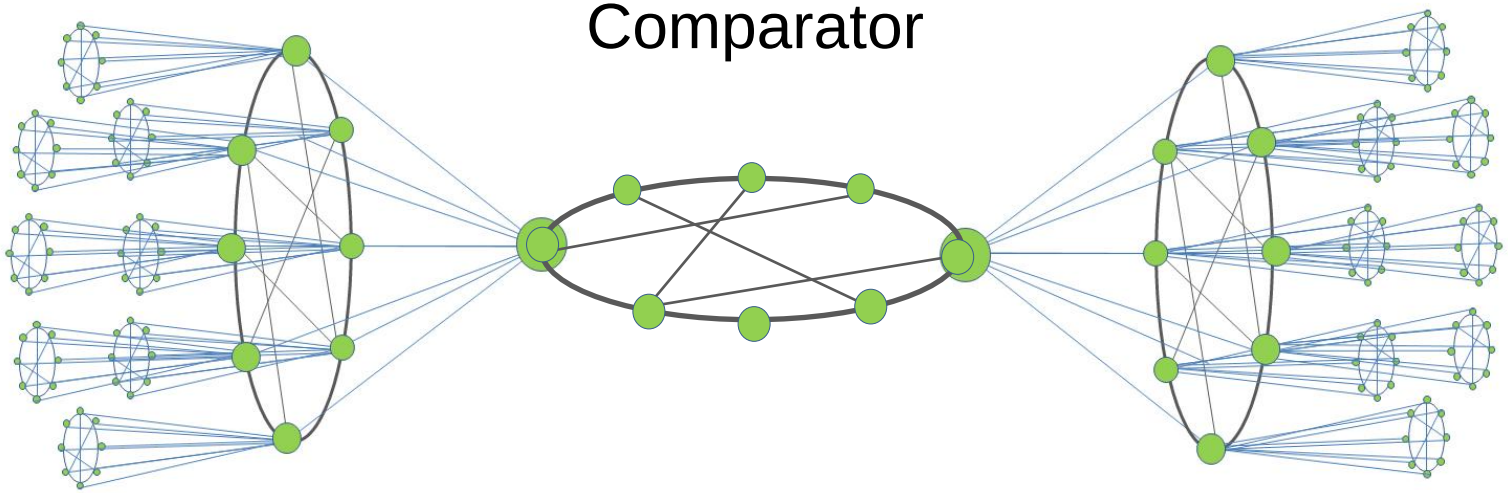


V. Stimulus – Evaluation – Response Organization

Sensor

Effector

Comparator



Stimulus Detection (Input)

Evaluation (Computation)

Response Formation (Output)

V. Stimulus – Evaluation – Response Organization

Bacteria

Cell Membrane

Cell Membrane

Receptors

Kinases

Glucose

Vet

pH

Vocht

Temp.

Plasmide

Genes

mRNA

Toxines

Verteer

Buffer

Glycocalx

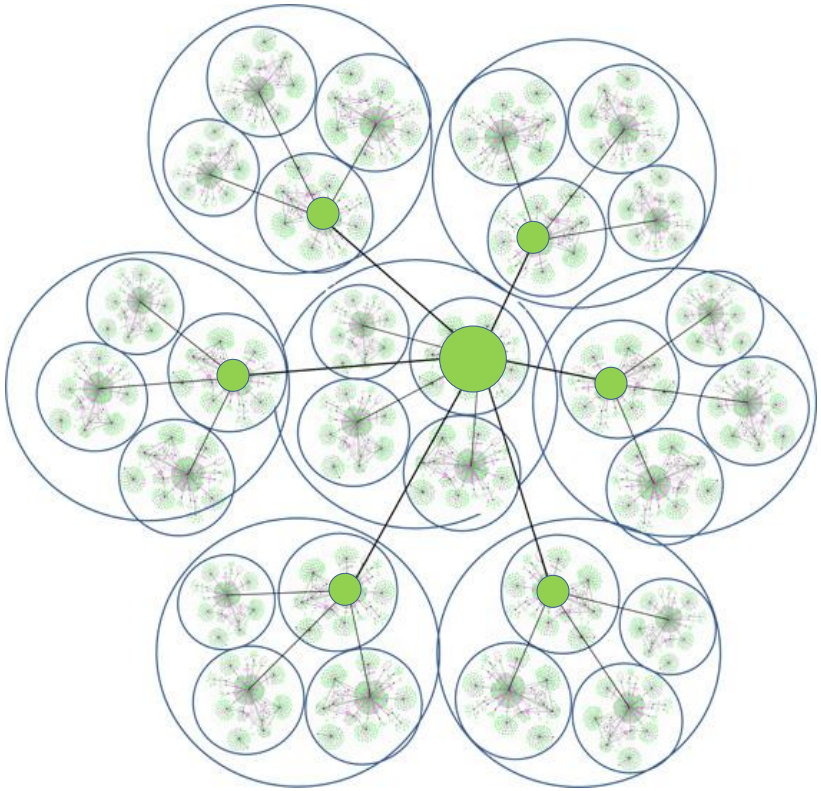
Signaal

Stimulus Detection (Input)

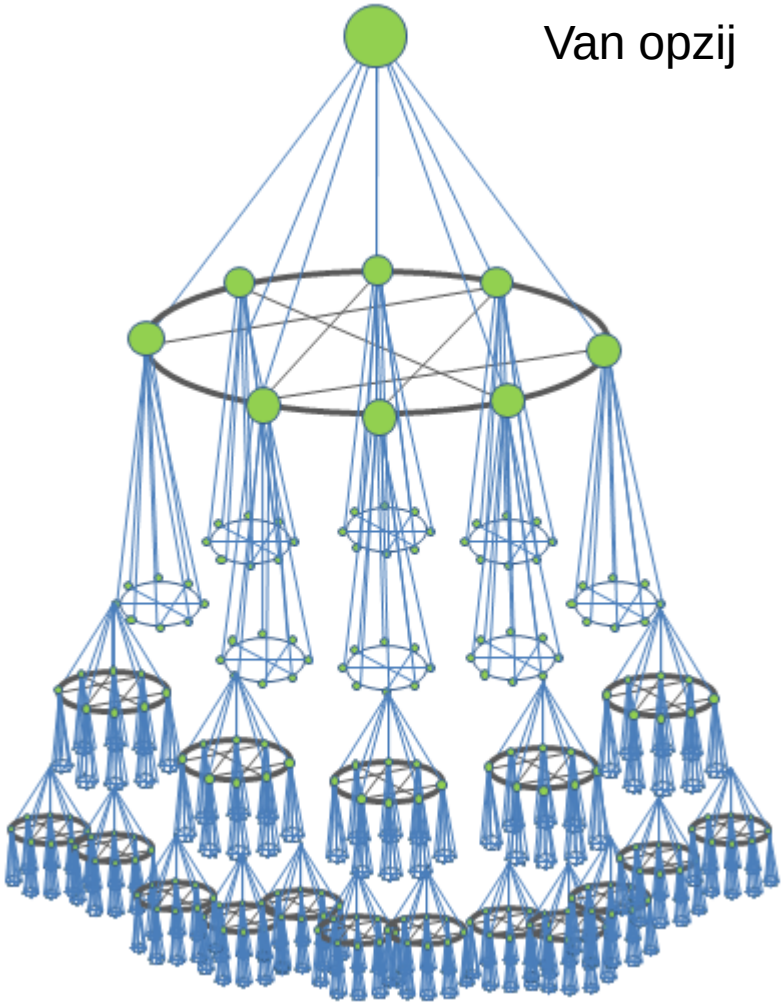
Response Formation (Output)

VI. “Scale-Free” organization

Van boven

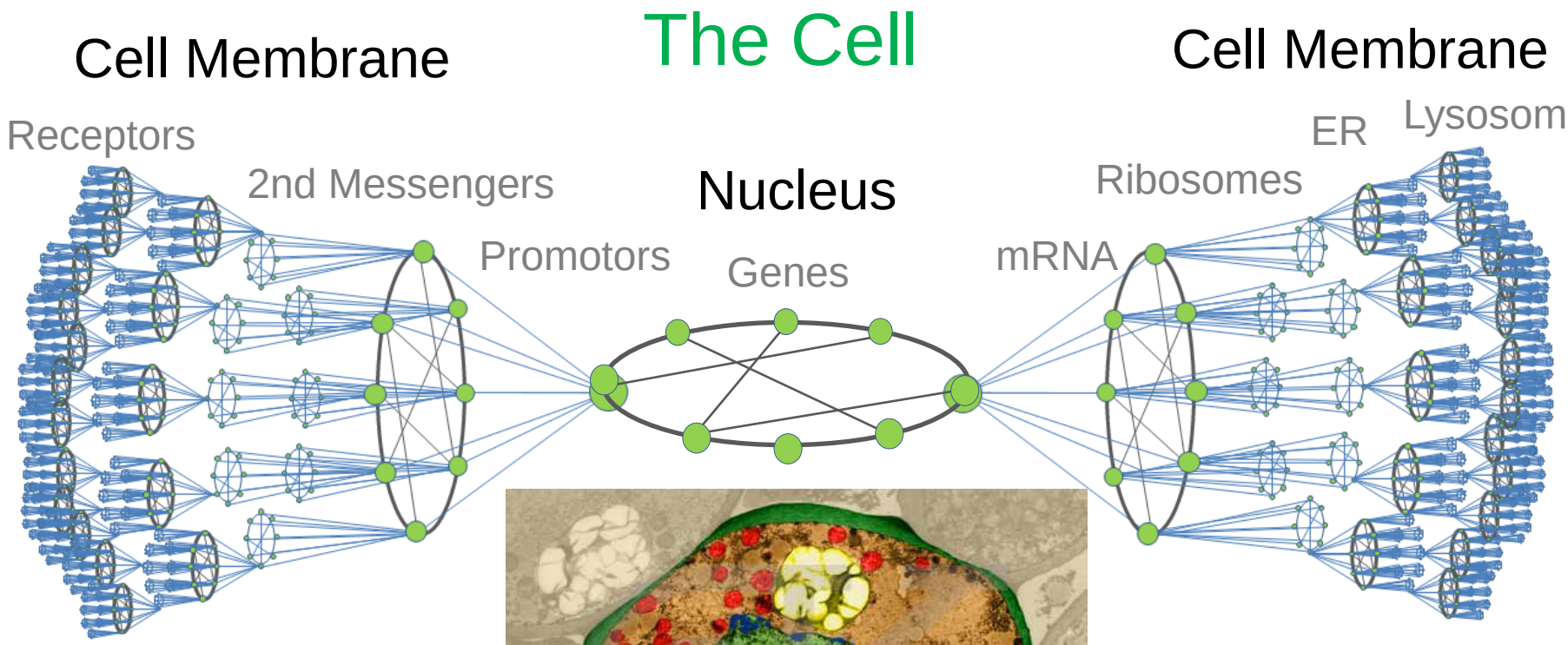


Van opzij

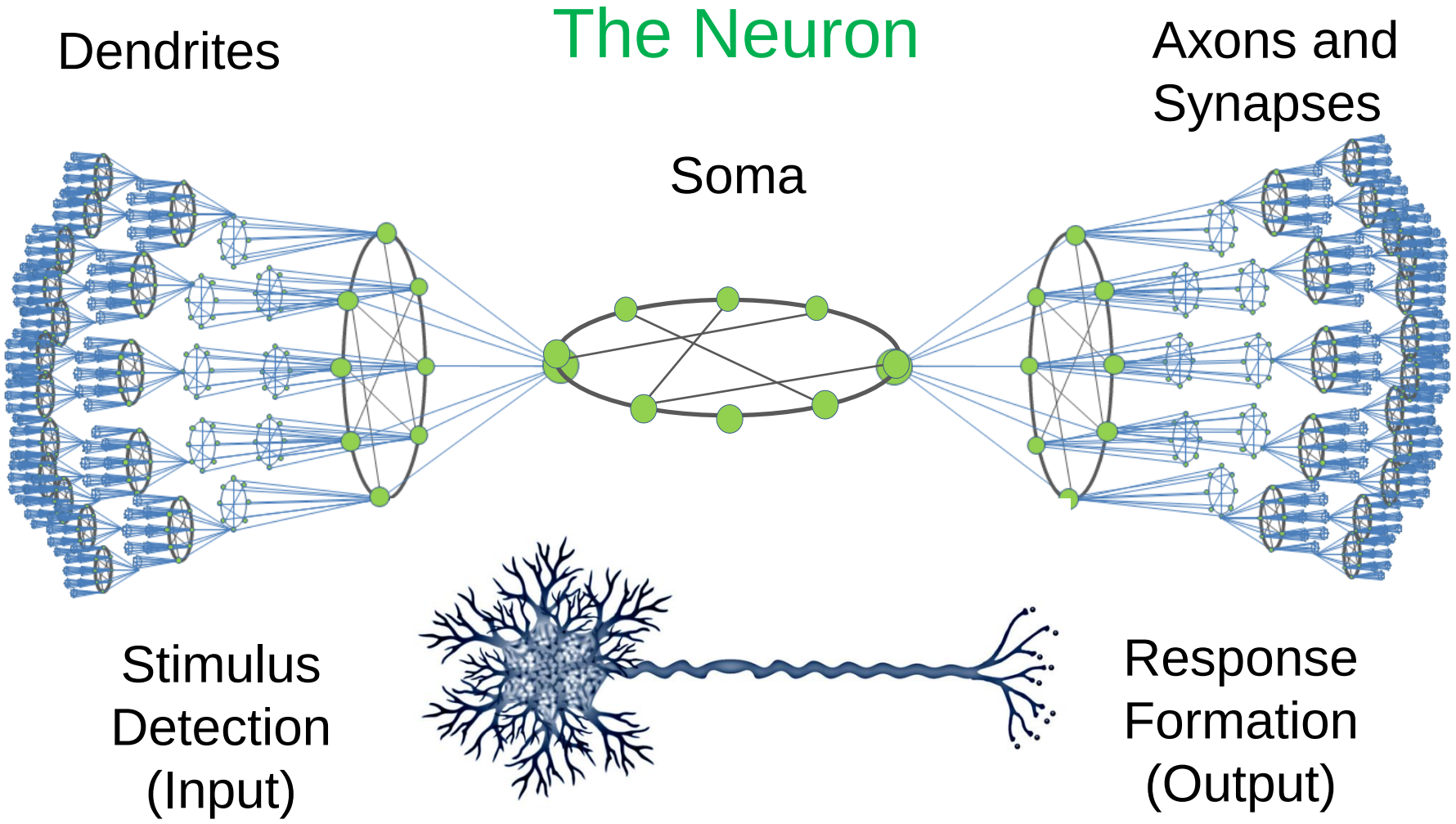


VI. “Scale-Free” organization (Fractals)

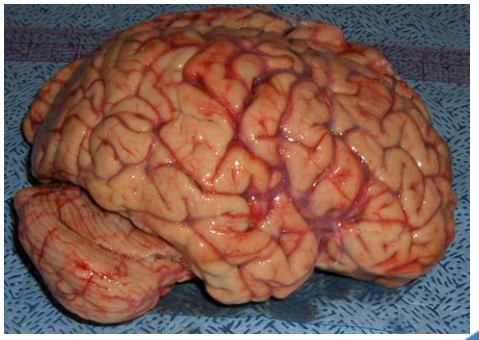
VI. Voorbeelden
“Scale Free” netwerken



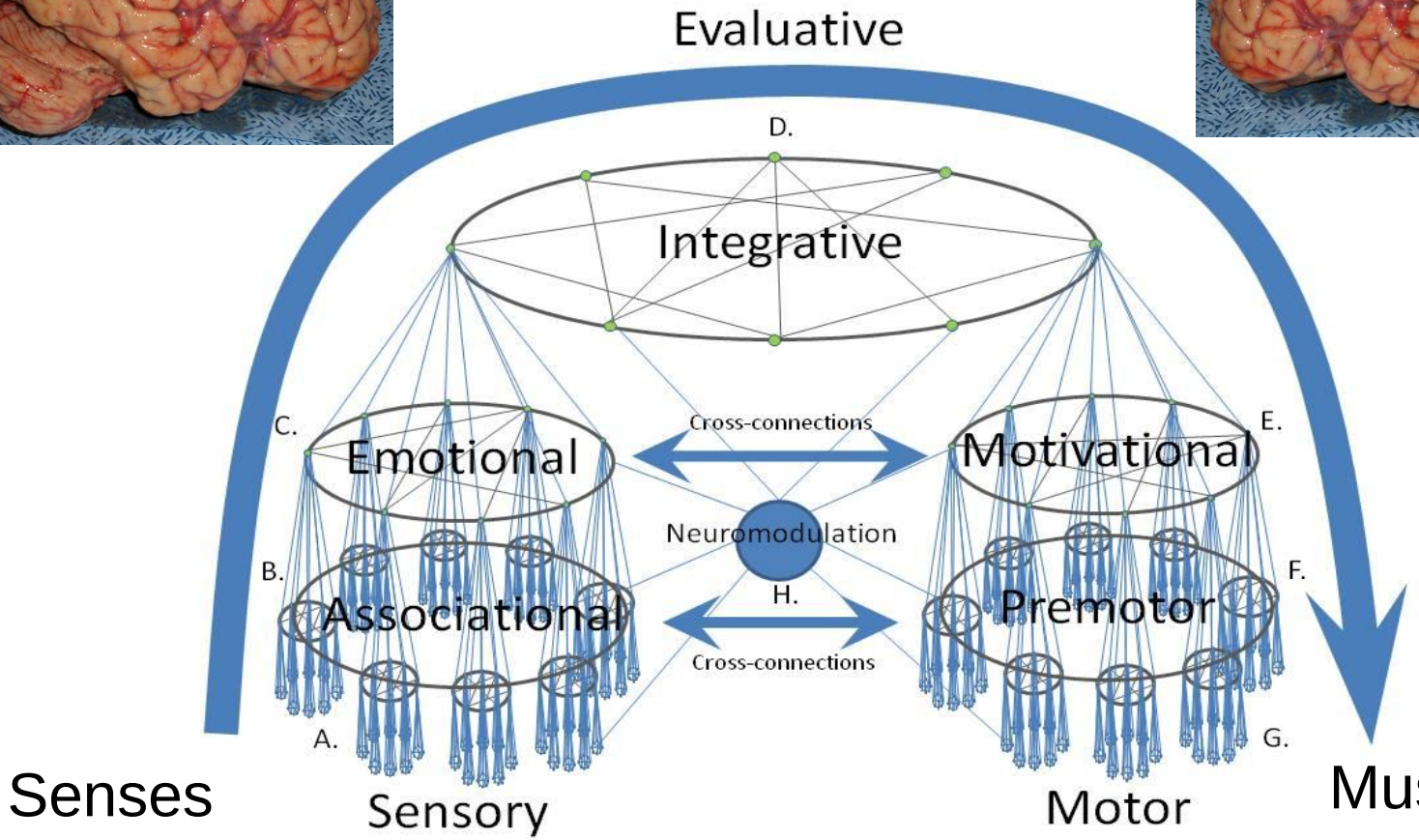
VI. Voorbeelden
“Scale Free” netwerken



VI. Voorbeelden
“Scale Free” netwerken

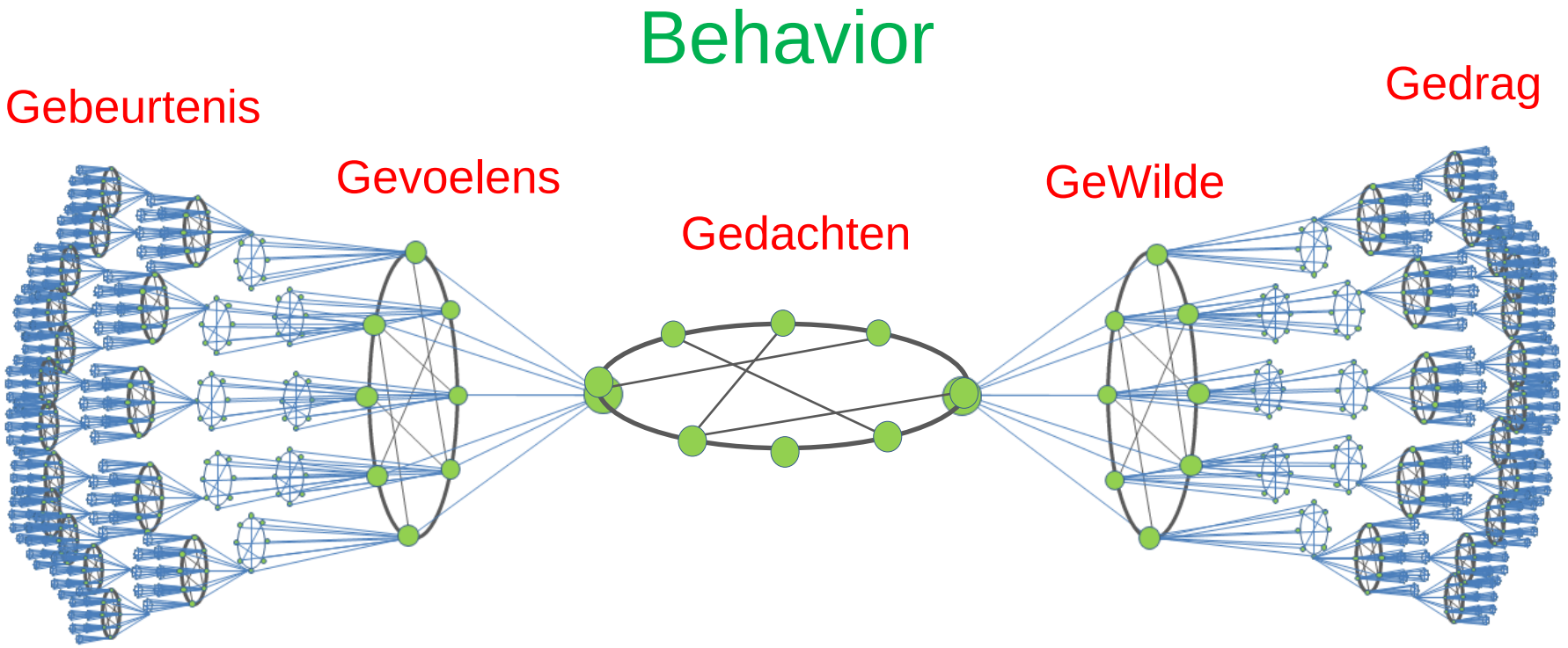


The Brain



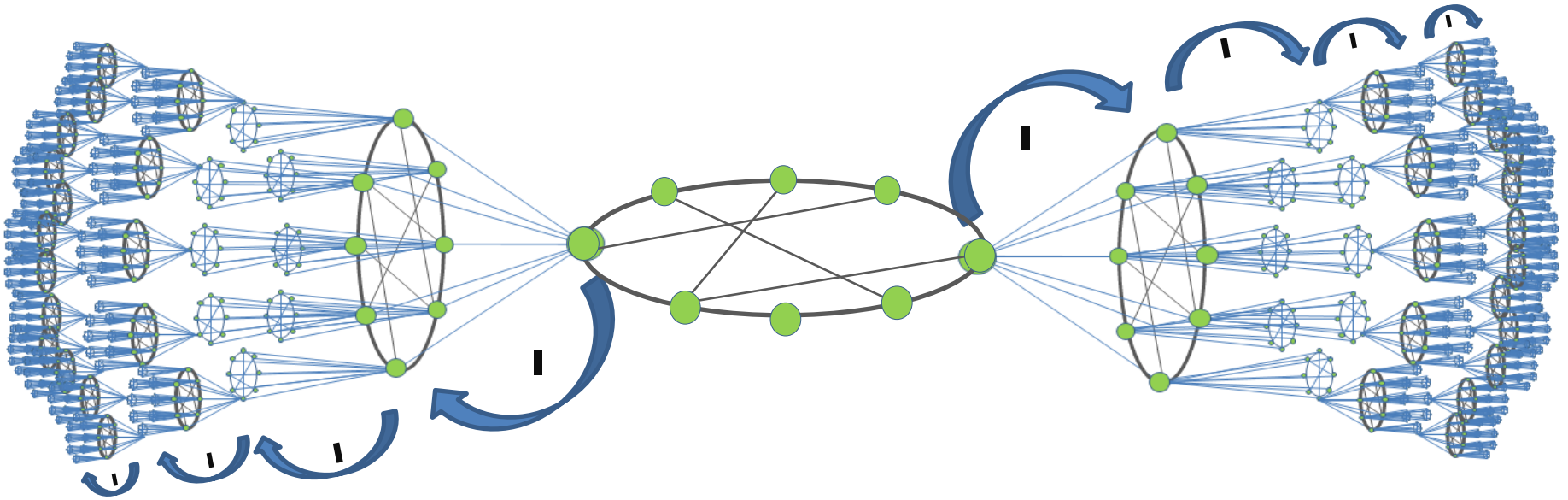
Fuster, 1995

VI. Voorbeelden
“Scale Free” netwerken



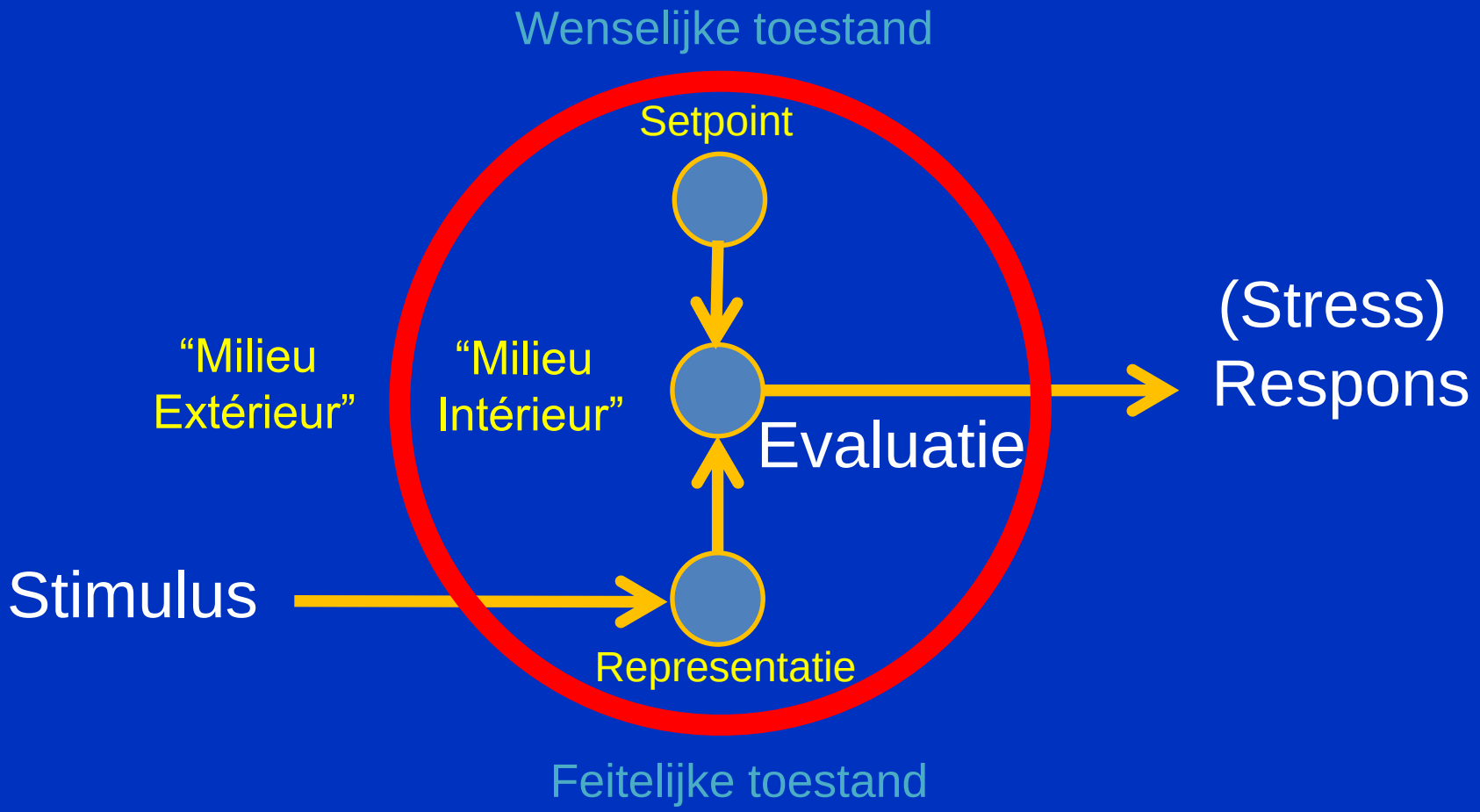
VI. Functie

- Meer genuanceerde stimulusdetectie
- Meer genuanceerde responspatronen.
- Meer genuanceerde vormen van bijsturing van lagere niveaus (top-down controle) mogelijk.



VI. Functie

- “Homeostase” (Asby, 1962):



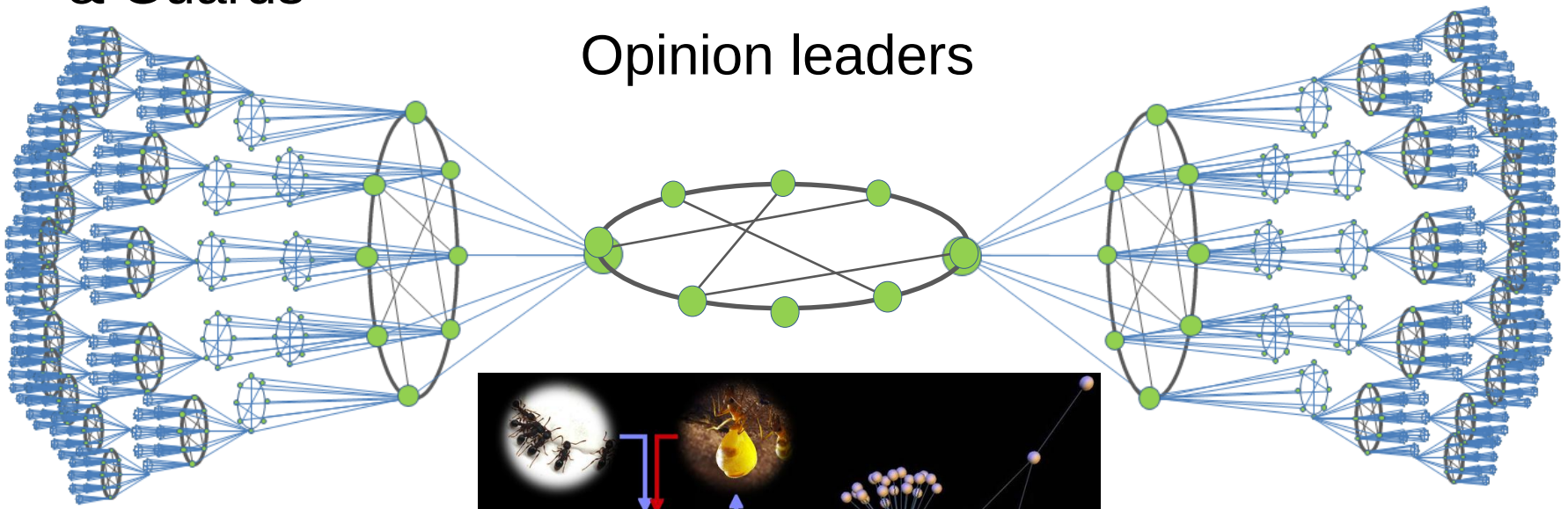
VI. Voorbeelden
“Scale Free” netwerken

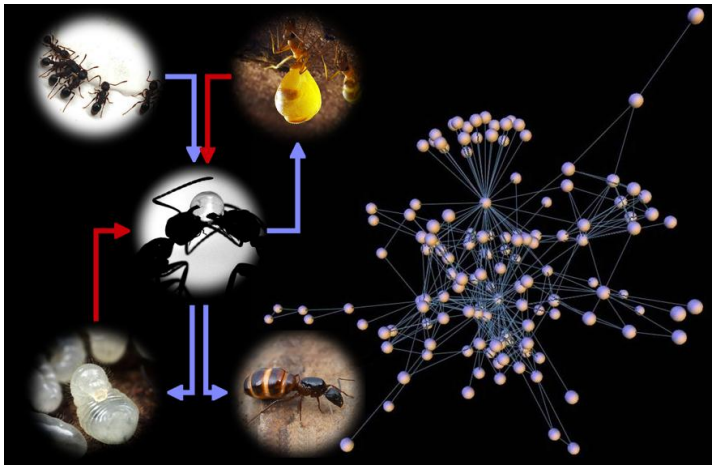
The Social Network

Sentinels
& Guards

Opinion leaders

Workers
& Soldiers





Stimulus
Detection
(Input)

Response
Formation
(Output)

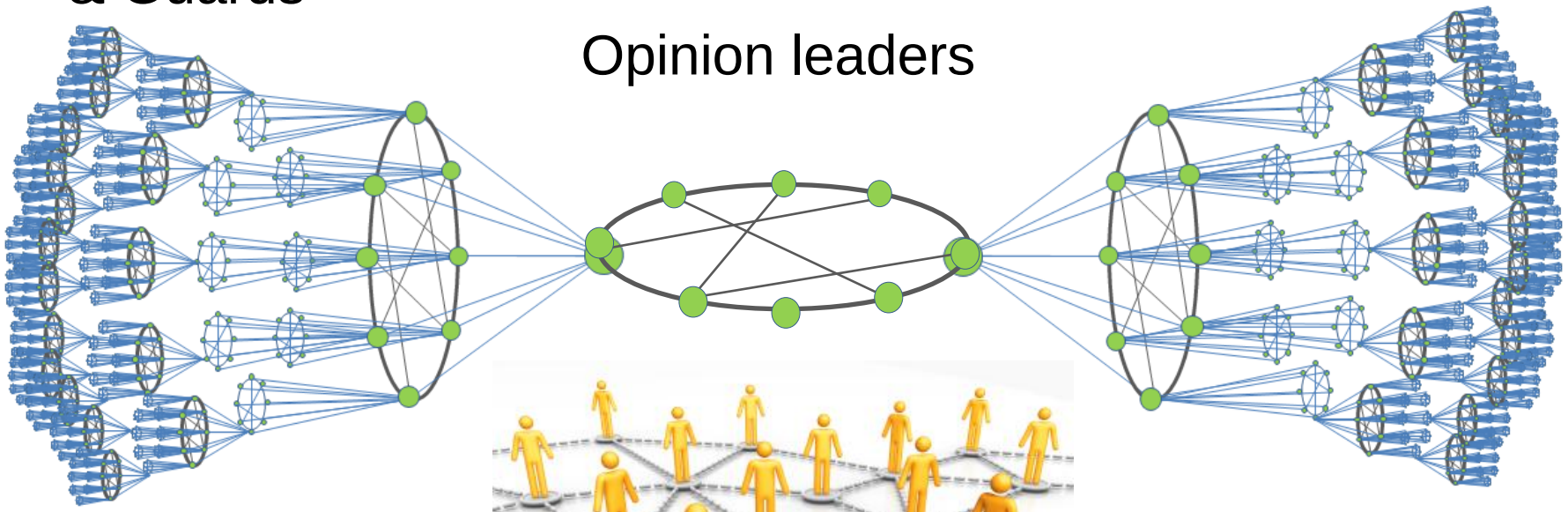
VI. Voorbeelden
“Scale Free” netwerken

The Social Network

Sentinels & Guards

Opinion leaders

Workers & Soldiers



Problem solving: - Patientenzorg

Stimulus Detection (Input)

Response Formation (Output)

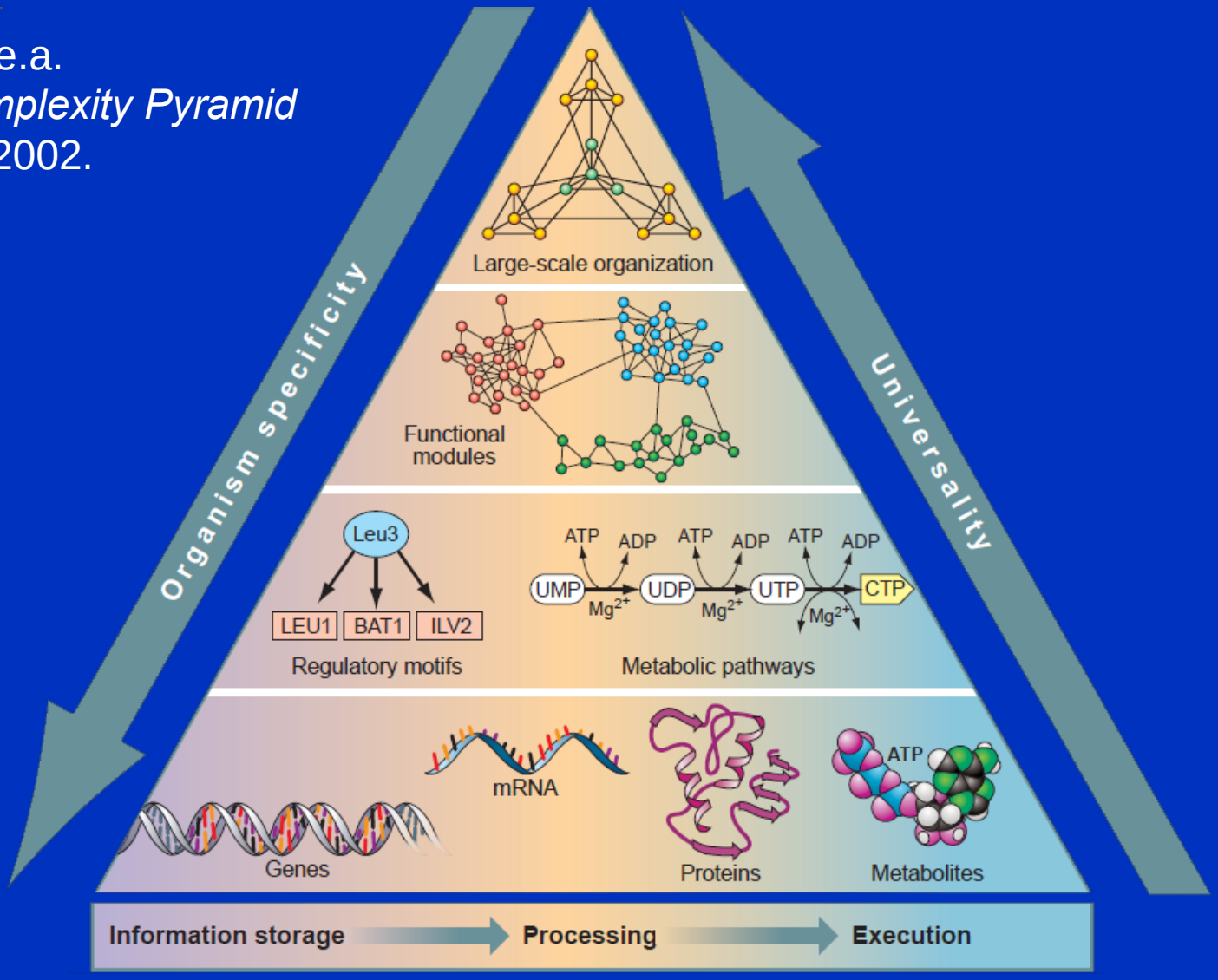
Samenvatting

I. **Netwerk STRUCTUUR**
   I. Small world.
   II. Multimodulair (gescheiden).
   III. Verbonden.
   IV. Hiërarchisch (Rich Clubs) .
   V. Scale-Free (hierarchische Stapelingen).
   VI. Input – Computation – Output organisatie.

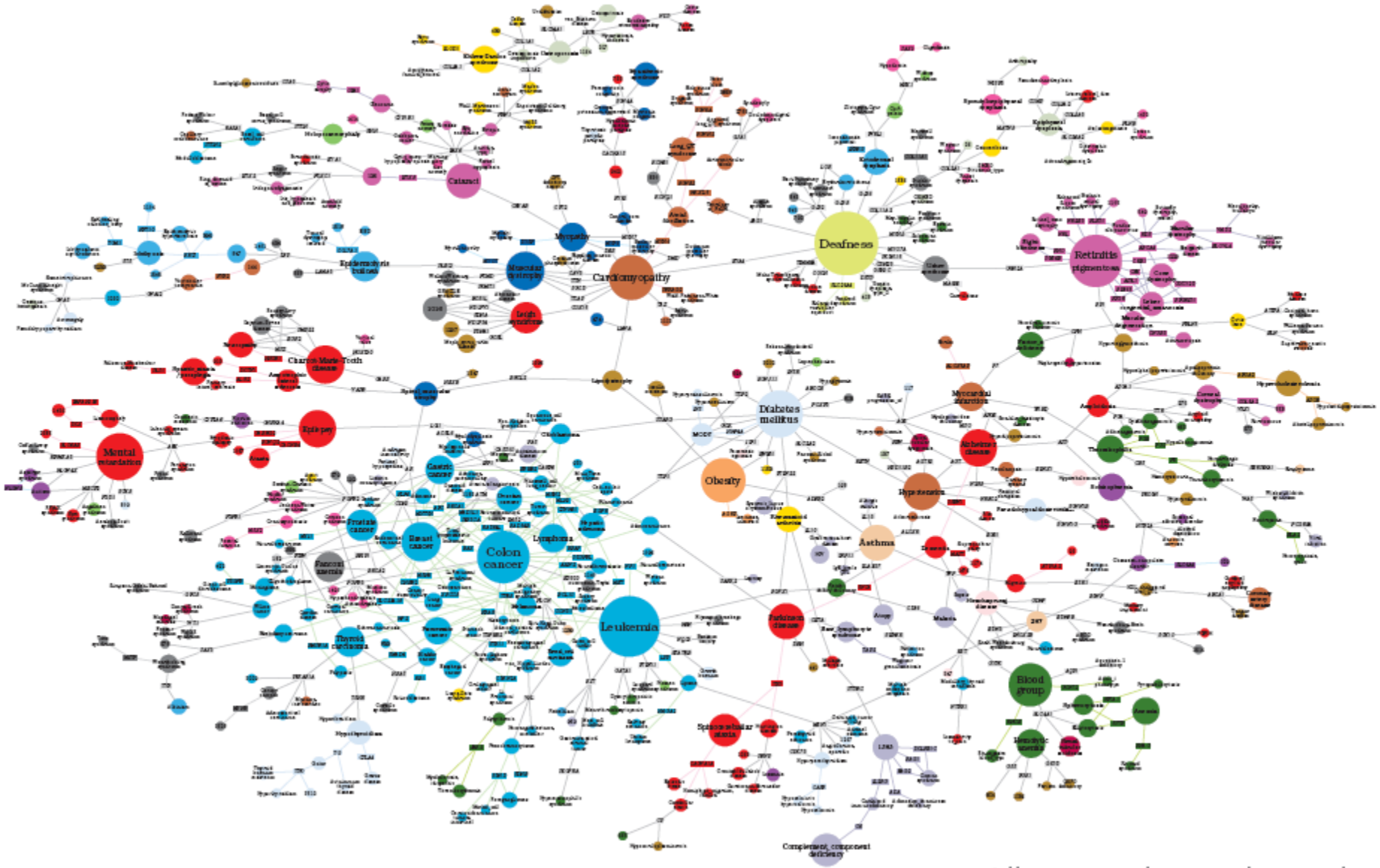
Netwerk FUNCTIE
   I. Snel, stevig.
   II. Functionele segregatie (specialisatie).
   III. Functionele integratie (cooperatie).
   IV. Ruisreductie, generalisatie.
   V. Complexe stimulus-representaties , respons-patronen, controle & coordinatie.
   VI. Optimale homeostase.

Pogingen tot integratie: algemeen

Barabasi e.a.
Life's Complexity Pyramid
Science, 2002.



Netwerktheorie en Geneeskunde



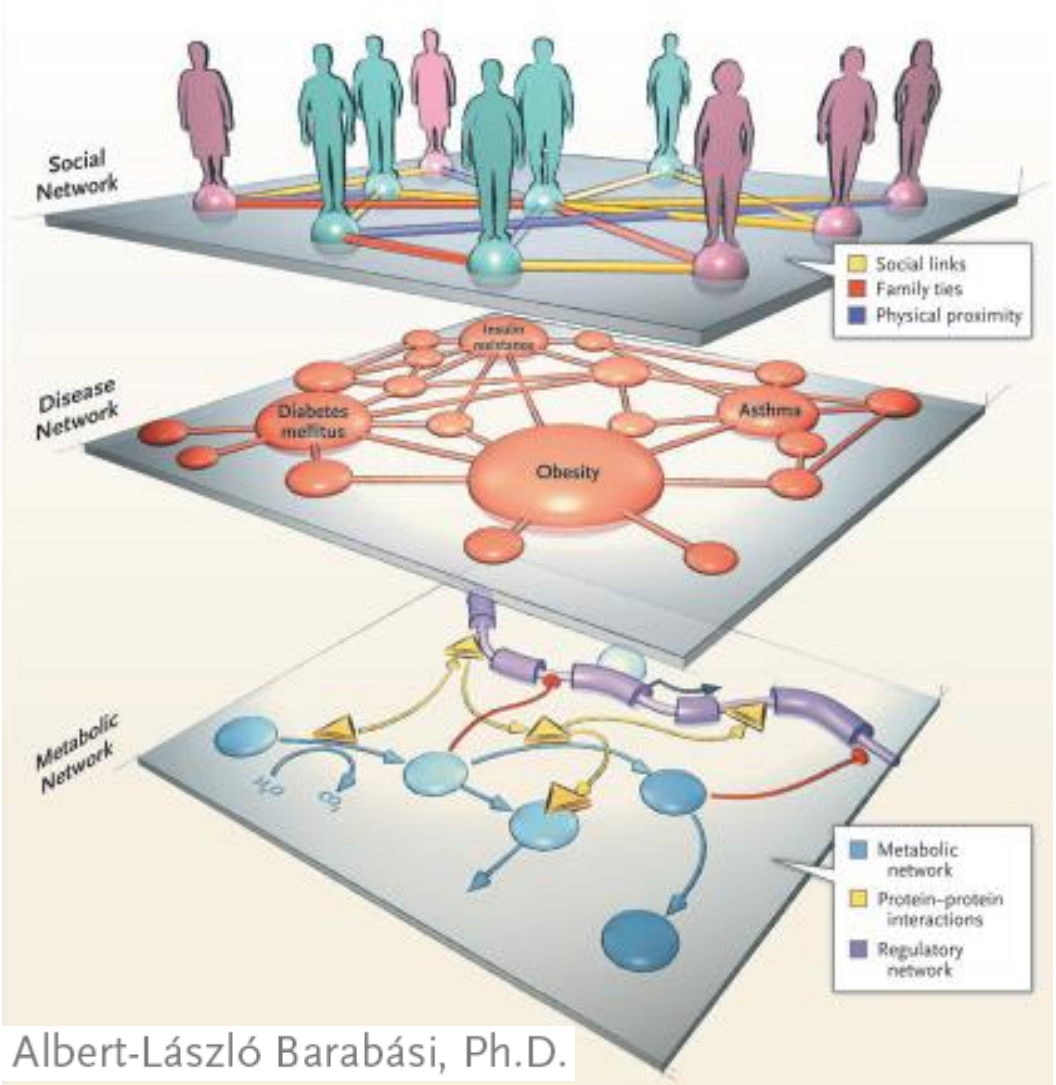
Albert-László Barabási, Ph.D.

A bio- “diseaso”- social model

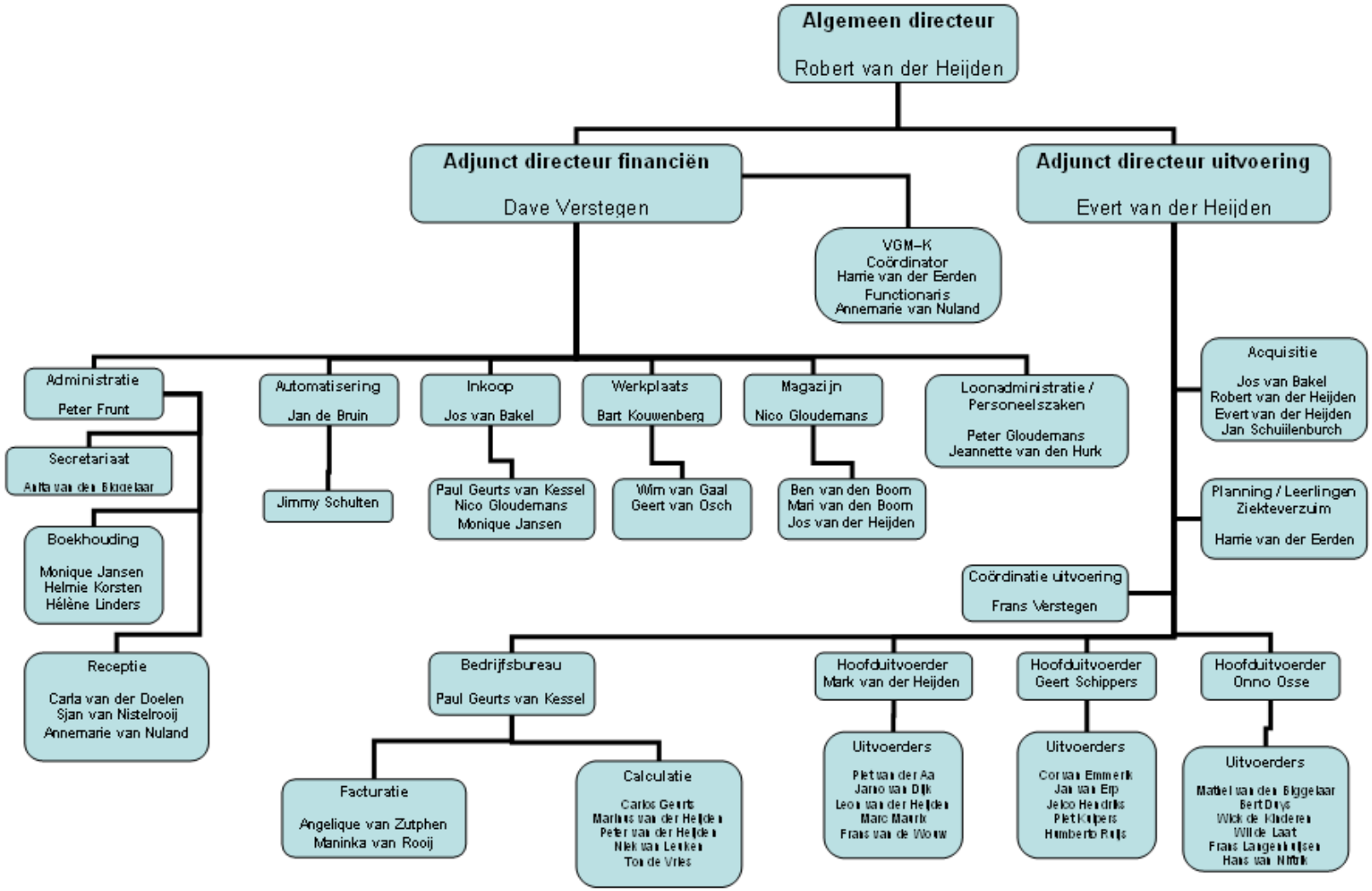
Social

Diseaso

Bio



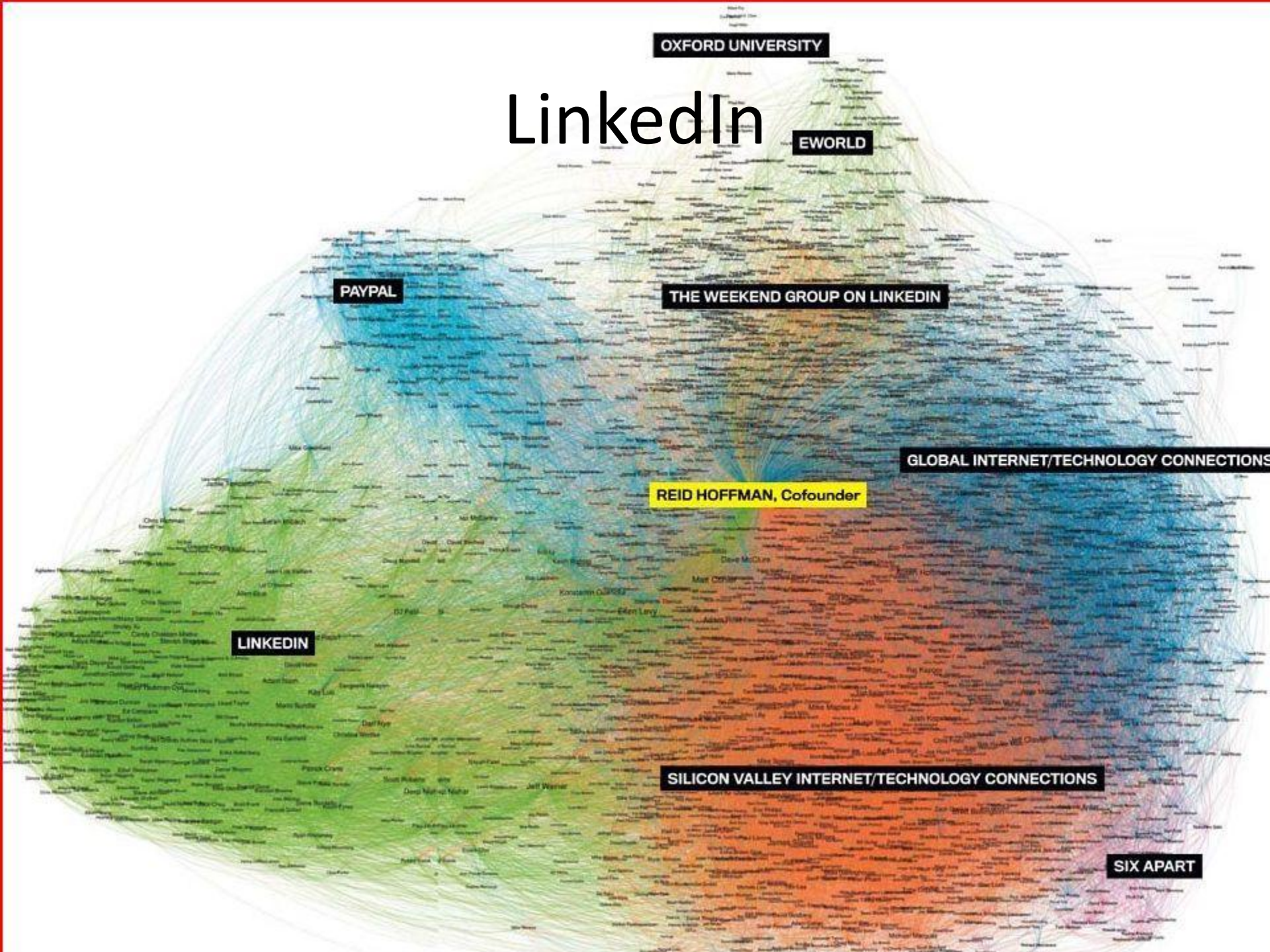
Netwerktheorie en Management

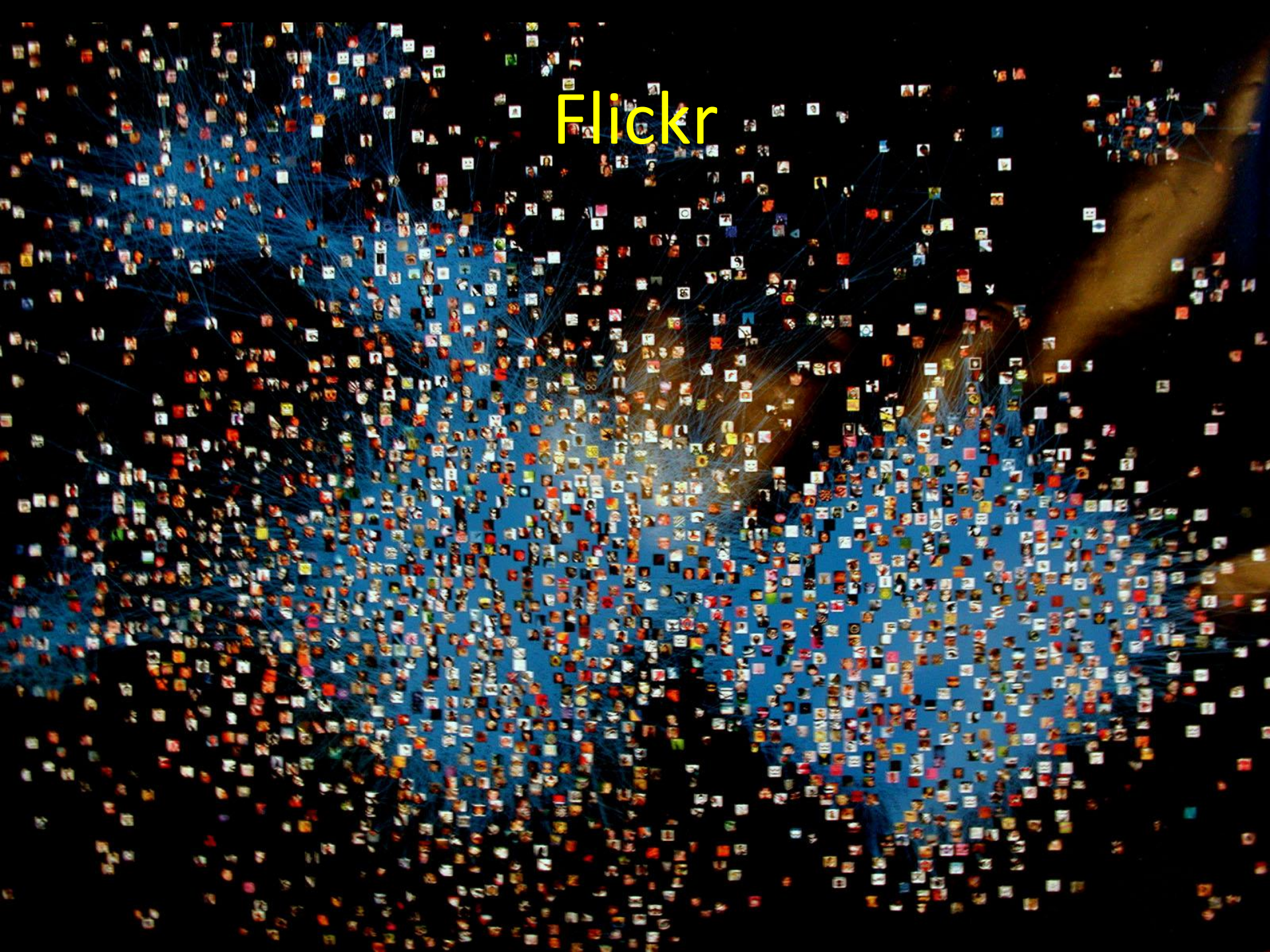


Journal of Management 2011 37: 443 ;Thomas P. Moliterno and Douglas M. Mahony **Network Theory of Organization: A Multilevel Approach**

Social Networks:
Hoe meet je ze?

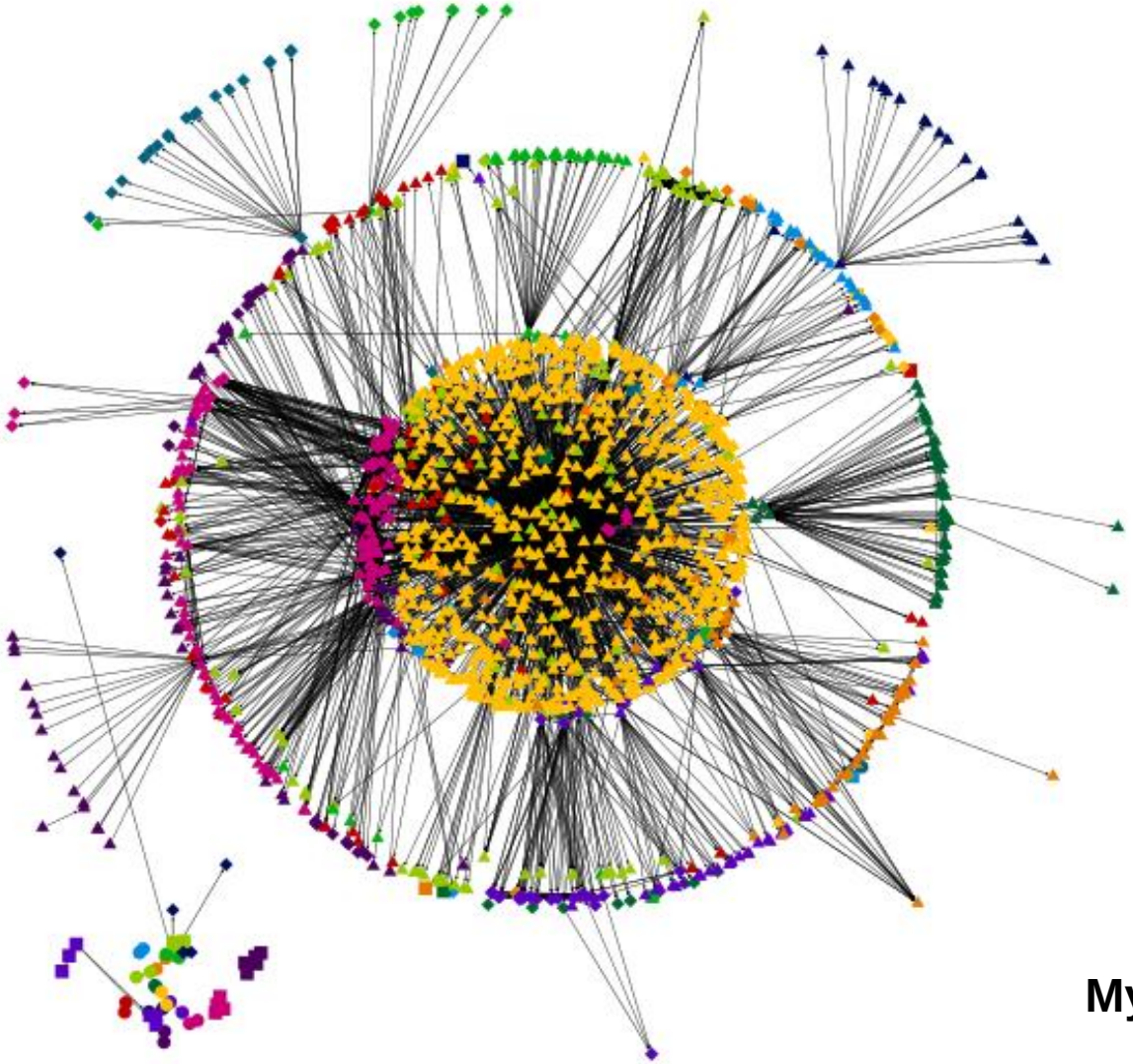
LinkedIn


OXFORD UNIVERSITY
EWORLD
PAYPAL
THE WEEKEND GROUP ON LINKEDIN
GLOBAL INTERNET/TECHNOLOGY CONNECTIONS
REID HOFFMAN, Cofounder
LINKEDIN
SILICON VALLEY INTERNET/TECHNOLOGY CONNECTIONS
SIX APART


Flickr

Facebook

Email / Telephone



My Email

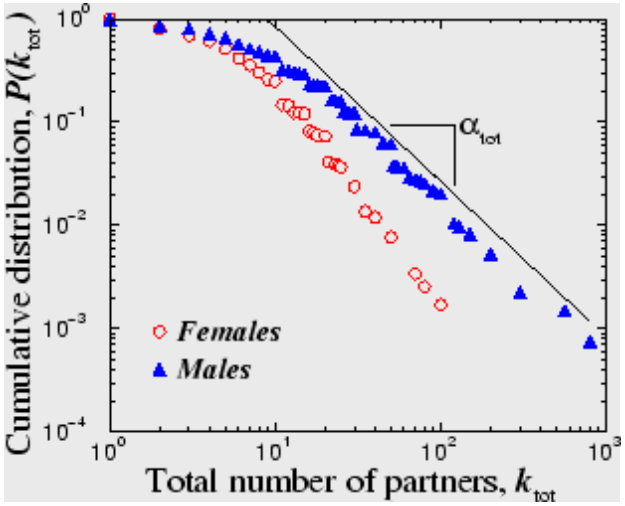
Created with NodeXL (http://nodexl.codeplex.com)

Questionnaires

Sexual network structure as an indicator of epidemic phase

J J Potterat, S Q Muth, R B Rothenberg, H Zimmerman-Rogers, D L Green, J E Taylor, M S Bonney, H A White

Sex Transm Infect 2002;**78**(Suppl I):i152–i158



"Chains of affection: The structure of adolescent romantic and sexual networks," *Bearman PS, Moody J, Stovel ;* The American Journal of Sociology, *Vol. 100, No. 1. 2006*

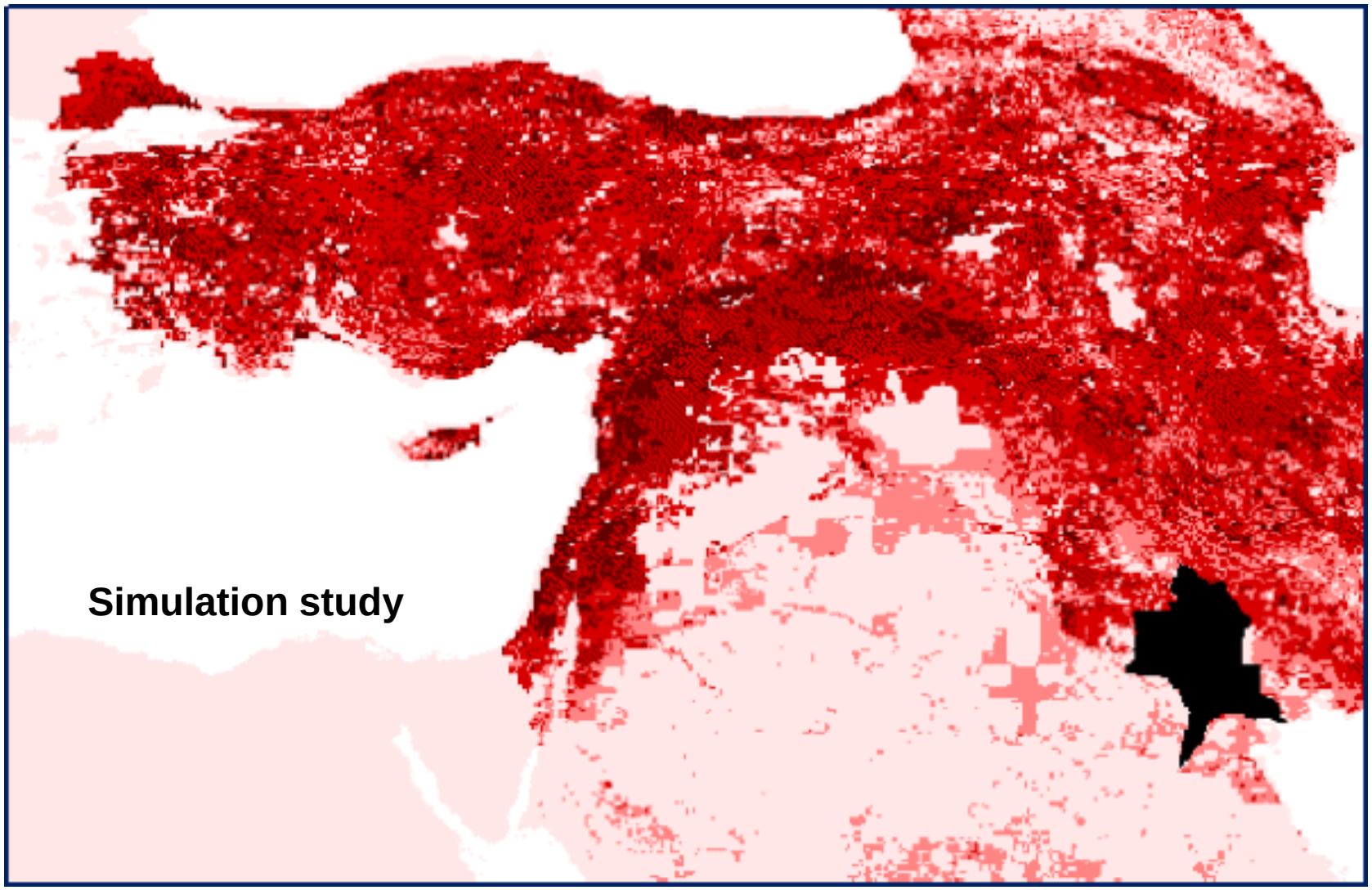
Social Networks:
Wat gebeurt er eigenlijk?

Social networks

Information flow: germs

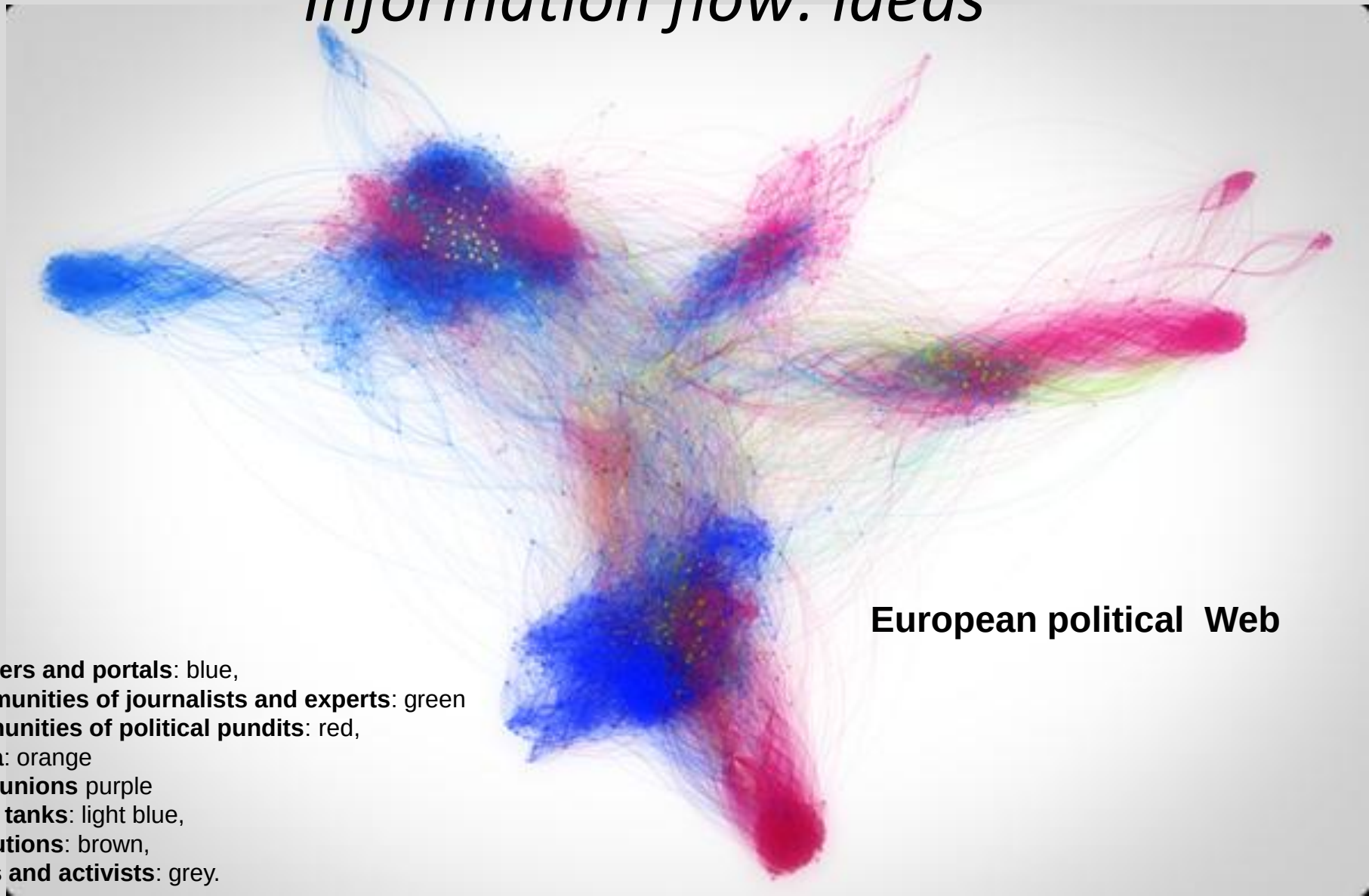
Social networks

Information flow: germs



Social networks

Information flow: ideas



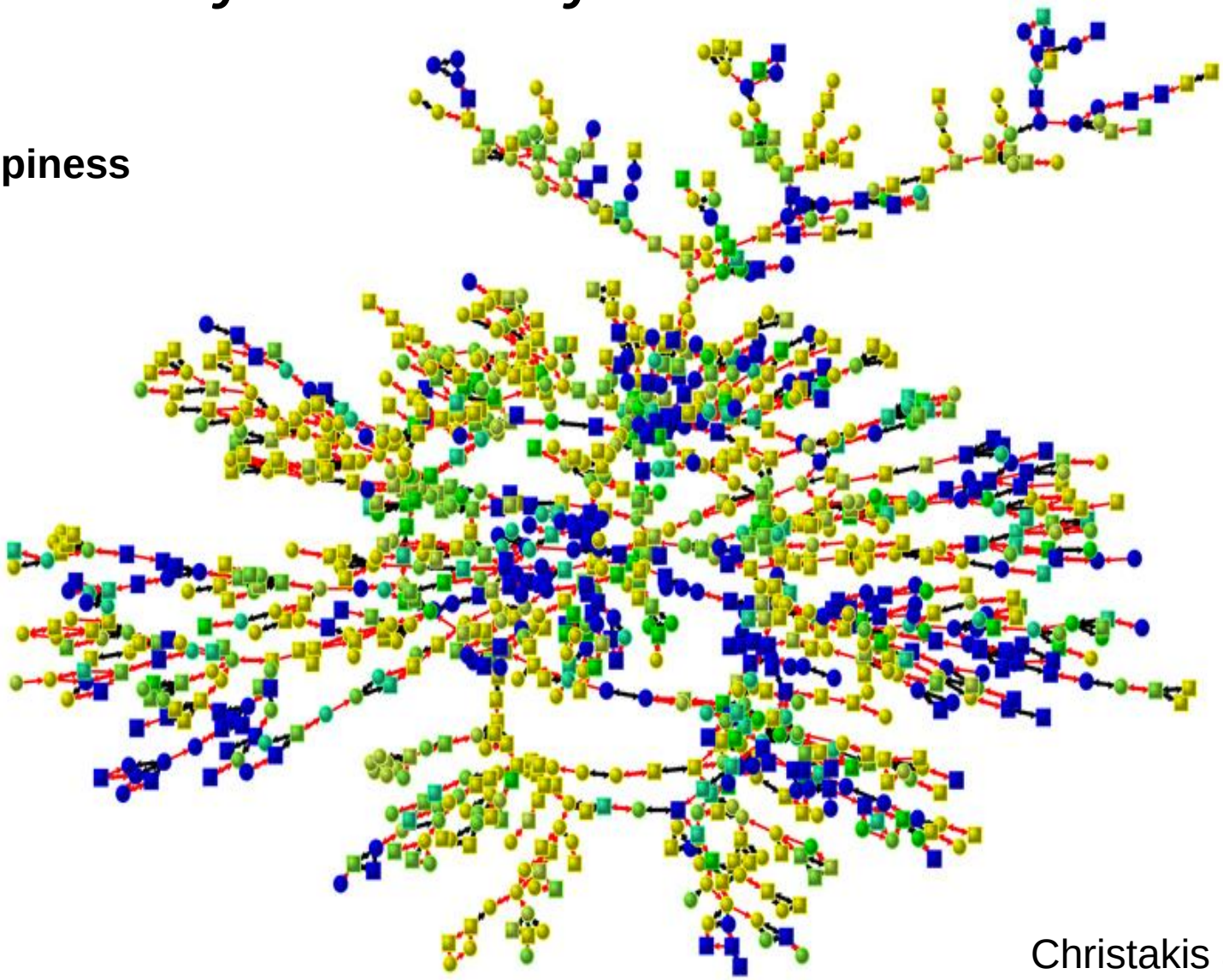
European political Web

bloggers and portals: blue,
communities of journalists and experts: green
communities of political pundits: red,
media: orange
trade unions purple
think tanks: light blue,
Institutions: brown,
NGOs and activists: grey.

Social networks

Information flow: emotions

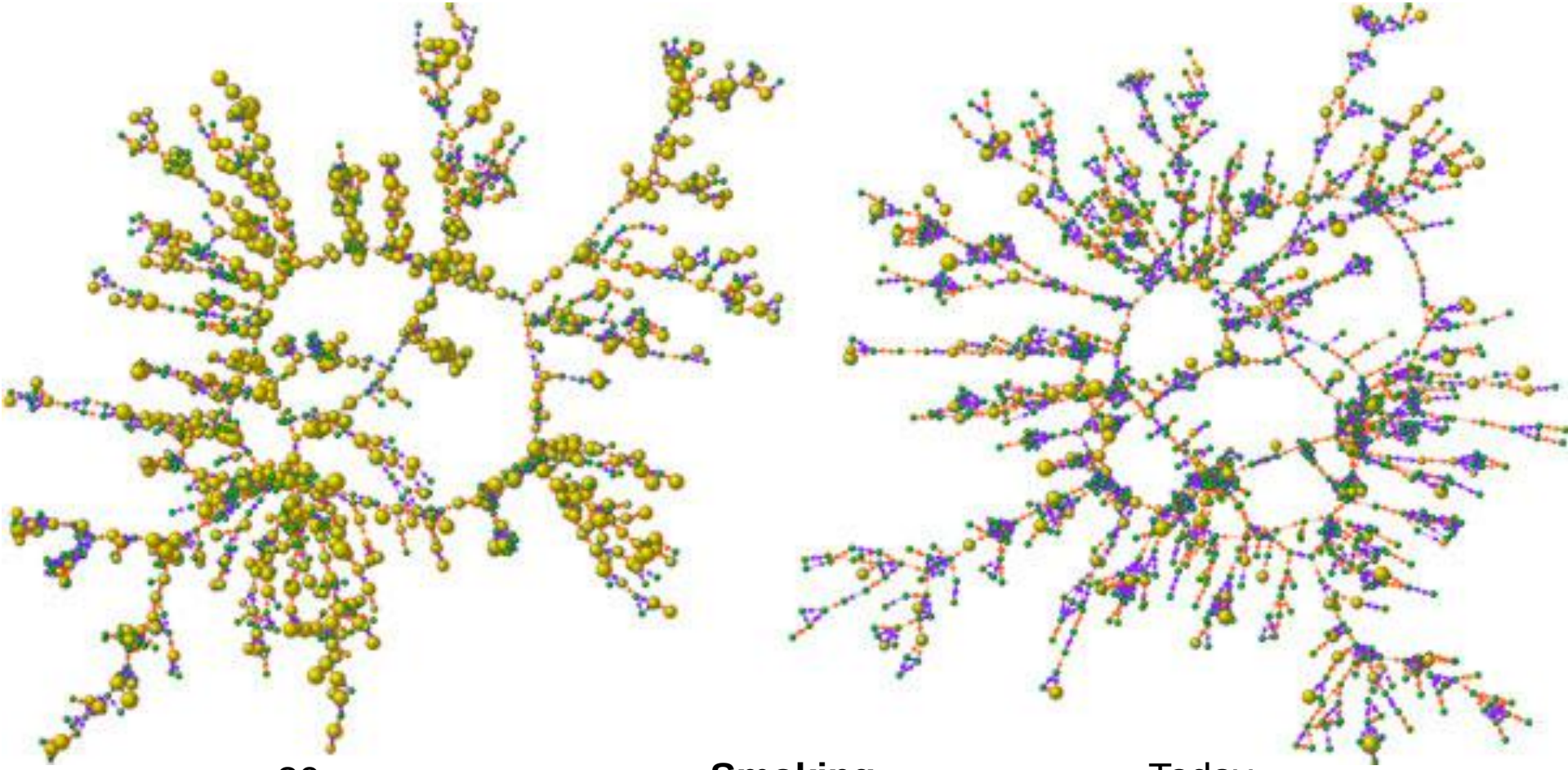
Happiness



Christakis and Fowler

Social networks

Information flow: habits



30 years ago

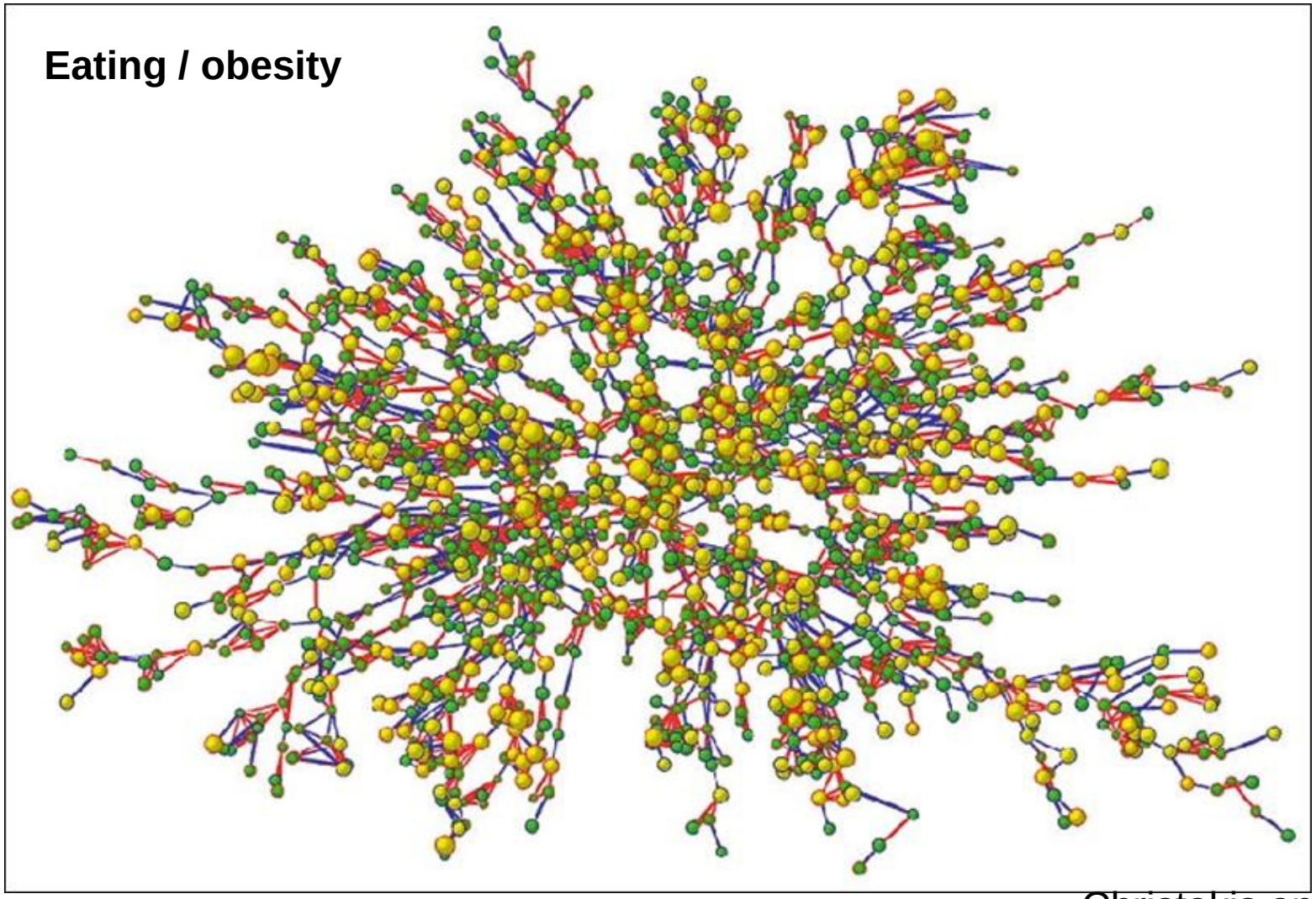
Smoking

Today

Christakis and Fowler

Social networks

Information flow: habits



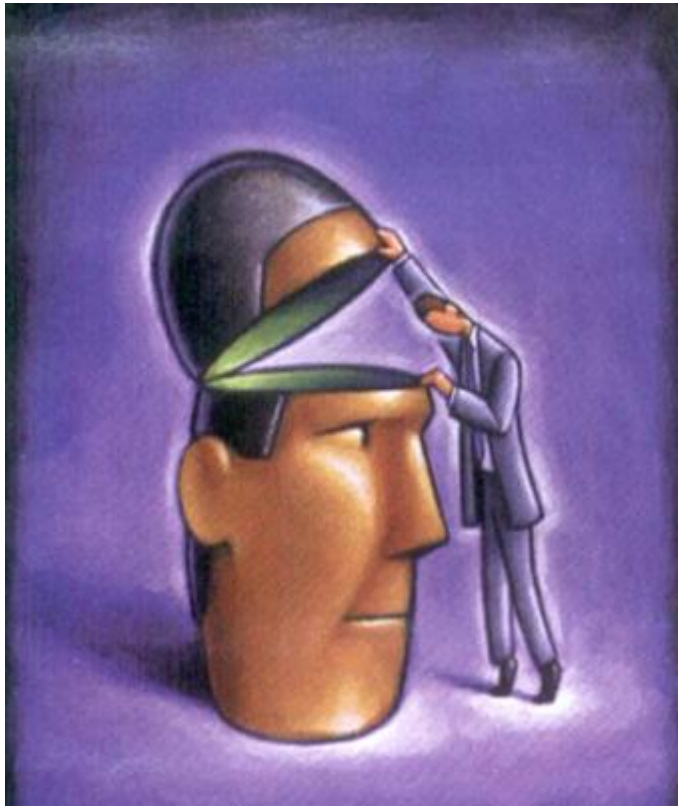
Christakis and Fowler

Social Networks

- The *Three Degrees of Influence* Rule:

Christakis and Fowler

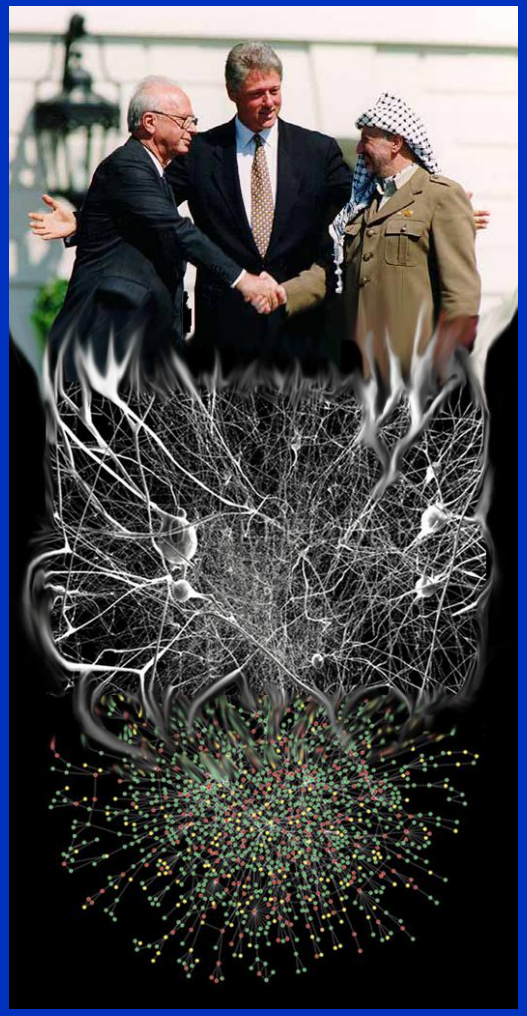
Consequenties voor management en psychiatrie



Na de Pauze!

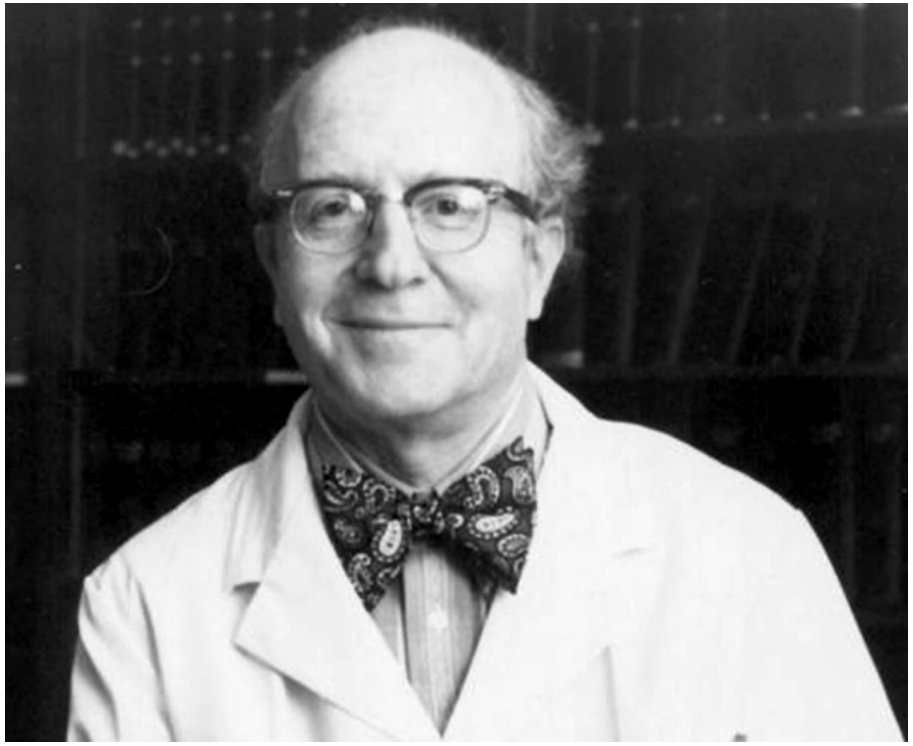
Pauze

Life's Complexity Pyramid



- "We are networks, and we form networks".
- Disease manifests itself as a disruption of:
  - Network ***structure*.**
  - Netwerk ***function***.
- Changes occur at all levels of organization.
- Interventions may be targeted at all levels.

Psychiatrie:
Biopsychosociaal model

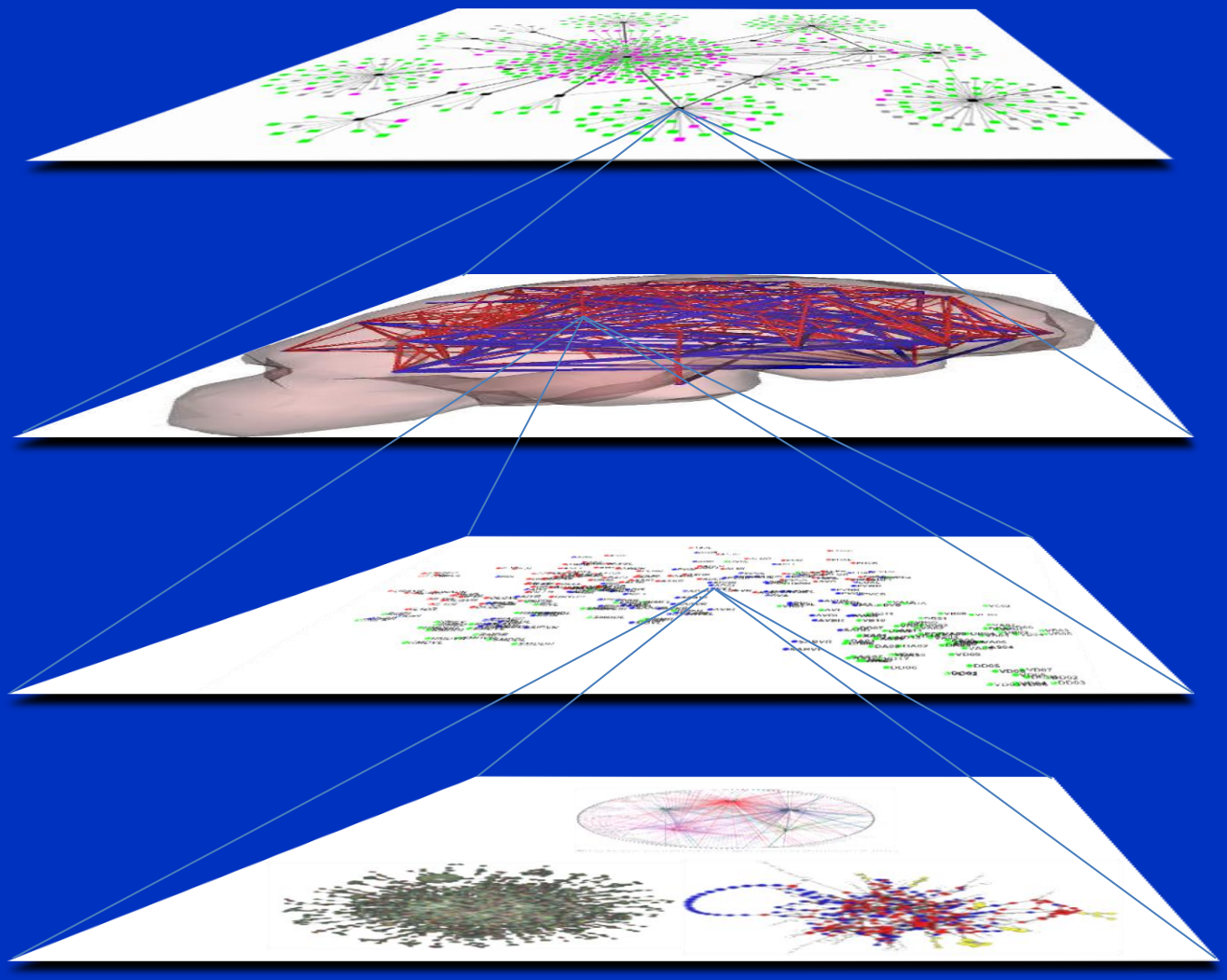


George Libman Engel (1913-1999)
Psychiater

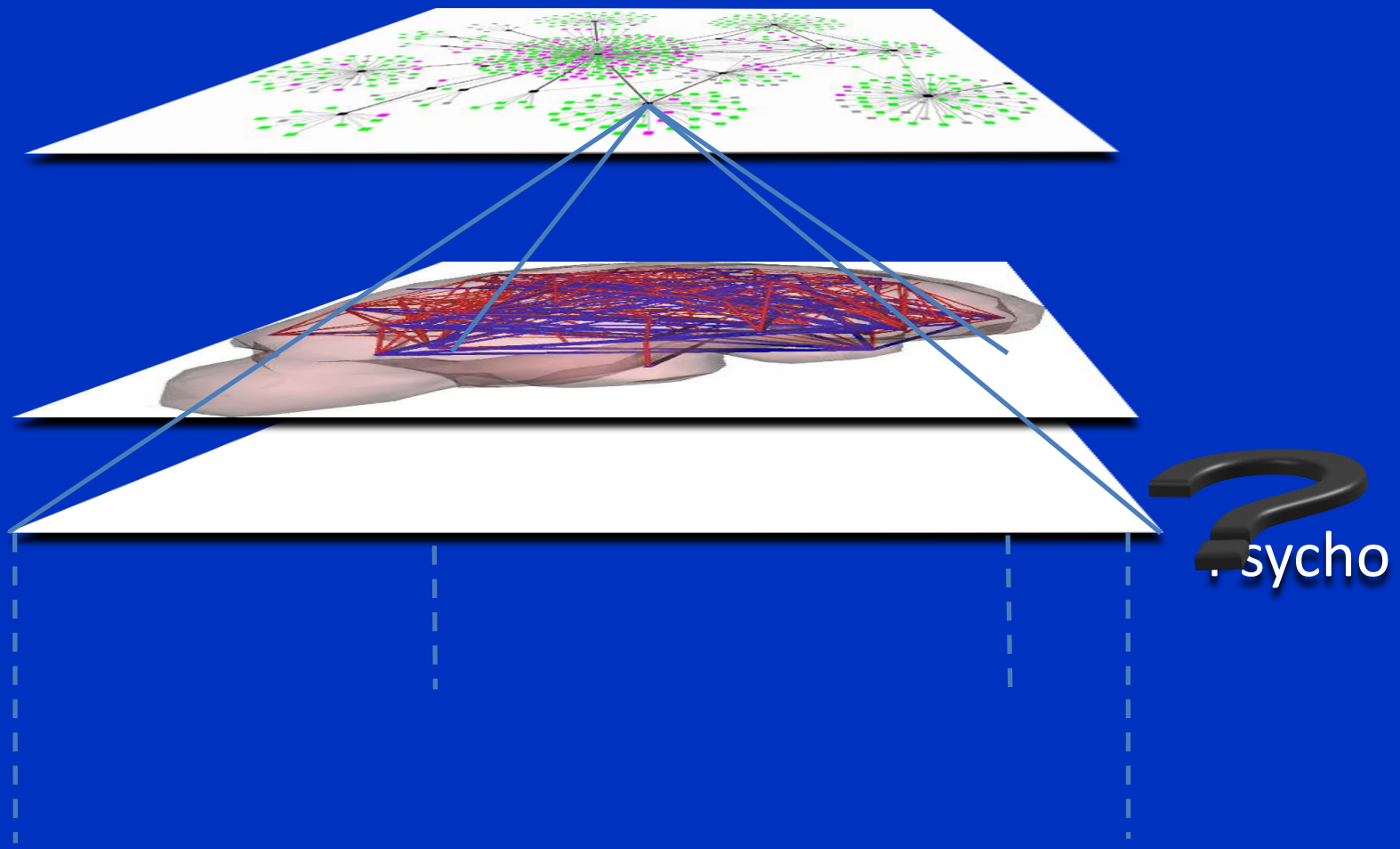
"Since the collapse of the 19th century models (psychoanalysis, biologism and behaviourism), psychiatrists have been in search of a model that integrates the psyche and the soma. So keen has been their search that they embraced the so-called 'biopsychosocial model' without ever bothering to check its details. If, at any time over the last three decades, they had done so, they would have found it had none. This would have forced them into the embarrassing position of having to acknowledge that modern psychiatry is operating in a theoretical vacuum."

Niall McLaren, psychiater

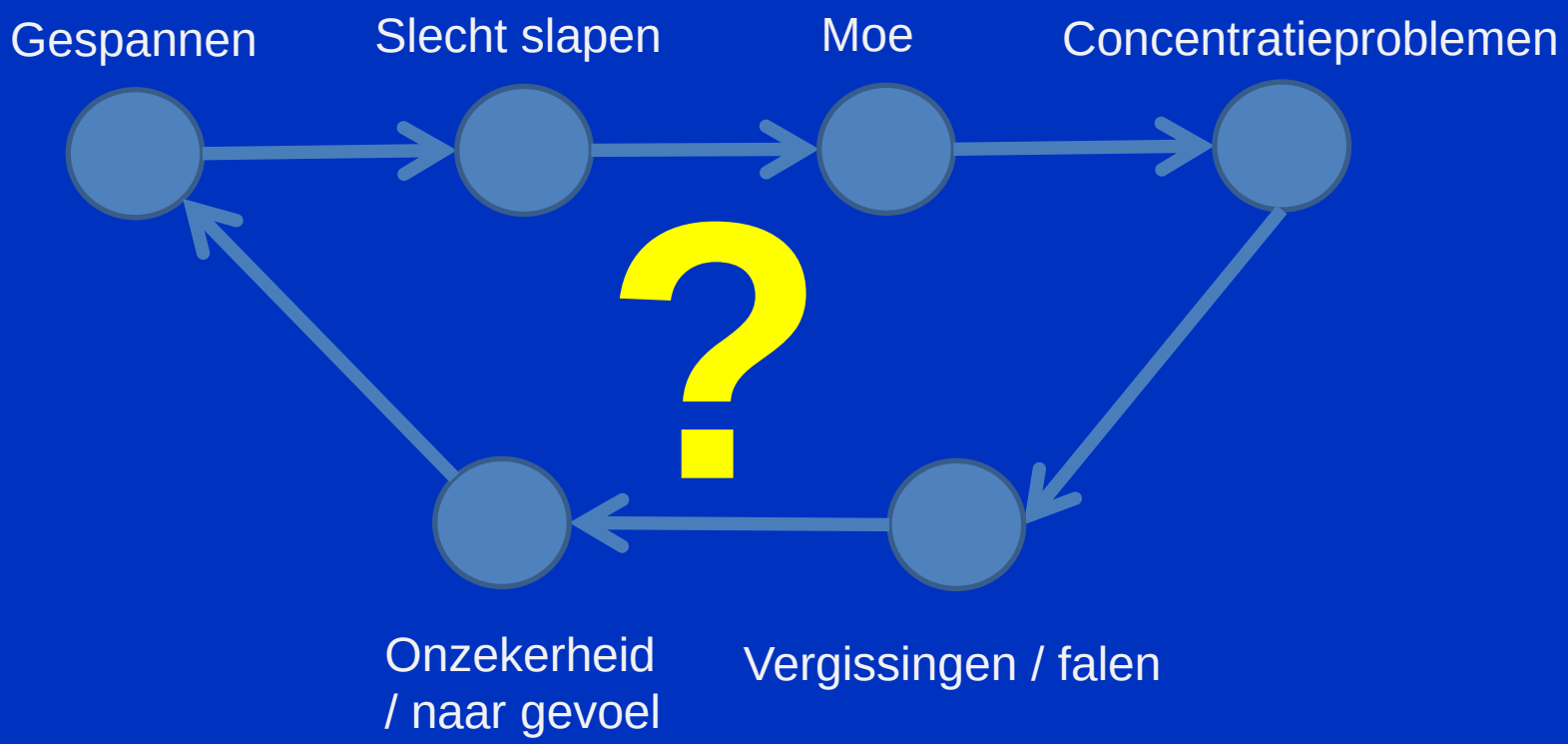
A *mathematically* integrated bio-psycho-social model



Bio-**psycho**-social network model



Vicieuze cirkels

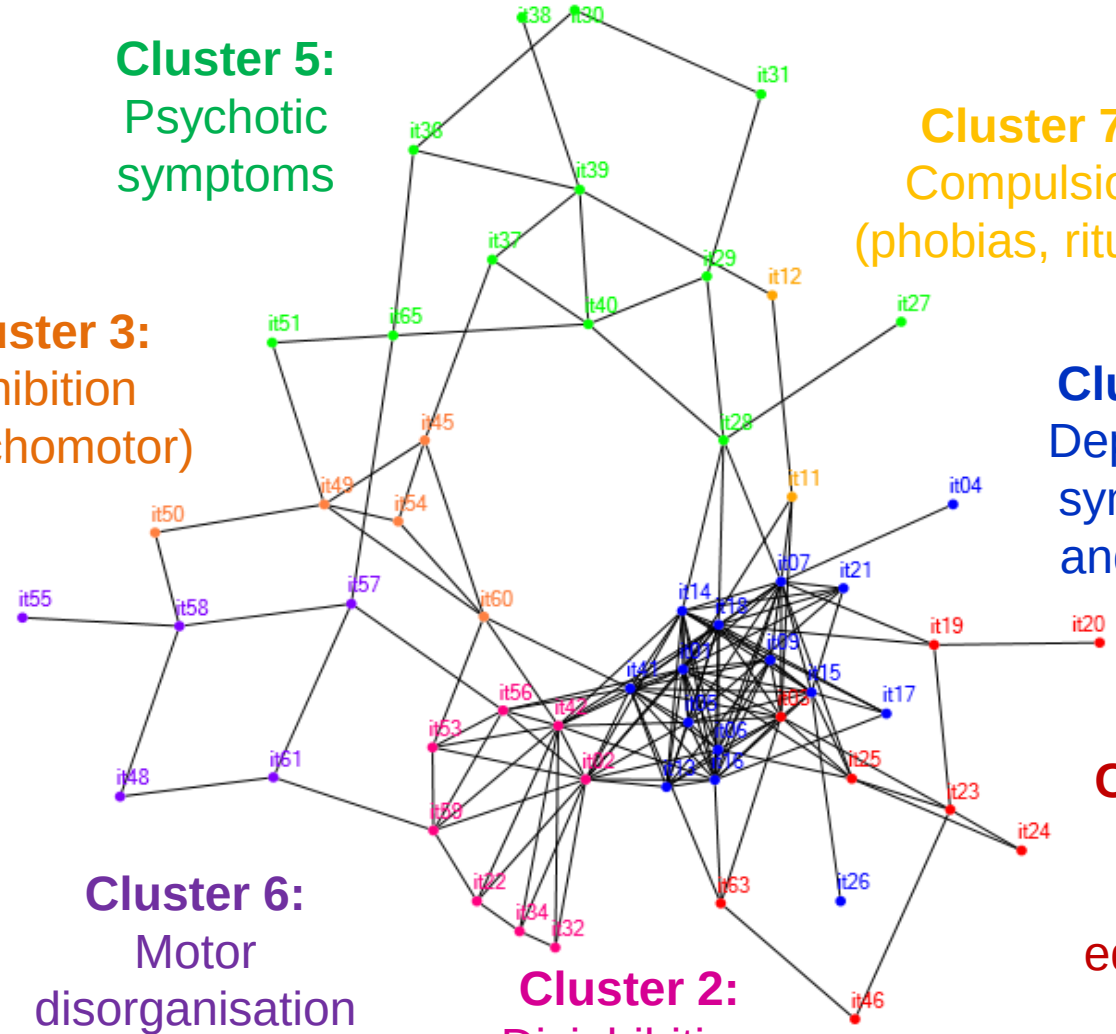


The intrapsychic network

- N = 192.
- Heterogeneous group of patients with acute (“As I”) disorders (Dr. J.G. Goekoop, 1992).
- Scored on the CPRS (comprehensive psychopatho-logical rating scale): 65 items.
- Bivariate correlational analysis on all itemscores (between-symptom correlations).
- Item = node, significant correlation = link, strength of correlation = weight of the link (NodeXL).

The intrapsychic network (Axis I)

Clusters (CPRS)



Cluster 5: Psychotic symptoms

Cluster 7: Compulsion (phobias, rituals)

Cluster 3: Inhibition (psychomotor)

Cluster 1: Depressive symptoms and anger

$P < 0.0005$

Cluster 4: Physical fear equivalents

Cluster 6: Motor disorganisation

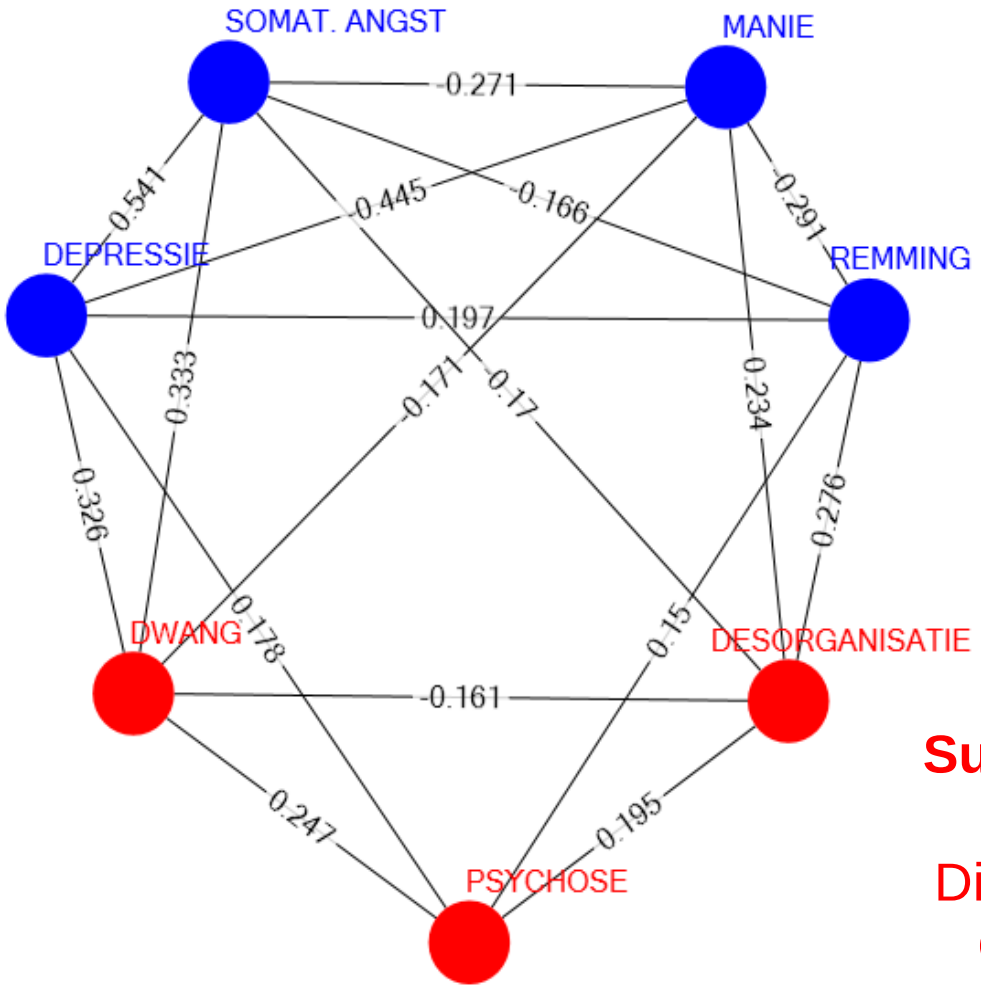
Cluster 2: Disinhibition (mania)

Goekoop R., Serrano M., Goekoop J.G., in preparation

The intrapsychic network (Axis I)

Superclusters (CPRS)

Super-cluster 1:
Depression
Mania,
Anxiety,
Inhibition.



P < 0.01

Super-cluster 2:
Psychosis,
Disorganization,
Compulsion.

Goekoop R., Serrano M., Goekoop J.G., in preparation

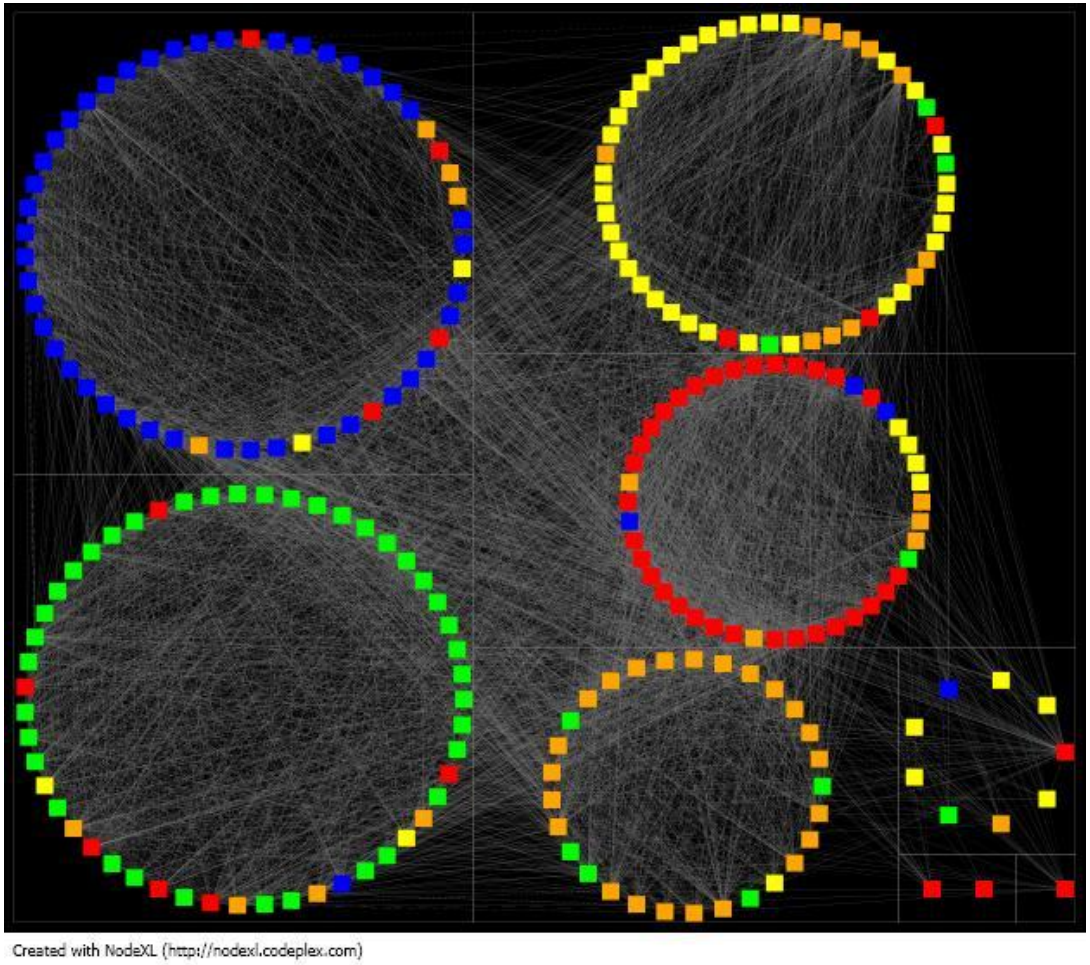
The intrapsychic network (Axis II)

- N = 441.
- Psychology students UvA without personality disorder (Dr. H.S. Scholte, 2008).
- Scored on NEO-PI-R (240 items) en de V-TCI (120 items).
- Bivariate correlational analysis on all itemscores (all correlations between personality characteristics).
- Item = node, significant correlation = link, strenght of correlation = weight of the link (NodeXL).

The intrapsychic network

Personality (NEO-PI-R clusters)

Cluster 1. Conscientious-ness +



Cluster 3: Openness

Cluster 4: Neuroticism +

Cluster 5: Extraversion +

Cluster 6: Agreeableness +

Cluster 2: Agreeableness

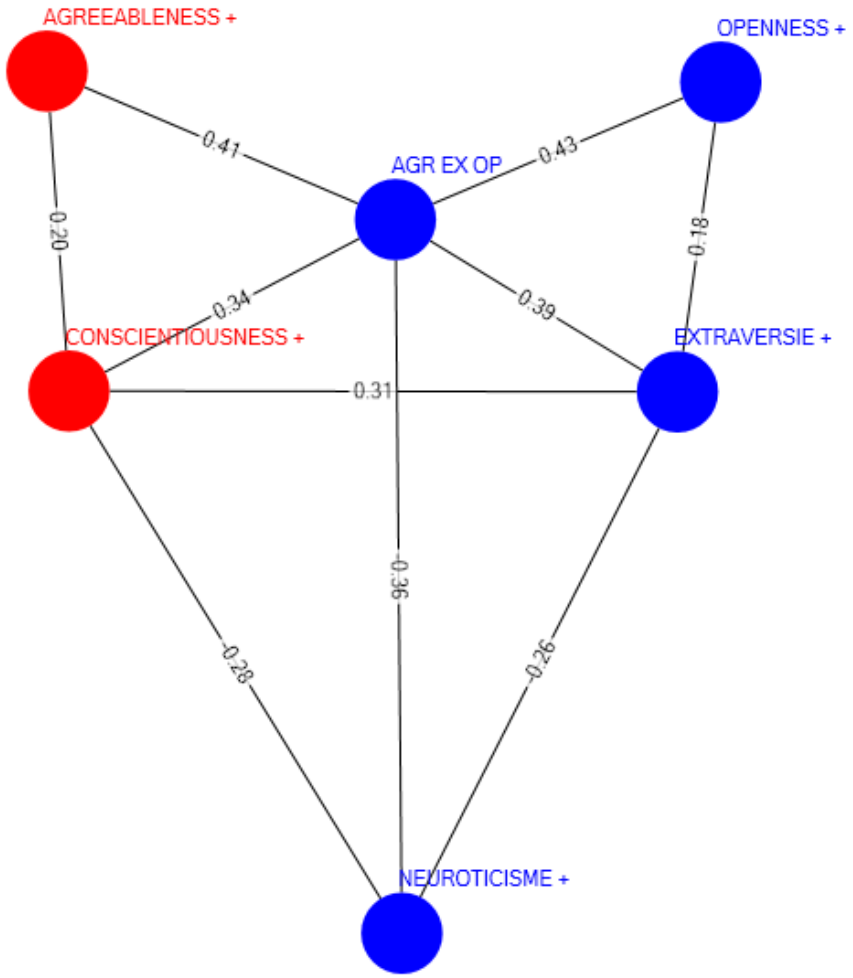
P = 4.59E-04

Goekoop R., Scholte H.S., Goekoop J.G., in preparation

The intrapsychic network

Personality (NEO-PI-R superclusters)

Super-cluster 1: Internalizing



Super-cluster 2: Externalizing

$P < 0.01$

Goekoop R., Scholte H.S., Goekoop J.G., in preparation

The intrapsychic network

Personality (TCI clusters)

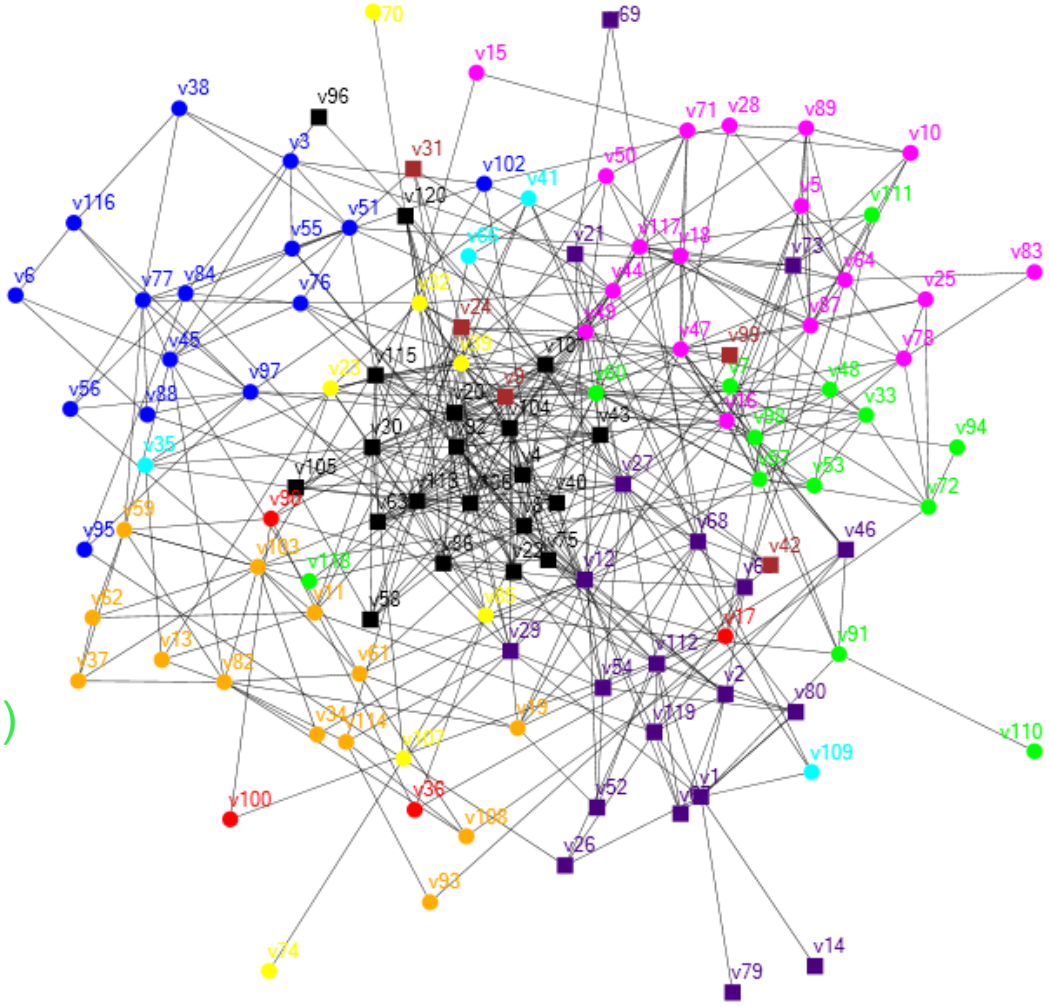
Cluster 1:
True to nature
("Echt-oprecht")

Cluster 2:
Selftransendent
magical thinking

Cluster 3:
Action proneness

Cluster 4:
Orderly and forgiving
("Aardig-rechtvaardig")

Cluster 5:
Benevolent
reward-
dependent
("Lief-naief")



Goekoop R., Scholte H.S., Goekoop J.G., in preparation

Cluster 6:
Self-
directedness
and closure

Cluster 7:
Impressing

Cluster 8:
Approach vs
avoidance

Cluster 9:
Basic
attachment

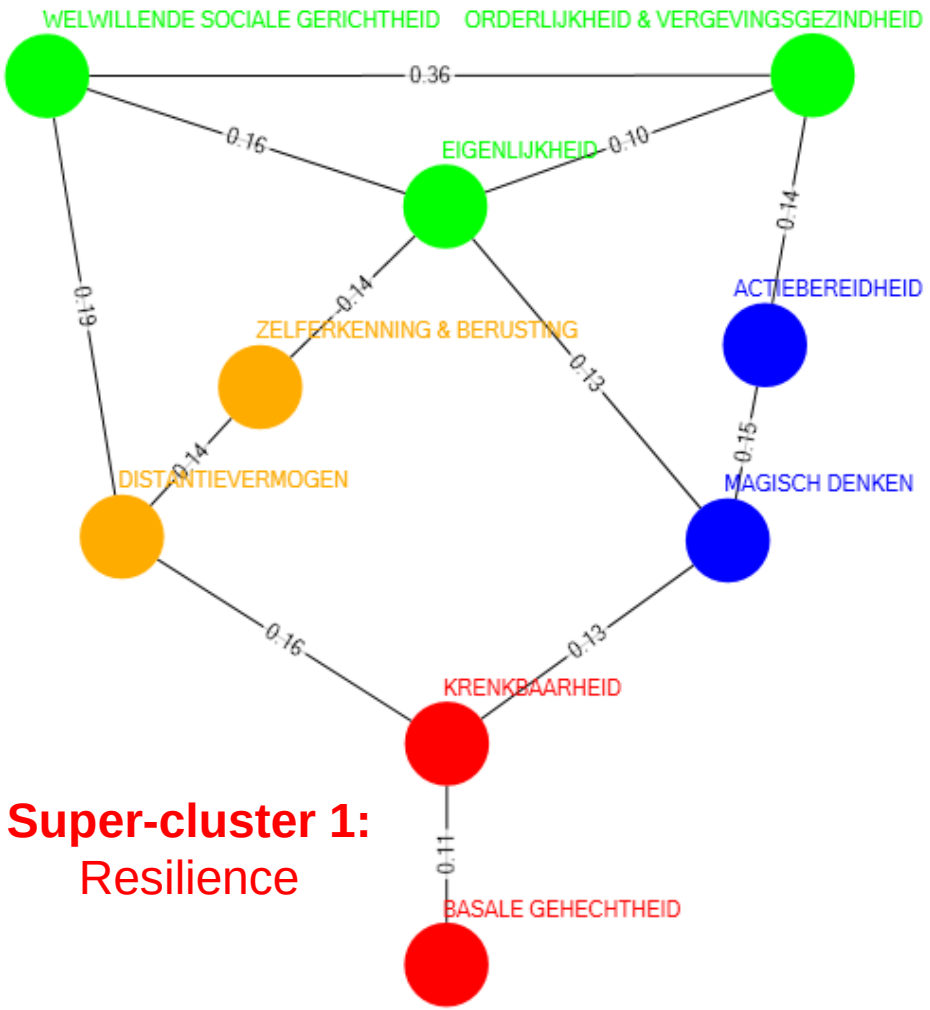
Cluster 10:
Vulnerability

$P < 0.005$

The intrapsychic network

Personality (TCI superclusters)

Super-cluster 4:
Maturity &
Righteousness



Super-cluster 3:
Basic autonomy

Super-cluster 2:
Magic positivism

Super-cluster 1:
Resilience

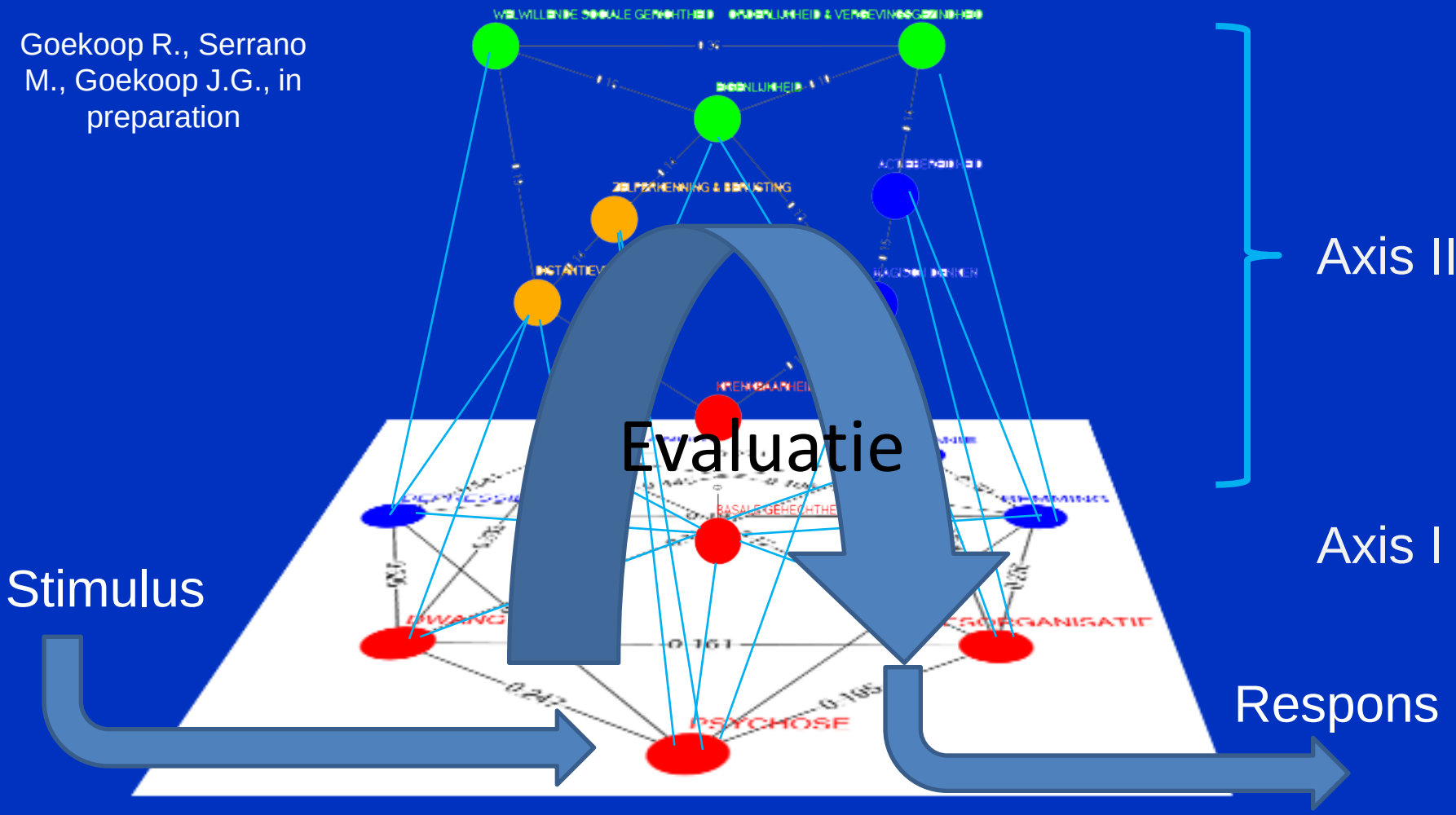
Goekoop R., Scholte H.S., Goekoop J.G., in preparation

$P < 0.05$

The Psyche as a Network

Personality AND psychopathology

Goekoop R., Serrano M., Goekoop J.G., in preparation



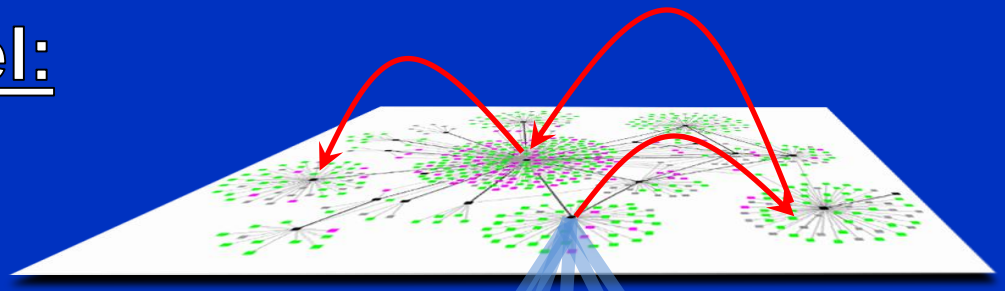
A bio-psycho-social network model

Scale level:

Intervention:

Social

Social Network-analysis

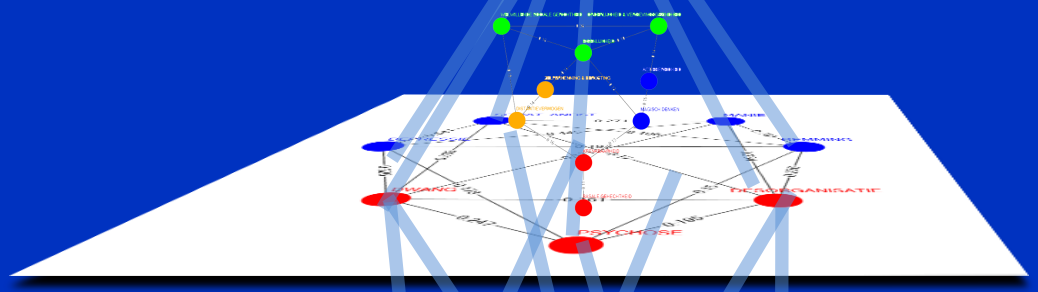


Input Computation Output

Systems therapy

Psycho

Questionnaires



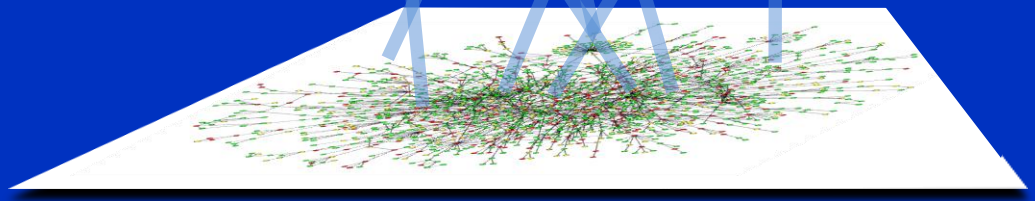
Input Computation Output

Psychotherapy

Bio

EEG

fMRI / Lab



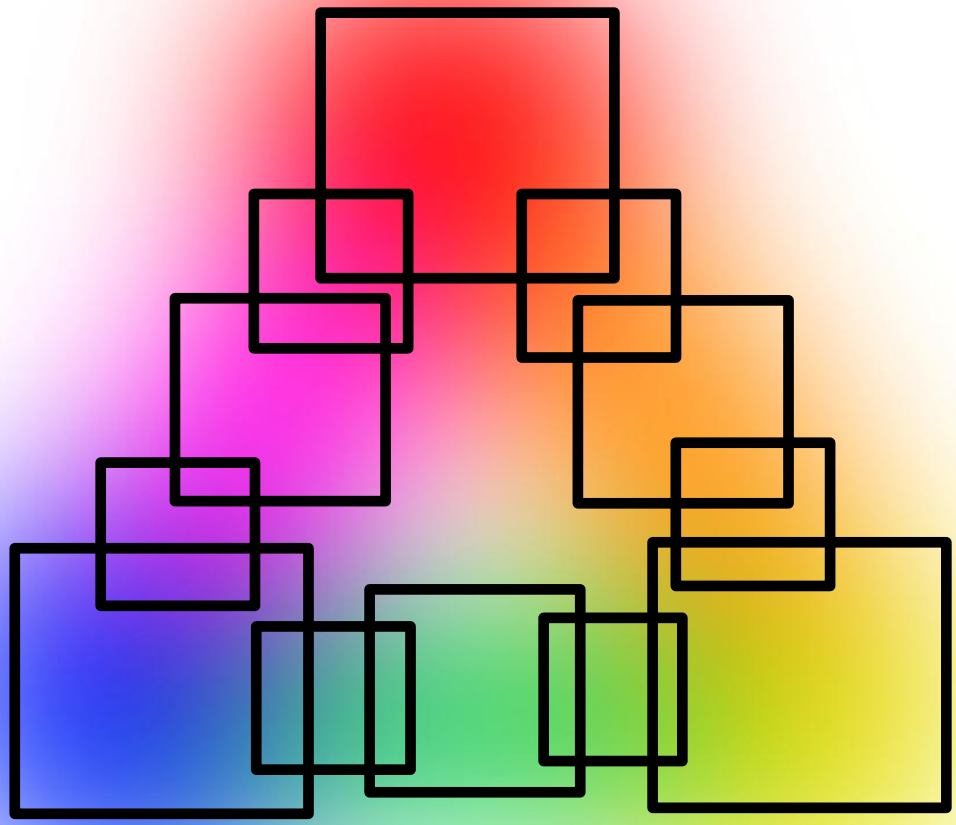
Input Computation Output

Farmacotherapy

Practical Relevance

Description of psychiatric illness

Kraepelin

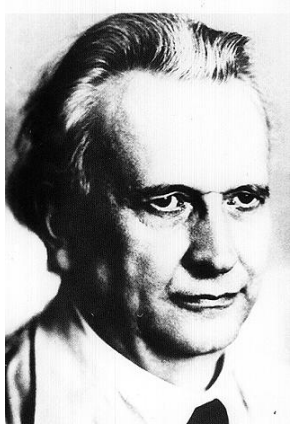


Categorical

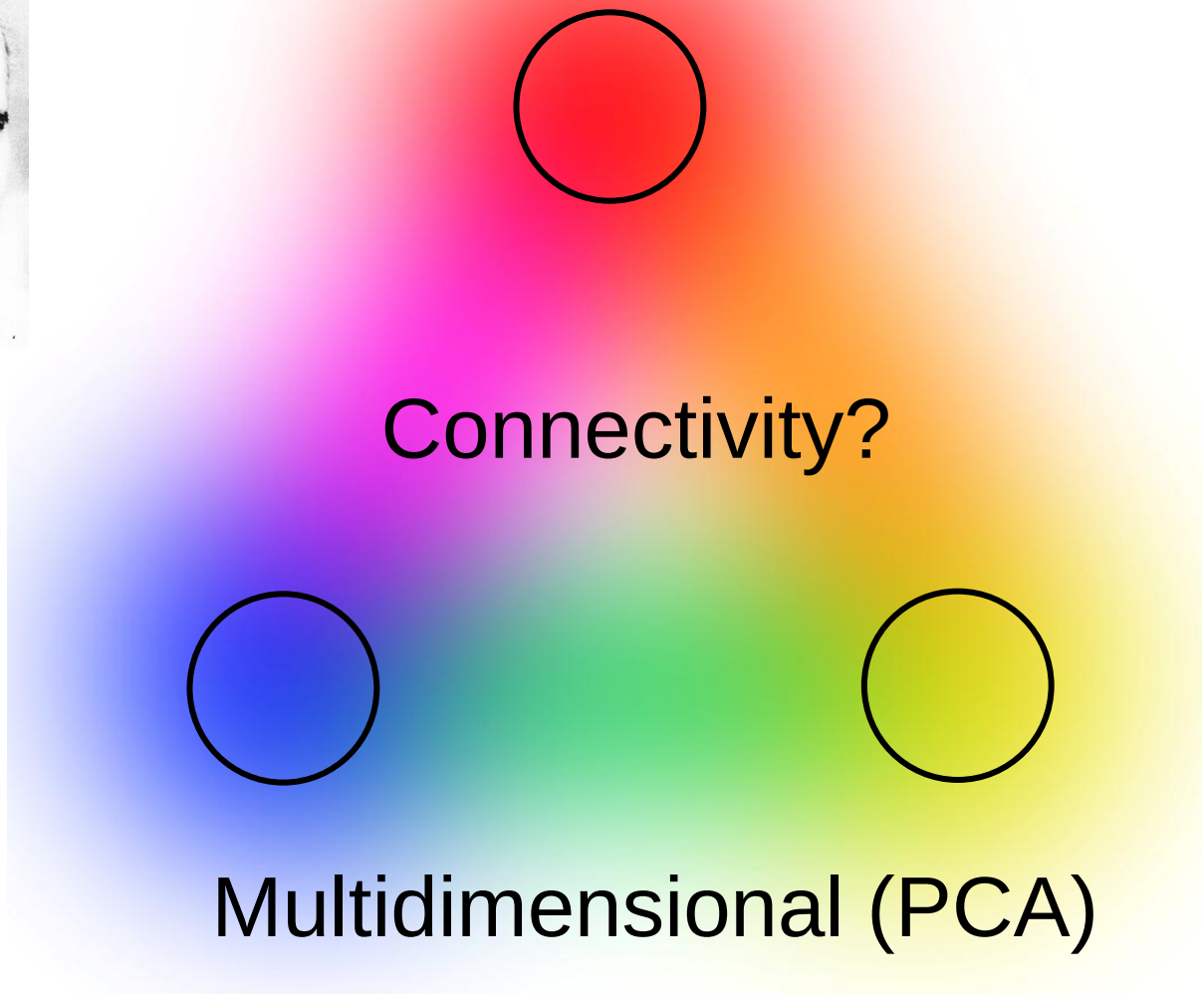
DSM I tot IV

Practical Relevance

Description of psychiatric illness

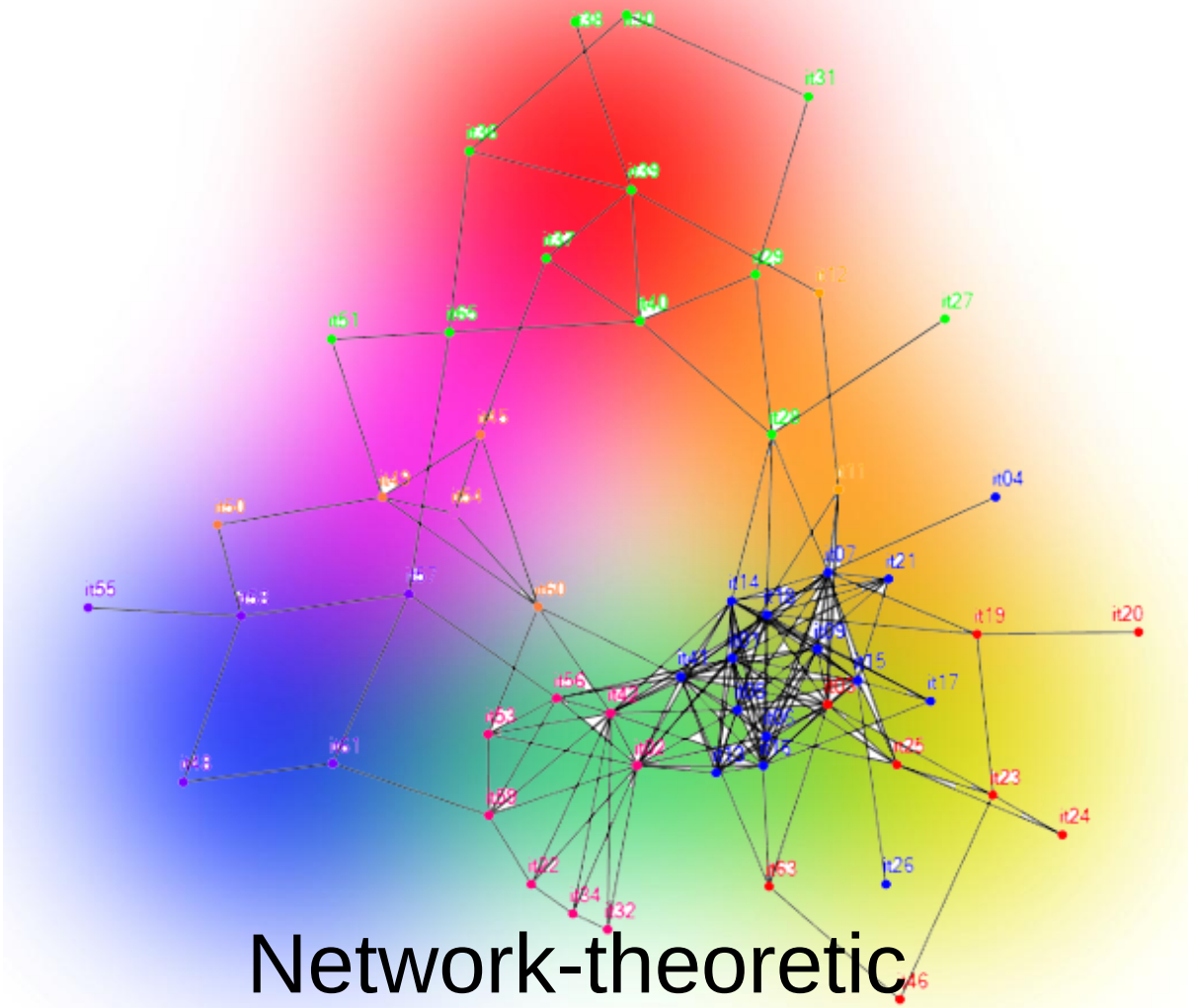


Jaspers



Practical Relevance

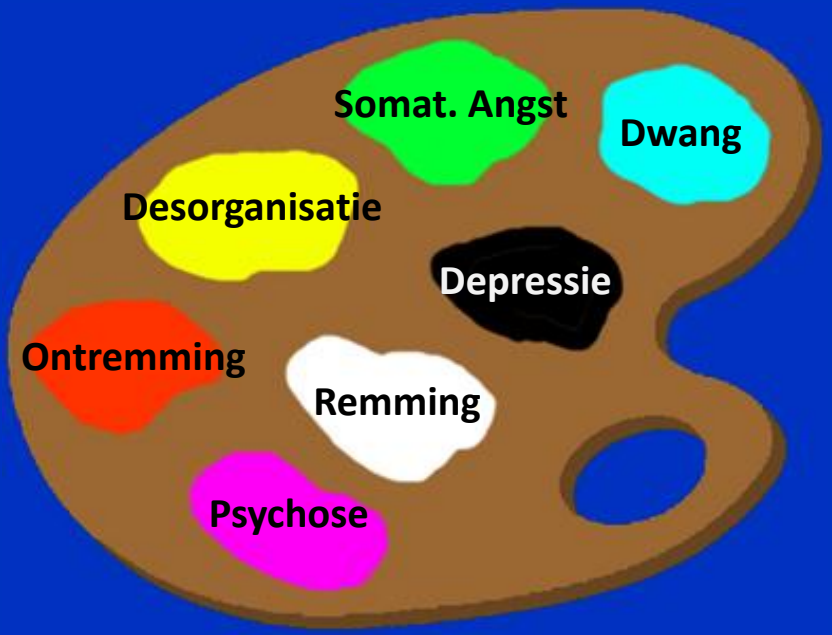
Description of psychiatric illness



Network-theoretic

Practical relevance:
Easy diagnostics

7 “basic colours”
(Clusters)



All Axis I disorders

Easy diagnostics

Profielen van gezondheid

‘Health’

‘Health’

Easy diagnostics

Profielen van gezondheid

Unipolar anxious-inhibited (melancholic) depression

Same, with psychotic features

Easy diagnostics

Profielen van ziekte

Bipolar I

Same, with psychosis

Easy diagnostics

Profielen van ziekte

Psychotic disorder

Same,
With KATATONIA

Easy diagnostics
Snelle anamneses (Triage)

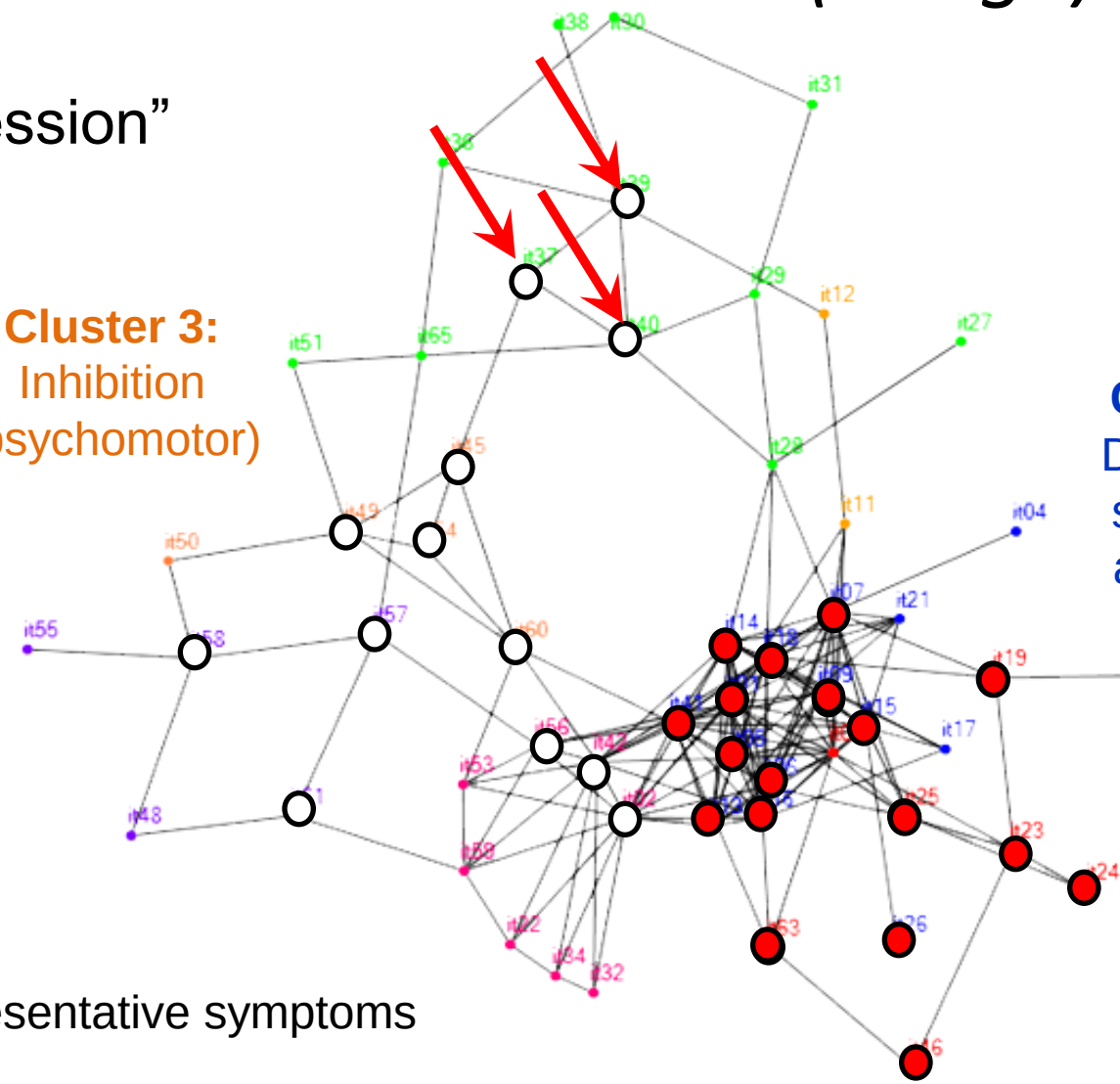
- **NETHERPASS:**
  - **NET**work-based **HE**uristic-**R**ecursive **P**sychopathology **AS**sessment **S**cale.
  - "Network-diagnostics".
- Presence of 21 most representative symptoms is checked in a cluster-by-cluster manner
  - IF no hits: NEXT cluster, etc.
  - Fast, systematic, reliable.
- Ideally suited for triage and R.O.M.

Easy diagnostics

Snelle anamneses (Triage)

Patient 1:

"Vital depression"



Cluster 3: Inhibition (psychomotor)

Cluster 1: Depressive symptoms and anger

Cluster 4: Physical anxiety-equivalents

- Most representative symptoms
- "Hits"

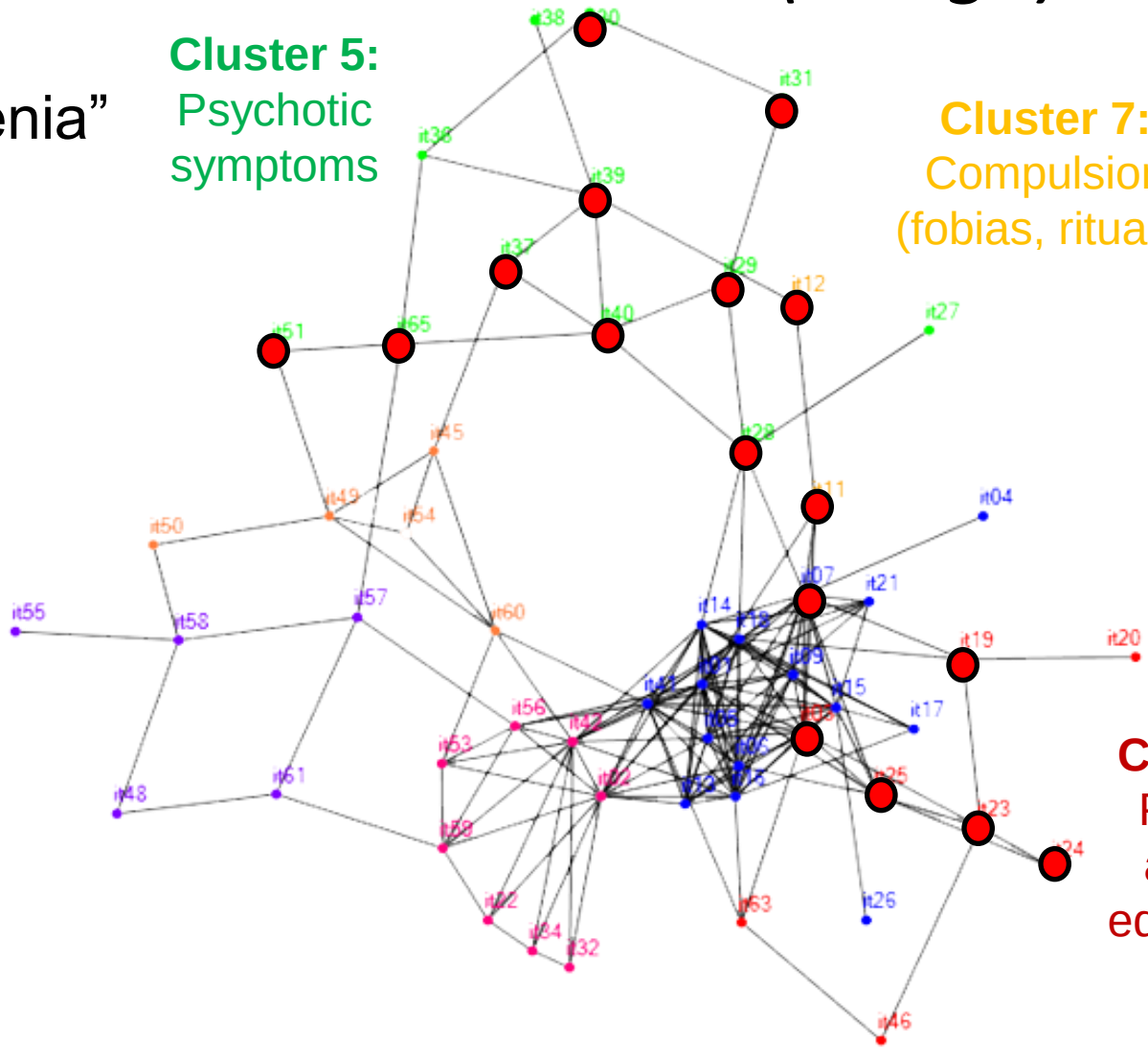
Easy diagnostics

Snelle anamneses (Triage)

Patient 2:
"Schizophrenia"

Cluster 5:
Psychotic symptoms

Cluster 7:
Compulsion (fobias, rituals)



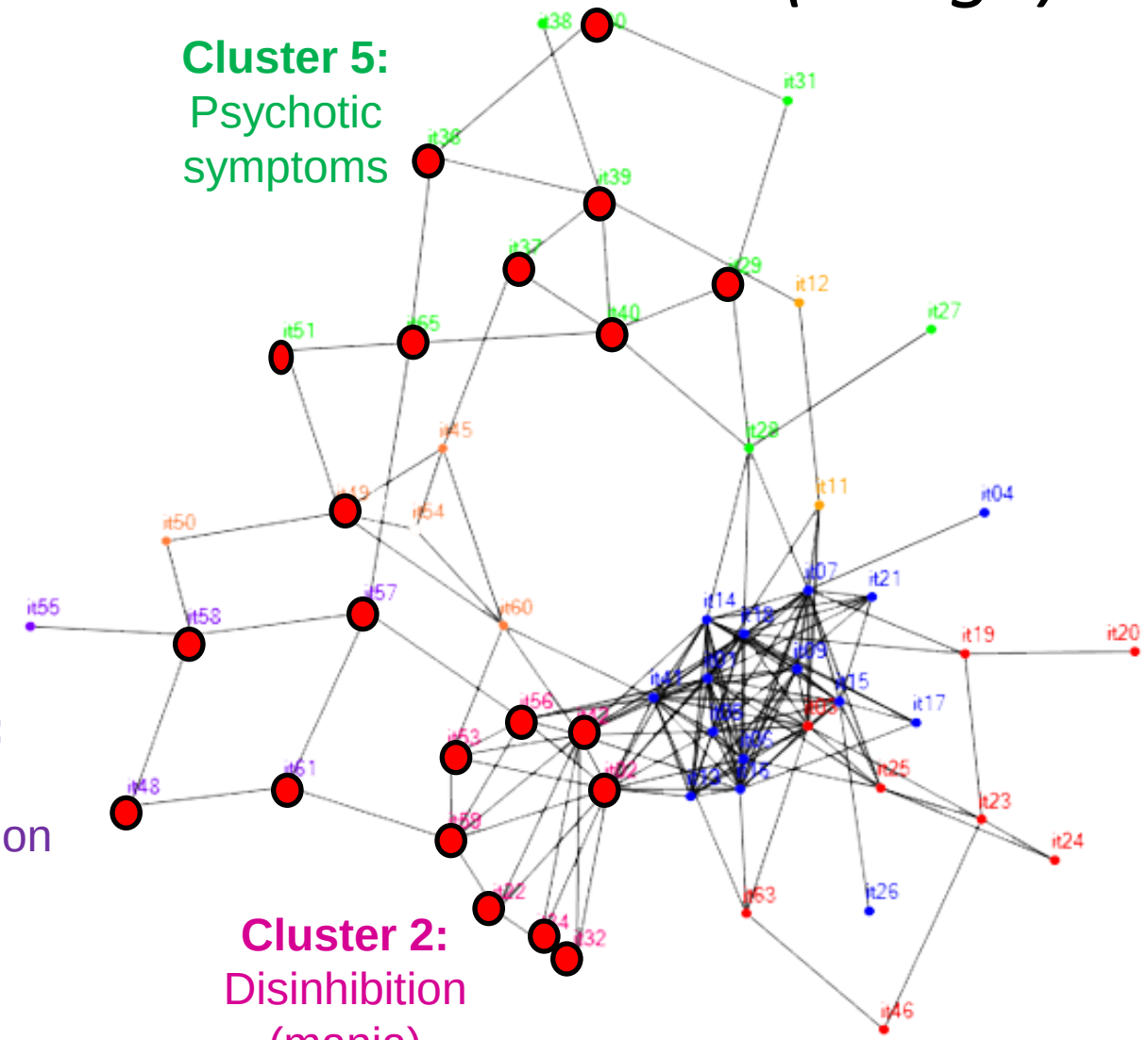
Cluster 4:
Physical anxiety-equivalents

"Hits"

Easy diagnostics

Snelle anamneses (Triage)

Patient 3:
"Manic psychosis"



Cluster 5:
Psychotic symptoms

Cluster 6:
Motor disorganisation

Cluster 2:
Disinhibition (mania)

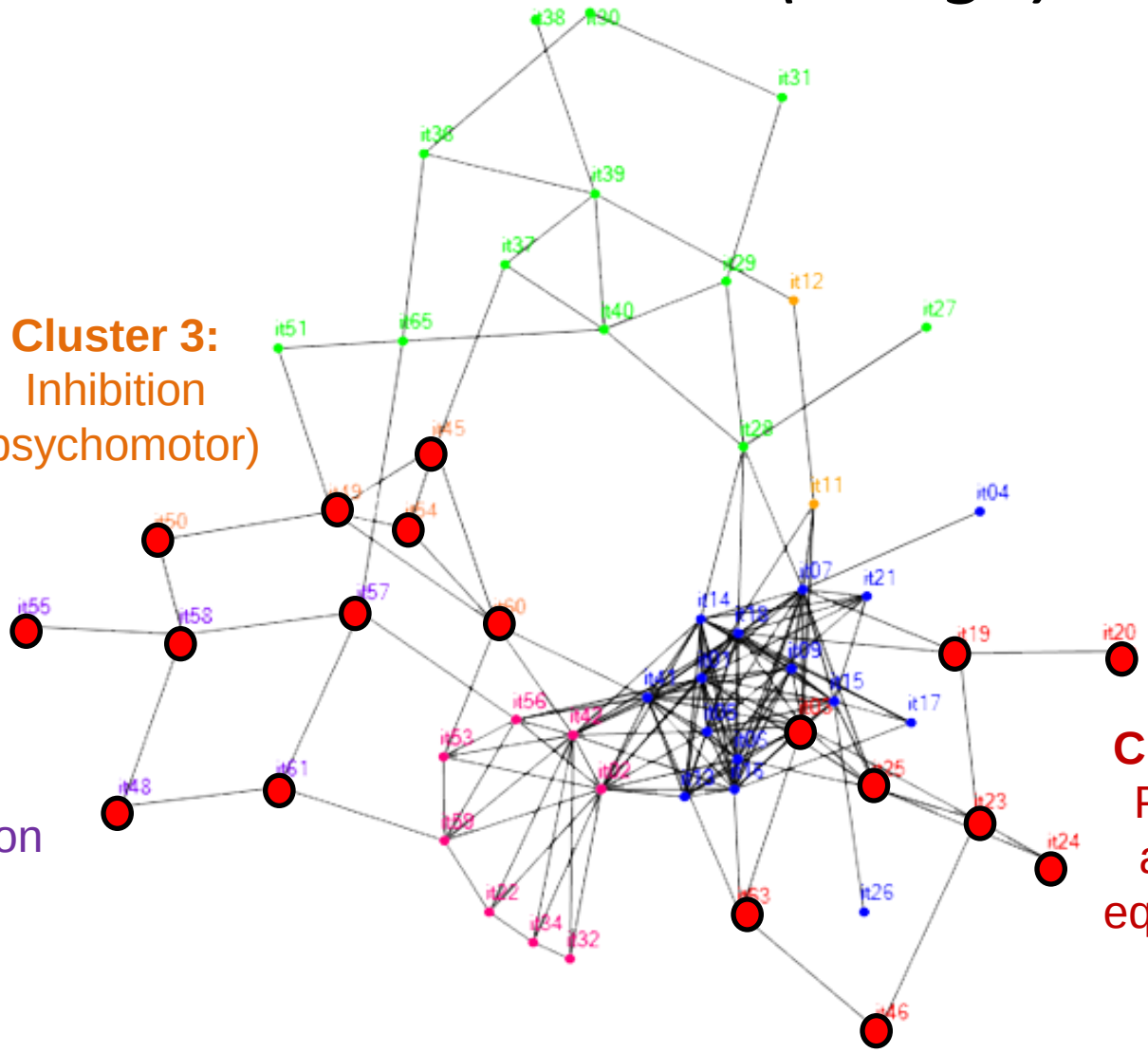
"Hits"

Easy diagnostics

Snelle anamneses (Triage)

Patient 4:

"Katatonia"



Cluster 3: Inhibition (psychomotor)

Cluster 6: Motor disorganisation

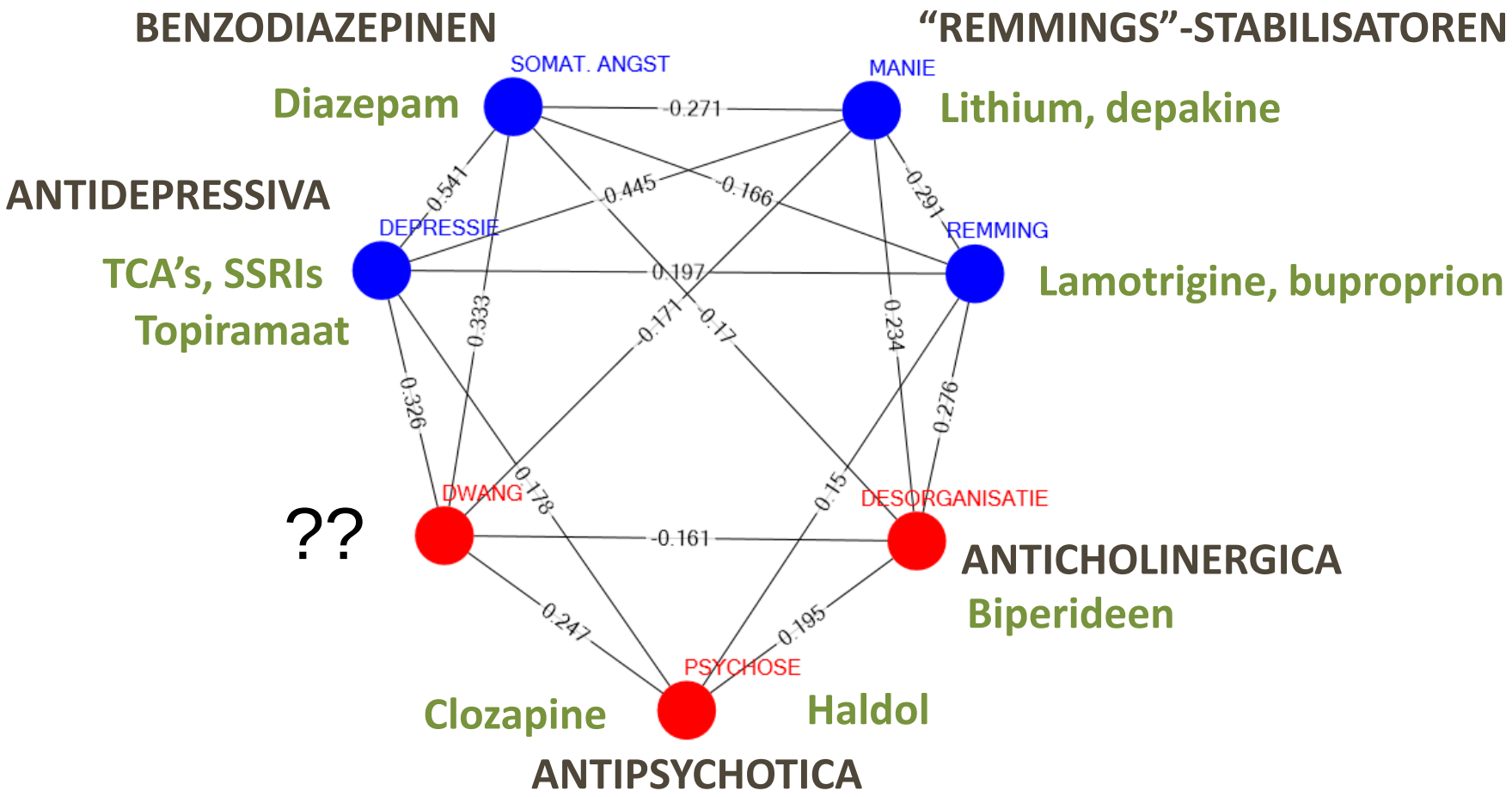
Cluster 4: Physical anxiety-equivalents

"Hits"

Easy farmacotherapy?

Classes of medication

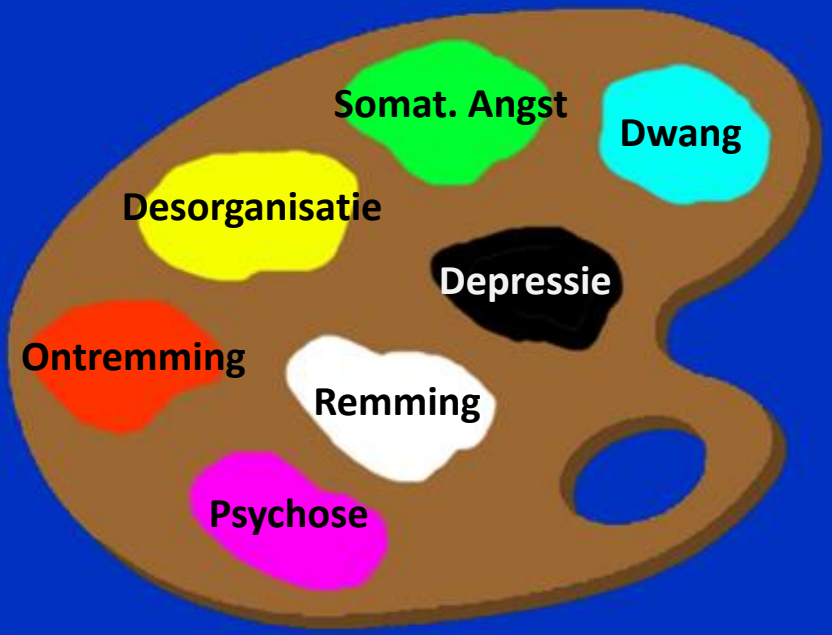
As I: 7 hoofdclusters. 7 typen farmacotherapie nodig?



Practical relevance

Routine Outcome Monitoring

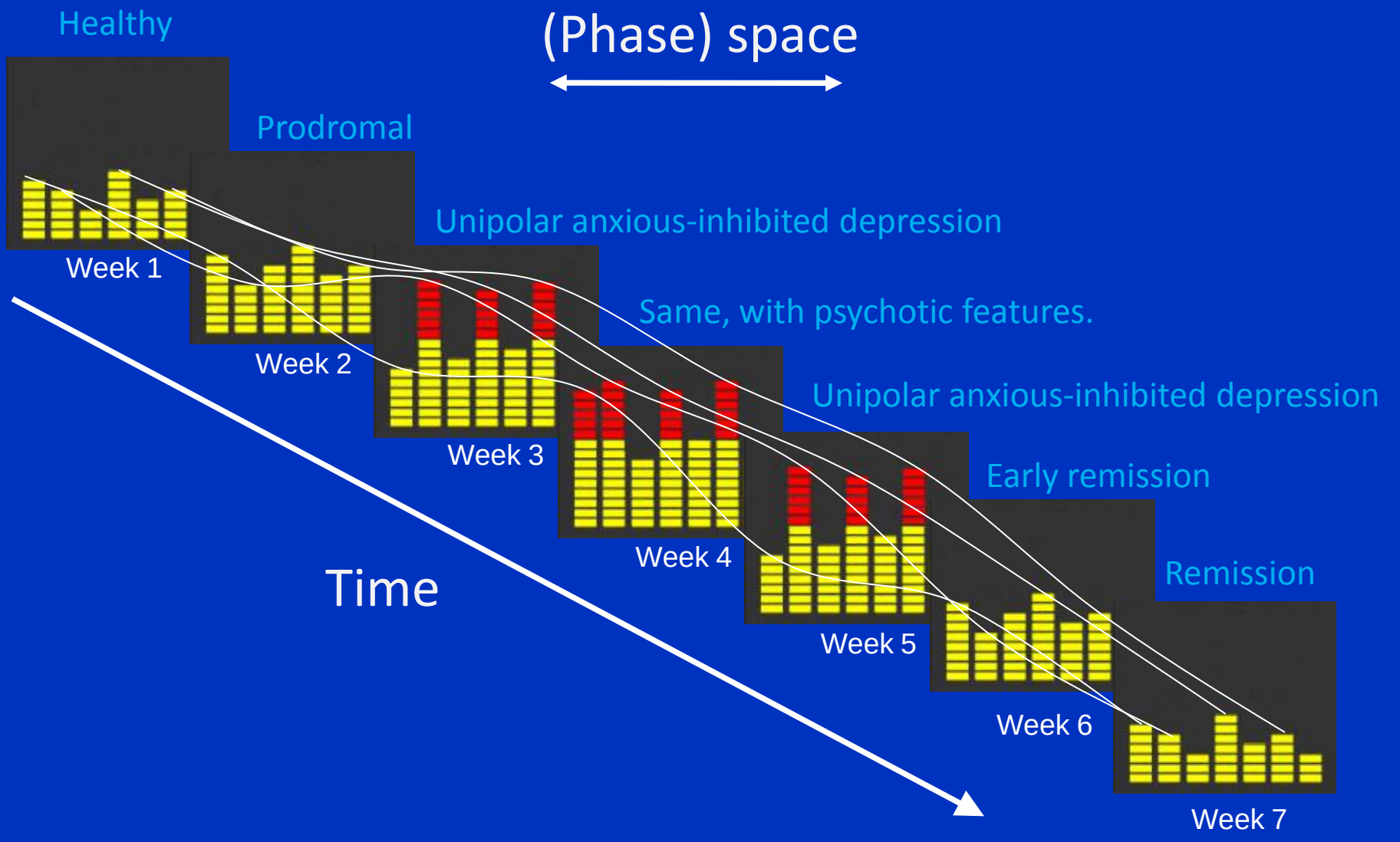
7 “primary colours” (Clusters)



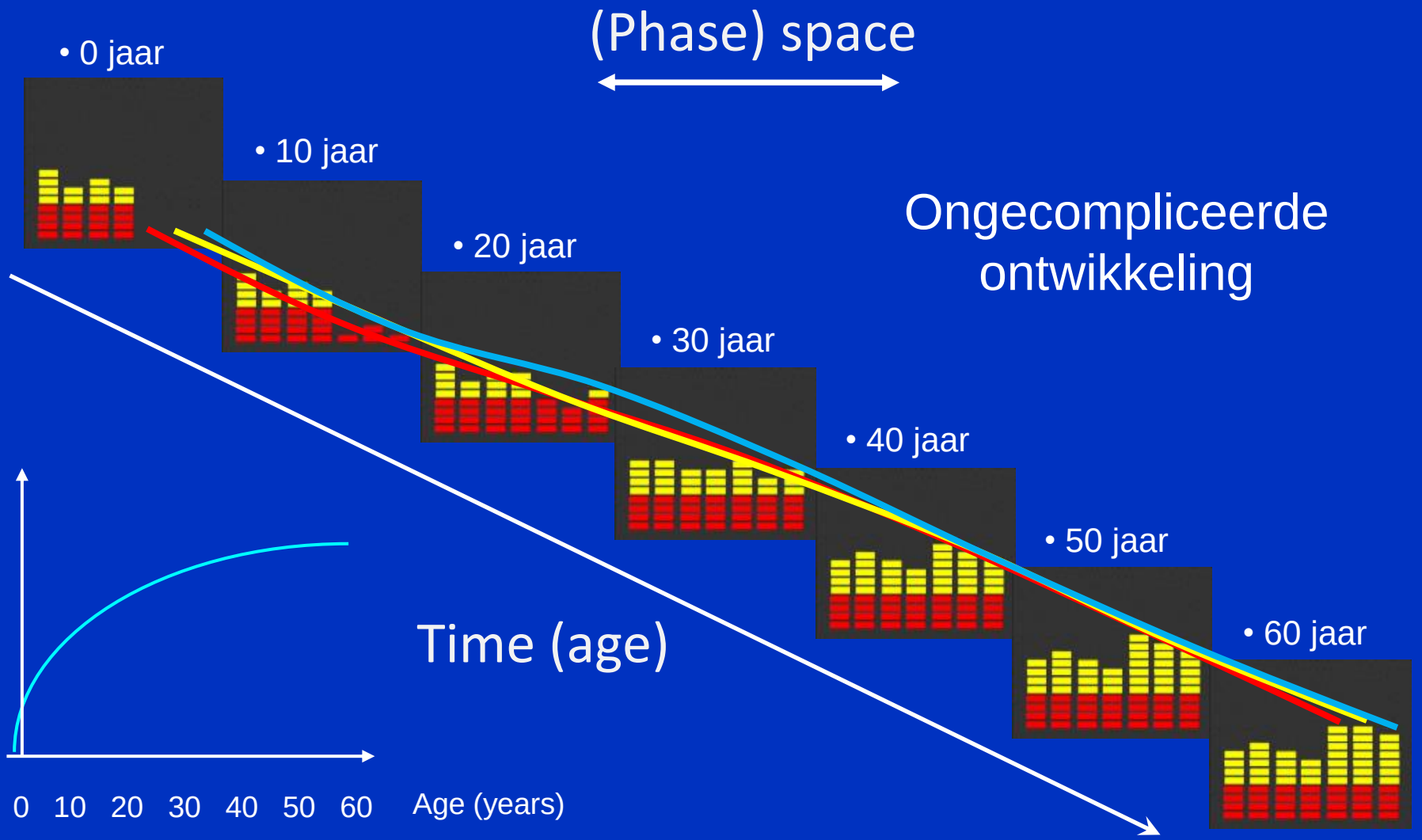
All acute disorders

…. changes in TIME.

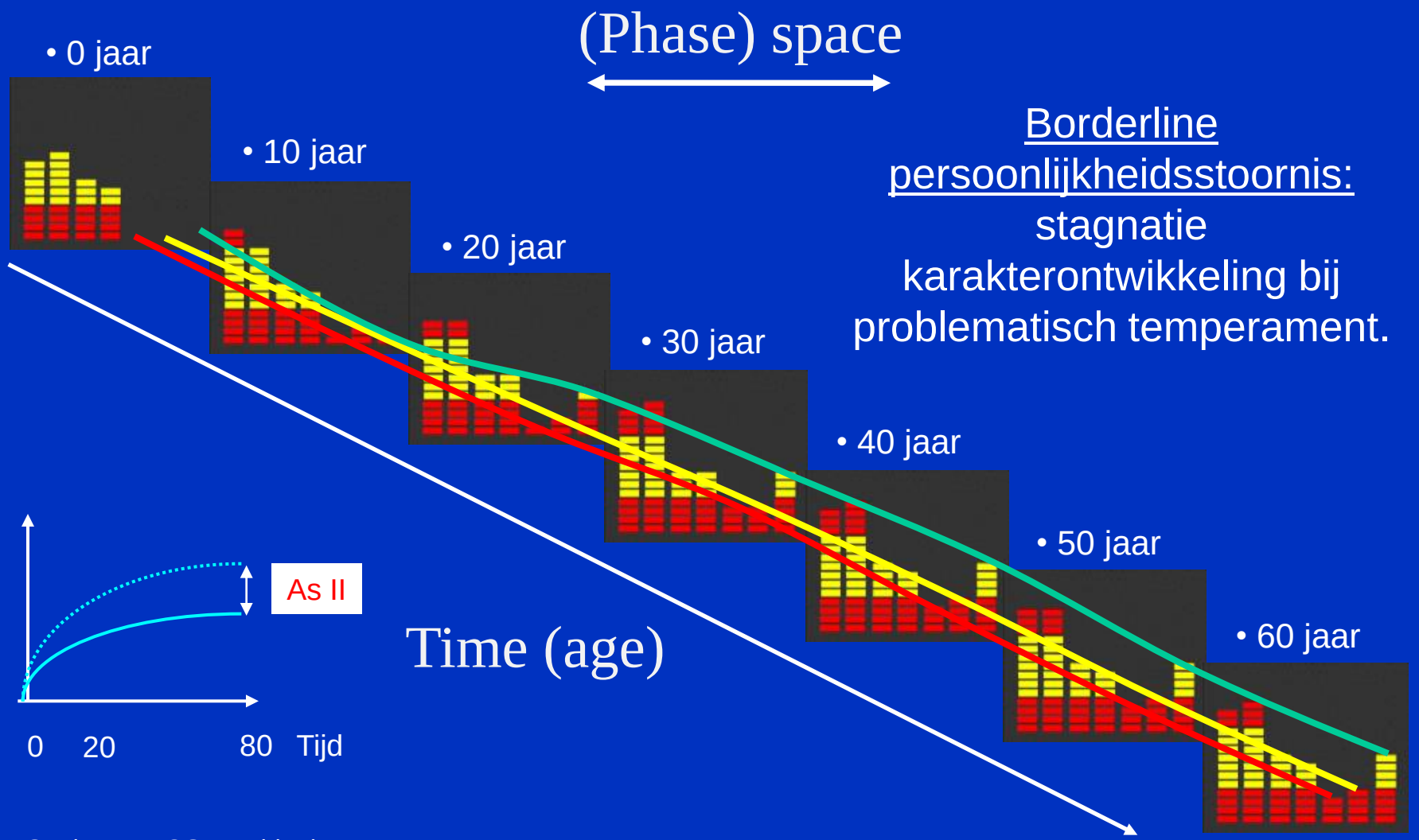
Routine Outcome Monitoring



Routine Outcome Monitoring



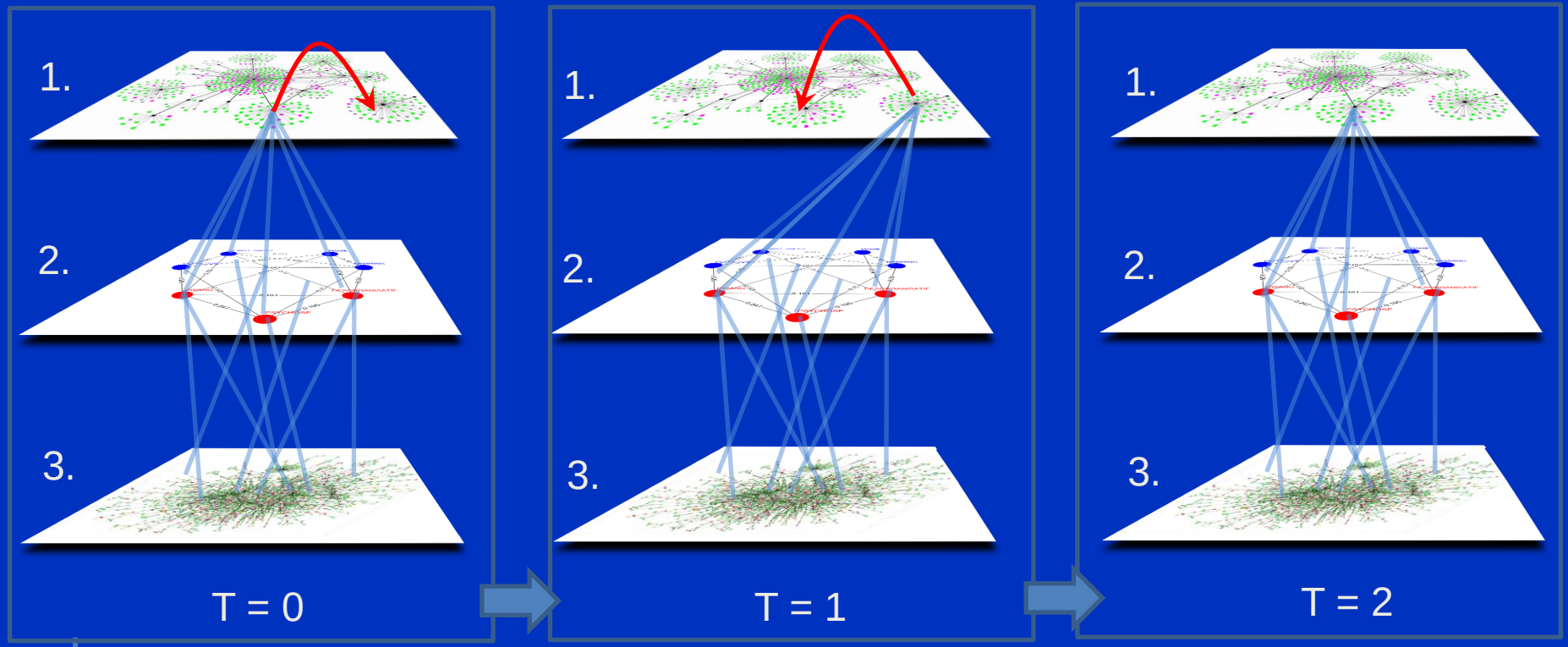
Routine Outcome Monitoring

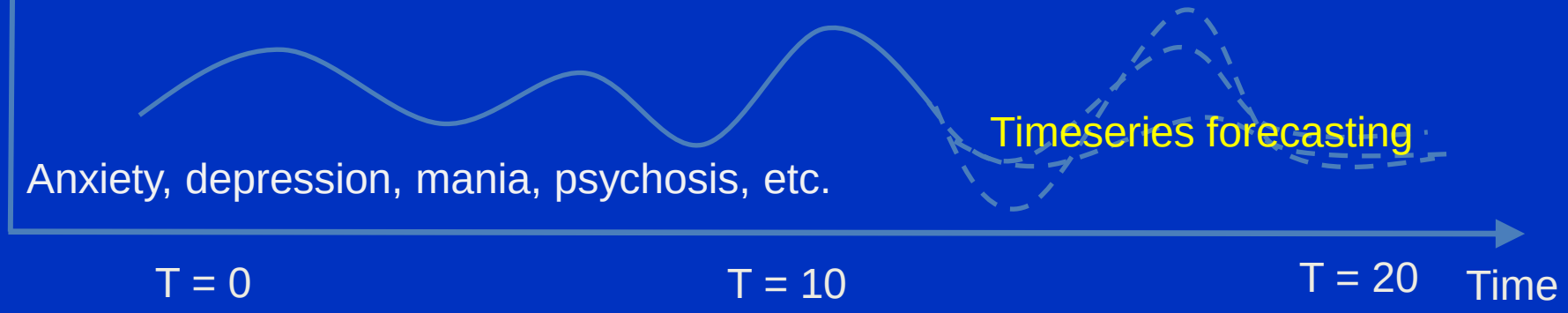


Borderline persoonlijkheidsstoornis:
stagnatie karakterontwikkeling bij problematisch temperament.

Routine Outcome Monitoring

A bio-psycho-social network model





Practical Relevance

Network ROM: *Predictive Psychiatry*

Biopsychosociale profielen

Social
- Getrouwd
- Werkend
- Ouderschap
- Conflicten
- …..

Psycho
- Angstig
- Geremd
- Depressief
- Boos
- Psychotisch
- As II
- ….

Bio
- Cortisol
- AVP
- Astma
- Genetica
- ….

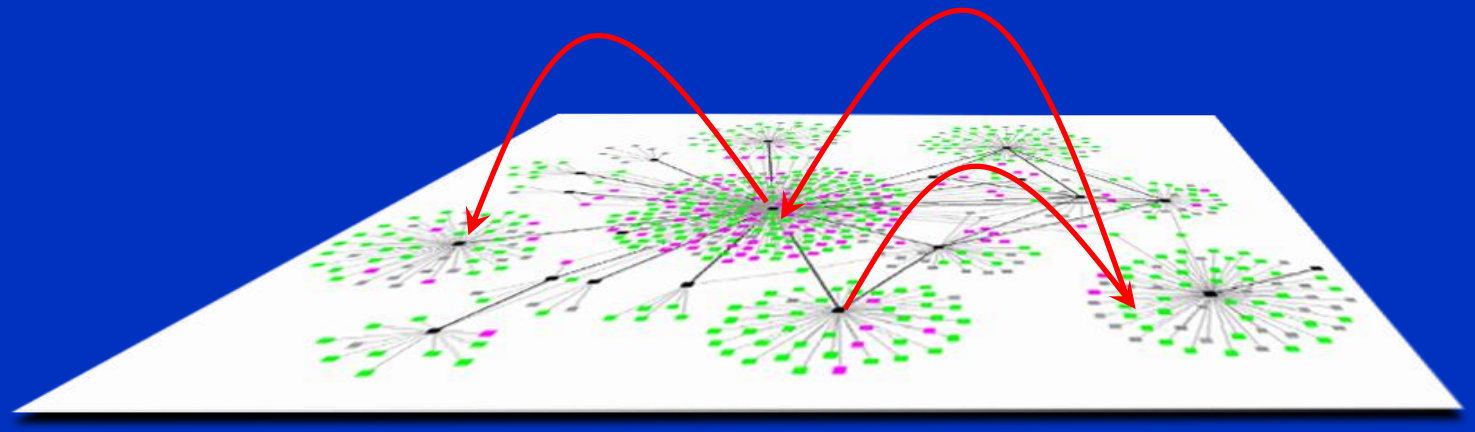
sense Observation Systems

- Natuurlijk beloop
- Respons op interventie

Predictie

Alan Turing Institute Almere
multidisciplinary health research

Predicting Optimal Social Niches



"*Walking along* with patients in the search for their optimal social niches".

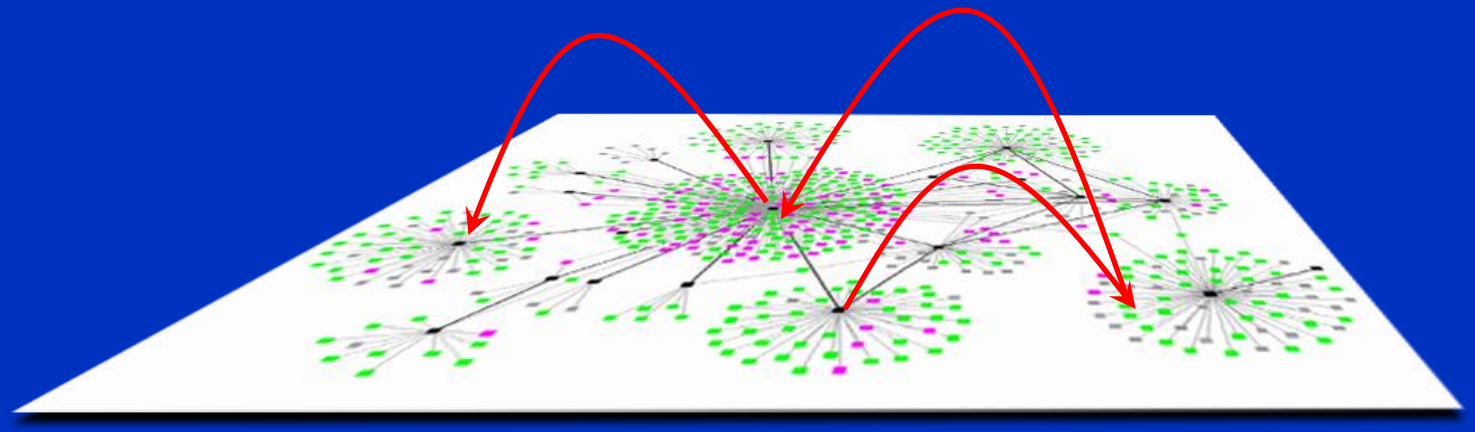
"Helping patients to find a pleasant, fulfilling and suitable place to live".

“Fitness” in psychiatry

- “Not fitting in”.
- (Temporally) unable to fulfill social roles.
  - Job / Work
  - Partner / Marriage
  - Father / Mother
- Social stigma, fear of social isolation.
- “That part of clinical medicine that concerns impairments of social functioning”

Predictive Psychiatry

Novel outcome measures

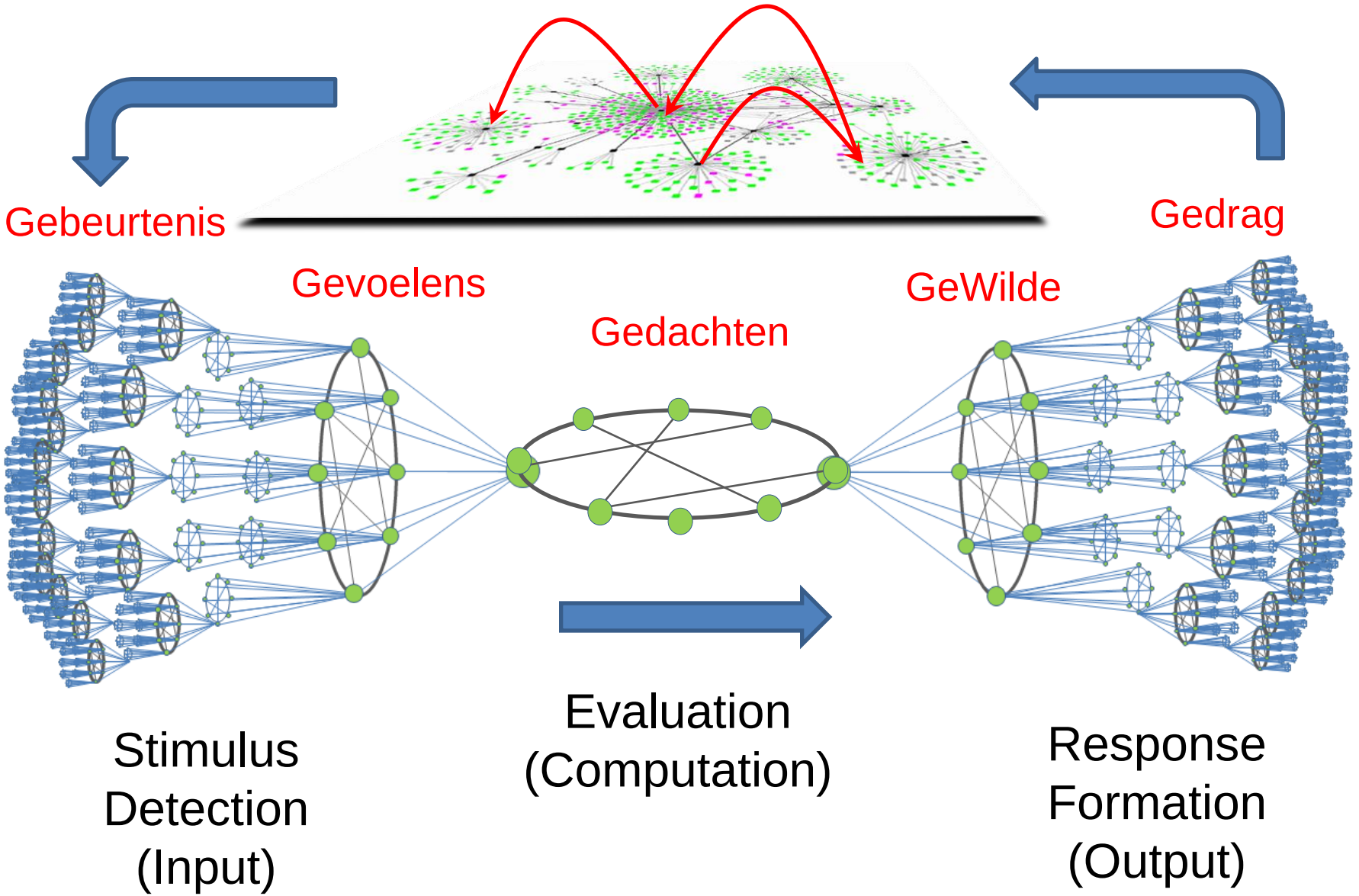


Fitness:

The degree to which a node fits a particular (social) network context (considering its intra-node characteristics, e.g. personality):

Fitness (η): $\Pi(k) \sim \eta k; \quad k(t) \sim t^{\eta a}$

Relevance to CGT

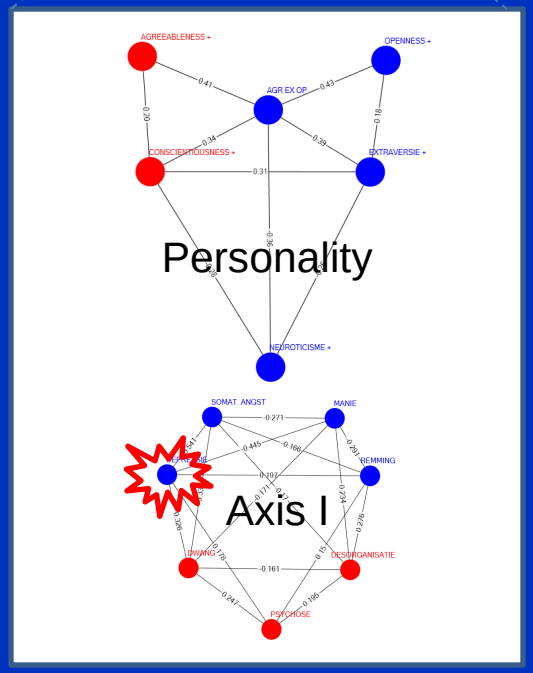


Relevance to IPT

Grief

Social network (Sociogram)

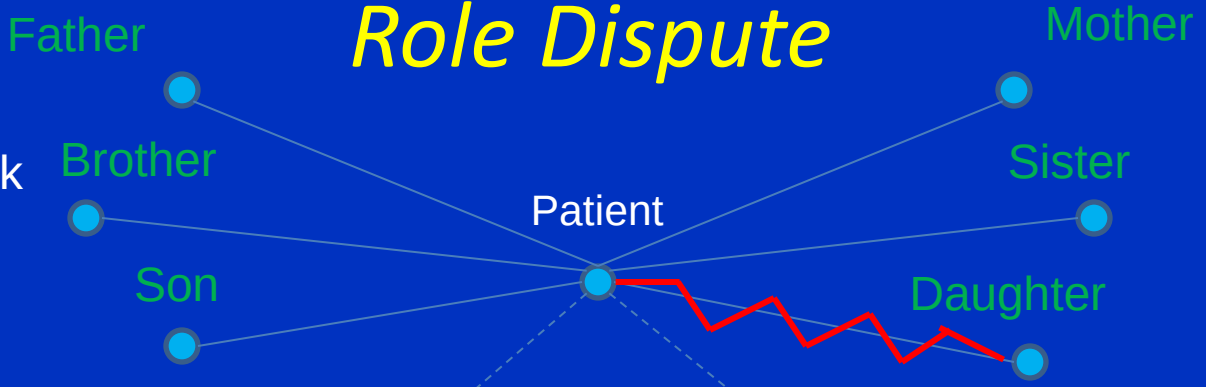
Personality & psychopathology network



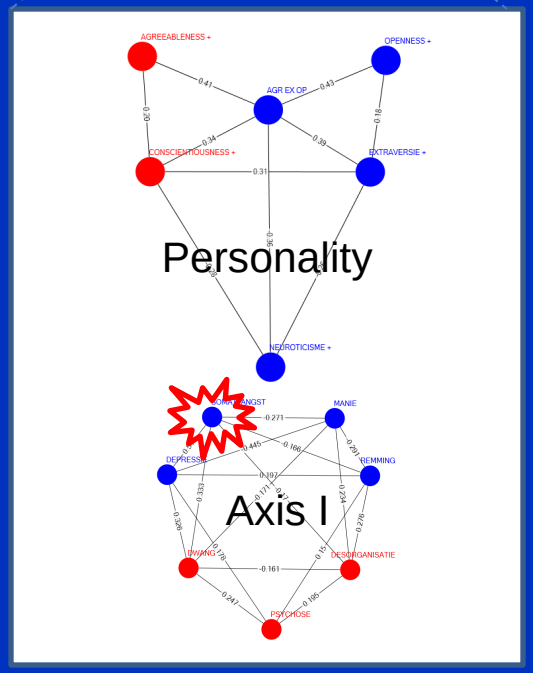
Relevance to IPT

Role Dispute

Social network (Sociogram)



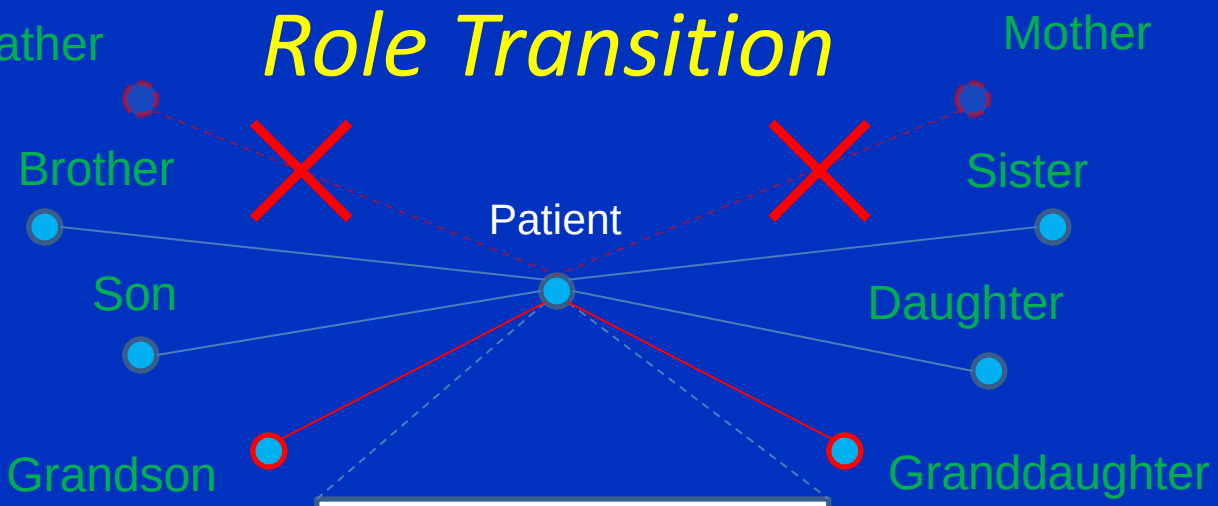
Personality & psychopathology network



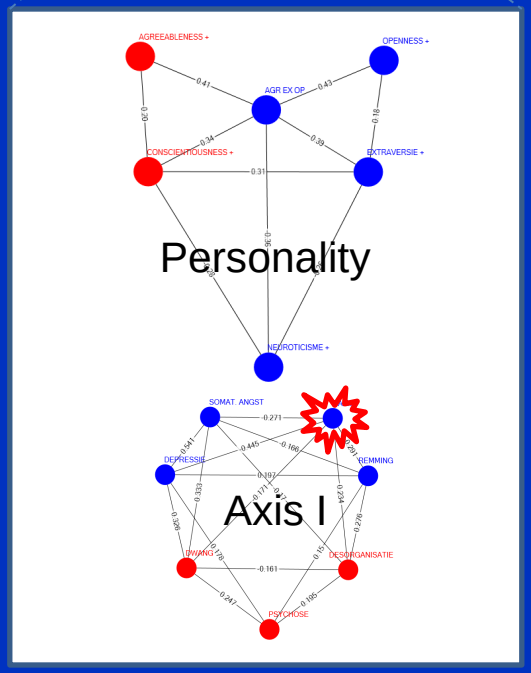
Relevance to IPT

Role Transition

Social network (Sociogram)



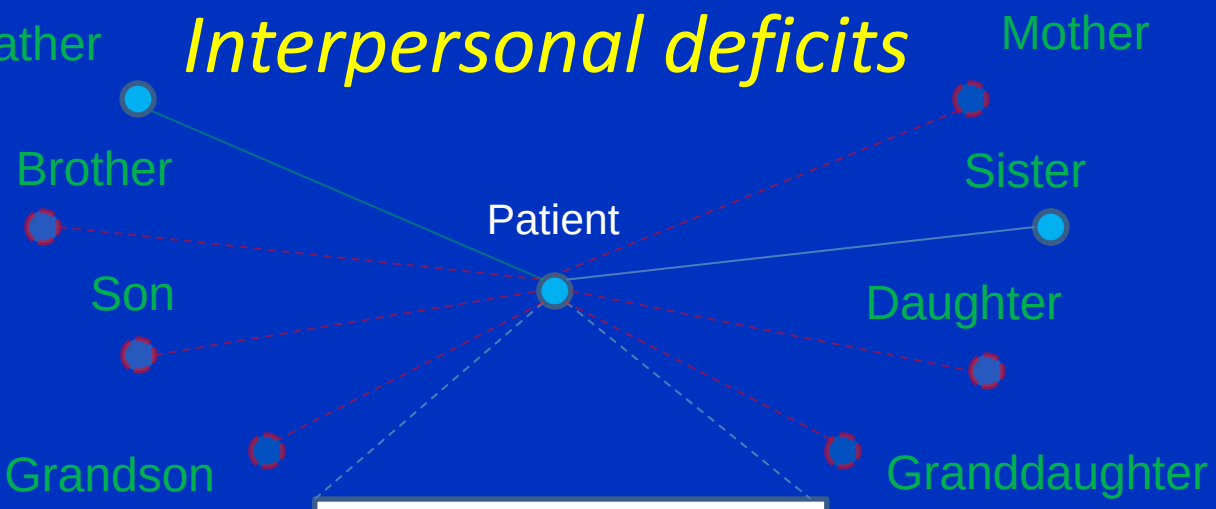
Personality & sychopathology network



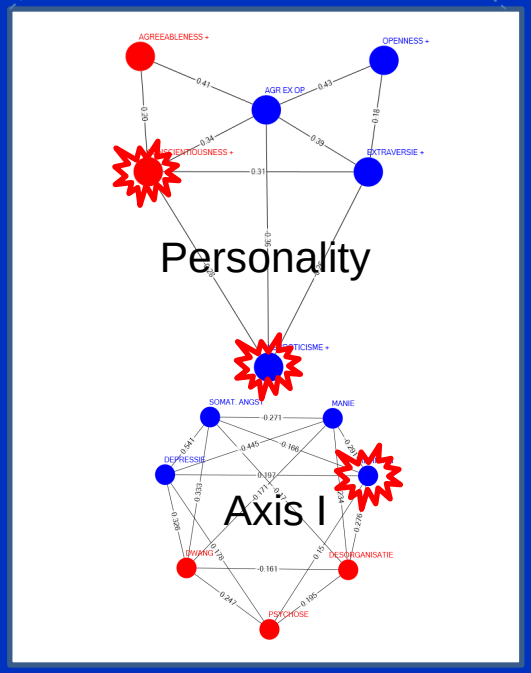
Relevance to IPT

Interpersonal deficits

Social network (Sociogram)

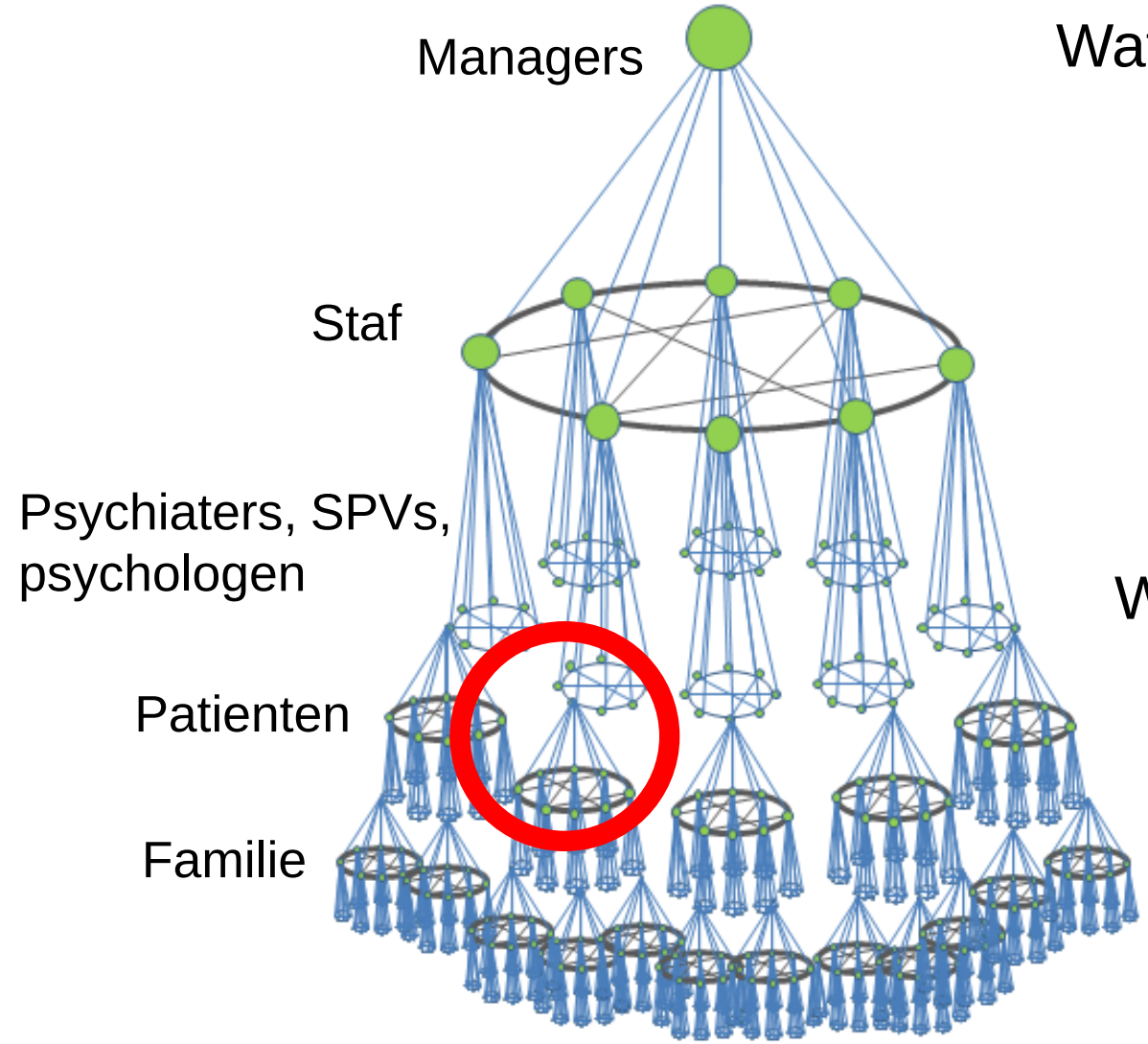


Personality & psychopathology network

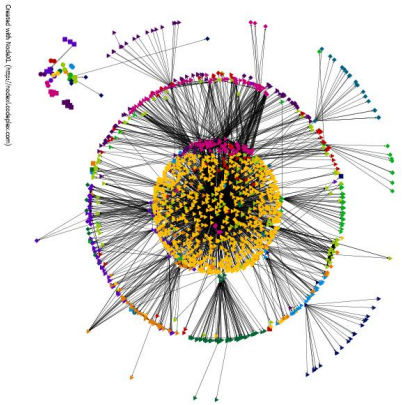


Relevance to management:

Het behandelteam



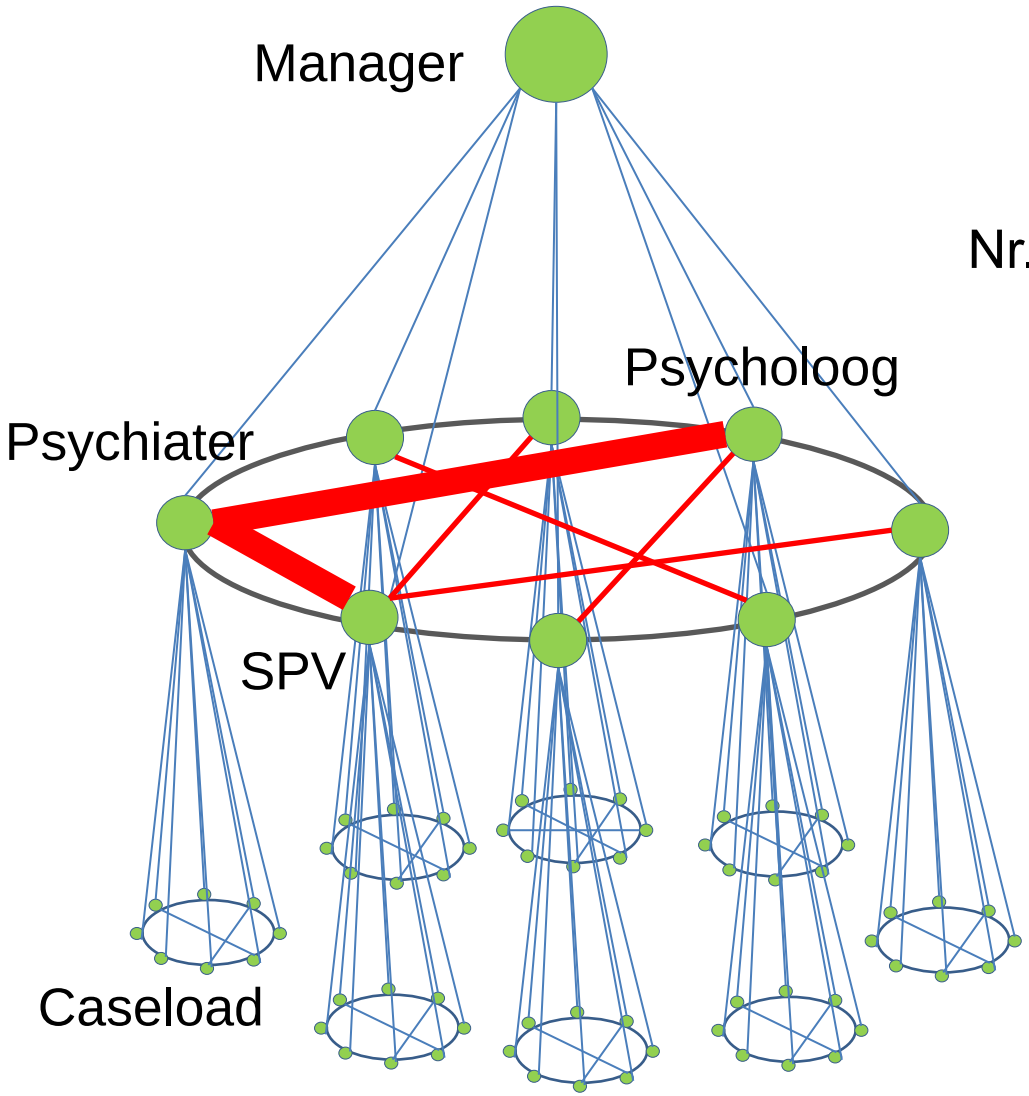
Wat is de netwerkstructuur?



Wat is de netwerkfunctie?

“Patienten (snel) beter maken”

Relevance to management



Nr. Nodes, Nr. links, “weight”

Netwerkstructuur

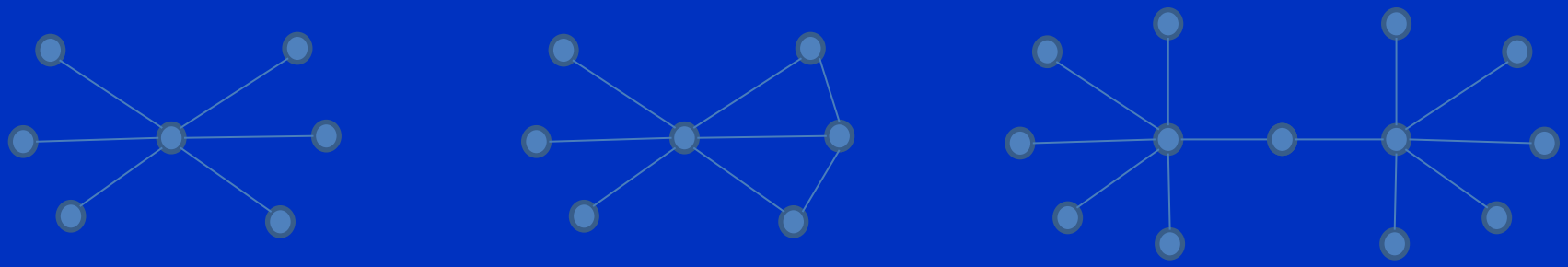
P < 0.05?

Depressie

R.O.M.

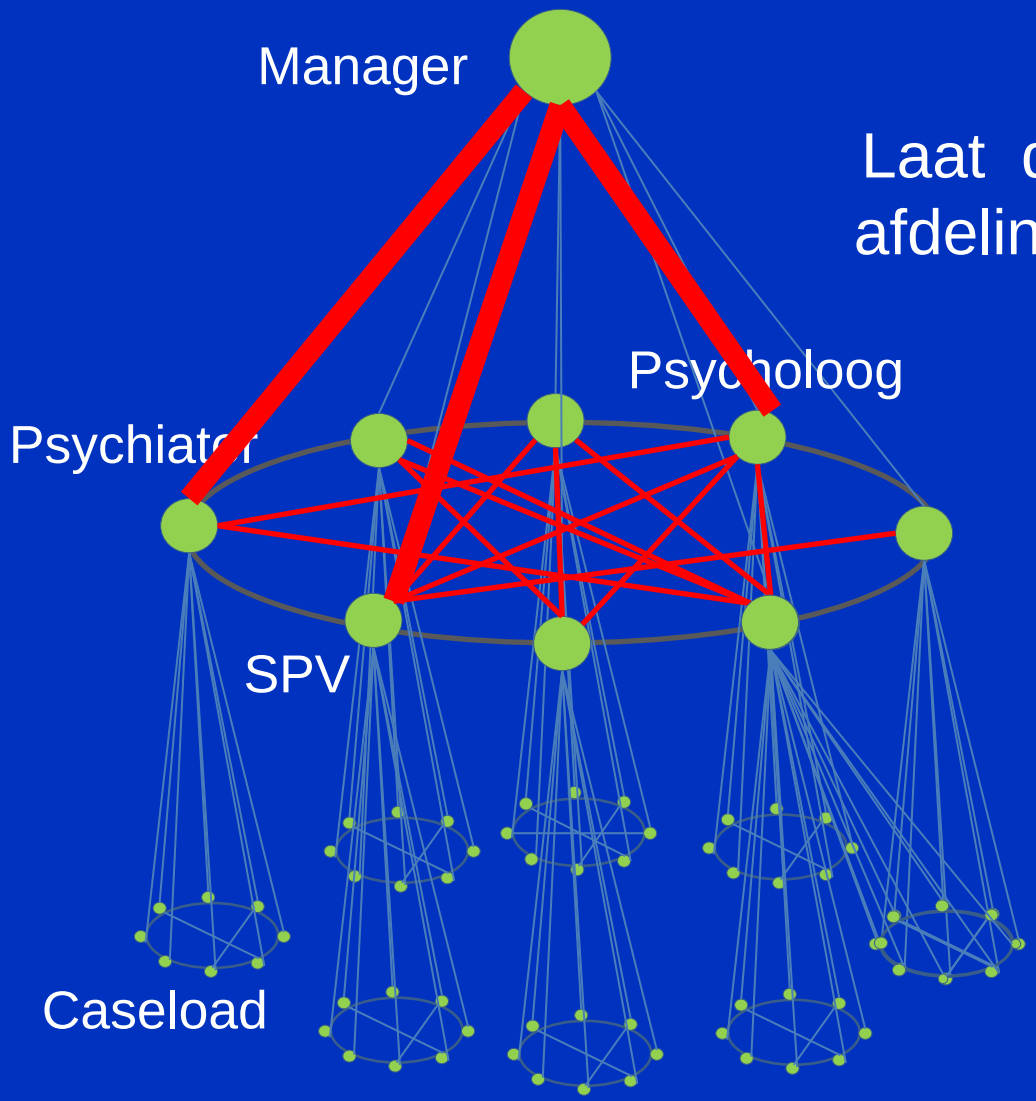
Nieuwe uitkomstmaten

- Degree, transivity, centrality.

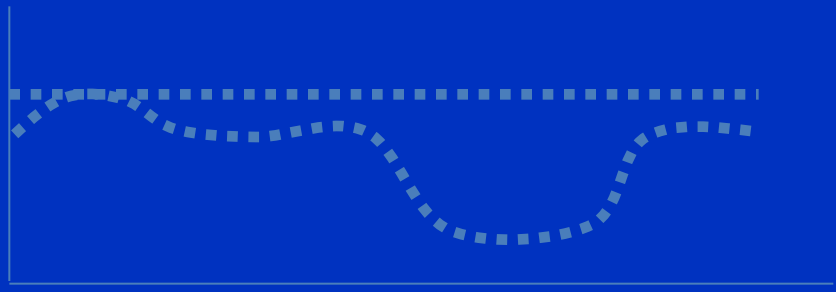


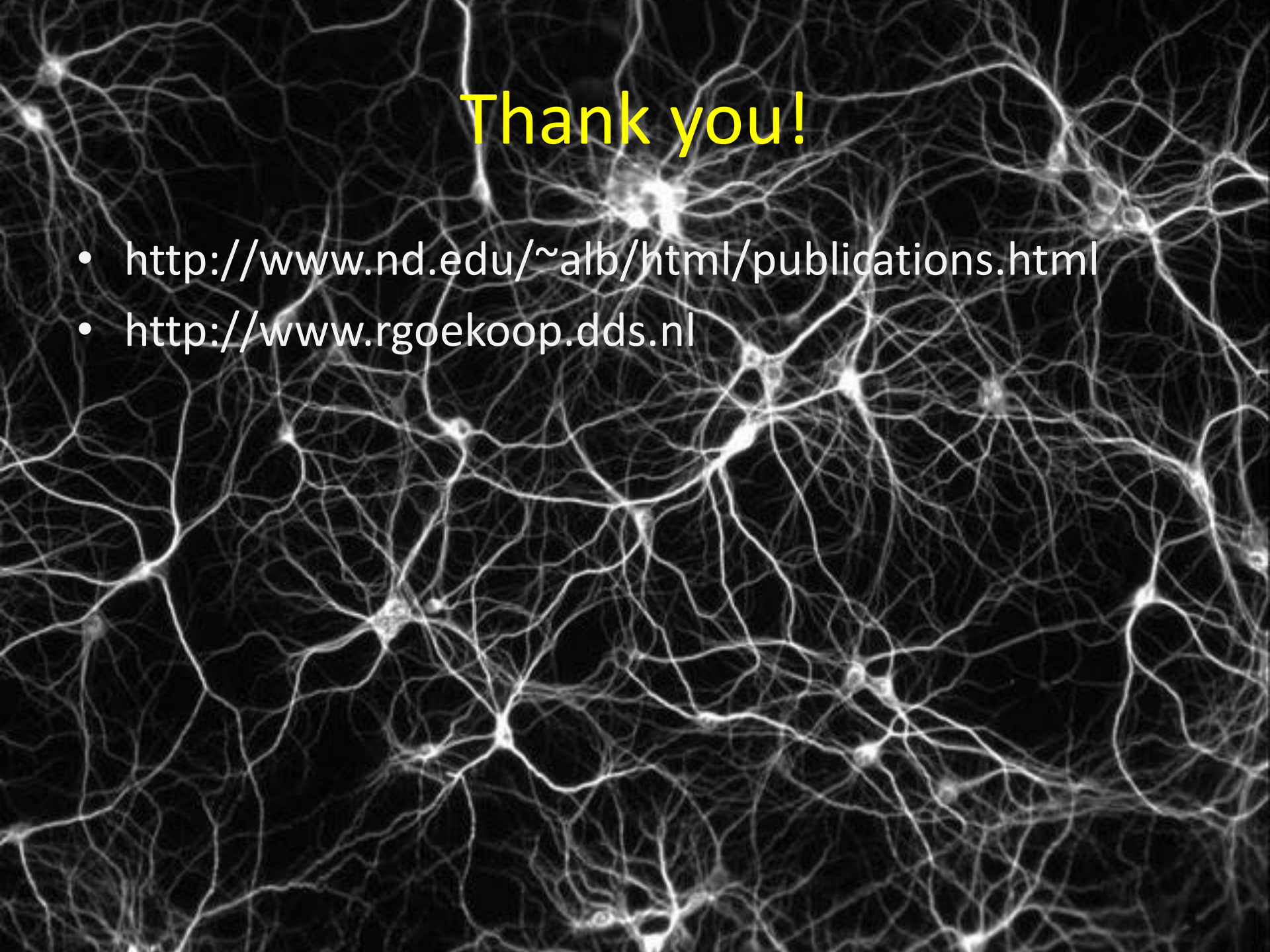
- *Fitness within particular Context*:
  - Sociale network van patienten.
  - Context van behandelaanbod.

Simuleer optimale netwerkstructuur van een afdeling



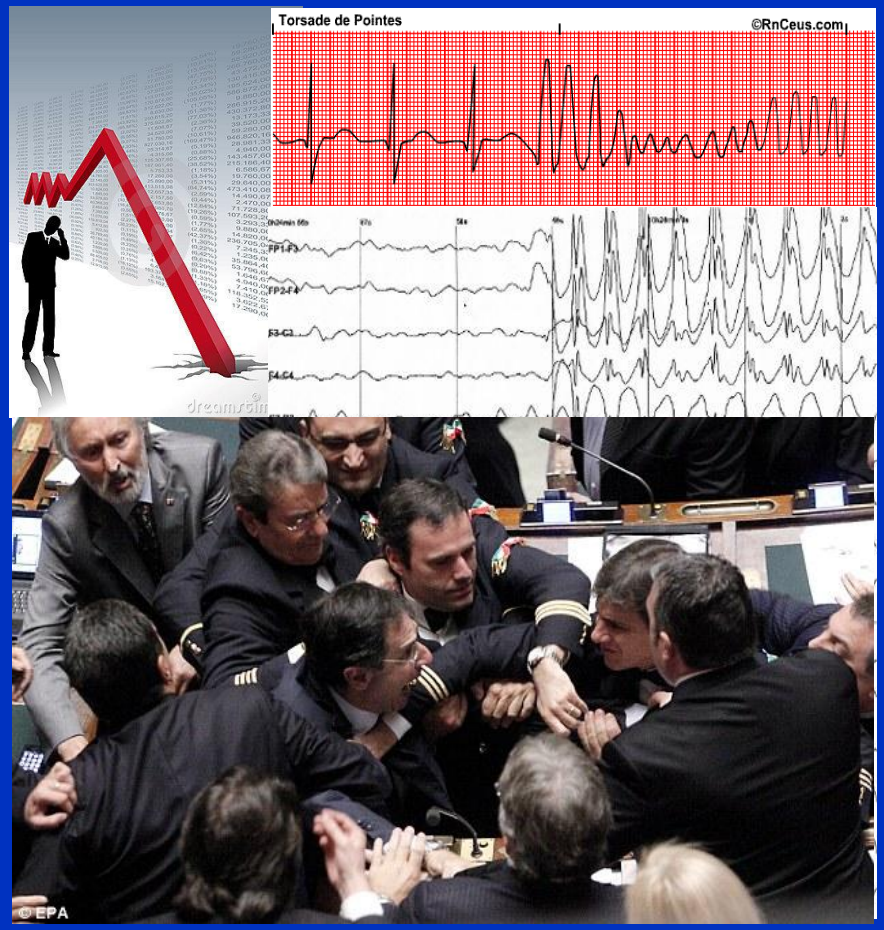
Laat de netwerkstructuur van je afdeling niet aan het toeval over!



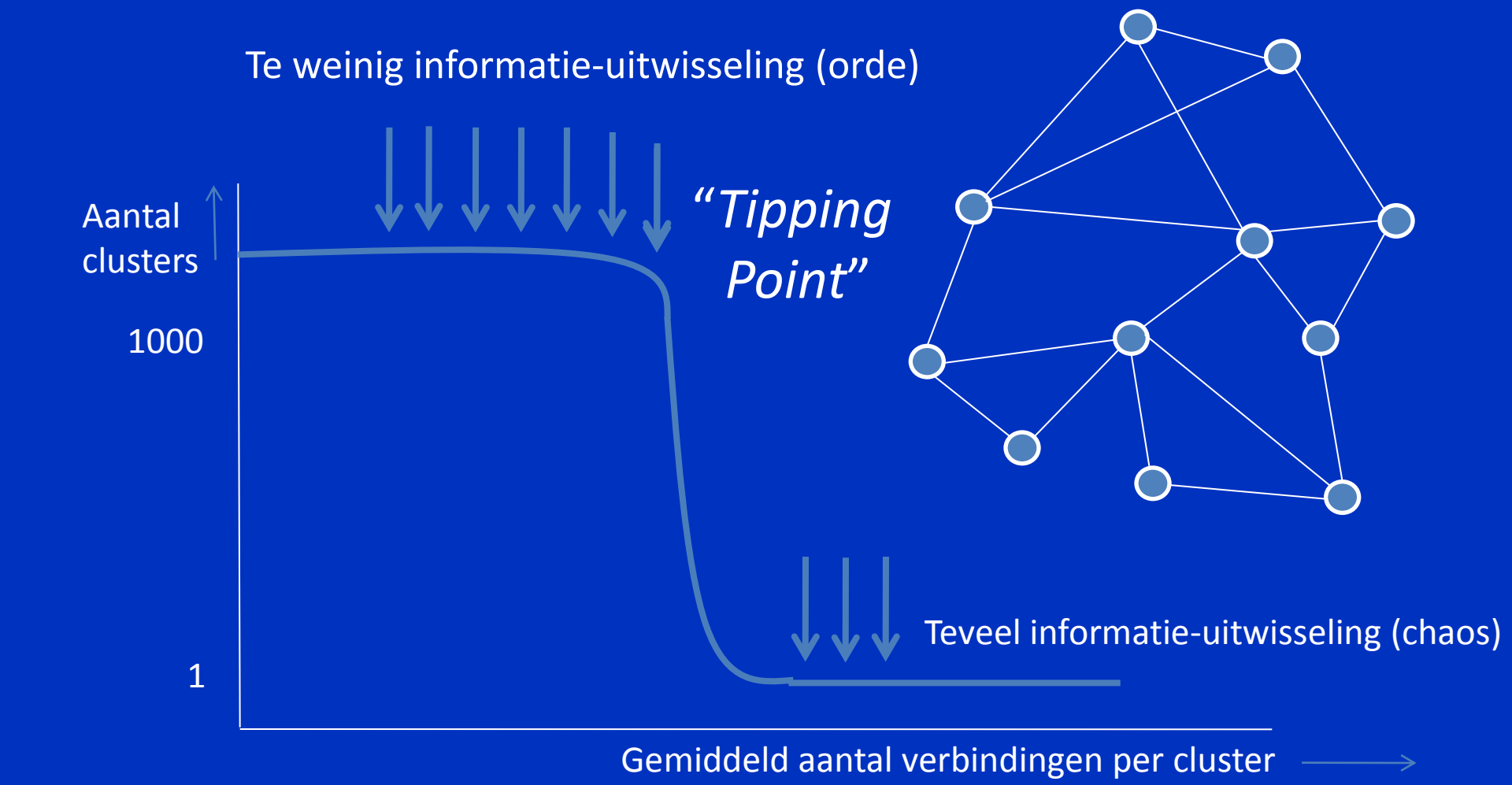

Thank you!
• http://www.nd.edu/~alb/html/publications.html
• http://www.rgoekoop.dds.nl

V. Netwerk functie

- Discrete faseovergangen: “bursts”.
  - Stolpunt / vriespunt / kookpunt
  - Denaturatiepunt.
  - Apoptose (celdood)
  - Depolarisatie
  - Hartritmestoornissen
  - Weeen
  - Epilepsie
  - Psychose, depressie
  - Rages, massahysterie
  - Paradigmashifts
  - Beurscrachs
  - Oorlogen.



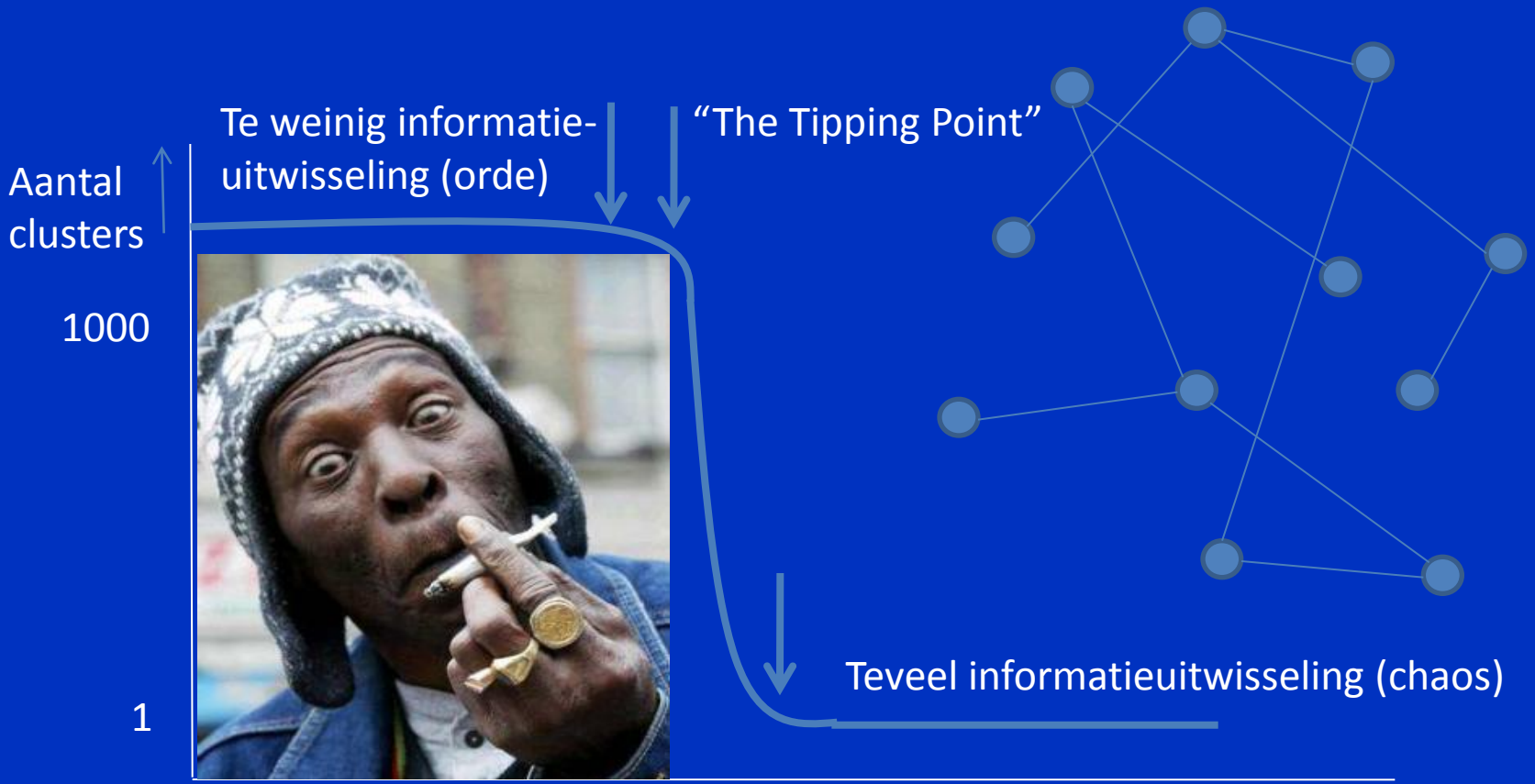
V. Self-Organized Criticality



Per Bak, 1996. Waldrop e.a. 1994; "The Edge of Chaos"

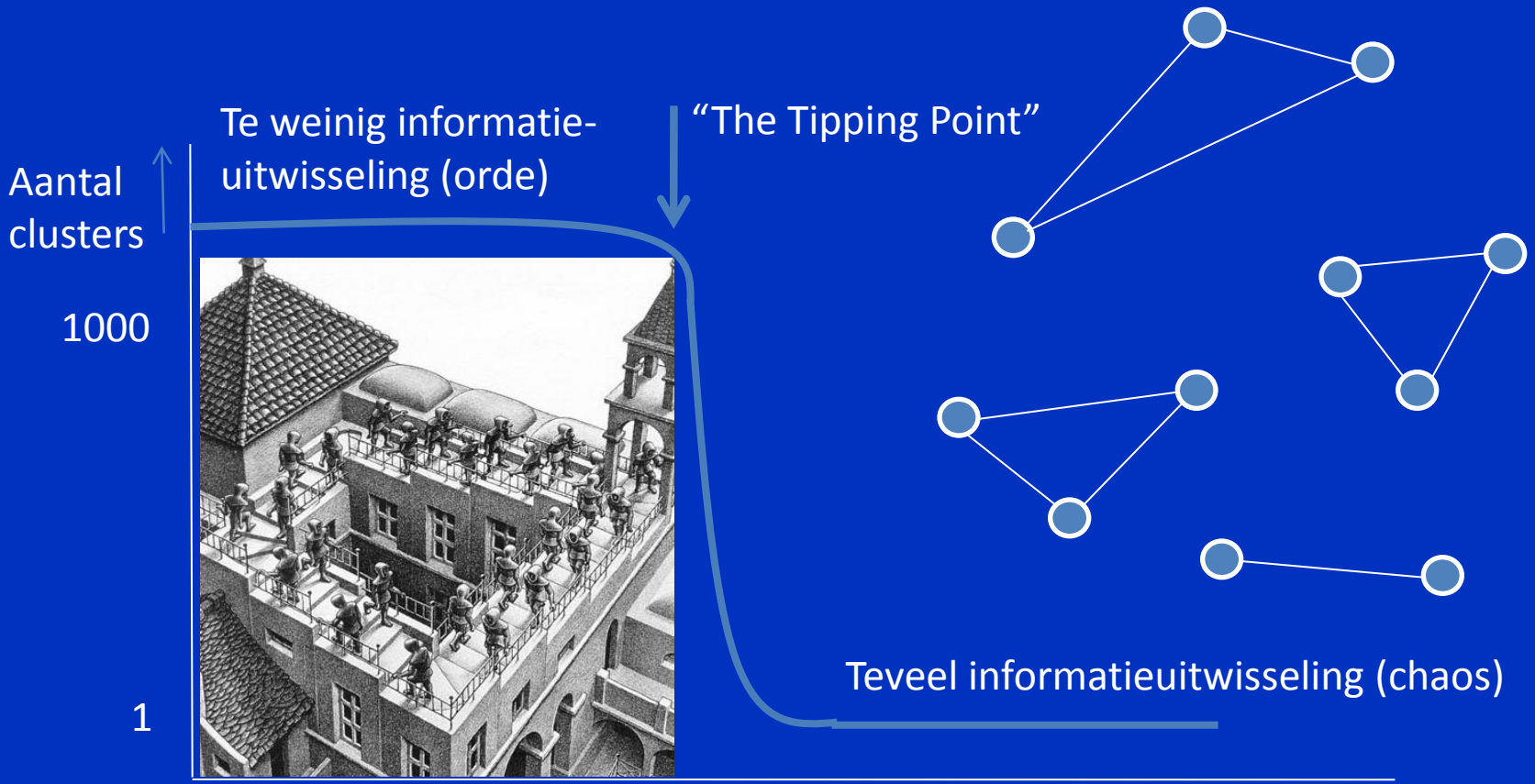
Klinische relevantie:
Schizofrenie, positieve symptomen

- Stoornis in de netwerkfunctie.



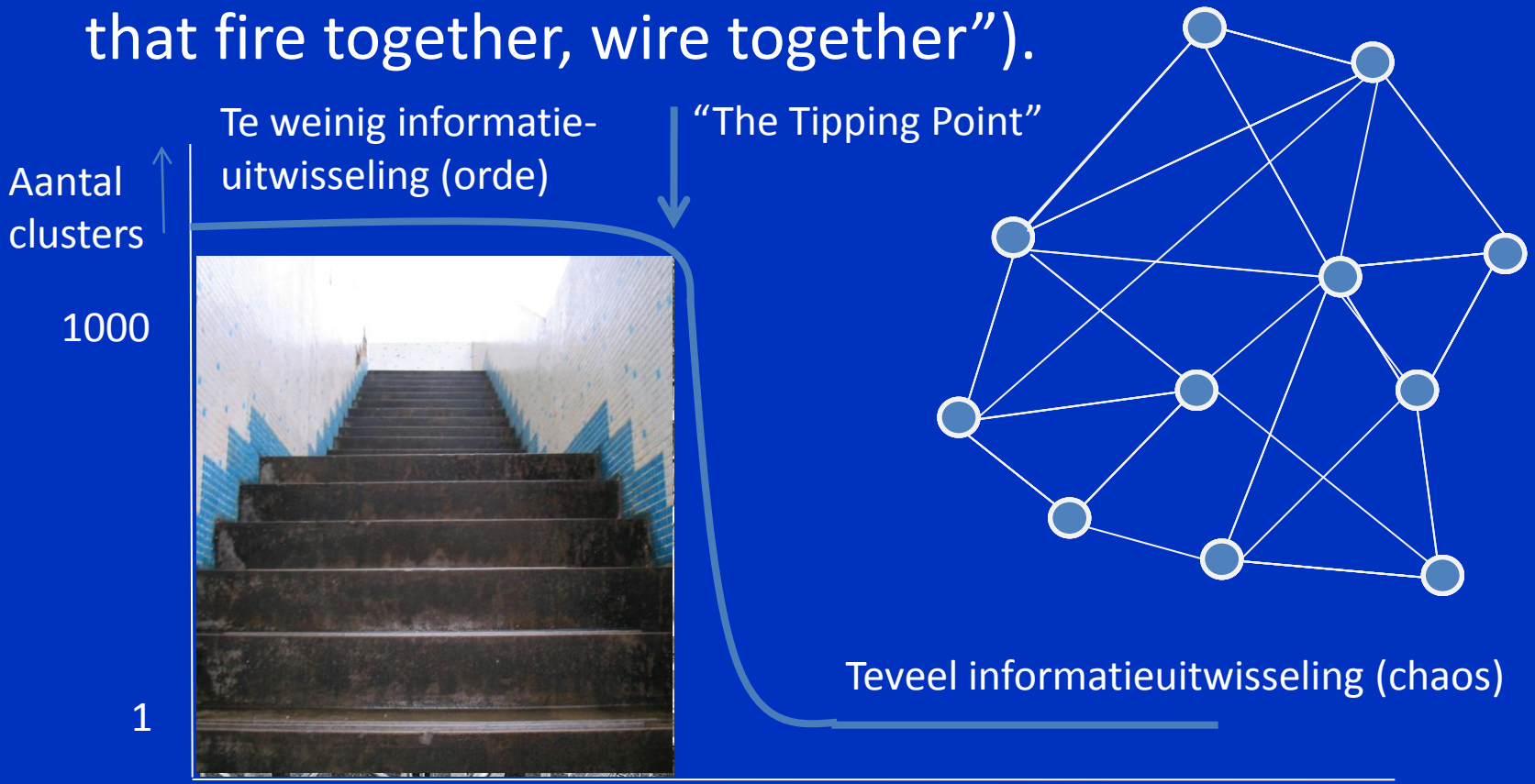
Klinische relevantie:
Depressie, rumineren

- Stoornis in structuur en functie.



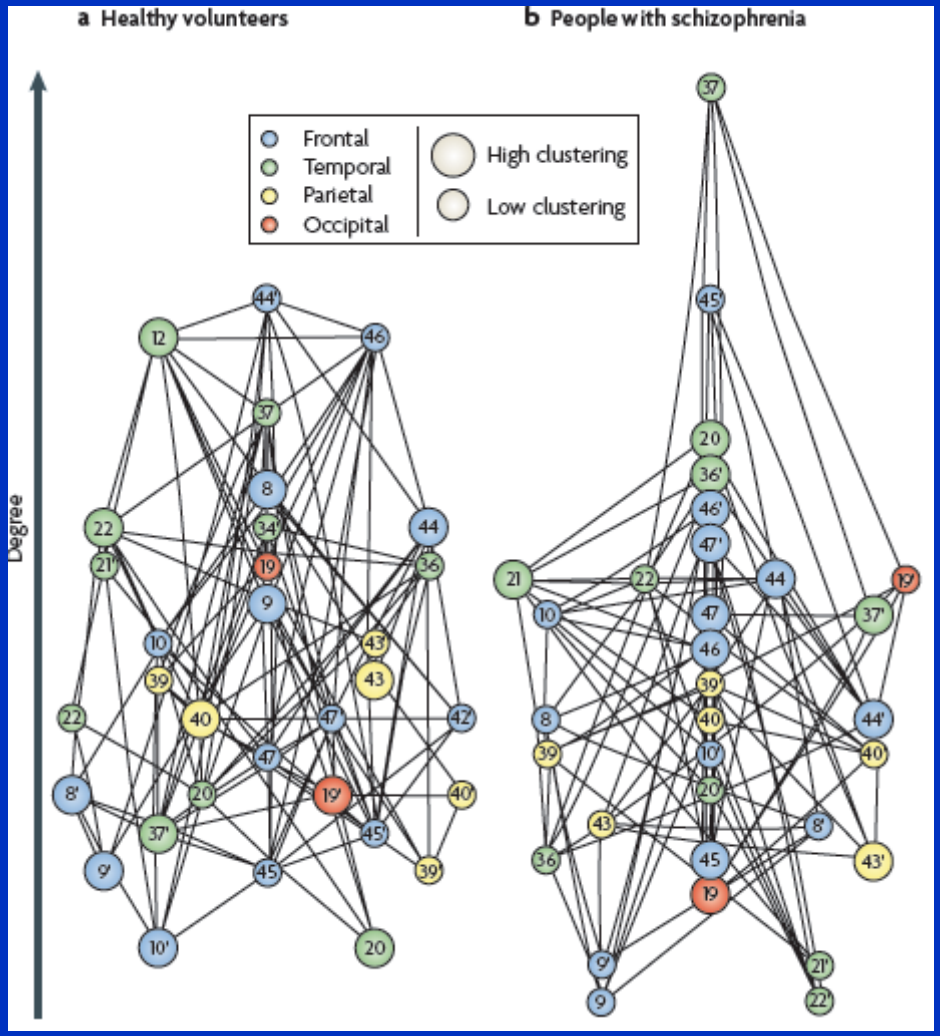
Klinische relevantie:
ECT: therapeutisch effect

- Reconnectie door massale synchronisatie (“Neurons that fire together, wire together”).



Klinische relevantie:

Schizofrenie, negatieve symptomen



- Stoornis in de neuroanatomische netwerkstructuur.

Bullmore e.a., Nature Rev Neurosc 2009