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Applied Complex Systems Sciences

WIVACE, September 19-21, 2017
Venice, Italy

Rudolf M. Füchslin
Zurich University of Applied Sciences

Applied Complex Systems Sciences

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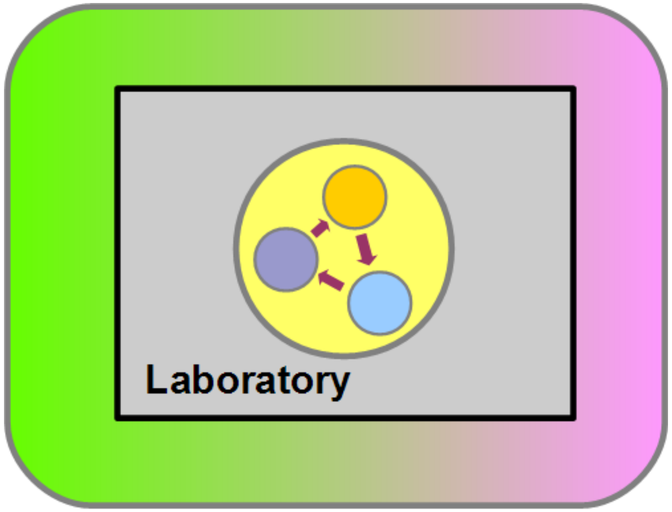
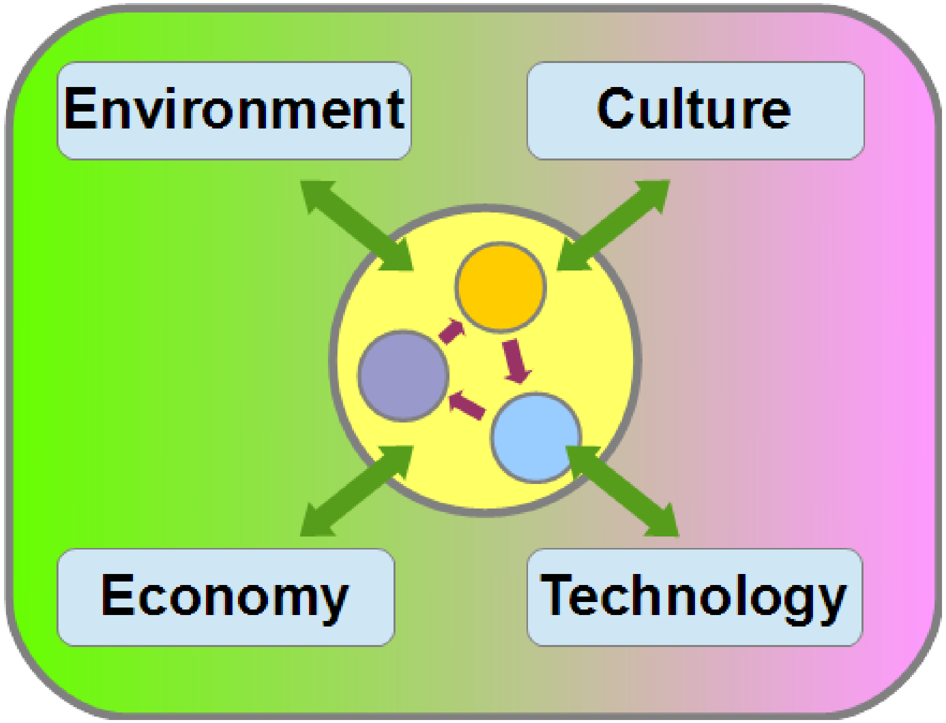
Basic science





Applied science

RBC and MPC

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Rule Based (RBC)

State of the art. Set of rules: If *condition* then *action*

„If *solar irradiation* > *threshold* then *close lid*" and heating/cooling curves

Parameters need to be adapted to suit a building, components

Control of operational parameters ➔ no direct control of output.

Model predictive (MPC)

e.g. the Opticontrol group, ETHZ
„[...]predictive control strategies in order to reduce the
energy usage of buildings, improve occupant comfort, and reduce peak electricity demand."

Use model to find operational paramters that yield desired output parameters

Hydrobus

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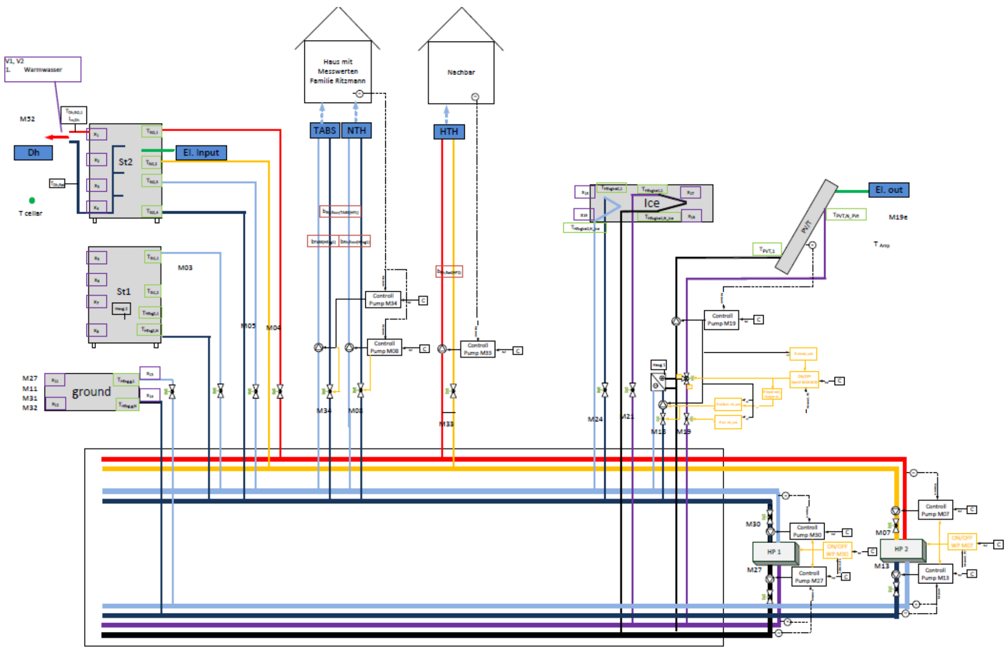

Offizielles Organ des
Schaffhauser Bauernverbandes
und seiner Fachsektionen

SCHAFFHAUSER BAUER

2

DONNERSTAG, 30. JUNI 2016, NUMMER 25

PILOTPROJEKT

Kreativität und Erfindergeist sind seine Markenzeichen

Jungunternehmer Remo Ritzmann blickt voraus. Dem Elektroingenieur ist klar: Öl wird bereits mittelfristig sehr knapp. Darum sucht der Entwickler neue Wege. In Guntmadingen wird derzeit ein Pilotprojekt fertiggestellt. Dieses setzt neben der Gewinnung nachhaltiger Energie auch auf deren Speicherung und die Möglichkeit der bedarfsgerechten Nutzung.

Anlässlich der Mitgliederversammlung des Vereins Landenergie Schaffhausen im letzten April war Remo Ritzmanns Idee von Eisspeichern in ehemaligen Güllengruben auf offene Ohren gestossen (s. «Schaffhauser Bauer» vom 12. Mai 2016). Letzte Woche wurden in der Folge zwei Führungen durch Ritzmanns Pilotprojekt Sunnegg in Guntmadingen organisiert.

Das ehemalige Bauernhaus ist umsowie ausgebaut und energieeffizient saniert worden. Heute umfasst der Komplex neben zwei Wohnungen im alten Gebäudeteil zusätzlich drei im Anbau. Im Erdgeschoss wurde ein kleines Café eingerichtet. Für diese Immobilie hat Ritzmann mit seiner Firma Rino Electronics AG und externen Partnerunternehmen ein ausgeklügeltes Gesamtsystem entwickelt, das Energie erzeugt, speichert und nach Bedarf freigibt. Erwärmt und gekühlt werden können damit zusätzlich rund 20 Wohnungen der Nachbarschaft.

Herzstück ist der Eisspeicher

Auf dem Dach nutzen Hybridkollektoren die Sonnenenergie optimal. Sie erzeugen zu 80 Prozent Wärme und zu 20 Prozent Strom. Die Umgebungswärme wird über Erdregister aufgenommen und dort mittelfristig gespeichert.

Eigentliches Herzstück der thermischen Energiespeicherung ist jedoch der Eisspeicher. Dieser befindet sich in der ehemaligen Güllengrube des Bauernhauses und wird mit 150 m³ Regenwasser befüllt. Im Winter kann dem Wasser Wärme für die Liegenschaft entzogen werden, wodurch es gefriert. Das vollständige Auftauen erfolgt im Sommer mittels Energie der Sonnenkollektoren. Das ganze Jahr über kann das Eis zudem über die Nutzung von Abwasserwärme aus der Gemeinde teilweise verflüssigt werden.

Sämtliche Systemkomponenten, Mauern, Böden, Röhren sowie Erdregister sind mit Temperatursensoren ausgestattet. Deren laufende Messungen ermöglichen es, die Effektivität der einzelnen Systemelemente zu überprüfen und deren Kosten-Nutzen-Verhältnis zu analysieren. Auch das zentrale Steuermodul, das die Produktions- und Speicherstationen reguliert, nutzt die Messungen. Dieses modellbasierte prädiktive System (MPC) ermittelt aufgrund der Messdaten, des Energiebezugs sowie von Wetterprognosen kontinuierlich die optimalen Einstellungen. Entsprechend steuert es die vernetzten Komponenten.

Das Projekt wird vom Bund unterstützt. Zurzeit betreut Ritzmann vier Eisspeicherprojekte: Zwei sind in Planung, zwei werden derzeit realisiert (www.eisspeicher.ch). *sbw*

BILD SANNA BÜHRER WINIGER

Remo Ritzmann (r.) erläutert die komplexe Vernetzung der verschiedenen Produktions- und Speicherelemente (l. Olaf Maier, Co-Entwickler des Projekts).

NACHGEFRAGT

«Faszinierend!»

Auch Hansueli Graf hat die Pilotanlage Sunnegg in Guntmadingen besichtigt. Der Landwirt und Präsident des Vereins Landenergie Schaffhausen erklärt im Interview, wie er das Projekt und den Nutzen von Eisspeichern in ehemaligen Güllengruben einschätzt.

Schaffhauser Bauer: Hansueli Graf, Sie beschäftigen sich seit Jahren mit erneuerbarer Energie. Was halten Sie vom Projekt Sunnegg?

Hansueli Graf, Präsident Schaffhauser Landenergie: Die Möglichkeit ist faszinierend, mit dem Eisspeicher im Sommer Energie zu speichern und diese dann im Winter abzurufen. Das ist in dieser Form und in diesem Ausmass absolut neu. Da zudem mit der Energie so ressourcenschonend umgegangen wird, braucht das Projekt insgesamt fast keine Fremdenergie mehr. Mich beeindruckt das sehr.

Ist der Eisspeicher im «Gülleloch» für Landwirtschaftsbetriebe eine Chance?

Der Ansatz ist grossartig und eröffnet eine völlig neue Dimensionen der Energiespeicherung im thermischen Bereich. Die Speicherung von Energie wird in Zukunft noch viel wichtiger werden. *Interview: sbw*

RINO
Electronics AG

Remo Ritzmann

Results

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	RBC	MPC
Heating / cooling	[kWh]	[kWh]
Heating energy	17119	17250
Energy DHW	2065	2065
delivered	**19184**	**19316**
Cooling energy	1371	1370
Electricity	[kWh]	[kWh]
produced PV	9508	9641
Demand heat pumps / circ. pump	5531	6467
export	8506	5995
import	**4528**	**2820**

MPC = 6.85
RBC = 4.24

Christian Jaeger

Peter Bolt

$$J = \frac{\int \dot{Q} dt}{\int \dot{E}_{ext} dt} \xrightarrow{!} \max.$$

Annual work number

Adaptive Control

Michael C. Mozer
Department of Computer Science and
Institute of Cognitive Science
University of Colorado, Boulder
http://www.cs.colorado.edu/~mozer/adaptive-house

The adaptive house

Not a programmable house, but a house that *programs itself*.

House *adapts* to the lifestyle of the inhabitants.

House monitors environmental state and senses actions of inhabitant.

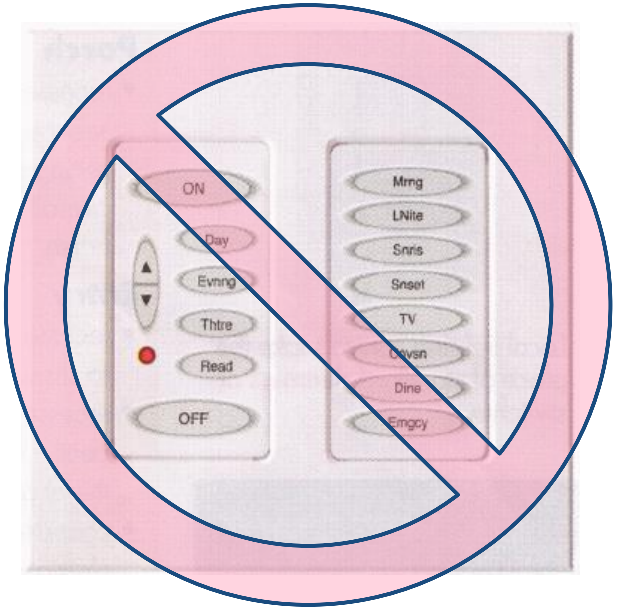
House learns inhabitants' schedules, preferences, and occupancy patterns.

House uses this information to achieve two objectives:
(1) anticipate inhabitant needs
(2) conserve energy

Domain: home comfort systems

- air heating
- lighting
- water heating
- ventilation

Mozer2005



Model Supported Adaptation

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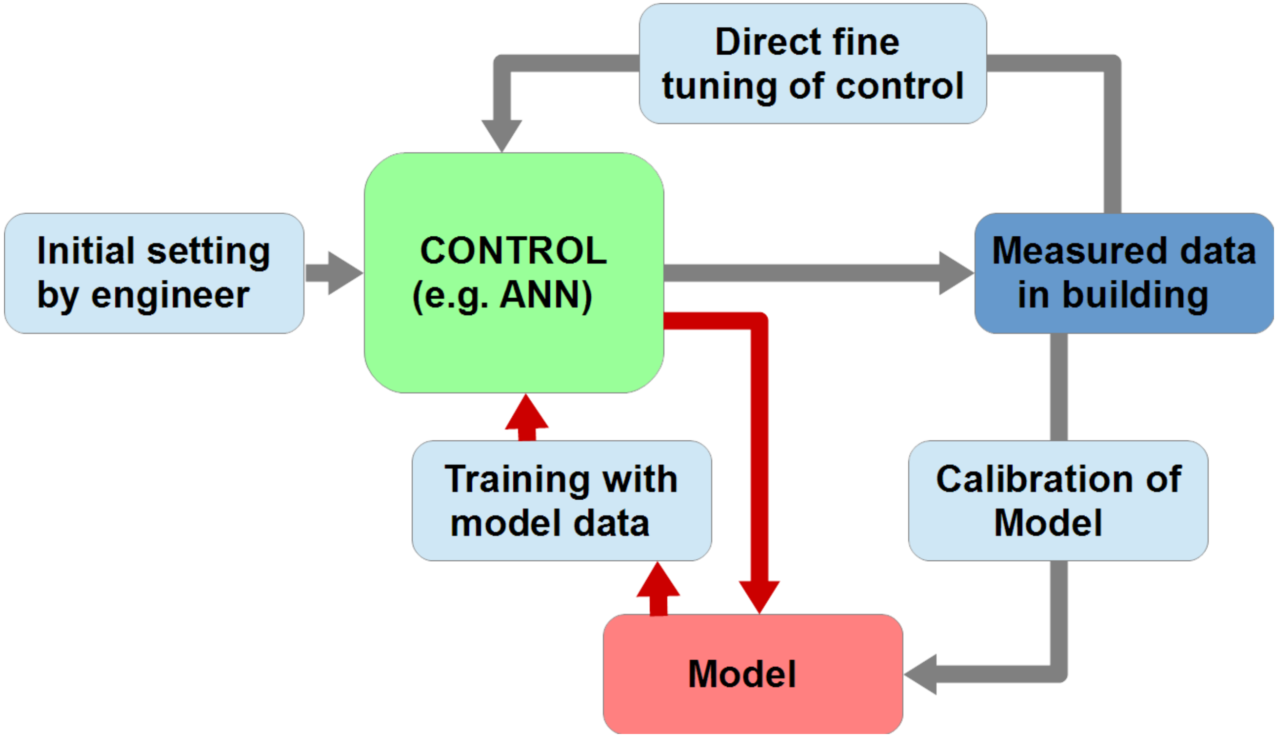
- Machine learning (especially new methods) need to much data for pure on – line training.
- Solution: Learn from model, fine – tune with reality.



Sieving Machines

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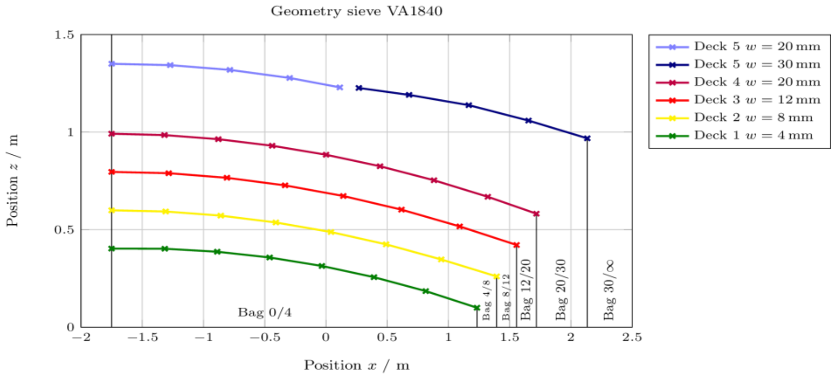
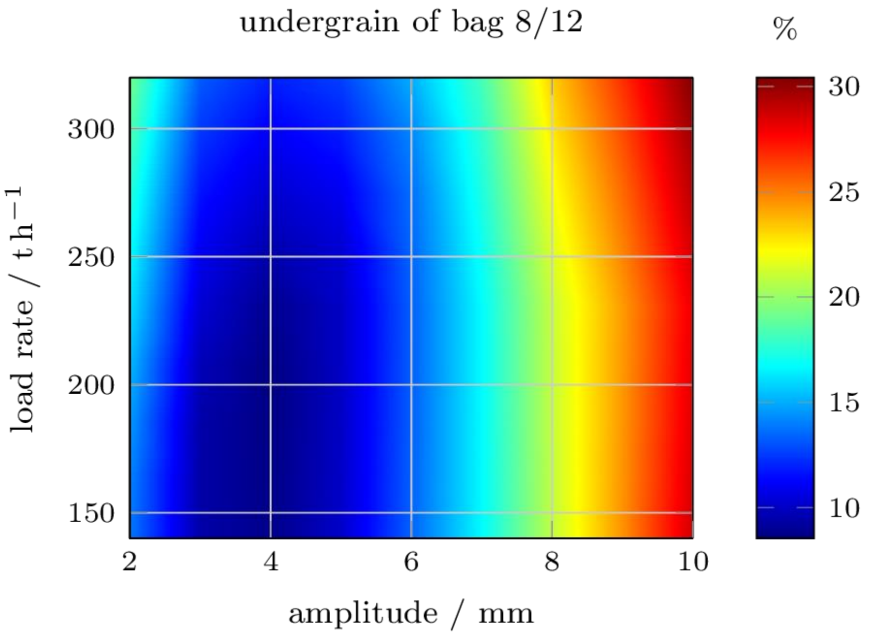
AMMANN





Jaeger, C.; Housseini, R.; Hertwig, M.; Füchslin, R. M. (2014). Performance Prediction and Optimization for Industrial Sieves by Simulation: a two-tier Approach. Tagungsband ASIM 2014. 22.

Evolutionary optimization

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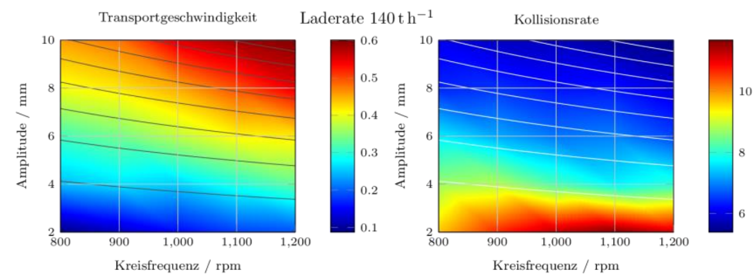
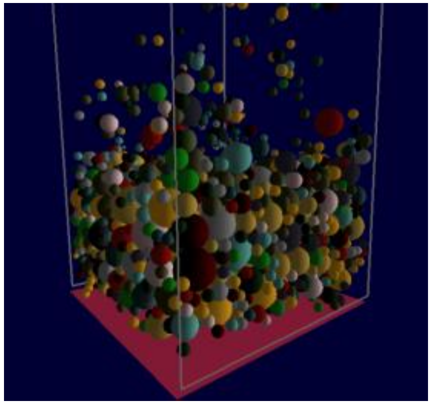
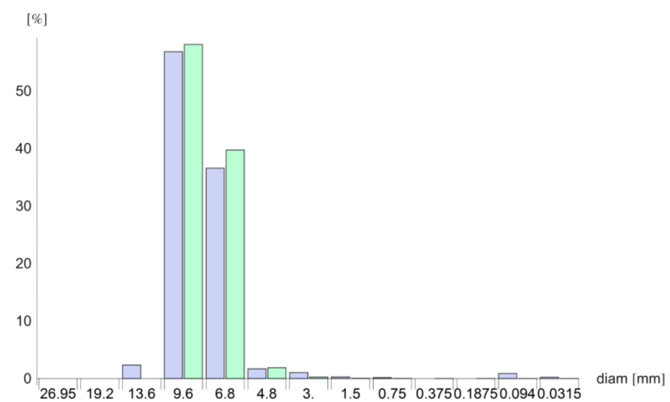
Determine measurable parameters → **Simulate example** → **Estimate parameters of model** → **Use model for optimization**

Machine:
- Geometry
- A, ω,…

Model:
- ν, σ,…







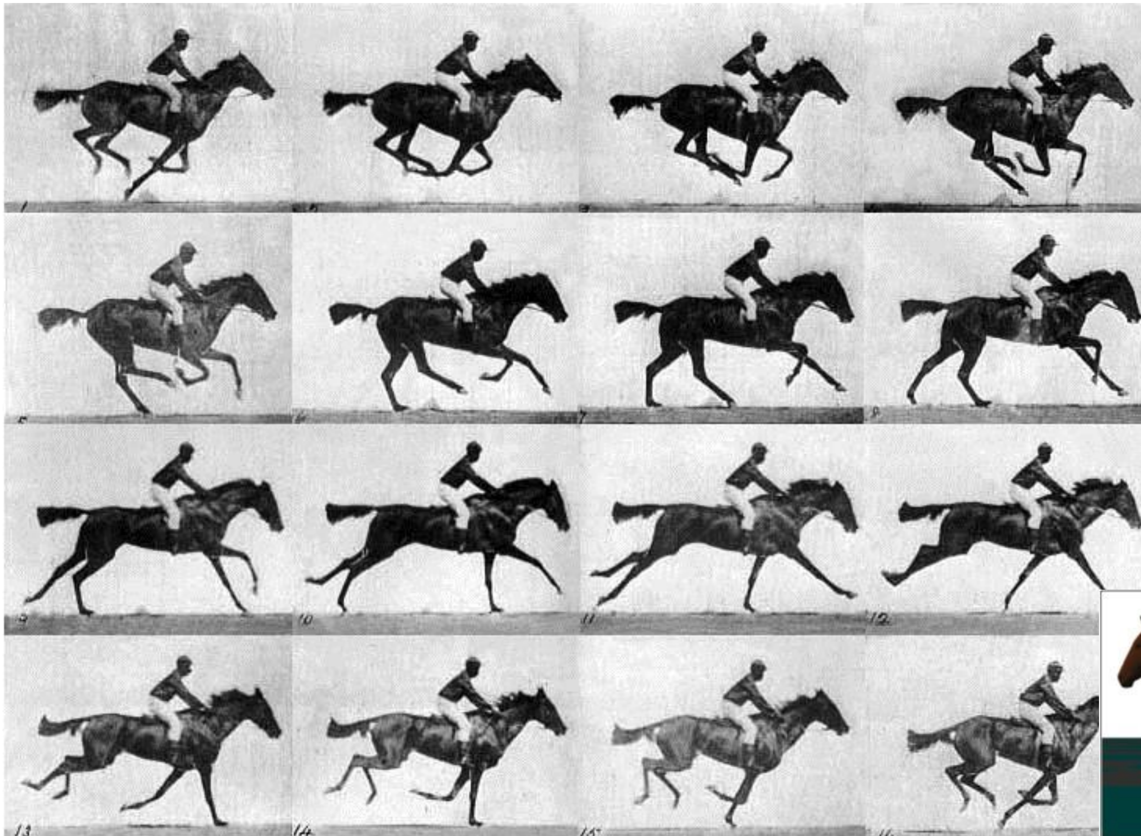
Embodied Intelligence

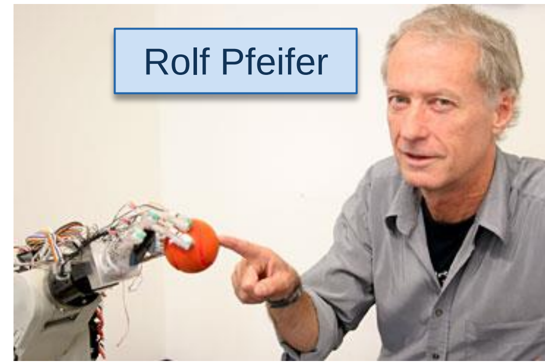
Technical Systems (Robocup 2013)

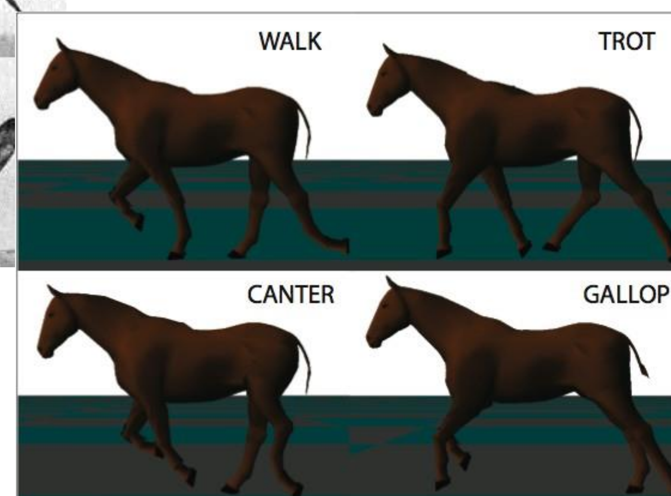
Pennsylvania Ballet's Valerie Amiss and Jonathon Stilesin the world premiere of Kirk Peterson's "Dancing With Monet (A Gathering at Argentuil)"
Photo: Paul Kolnik

Biological Systems

Gait Patterns

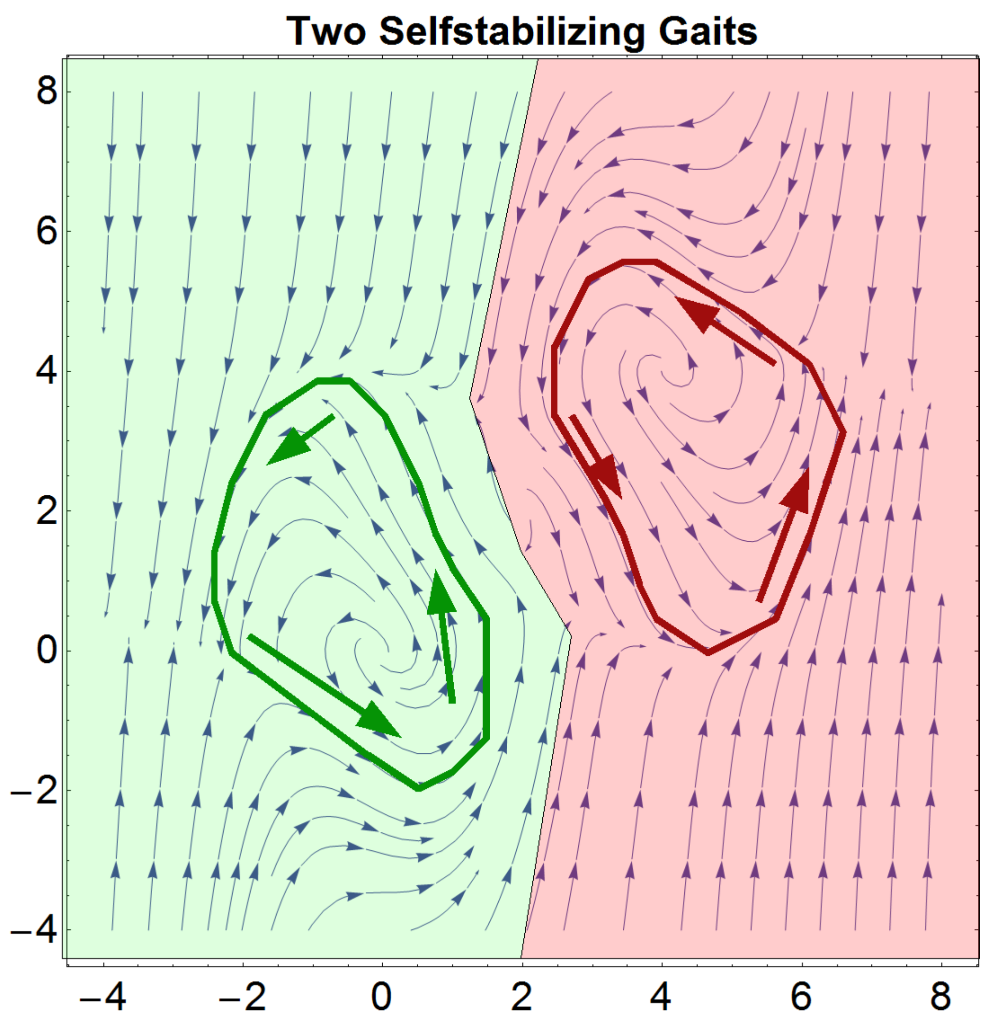






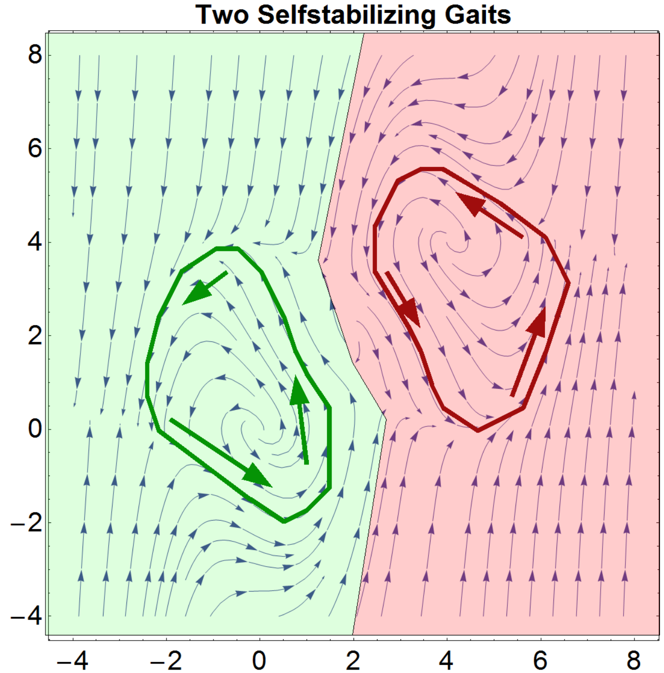
Morphology = Shape + material properties

Gait Patterns



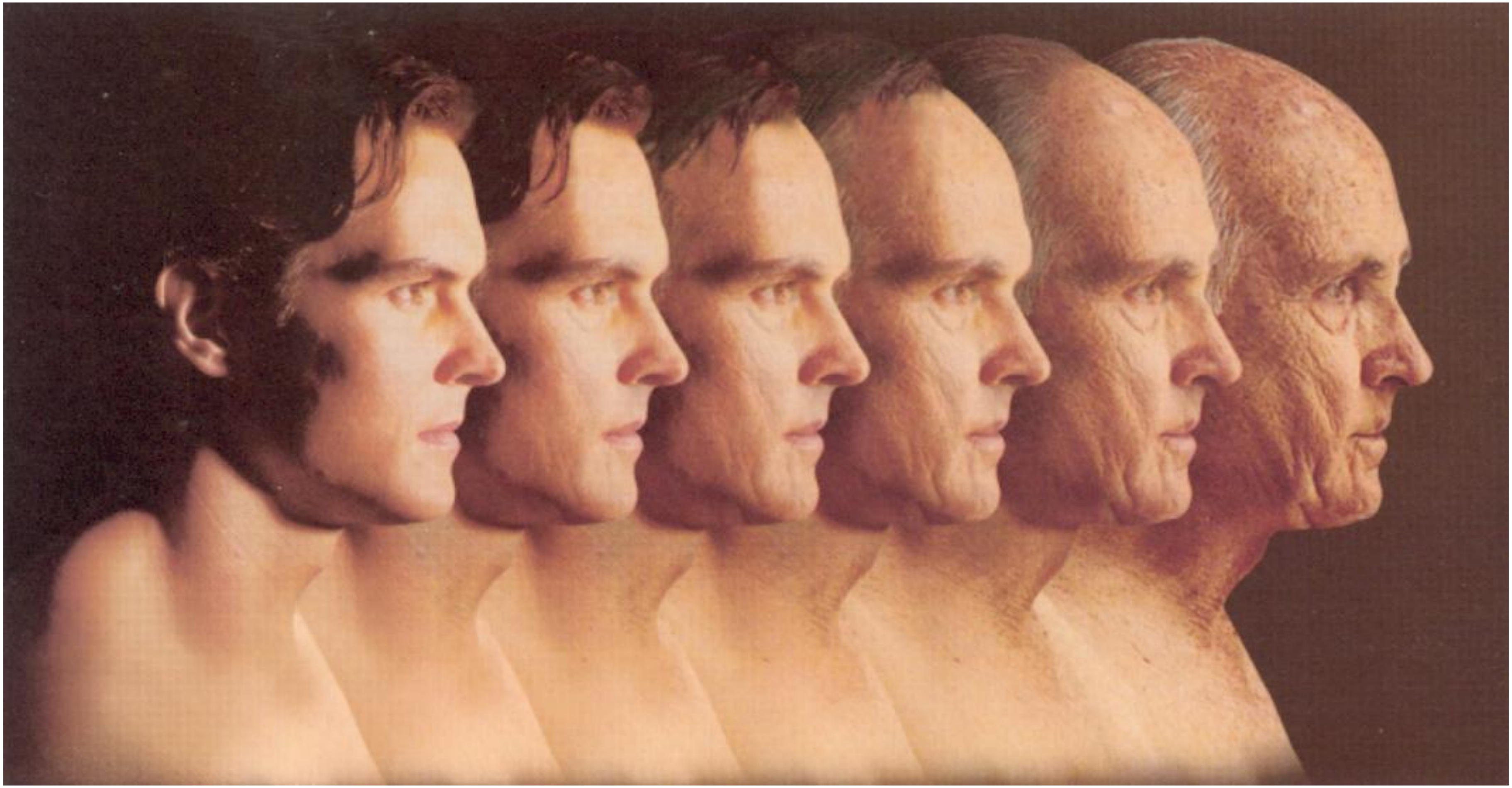
- **Brain** chooses red or green basin of attraction.
- **Body-dynamics** drives system into attractor (and keeps it there).

Gait Patterns: Picture incomplete



- **Transient time should be short.**
- **Fluctuations: Strong damping**
- **Attractor landscape can be changed.**

Aging: Loss of Control over Movements



Good News from MorphControl

We can't rejuvenate your body.
But maybe, we can rejuvenate your attractor landscape!

Brain & Body: A Result from Robotics

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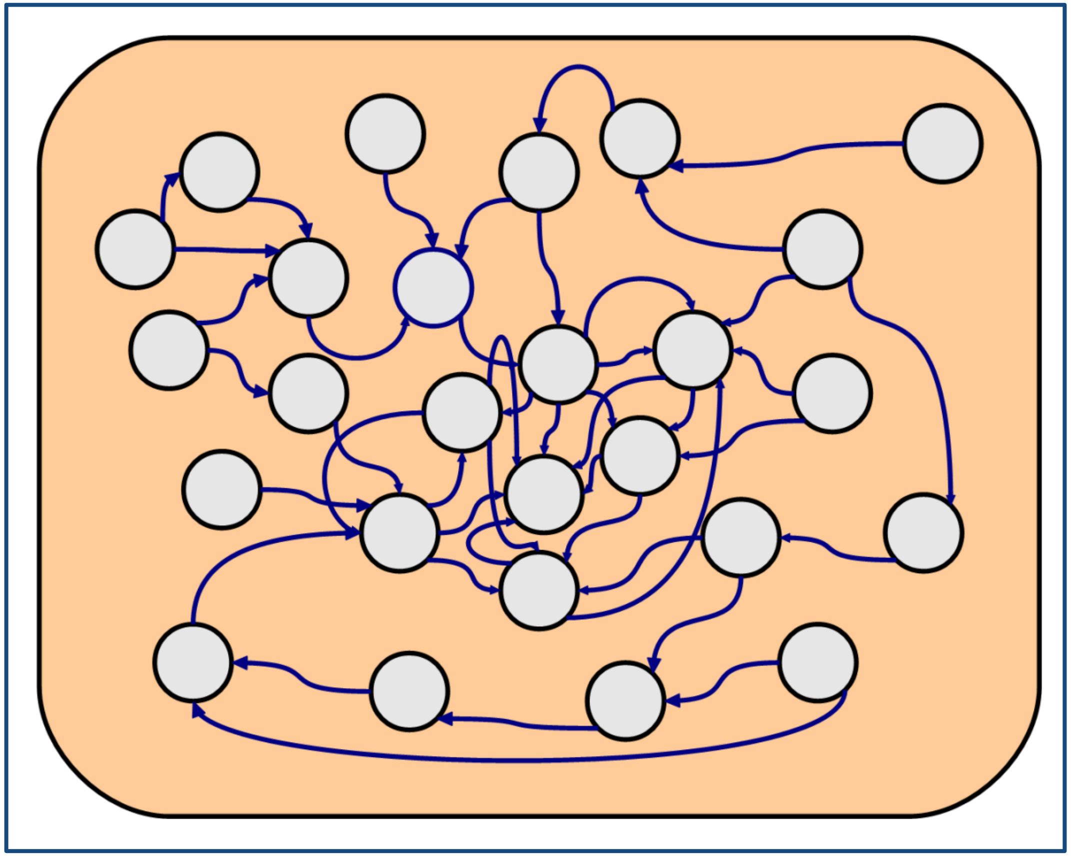
- **Feed-forward neural networks** have some but not universal computational power.
- **Mechanical mass-spring systems** can generate time-dependent signals.

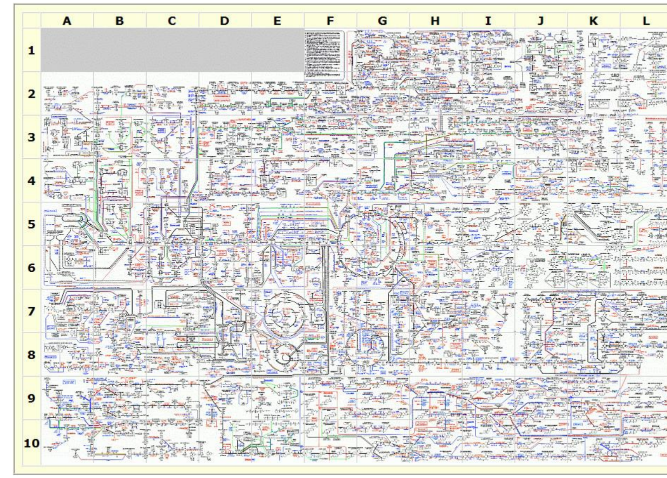
Recent result: A properly interfaced hybrid system (mass-spring + feed forward neural network) can emulate/compute large classes of filters (functions onto functions).

Hauser, H.; Ijspeert, A.J.; Füchslin, R.M.; Pfeifer, R., Maass, W.„**Towards a theoretical foundation for morphological computation with compliant bodies**", Biological Cybernetics, 2011, Volume 105, Numbers 5-6, p 355-370.

Füchslin; R.M., Dzyakanchuk, A.; Flumini, D.; Hauser, H.; Hunt, K.J.; Luchsinger, R.H.; Reller, B.; Scheidegger,S.;Walker, R . "**Morphological Control Applications and Steps Towards a Formal Theory**". Artificial Life 19 9-34.

Cells: The Network Picture





Cell as a dynamical network of physico – chemcial interaction

Two Types of Diseases

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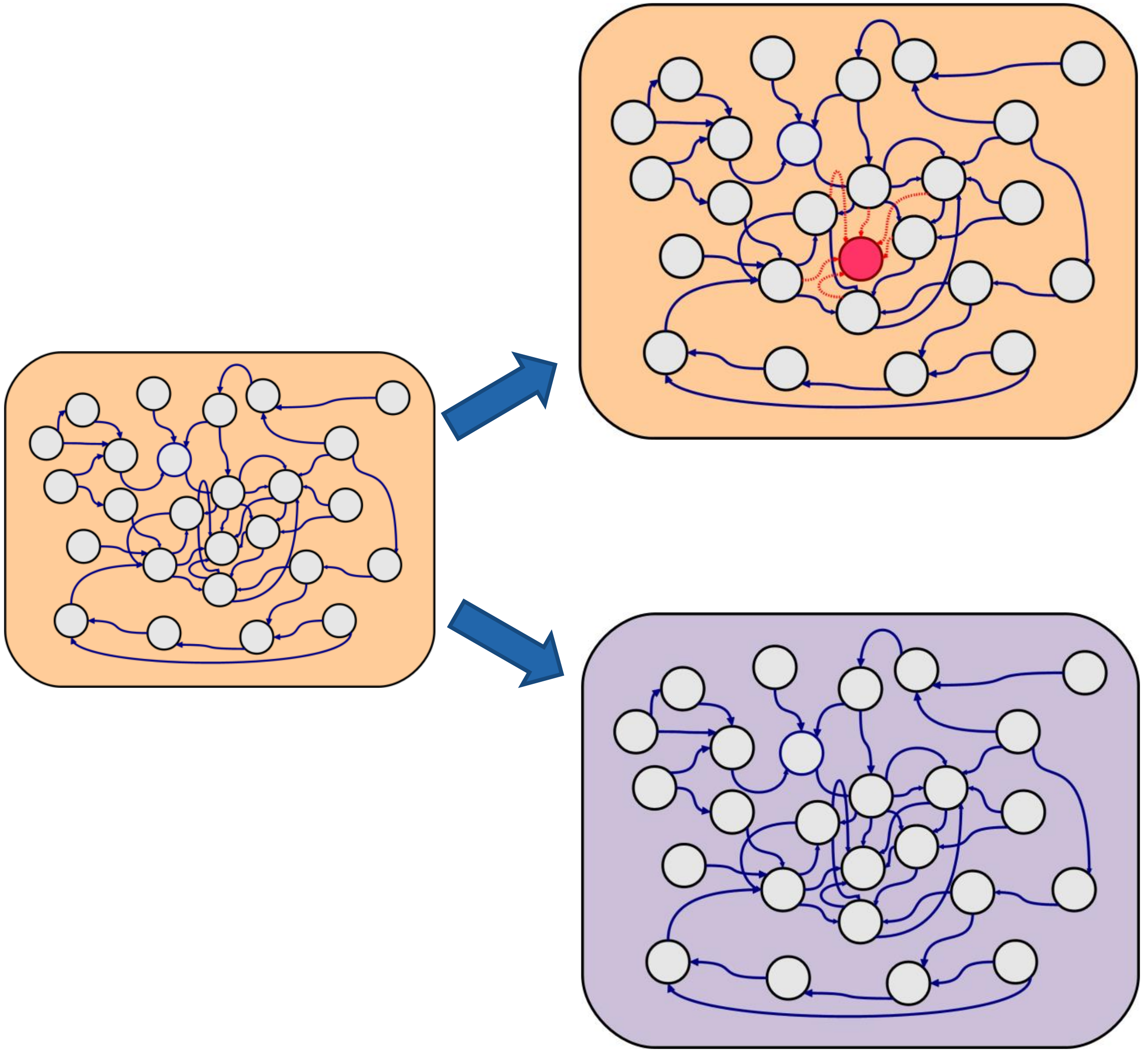


One ore several nodes are dysfunctional ➔ network functionality may be affected.

All system components are functional, but system is in wrong basin of attraction.

Cells as Dynamical Systems

OPINION

Darwinian medicine: a case for cancer

Mel Greaves

Abstract | Epidemiological, genetic and mol…
collectively provided us with a rich source of d…
understanding of the aetiology and molecular …
perspective focuses on proximate mechani…
adequate explanation for the prevalence of tum…
or what seems to be the striking vulnerability…
precept of Darwinian medicine is that vulnerab…
diseases, arises at least in part as a conseque…
compromises and trade-offs that characterize evolutionary processes.

OPEN ACCESS Freely available online PLoS one

A Dynamical Model of Genetic Networks for Cell Differentiation

Marco Villani[1,2], Alessia Barbieri[1], Roberto Serra[1,2]*
1 Modelling and Simulation Laboratory, Department of Communications and Economics, University of Modena and Reggio Emilia, Reggio Emilia, Italy, 2 European Centre for Living Technology, Venice, Italy

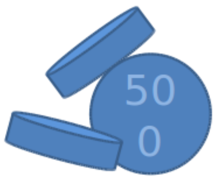
M. Greaves, Nature Reviews Cancer 7, 213 – 221 (2007).

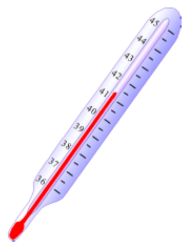
M. Villani

R. Serra

Use of abstract random Boolean networks.

Synergistic Therapies in Oncology

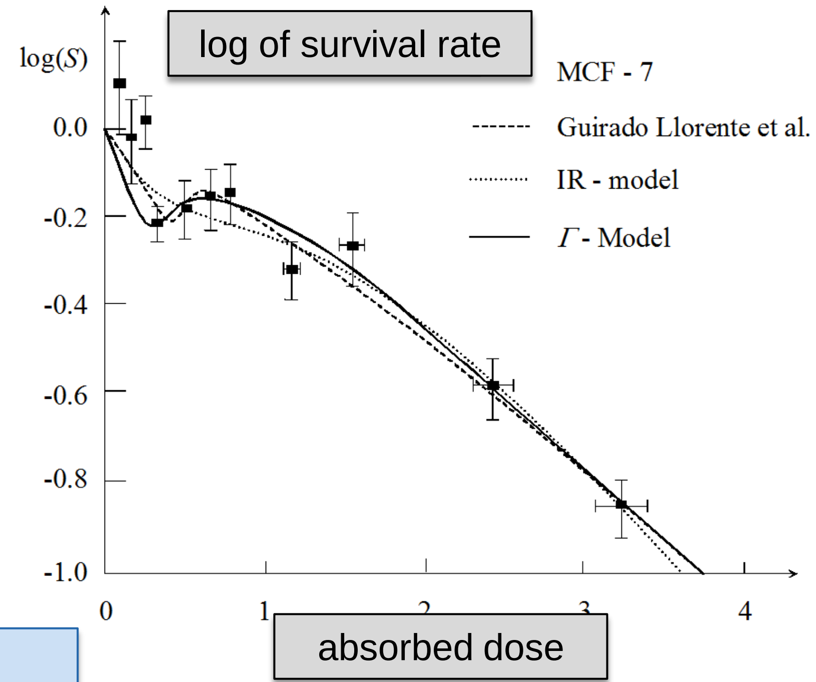




«Doses»: Drugs, Radiation, Thermal (?)

S. Scheidegger

M. Weyland



Conundrum: Reaction of cells to irradiation highly non-linear. "The more intensity, the more (long-term) damage" does not hold (Fig. by S. Scheidegger).

- Probable cause: Repair processes
- Hyperthermia before irradiation ➔ reduction of repair
- Needed: Quantification of thermal effect, **thermal dose**

Scheidegger, S.; Füchslin, R.M.; Timm, O.; Eberle, B.; Bodis, S. (2015). **A novel approach for thermal dosimetry**. In: Proc. of the ESHO Annual Meeting 2015. (26). Zurich: European Society for Oncological Hyperthermia.

Aging Again

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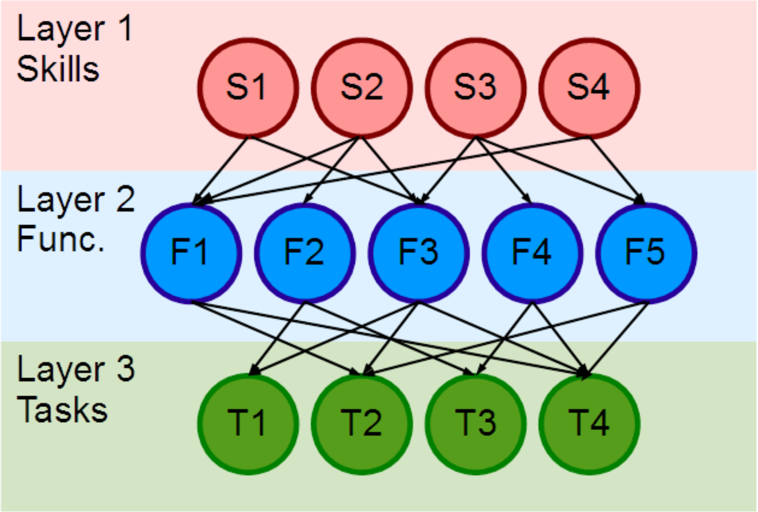
- Frequent observation: Elderly patients often exhibit a sharp transition in the ability to life an indepedent life.
- Potential explanation: Decompensation effects.
- Role of complex systems sciences: Detection of early warning signals and determination targeted application of support systems.



H. Becker, C. Brombach, A. Färber, A. Filisetti, M. Melloh

Optimization of Vaccination Strategies

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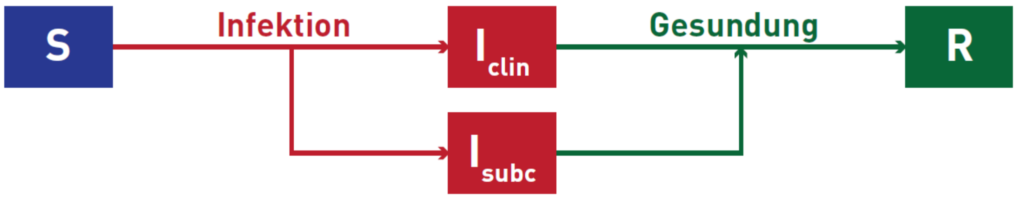
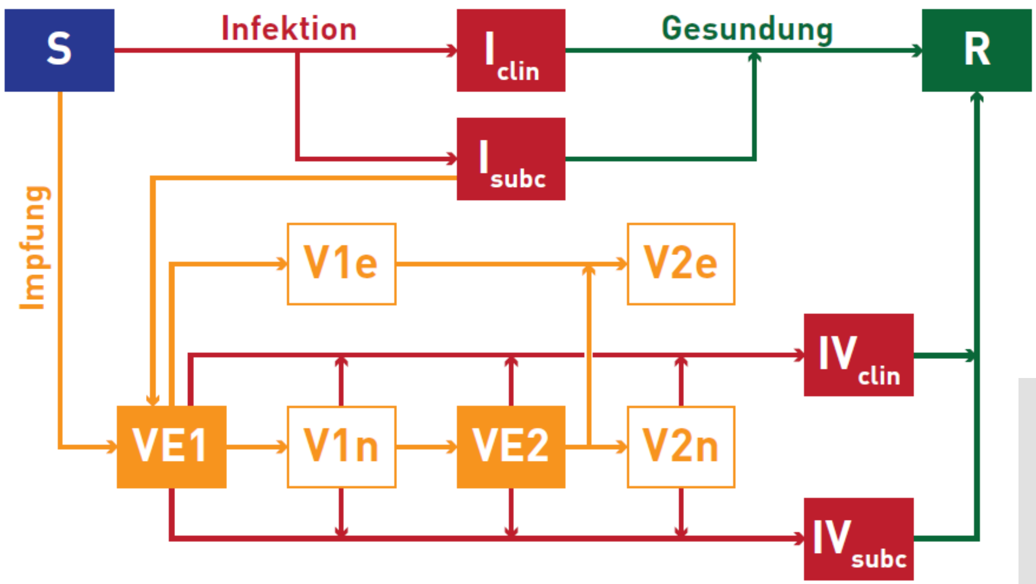
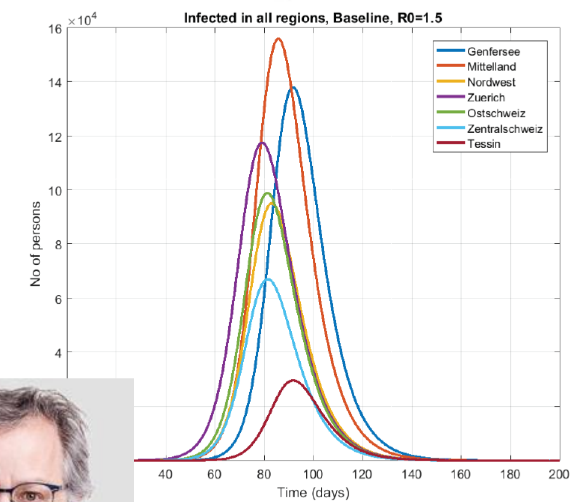


Simple SIR - Model



Realistic vaccination process



Patrik Eschle

What is optimal?

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800'000 / Woche

R0	Eff. Delay	Strategie	t_0			$T_{lmax}/2$			T_{lmax}		
			80/80/60	60/60/40	40/40/20	80/80/60	60/60/40	40/40/20	80/80/60	60/60/40	40/40/20
1.5	7	Zufall	100%	100%	79%	75%	59%	37%	8%	6%	4%
		Risiko-gruppen	100%	99%	81%	70%	55%	35%	11%	8%	5%
		Jüngste zuerst	100%	100%	84%	85%	71%	45%	5%	4%	3%
		Gesundheits-berufe	100%	100%	78%	74%	58%	37%	7%	6%	4%
		Pandemie-plan	100%	100%	80%	88%	72%	45%	9%	6%	4%
	14	Zufall	100%	99%	72%	64%	49%	31%	5%	4%	2%
		Risiko-gruppen	100%	98%	74%	73%	58%	36%	8%	6%	3%
		Jüngste zuerst	100%	100%	99%	80%	69%	47%	3%	2%	2%
		Gesundheits-berufe	100%	99%	73%	66%	51%	33%	5%	3%	2%
		Pandemie-plan	100%	100%	99%	86%	75%	51%	5%	4%	2%
2.0	7	Zufall	75%	51%	28%	28%	20%	12%	3%	2%	1%
		Risiko-gruppen	70%	49%	28%	42%	30%	16%	5%	4%	2%
		Jüngste zuerst	92%	67%	33%	20%	14%	8%	1%	1%	0%
		Gesundheits-berufe	74%	50%	27%	28%	20%	12%	3%	2%	1%
		Pandemie-plan	88%	65%	36%	44%	30%	16%	3%	2%	1%
	14	Zufall	63%	43%	24%	22%	16%	10%	2%	1%	1%
		Risiko-gruppen	73%	55%	32%	48%	34%	19%	3%	2%	1%
		Jüngste zuerst	95%	72%	34%	13%	9%	6%	0%	0%	0%
		Gesundheits-berufe	65%	45%	25%	23%	17%	10%	1%	1%	1%
		Pandemie-plan	95%	75%	42%	27%	20%	11%	1%	1%	1%
2.5	7	Zufall	33%	22%	12%	12%	9%	5%	1%	1%	1%
		Risiko-gruppen	44%	31%	17%	31%	21%	11%	3%	2%	1%
		Jüngste zuerst	27%	15%	8%	4%	3%	2%	0%	0%	0%
		Gesundheits-berufe	32%	21%	11%	12%	9%	5%	1%	1%	0%
		Pandemie-plan	62%	43%	22%	15%	10%	5%	1%	1%	0%
	14	Zufall	25%	17%	10%	7%	5%	3%	1%	0%	0%
		Risiko-gruppen	60%	42%	23%	19%	13%	7%	1%	1%	0%
		Jüngste zuerst	22%	13%	7%	1%	1%	1%	0%	0%	0%
		Gesundheits-berufe	26%	18%	10%	6%	4%	2%	1%	0%	0%
		Pandemie-plan	53%	36%	18%	4%	3%	2%	0%	0%	0%

1 Mio / Woche

R0	Eff. Delay	Strategie	t_0			$T_{lmax}/2$			T_{lmax}		
			80/80/60	60/60/40	40/40/20	80/80/60	60/60/40	40/40/20	80/80/60	60/60/40	40/40/20
1.5	7	Zufall	100%	100%	80%	84%	69%	46%	9%	7%	5%
		Risiko-gruppen	100%	100%	89%	82%	69%	46%	13%	10%	6%
		Jüngste zuerst	100%	100%	94%	93%	83%	57%	6%	5%	3%
		Gesundheits-berufe	100%	100%	81%	84%	69%	45%	9%	7%	4%
		Pandemie-plan	100%	100%	92%	93%	82%	55%	11%	8%	5%
	14	Zufall	100%	100%	82%	74%	59%	39%	5%	4%	3%
		Risiko-gruppen	100%	100%	88%	83%	68%	45%	9%	6%	4%
		Jüngste zuerst	100%	100%	100%	87%	79%	58%	3%	3%	2%
		Gesundheits-berufe	100%	100%	84%	76%	61%	40%	5%	4%	3%
		Pandemie-plan	100%	100%	99%	90%	81%	57%	6%	5%	3%
2.0	7	Zufall	87%	63%	35%	35%	25%	14%	4%	3%	2%
		Risiko-gruppen	89%	65%	37%	48%	35%	20%	6%	4%	2%
		Jüngste zuerst	98%	74%	43%	32%	21%	12%	1%	1%	1%
		Gesundheits-berufe	87%	62%	35%	35%	25%	14%	3%	2%	1%
		Pandemie-plan	96%	72%	42%	52%	37%	20%	3%	2%	1%
	14	Zufall	80%	56%	31%	28%	20%	12%	2%	1%	1%
		Risiko-gruppen	87%	67%	40%	53%	38%	21%	3%	2%	1%
		Jüngste zuerst	99%	88%	47%	18%	13%	8%	1%	0%	0%
		Gesundheits-berufe	81%	57%	32%	28%	21%	12%	2%	1%	1%
		Pandemie-plan	98%	84%	47%	39%	28%	16%	2%	1%	1%
2.5	7	Zufall	43%	28%	15%	15%	11%	6%	2%	1%	1%
		Risiko-gruppen	52%	36%	20%	36%	25%	13%	3%	2%	1%
		Jüngste zuerst	53%	27%	12%	7%	5%	3%	0%	0%	0%
		Gesundheits-berufe	42%	28%	15%	15%	11%	6%	1%	1%	1%
		Pandemie-plan	64%	44%	23%	23%	16%	8%	1%	1%	0%
	14	Zufall	33%	22%	12%	8%	6%	3%	1%	1%	0%
		Risiko-gruppen	67%	48%	27%	22%	15%	8%	1%	1%	1%
		Jüngste zuerst	39%	22%	11%	1%	1%	1%	0%	0%	0%
		Gesundheits-berufe	34%	23%	13%	7%	5%	3%	1%	1%	0%
		Pandemie-plan	67%	47%	25%	7%	5%	3%	1%	0%	0%

1.2 Mio / Woche

R0	Eff. Delay	Strategie	t_0			$T_{lmax}/2$			T_{lmax}		
			80/80/60	60/60/40	40/40/20	80/80/60	60/60/40	40/40/20	80/80/60	60/60/40	40/40/20
1.5	7	Zufall	100%	100%	88%	90%	77%	52%	10%	8%	5%
		Risiko-gruppen	100%	100%	88%	88%	76%	52%	15%	11%	7%
		Jüngste zuerst	100%	100%	98%	95%	90%	65%	7%	6%	4%
		Gesundheits-berufe	100%	100%	87%	90%	77%	52%	10%	8%	5%
		Pandemie-plan	100%	100%	98%	96%	89%	64%	12%	10%	6%
	14	Zufall	100%	100%	82%	81%	67%	45%	6%	5%	3%
		Risiko-gruppen	100%	100%	92%	88%	76%	53%	9%	7%	4%
		Jüngste zuerst	100%	100%	100%	91%	85%	67%	4%	3%	2%
		Gesundheits-berufe	100%	100%	84%	82%	69%	46%	6%	5%	3%
		Pandemie-plan	100%	100%	99%	93%	85%	62%	7%	5%	3%
2.0	7	Zufall	95%	70%	41%	42%	30%	17%	4%	3%	2%
		Risiko-gruppen	94%	71%	43%	56%	41%	23%	7%	5%	3%
		Jüngste zuerst	100%	78%	46%	45%	30%	16%	1%	1%	1%
		Gesundheits-berufe	94%	69%	41%	42%	30%	17%	4%	3%	2%
		Pandemie-plan	100%	79%	46%	60%	43%	24%	4%	3%	2%
	14	Zufall	88%	64%	37%	33%	24%	14%	2%	1%	1%
		Risiko-gruppen	95%	76%	47%	56%	41%	23%	3%	2%	1%
		Jüngste zuerst	100%	95%	55%	24%	18%	11%	1%	1%	0%
		Gesundheits-berufe	89%	65%	38%	33%	24%	15%	2%	1%	1%
		Pandemie-plan	99%	87%	51%	47%	34%	19%	2%	1%	1%
2.5	7	Zufall	55%	36%	19%	18%	13%	7%	2%	1%	1%
		Risiko-gruppen	61%	43%	24%	42%	29%	16%	3%	2%	1%
		Jüngste zuerst	76%	45%	19%	9%	6%	4%	0%	0%	0%
		Gesundheits-berufe	54%	35%	18%	18%	13%	7%	2%	1%	1%
		Pandemie-plan	74%	49%	26%	30%	21%	11%	2%	1%	1%
	14	Zufall	41%	27%	15%	10%	7%	4%	1%	1%	0%
		Risiko-gruppen	71%	52%	29%	24%	17%	9%	1%	1%	1%
		Jüngste zuerst	63%	36%	16%	2%	1%	1%	0%	0%	0%
		Gesundheits-berufe	42%	28%	15%	9%	6%	4%	1%	1%	0%
		Pandemie-plan	75%	54%	29%	9%	7%	4%	1%	0%	0%

Number of survivors, red = dead

What is Optimal?

- Lessons learnt:
  - Vaccinate early (vaccination campaigns after peak of infection ➔ waste of money).
  - Ask what you want to achieve: Low death rate or low number of infections.
  - Result depends on strategy / priorization (First come – first serve / youngest first / risk group first / medical profession).
  - **"Youngest first" reduces overall death toll.**
  - **Ethics: Distinguish functional and normative priorization!**

Spillover: Spread of Skills

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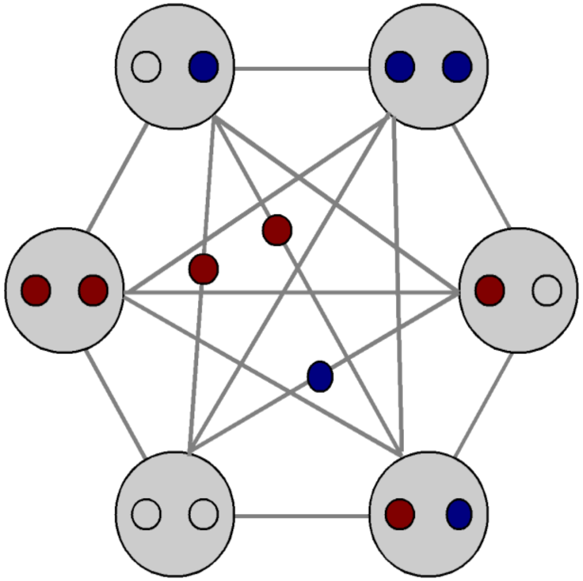
- Assume two skill sets A and B.
- Skill set A is easy to learn, but yields smaller benefits.
- Skill set B takes more time to learn, but yields high benefits.
- Given a large number of small dwellings / villages and some mobility between them.
- **Which skill set will prevail?**

Richard Walker

Social Dynamics on a Simplex

- We assume very simple villages with max. two inhabitants.
- The villages form an infinite simplex: inhabitants may travel with migration rate m.

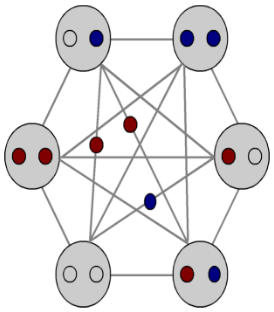


Finite simplex of villages

McCaskill, John S.; Füchslin, Rudolf M.; Altmeyer, Stephan (2001). The stochastic evolution of catalysts in spatially resolved molecular systems. Biol. Chem. 382 (9): 1343-1363.

Social Dynamics on a Simplex

- Individuals reproduce and die.
- Individuals are uneducated (U), have skill set A or B.
- The "villages" can only be in a finite number of states (00, A0, AU, …).
- Infinite simplex ➔ Spatial heterogeneity, but trivial neighborhood structure ➔ mean field approach
- ➔ Dynamics of occupation probabilities.



Social Dynamics on a Simplex

$$\frac{d\vec{P}}{dt} = A(\vec{P}(t))\vec{P}, \qquad \vec{P} = \begin{pmatrix} p_{000}(t) \\ \vdots \\ p_{002}(t) \end{pmatrix}$$

$p_{UAB}(t) =$ Prob. for a village having A indviduals with skill set A, B with set B and U uneducated inhabitants.

$A + B + U \leq 2$

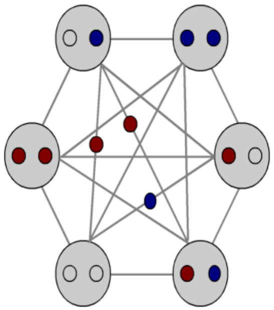
Example: Teaching processes

$$\left.\frac{dp_{UAB}}{dt}\right|_{teach} = (U+1)(A-1)\tau_A p_{(U+1)(A-1)B} + (U+1)(B-1)\tau_B p_{(U+1)\,A(B-1)} - UA\tau_A p_{UAB} - UB\tau_B p_{UAB}$$

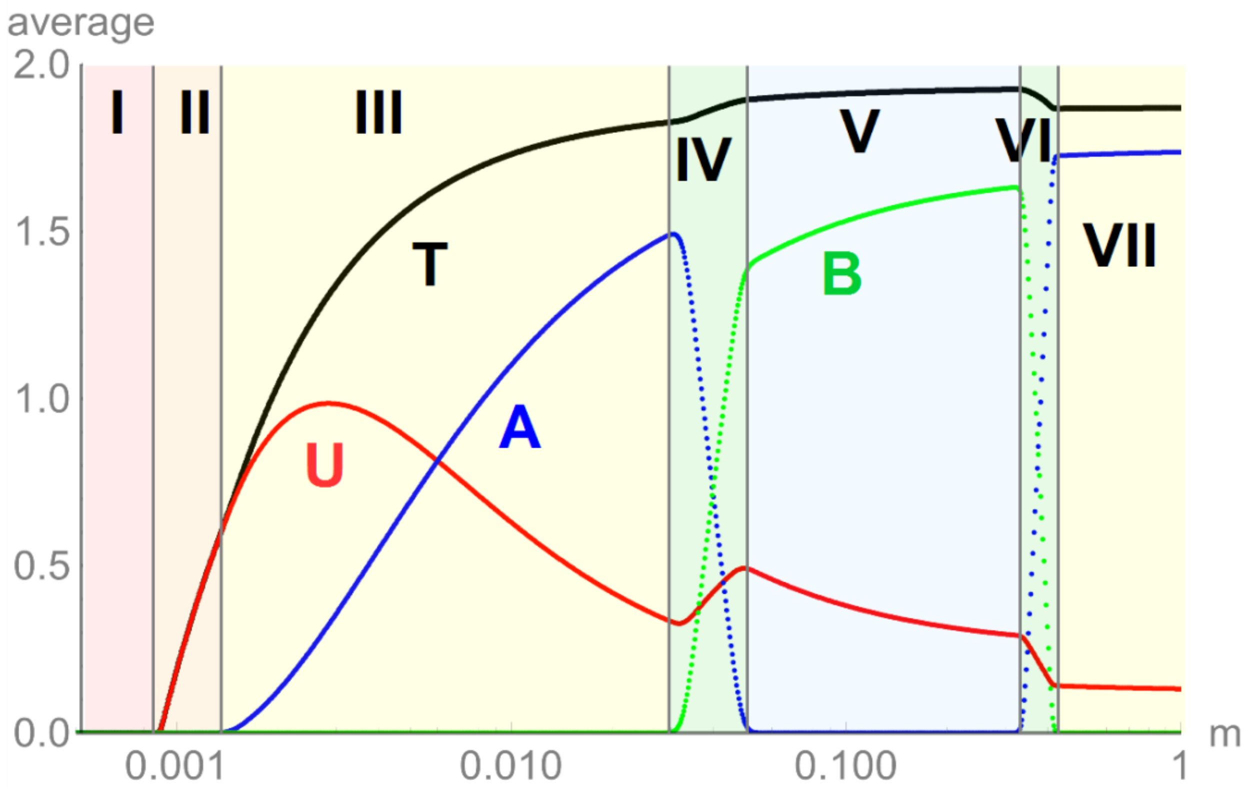
Simplex ➔ Diffusion processes depend only on average occupation numbers.

Master equation for p_{UAB}:

$$\frac{dp_{UAB}}{dt} = \left.\frac{dp_{UAB}}{dt}\right|_{birth} + \left.\frac{dp_{UAB}}{dt}\right|_{death} + \left.\frac{dp_{UAB}}{dt}\right|_{teach} + \left.\frac{dp_{UAB}}{dt}\right|_{in-diff} \quad \left.\frac{dp_{UAB}}{dt}\right|_{out-diff}$$



Role of Migration for Spread of Skills



$\beta_U = 1/10$

$\beta_A = 1/5$

$\beta_B = 1/2.5$

$\delta_U = \delta_A = \delta_B = 1/80$

$\tau_A = 1/5$

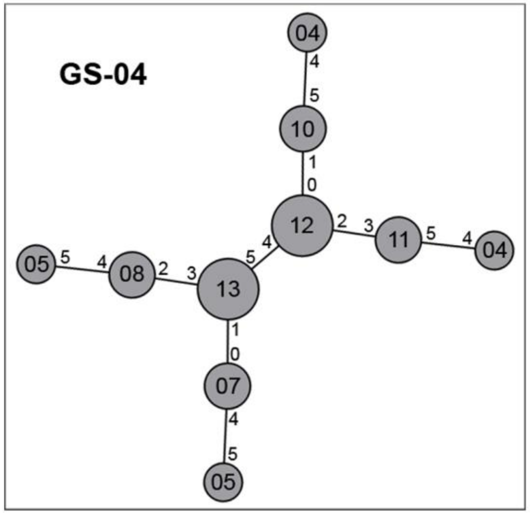
$\tau_B = 1/10$

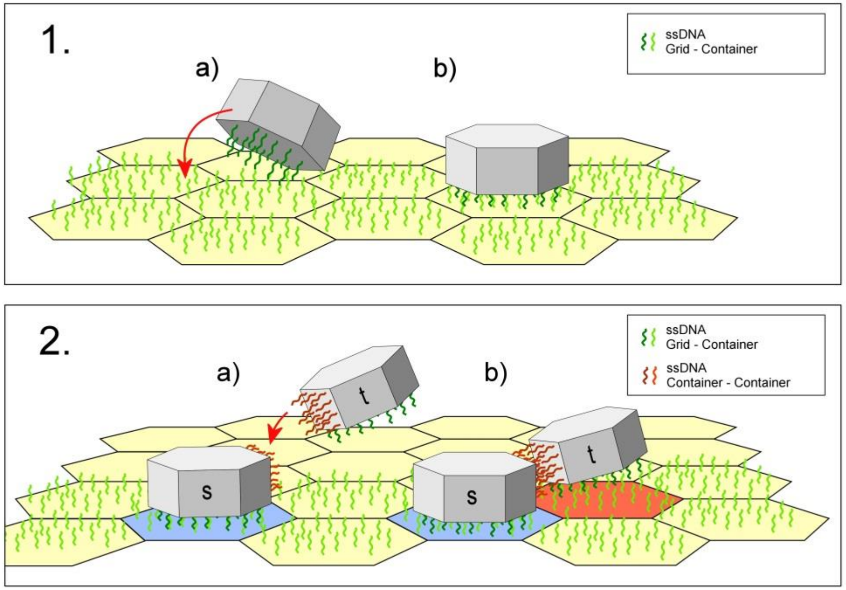
What type of skill set survives depends on migration rate.
➔ Model can support theories in anthropology.

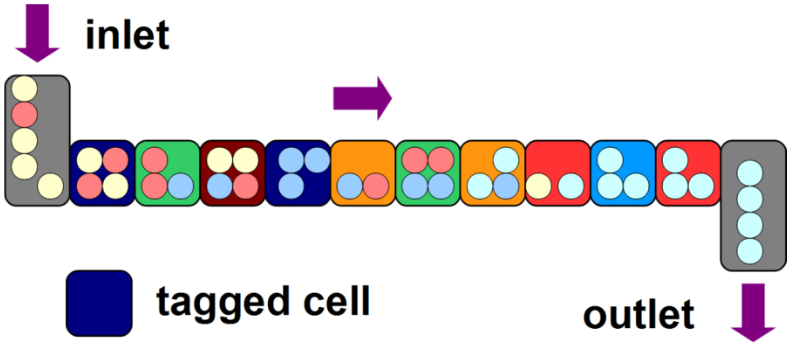
Synthetizing Branched Molecules by Spatially Structured Reactors

Zurich University of Applied Sciences
zh aw School of Engineering
IAMP Institute of Applied Mathematics and Physics

D. Lancet, S. Rasmmussen, J. S. McCaskill, M. Weyland



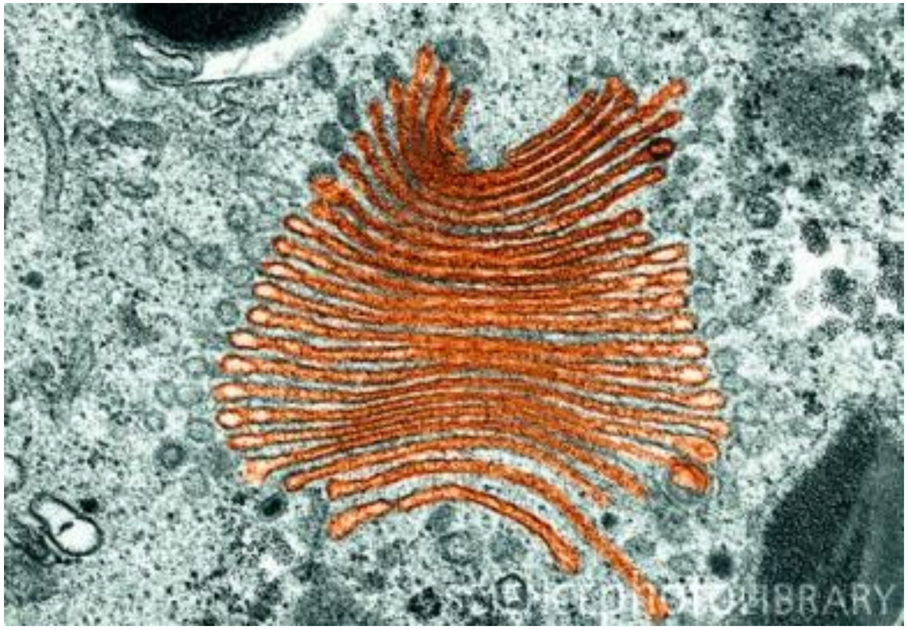




Evolved (B. Reller)

Compiled

Golgi Apparatus



http://jennarever.weebly.com/index.html

Production of oligosaccharides (among other things)

Weyland, M. S.; Fellermann, H.; Hadorn, M.; Sorek, D.; Lancet, D.; Rasmussen, S.; Füchslin, R.M. (2013). **The MATCHIT Automaton: Exploiting Compartmentalization for the Synthesis of Branched Polymers. Computational and Mathematical Methods in Medicine**, 2013, Article ID 467428.

Fellermann, Harold; Hadorn , Maik; Füchslin, Rudolf Marcel; Krasnogor, Natalio (2014). **Formalizing Modularization and Data Hiding in Synthetic Biology**. ACM Journal on Emerging Technologies in Computing Systems, 11, 3. article nr. 24

The Hidden Benefit of Small Size

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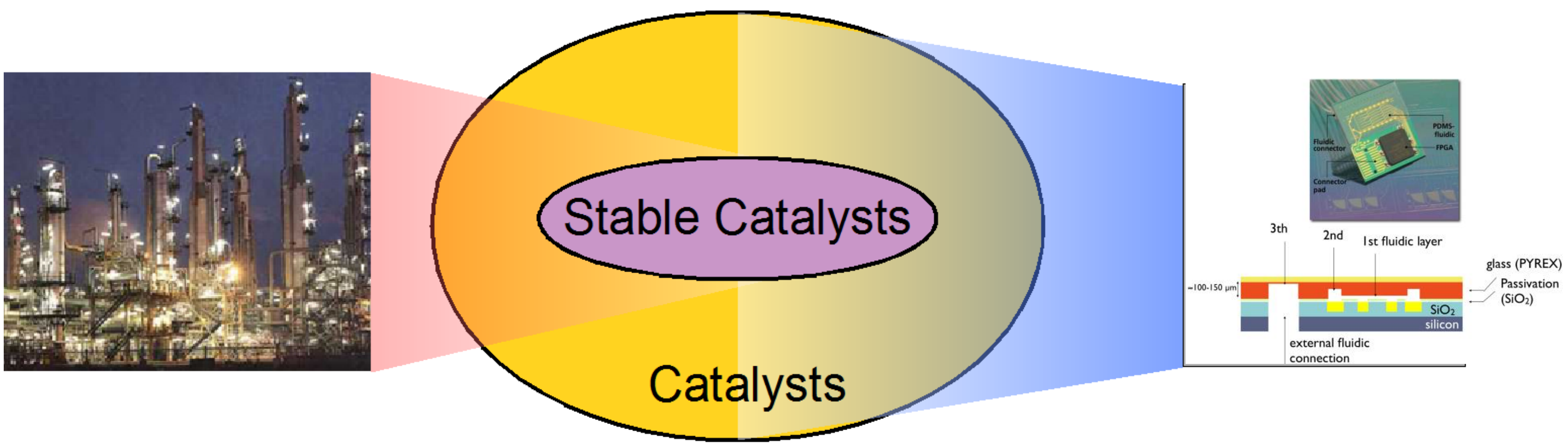
Macroscopic processes: Metastable substances can only be used with considerable effort.

On the micrometer – scale, a few seconds life time are sufficient for diffusive transport.

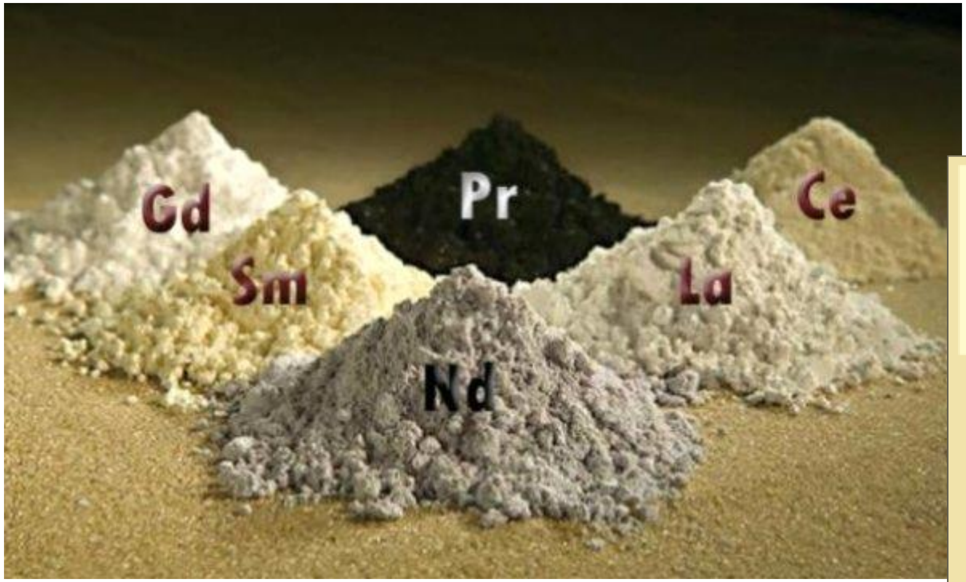
Macroscopic Catalysts: Need efficiency and stability

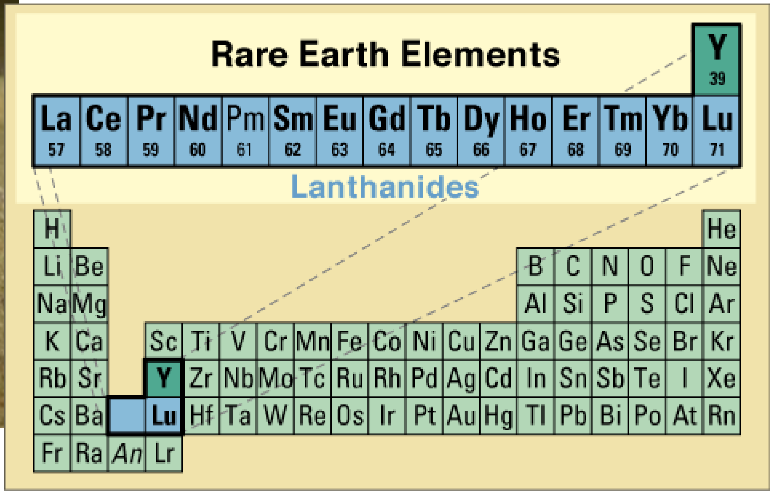
Microscopic Catalysts: Efficiency is sufficient!



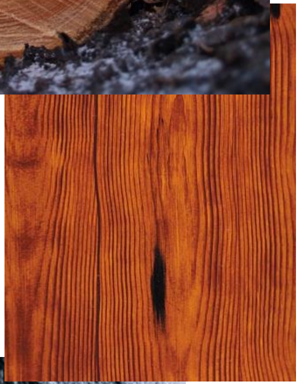
Self-Assembly and Novel Materials

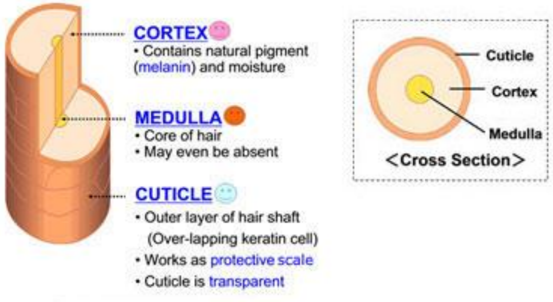
- Most modern materials rely on the **properties of atoms**, either with respect to stability or catalycity.
- Almost all elements are used in todays technology, includding the so called "rare earths".

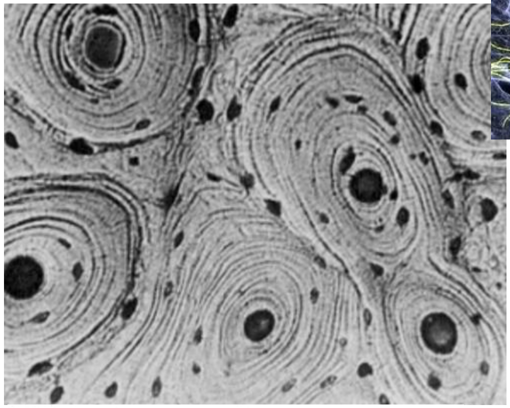


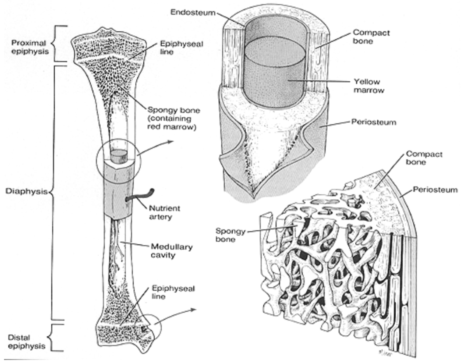


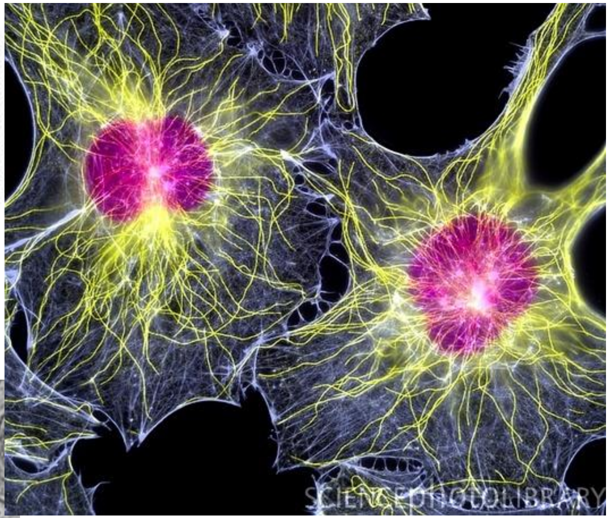
Self-Assembly and Novel Materials

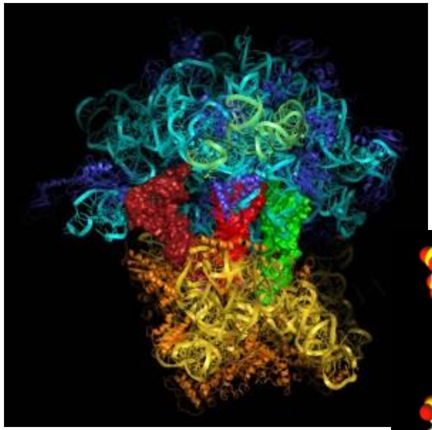


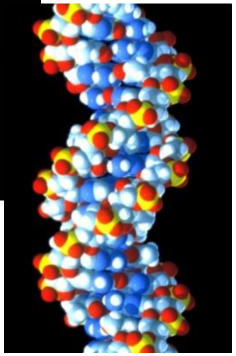








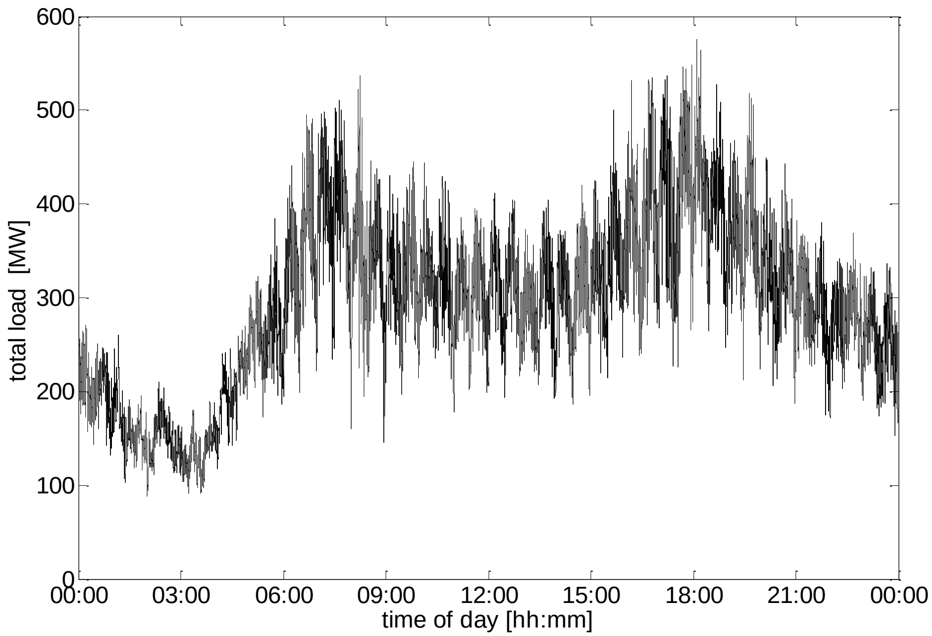




Rare Earths vs. Artificial Bioinpired Materials

	"Atomic" Matter	Multiscale Matter
Gets ist features	From atomic properties	Properties of structures on various length scales.
Production	"Simple"	Very hard, usually requires synthesis more complex than what present technology is able of.
Basic materials	Some are rare	Abundant
Toxicity	Potentially high, difficult to degrade	Often: Degradable by digestion
Stability	Potentially high	Usually not so high (but notable exceptions, such as wood).
Properties understood	Mostly in reach of present science.	

Energy Efficiency



Energy Efficiency:

- Improve efficiency of trains.
- Reduce reserve energy.

C. Zaugg

Better understanding of fluctuations

➔ improved possibilities for risk assessment and energy trading

➔ potential for reduction of reserve energy.

The End of Theory?

The End of Theory: The Data Deluge Makes the Scientific Method Obsolete

By Chris Anderson 06.23.08

Illustration: Marian Bantjes

Wired, 16/7, 2008

C. Anderson

The End of Theory?

The End of Theory?

Why Models?

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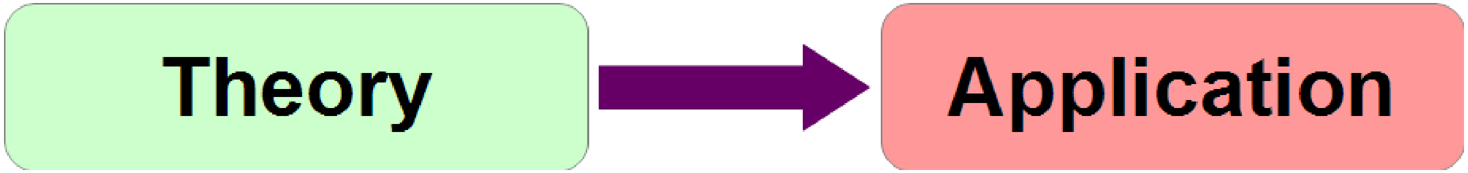
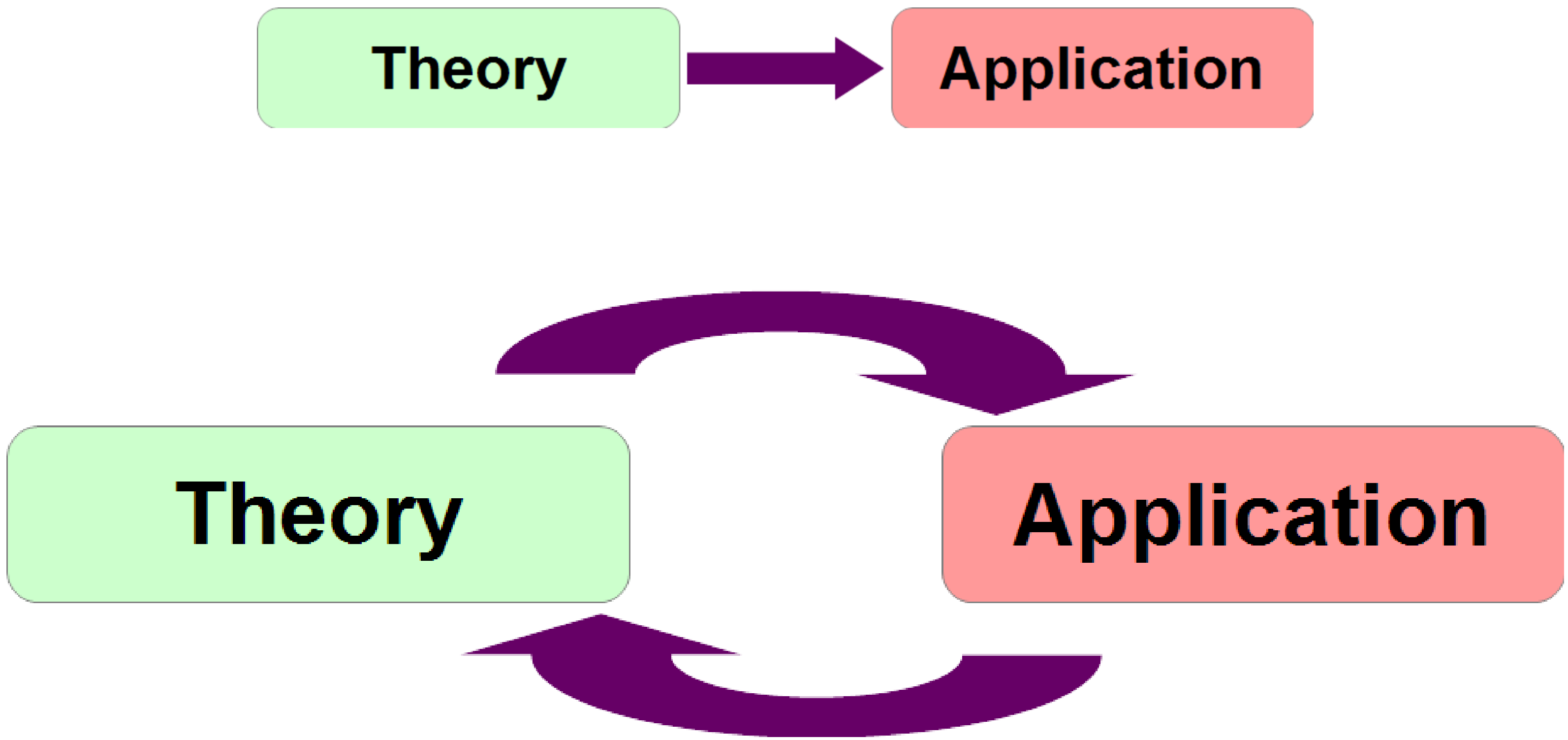
- Check your **understanding** of the past
- **Optimize** the present
- **Predict the future** if you know the present
- **Estimate the future** if you guess the present
- The non – ideal world: Dealing with **fluctuations**
- Find your **weaknesses,** identify your **strengths**

Applied Science is not Development



Applied Science is not Development



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