Human Population 2018

Lecture 21
Technology, transitions

valuation allowed only after good/bad is defined

Growth is bad!

- **LtG chapter on Technology, Markets and Overshoot**
- ...points out that no new technology can overcome **exponential growth** of the population for long, since by its nature, exponential growth accelerates past any rate of abatement or adaptation. (See Malthus!)
- Overcoming one limiting factor only leads to another coming soon after, until "**ability to cope**" limit is itself overcome.
- No solution other than "game change"

The rules of the economy

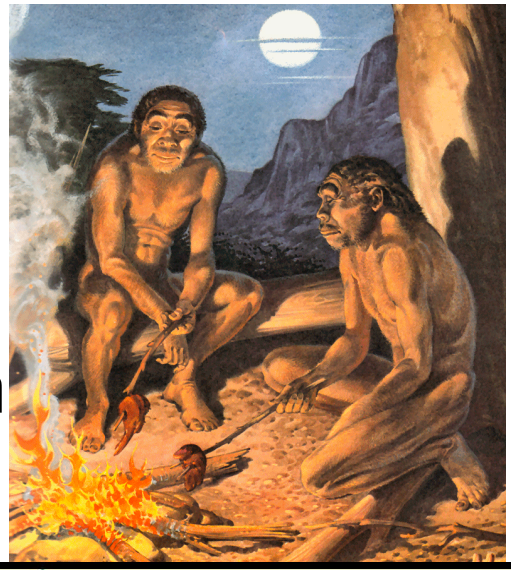
- **Markets assume growth.**
- **Growth is bad.**
- **We can't live without markets.**

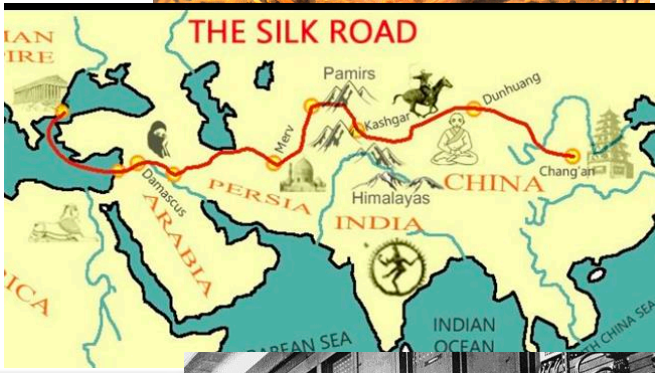
∴ **We're doomed!**

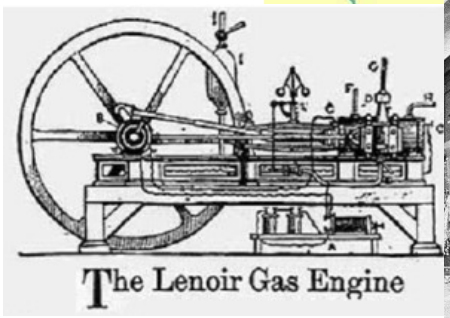
.....we will return to this.....

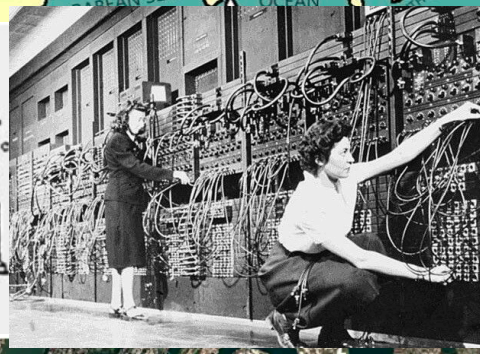
Technology

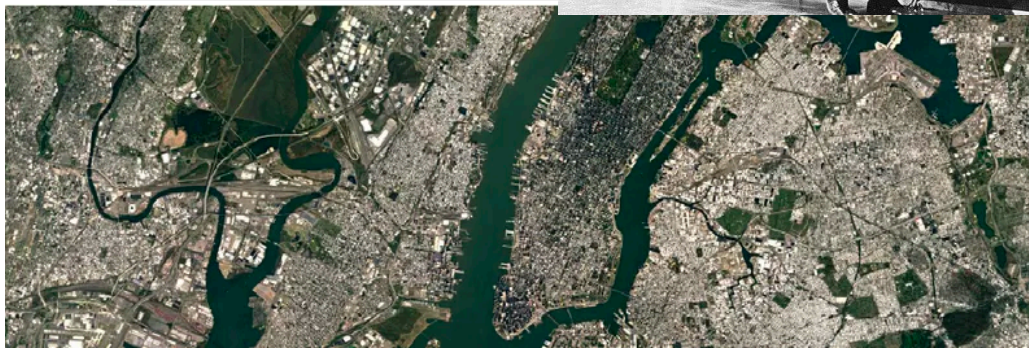
stone tools, fire, cooking, clothing, language, writing, ceramics, metal, wheel, domestication agriculture, soap, government, law, trade, money, philosophy, math, chemistry, weapons, explosives, ships, navigation, oil, combustion engine, sewers, economics, banks, camera, universities, aircraft, electronics, radio, video, vaccines, telephone, antibiotics, computers, internet, satellites, cell phones, social media, anti-cancer drugs.
What's next?











How does technology affect the human condition?

$$N_t = N_0 \exp(\alpha - \beta)$$

α=birth rate

β=death rate

How does incr. technology affect α
(increase, decrease, both, neither)

How does incr. technology affect β
(increase, decrease, both, neither)

What is the net effect of technology on growth?
(increase, decrease, both, neither)

How fast does technology change?

(a) stays constant

(b) grows and shrinks

(c) grows only

(a) grows at a constant rate

(b) grows at an ever decreasing rate

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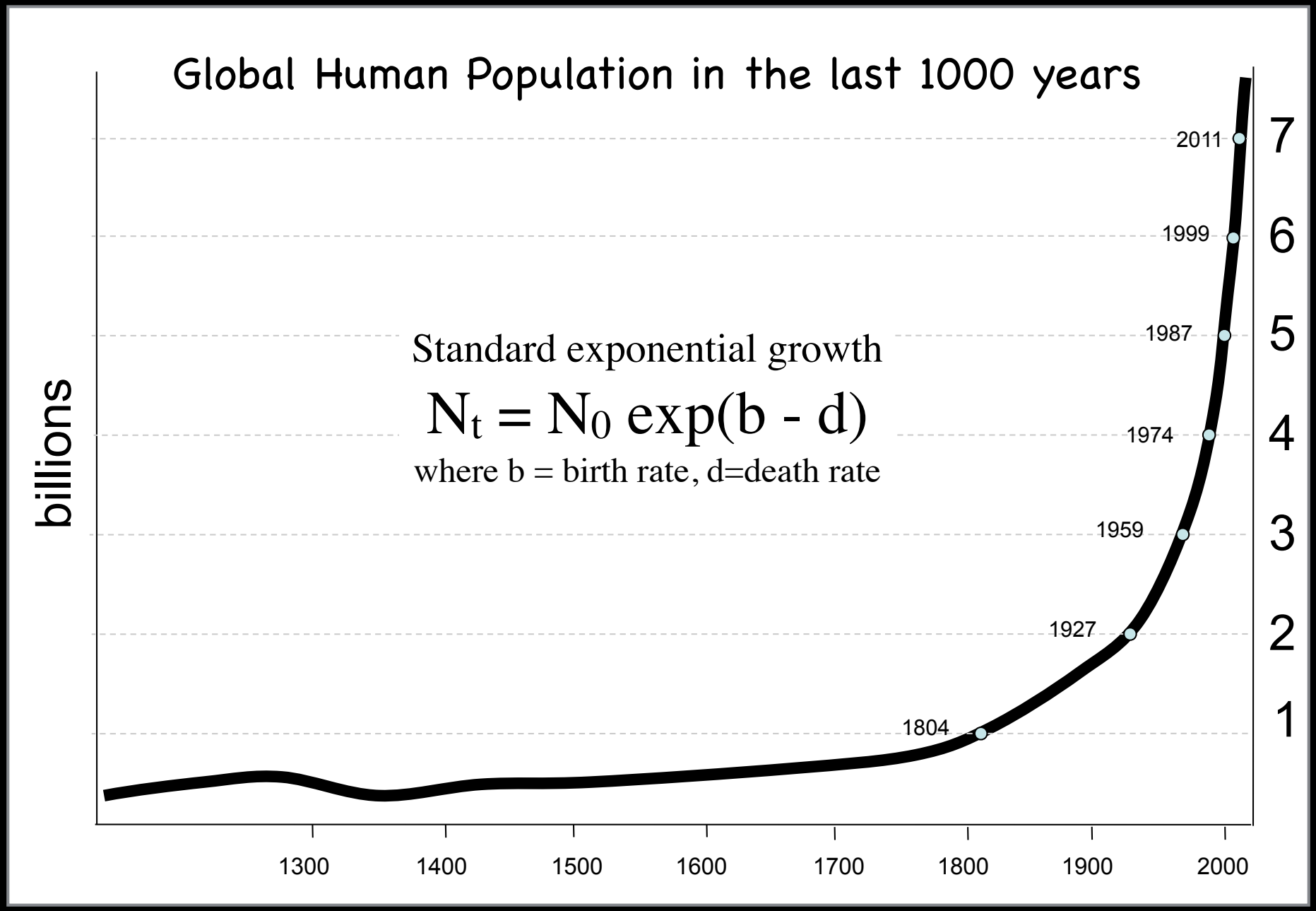
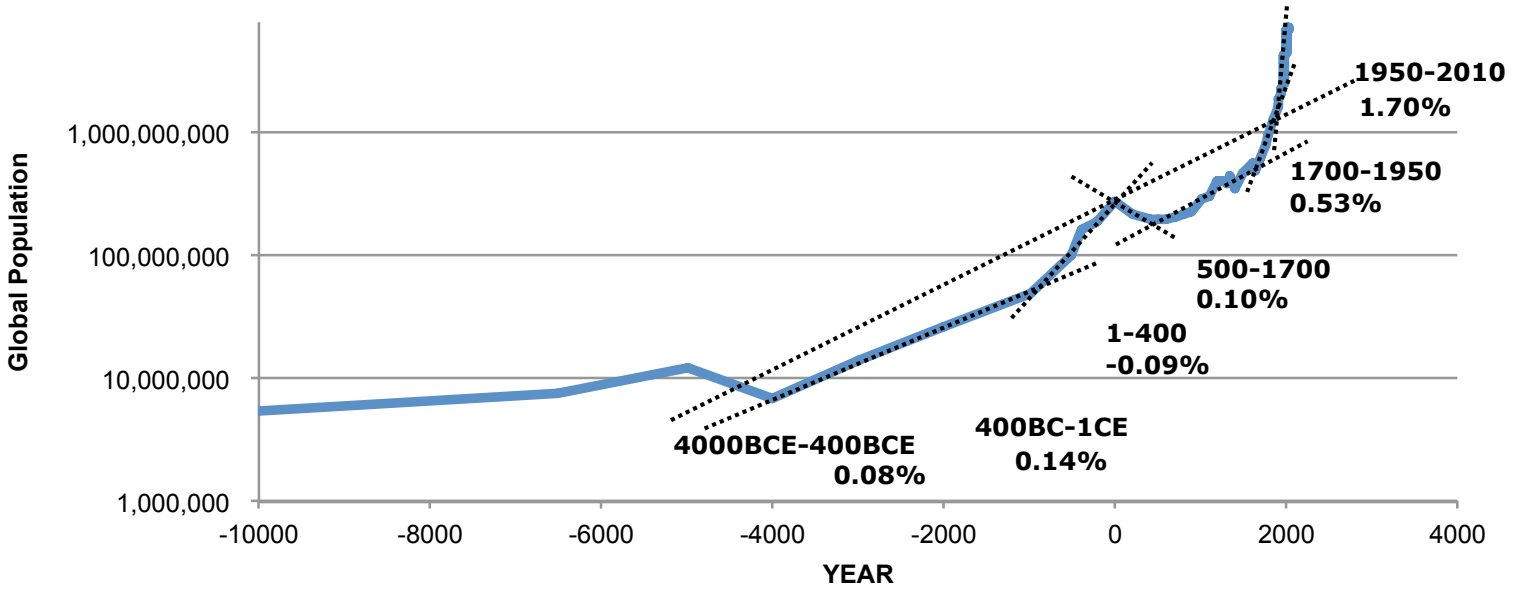

Global Human Population in the last 1000 years
billions
Standard exponential growth
$N_t = N_0 \exp(b - d)$
where b = birth rate, d=death rate
2011
1999
1987
1974
1959
1927
1804
7
6
5
4
3
2
1
1300
1400
1500
1600
1700
1800
1900
2000

Super-exponential growth

log scale



fits the data, but not simple

https://www.census.gov/programs-surveys/international-programs.html

Doubling time is decreasing linearly with time

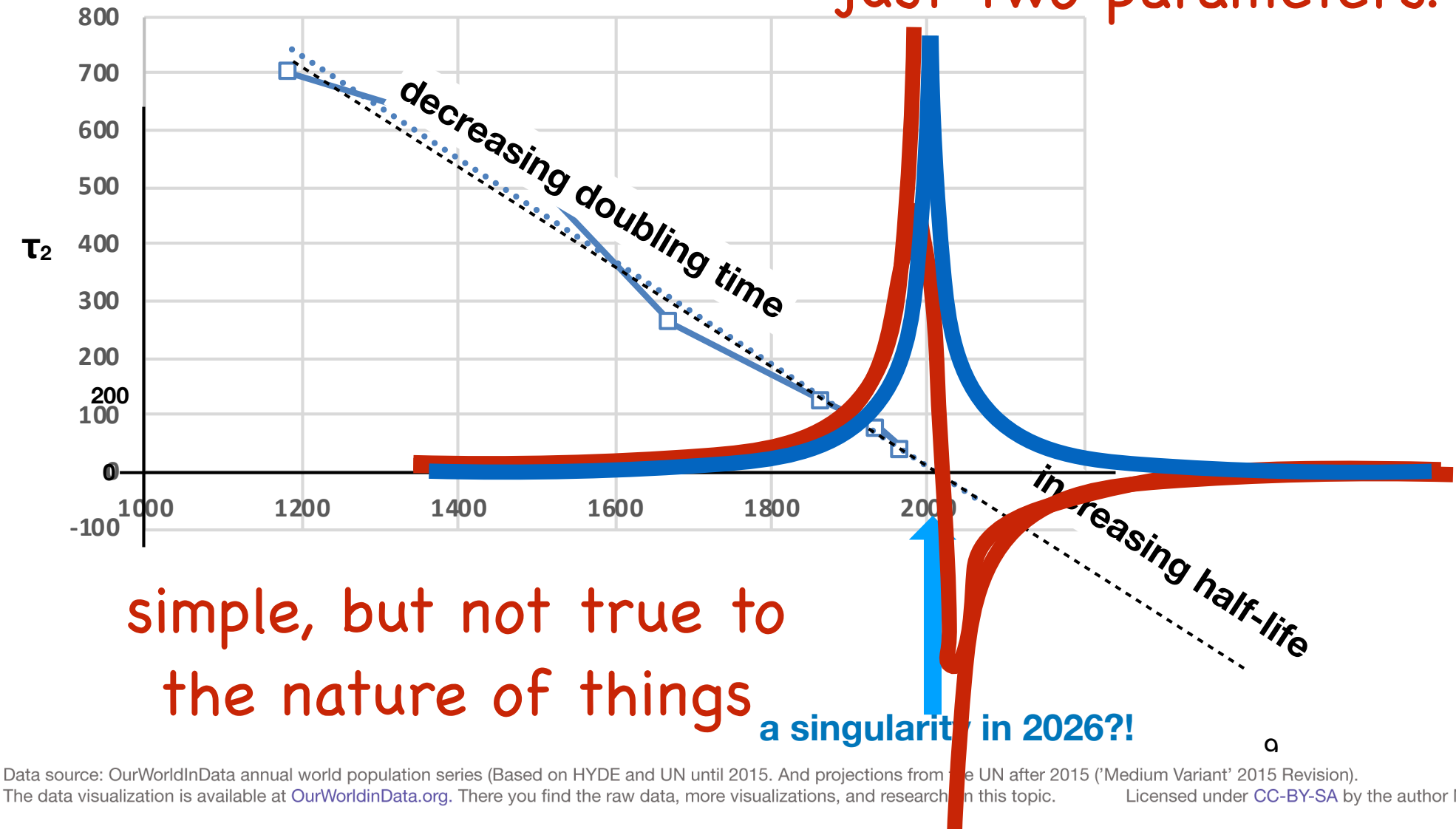
$\tau_2 = mx + b$

$\tau = \ln 2 / k$

$k = \ln(2)/\tau$

$k = \ln(2)/(mx+b)$

just two parameters!



simple, but not true to the nature of things

a singularity in 2026?!

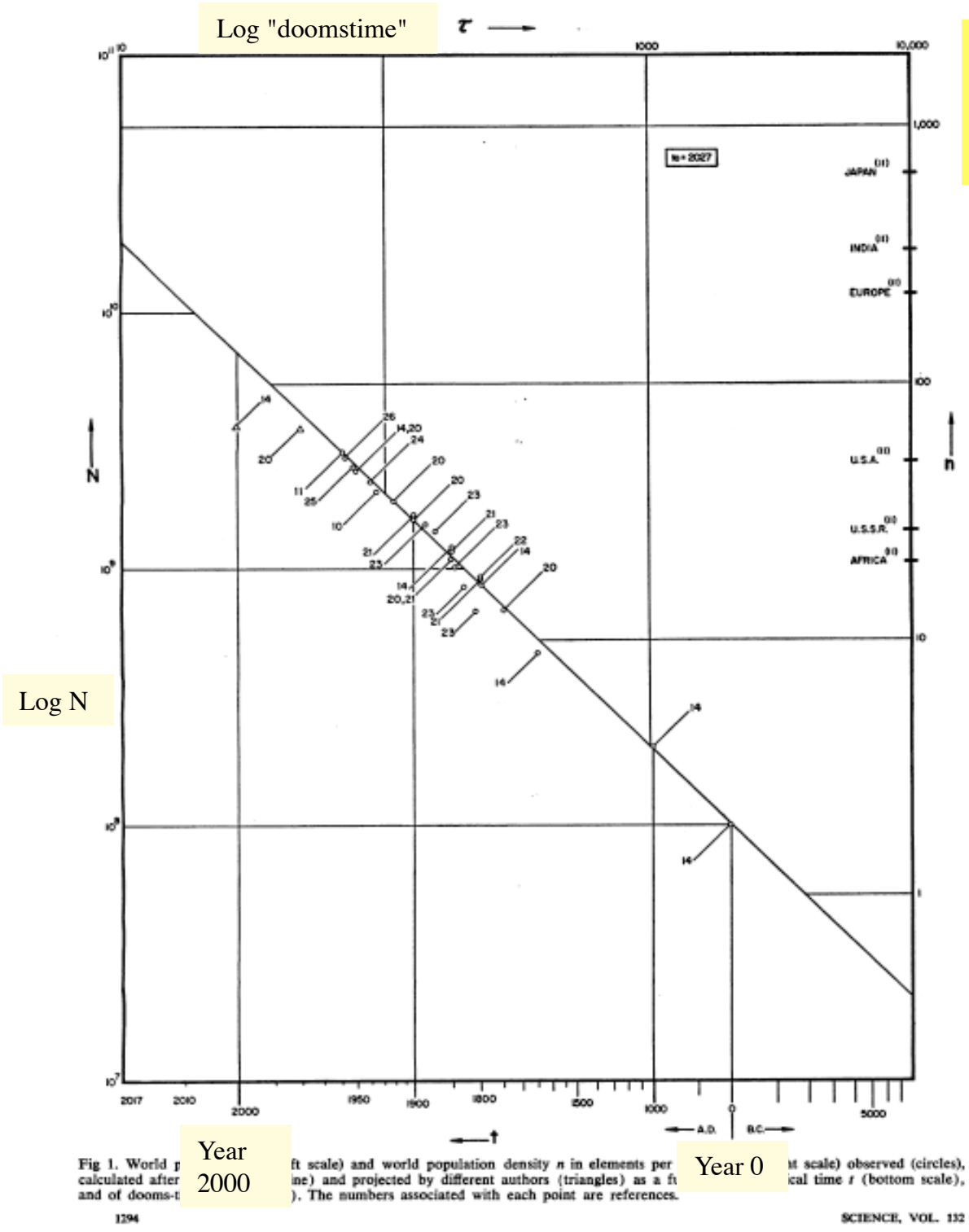


Fig 1. World p ft scale) and world population density n in elements per t scale) observed (circles), calculated after ine) and projected by different authors (triangles) as a ft ical time t (bottom scale), and of dooms-t). The numbers associated with each point are references.

1294 SCIENCE, VOL. 132

The Doomsday equation fits historical global population data up to 1960

$$N_t = N_1 \left(\frac{t_0 - t_1}{t_o - t} \right)^k$$

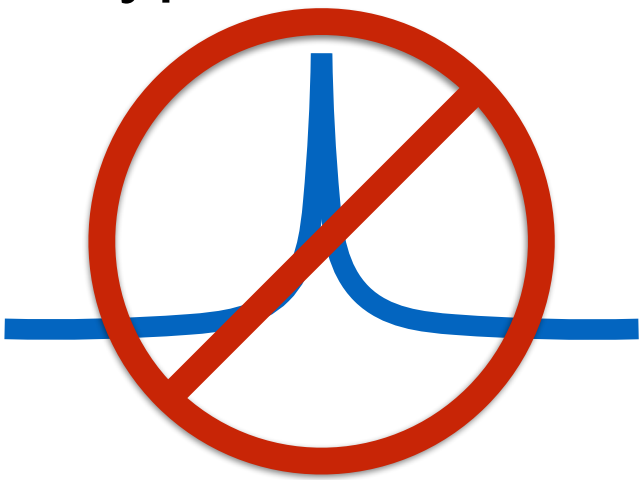
Log-log plot of historical human population versus time (lower x-axis) and dooms-time (upper x-axis). The fit is hyperbolic!

H. von Foerster, PM Mora, LW Amiot (1960) "Doomsday: Friday 13 November, A.D. 2026" Science132:1291-95.

Criterea for a model system

1. Fits the data
2. True to the nature of things

a hyperbola is <u>not</u>



Hyper-exponential growth model

- Population grow at the rate of birth (b) minus the rate of death (d), per capita. $N_t = N_{t-1} \exp(b - d)$
- Assume the dominant contributor to the death rate is "*disease*" (an abstract quantity*) $d = \text{disease}$
- Assume another abstract quantity, "*technology*", subtracts from disease, which starts at a base level C. $\text{disease} = C - \text{technology} \geq 0.0$
- Substitution. $N_t = N_{t-1} \exp(b - C + \text{technology})$
- Define base growth rate. $g = b - C$
- Substituting. $N_t = N_{t-1} \exp(g) \exp(\text{technology})$

What is an abstract quantity

"x" is an abstract quantity. It's meaning is undefined. An abstract quantity is a variable in an equation that does not yet have a real world meaning.

If I give the abstract quantity a **name**, like "**technology**", it suggests that I am going to try to give the quantity a real-world meaning, specifically a meaning related to what we call technology.

What if the abstract quantity that eradicates disease, "**technology**", grows exponentially?

- Technology fits exponential growth. $\mathbf{technology = T_0 \exp(T_g t)}$
- Recursive form for population as mixed exponential, hyperexponential. $\mathbf{N_t = N_{t-1}(\exp(g)\exp(T_0 \exp(T_g t)))}$
- Standard form. $\mathbf{N_t = N_0 \exp(g t) \exp(T_0 \exp(T_g t))}$
- Product of exponents is exponent of sum. $\mathbf{N_t = N_0 \exp(g t + T_0 \exp(T_g t))}$

where,
N_t = population at time t
N_0 = population at time 0
g = inherent growth rate
T_0 = "technology" at time 0
T_g = "technology" growth rate

Fits

Simple exponential

$N_t = 0.2798\exp(0.0007\mathbf{t})$

*Does not fit the data.

Simple hyper-exponential

$N_t = 0.038\ \exp(1.5E\text{-}33\ \exp(0.00638\ \mathbf{t}))$

*Does not fit the data.

Sum of exponential, hyper-exponential *

$N_t = 0.03188\ \exp(0.0008302\ \mathbf{t}) + 0.000335\ \exp(0.0000419\ \exp(0.00107\ \mathbf{t}))$

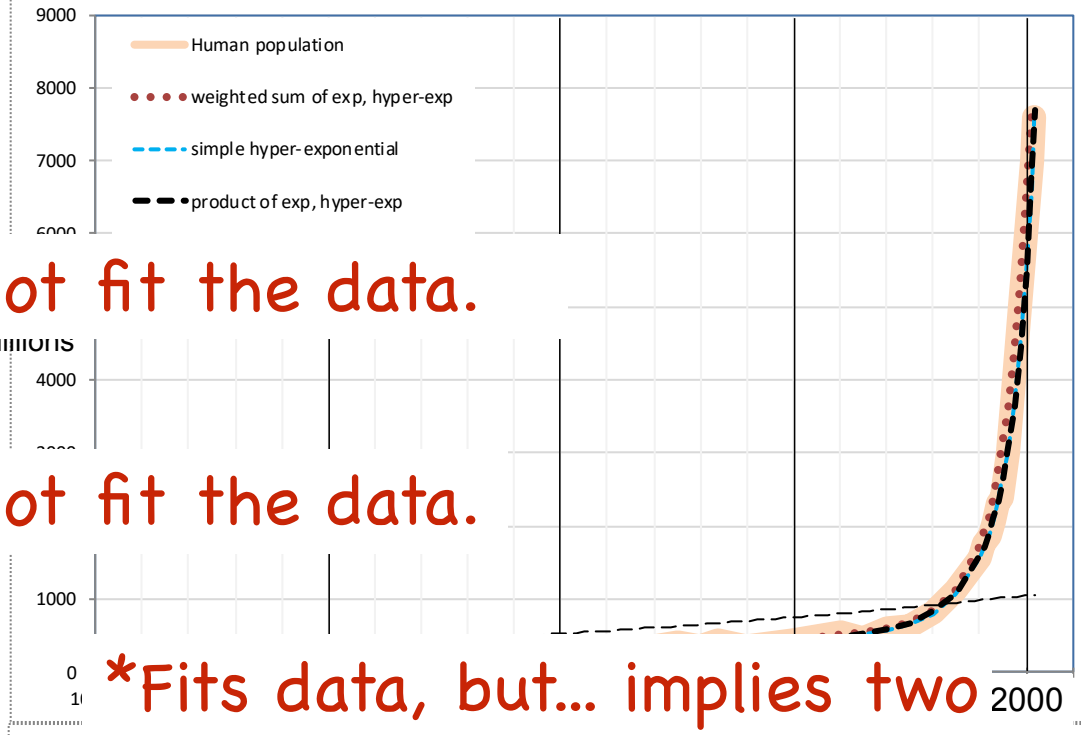
*Fits data, but... implies two independent human populations, not interacting throughout history.

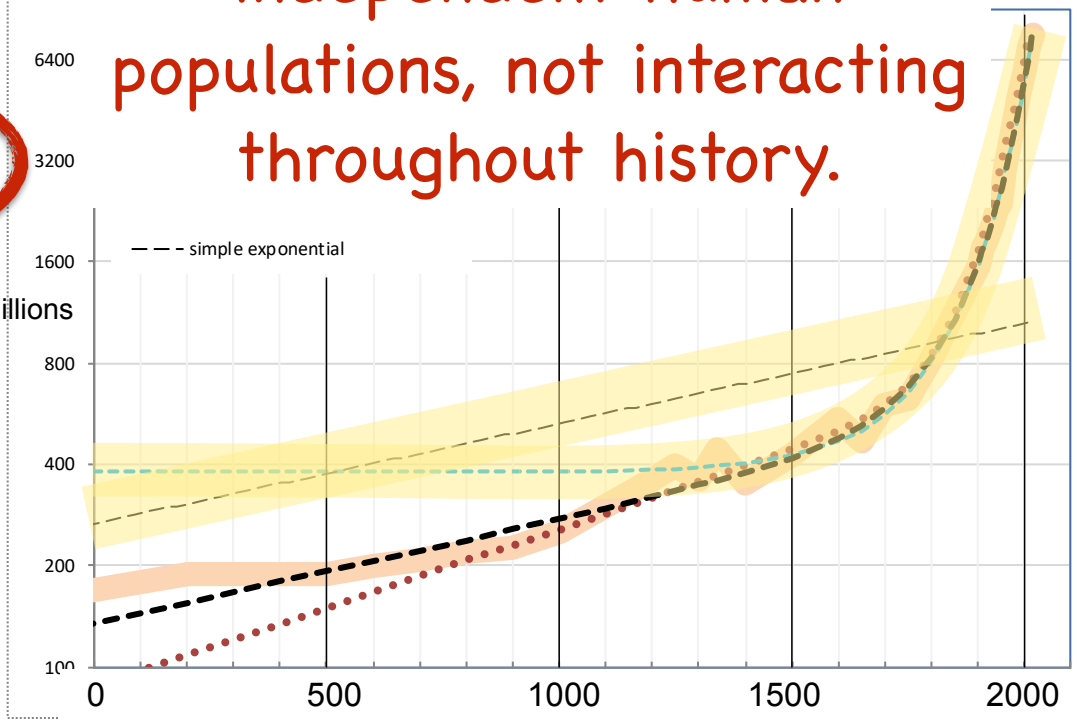
Product of exponential, hyper-exponential

$Nt = 0.10\exp(0.00072t)\exp(1.0E\text{-}38\ \exp(0.00736t))$

fits the data,

true to the nature of things

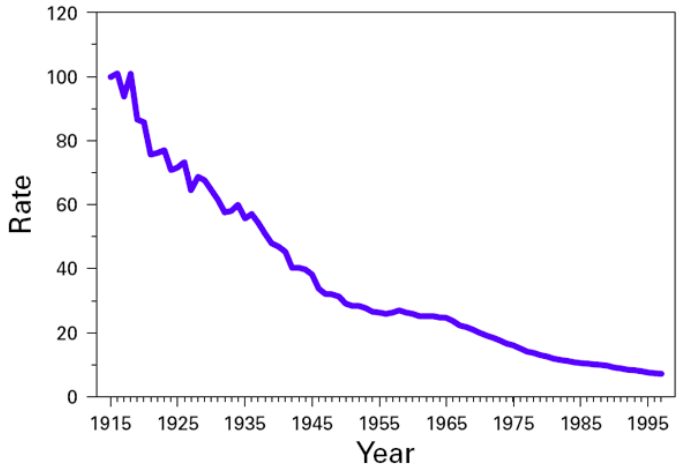




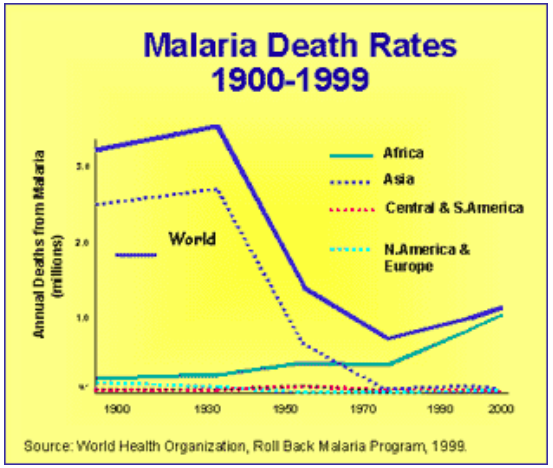
Implications

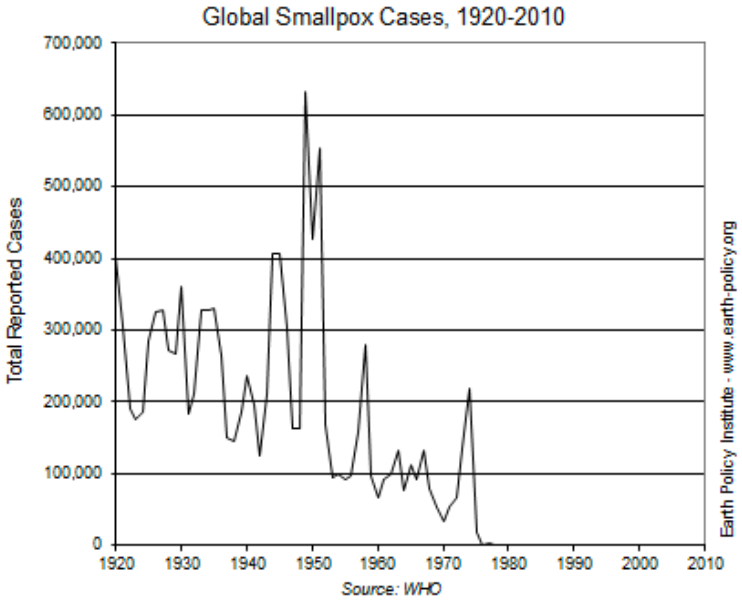
- Population since 1000 fits **four parameters**, not two.
- Human since 1000 behave as a **single entity**.
- "**Technology**" increases the growth rate by eradicating "**Disease**" (cause of death, infant mortality)
- "**Technology**" grows intrinsically, not proportional to human population. (If it grew proportionally to human population, population growth would be even faster.)

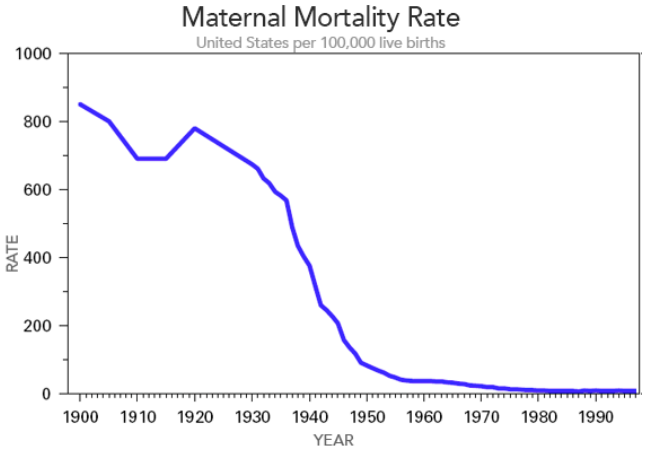
FIGURE 1. Infant mortality rate,* by year — United States, 1915–1997

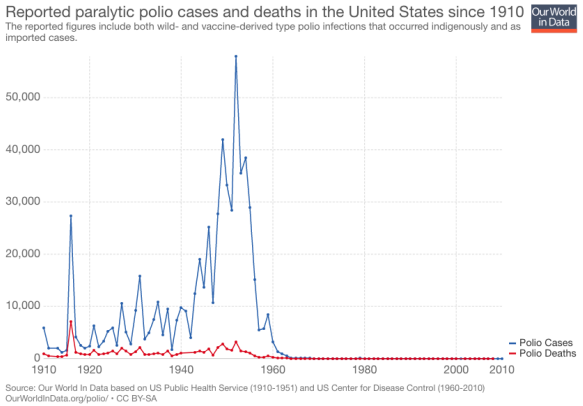


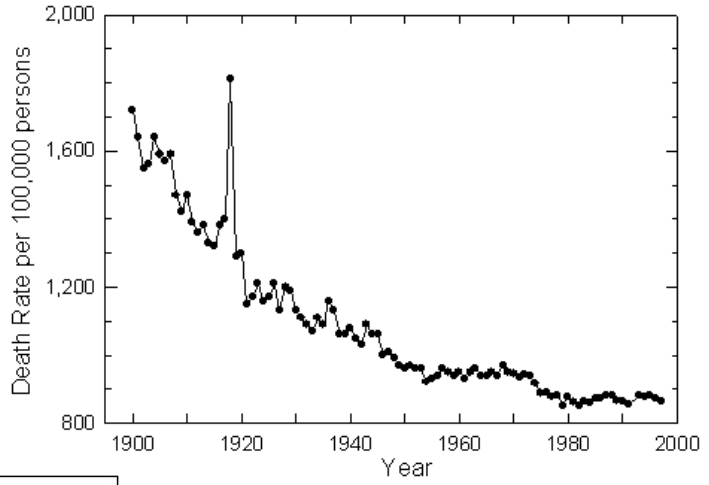
*Per 1000 live births.

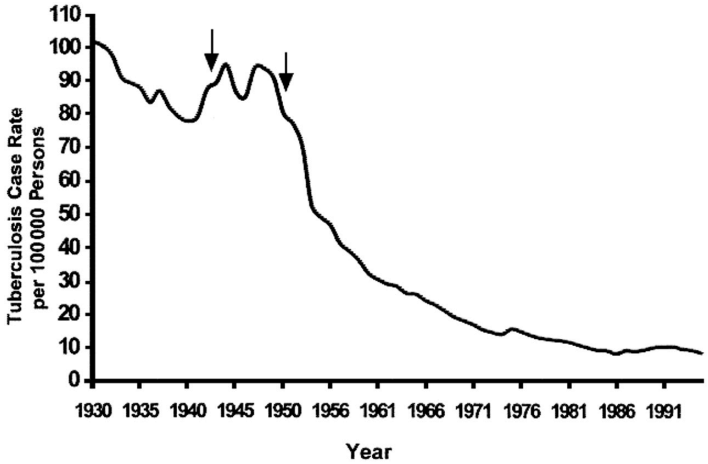


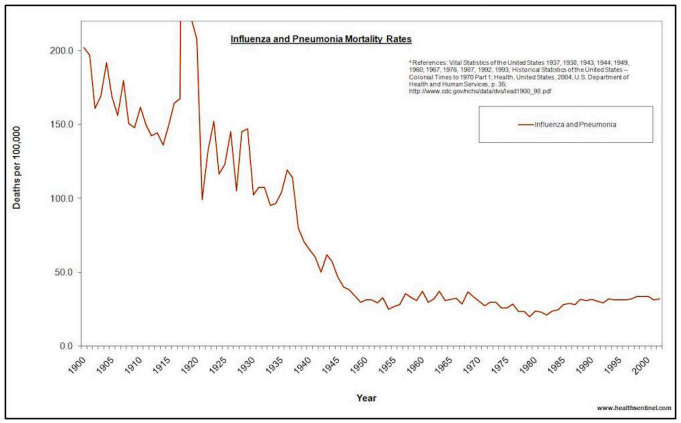


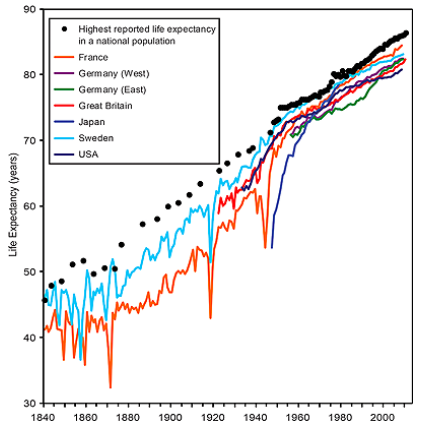






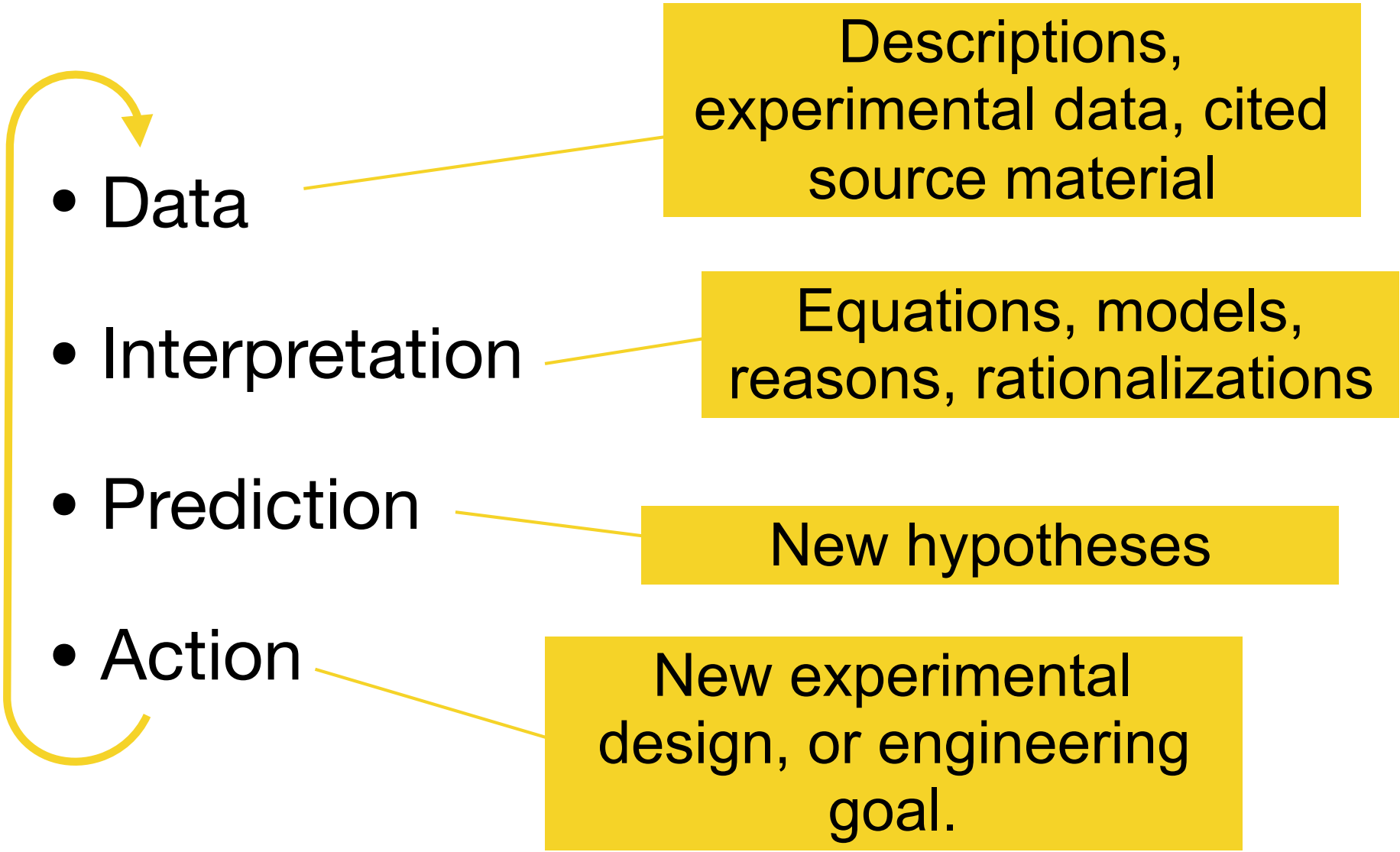






Yes, but, what about the future?

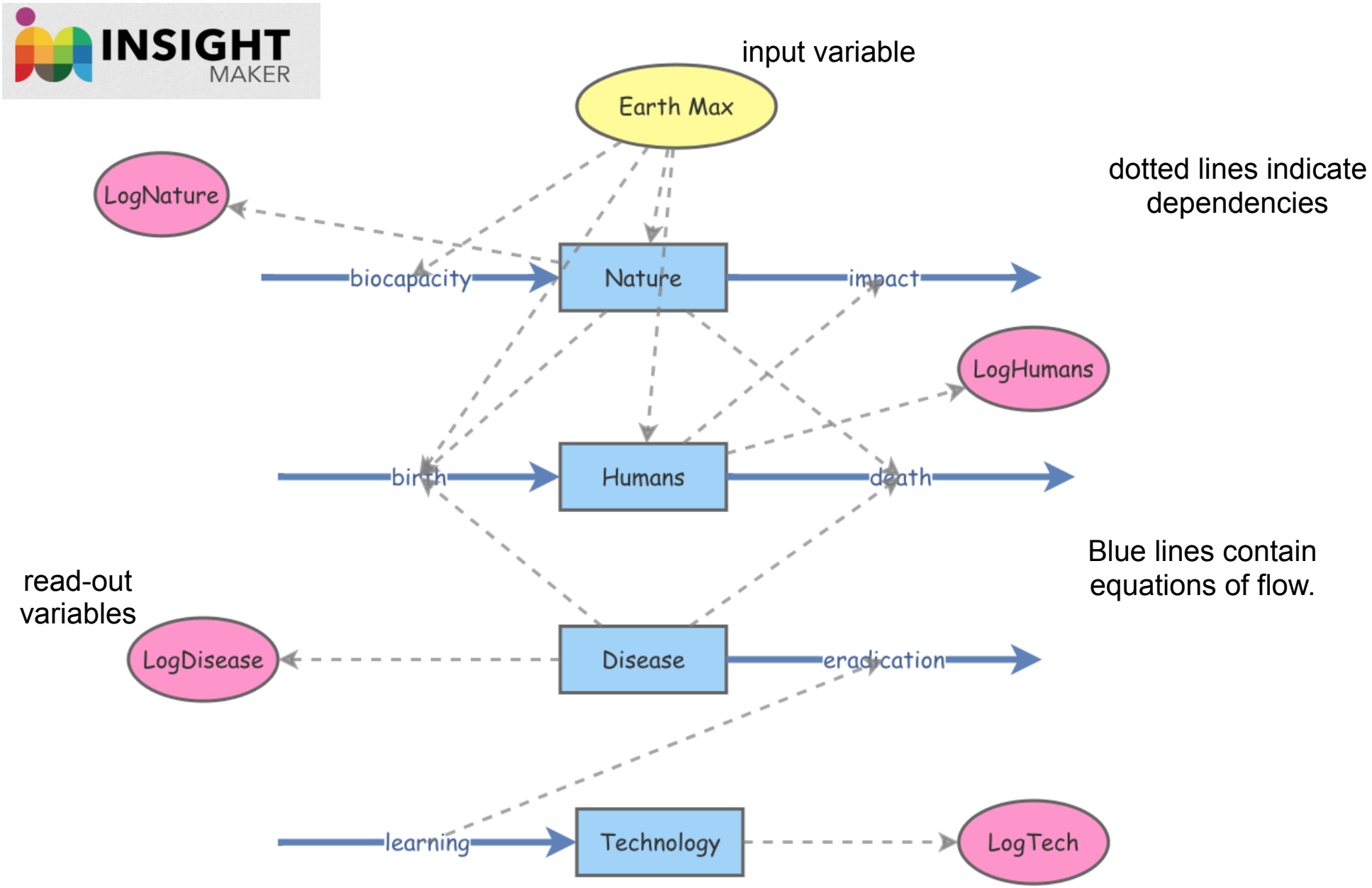
DIPA, a pedagogy



No jumping to conclusions. No action before prediction.

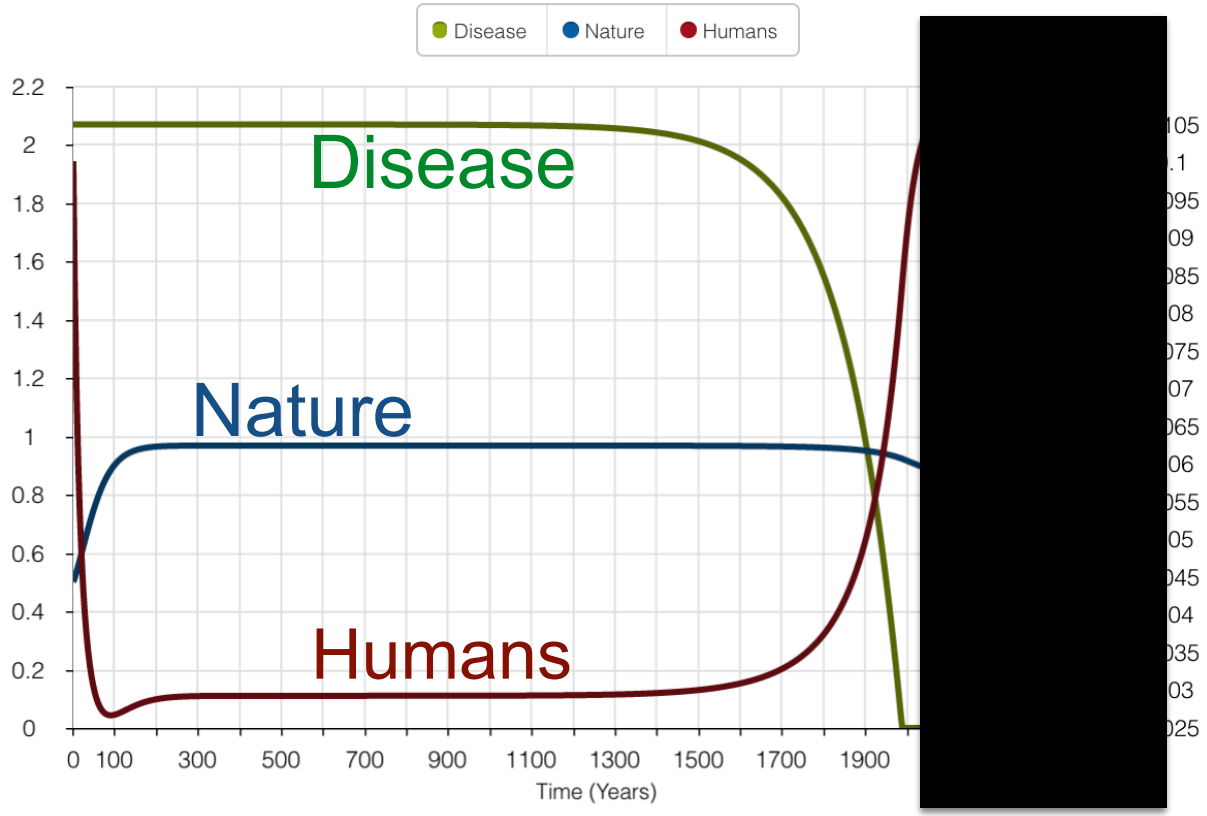
"Systems thinking"

- Complex system behavior can be reproduced by **interconnected and interacting quantities.**
- Equations within the system can be **fit to data.**
- Systems dynamics can be used to predict the **future.**
- Systems dynamics can predict **sensitivities.**



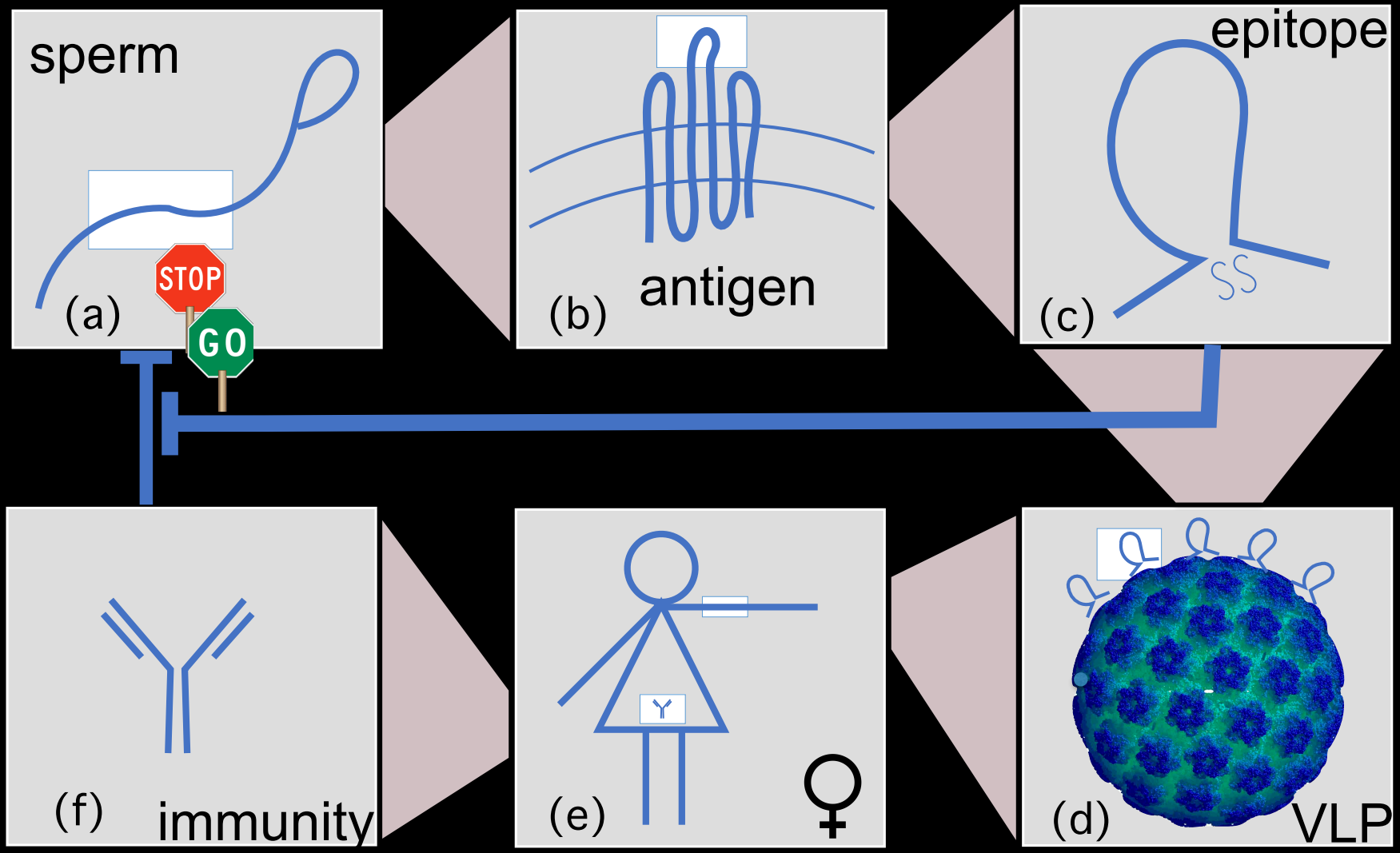
A fourth abstract quantity "Nature" models the carrying capacity, which decays as a function of the number of Humans

Systems dynamics can predict a possible "future"



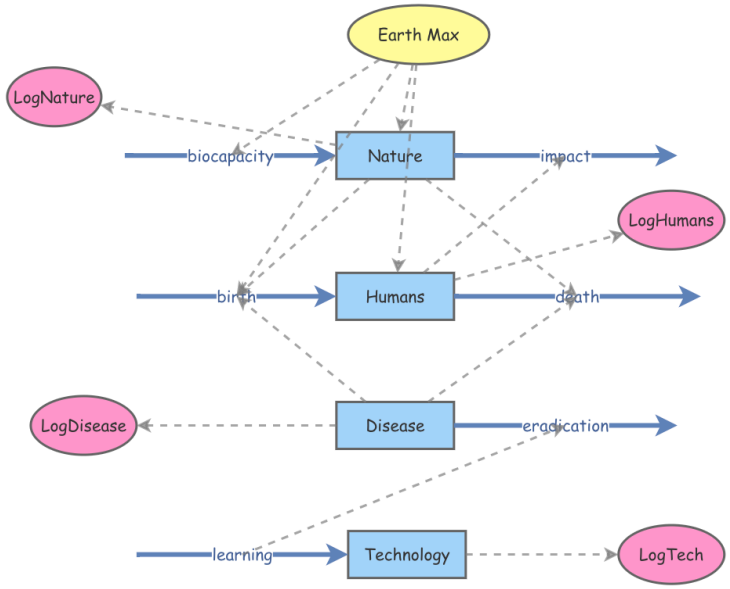
What the true future holds depends on what we do.

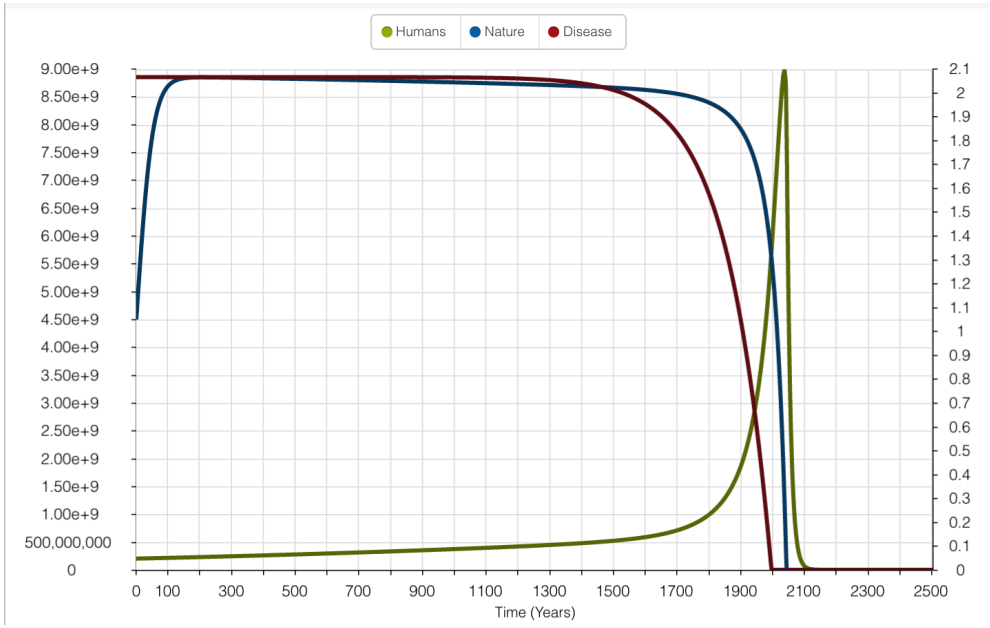
A reversible contraceptive vaccine

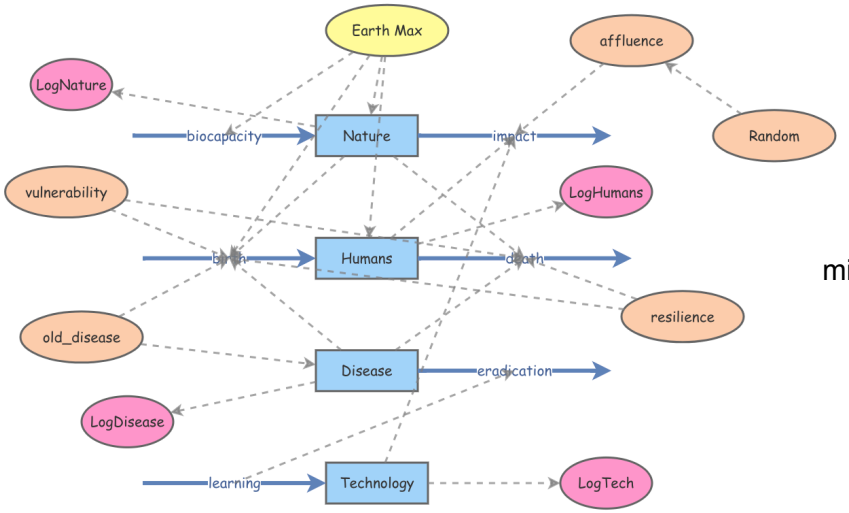


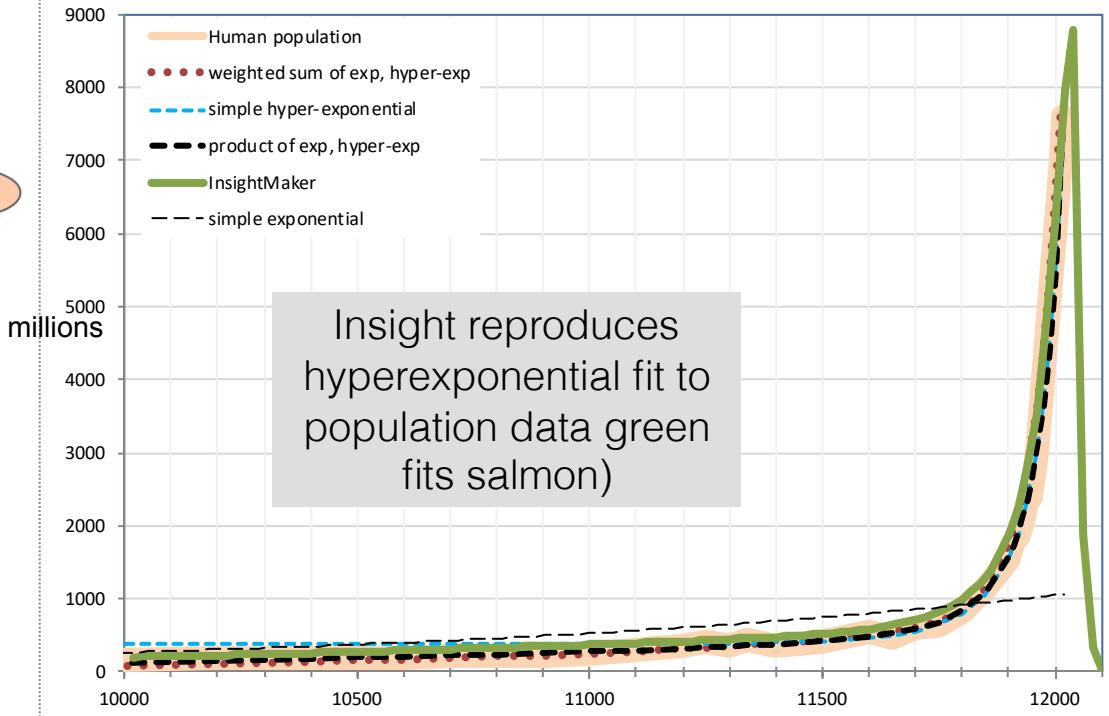
The other Homework 5

Use the model from Homework 4 to reproduce the actual history of human population.

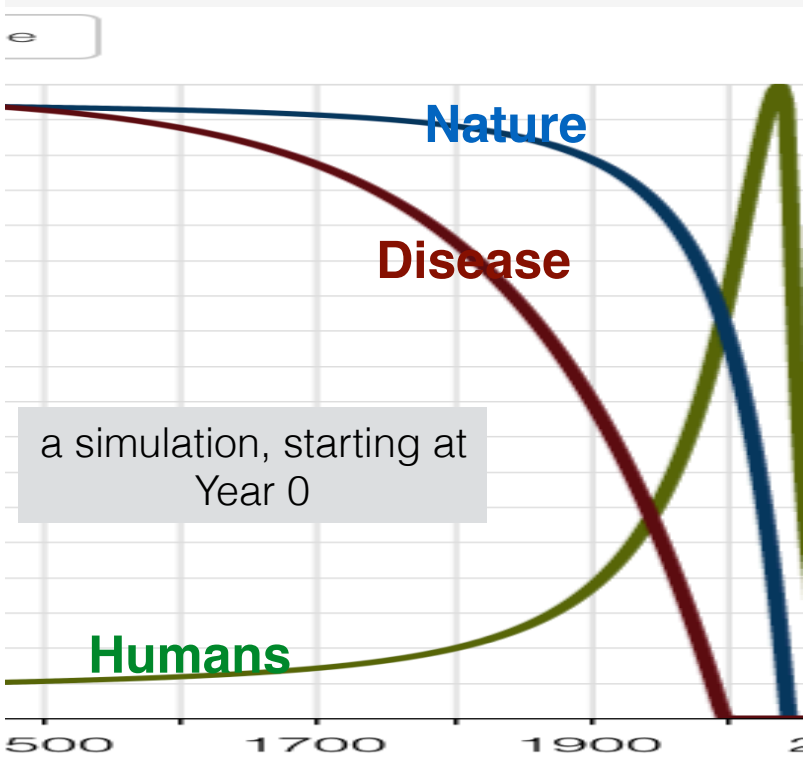




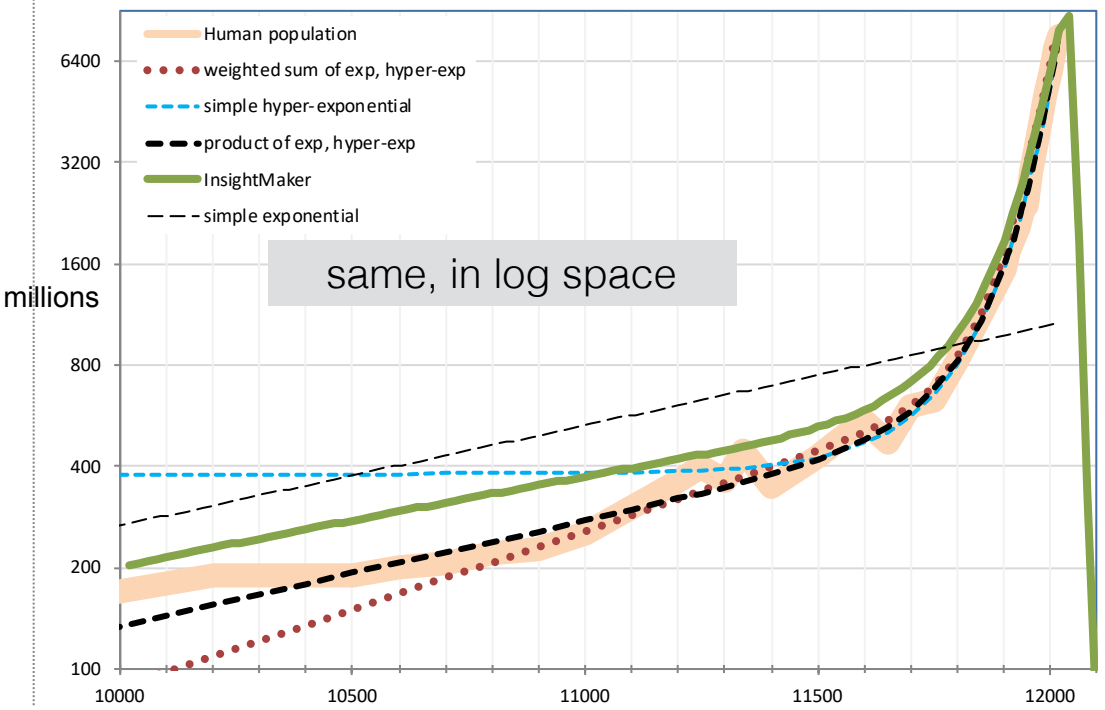




Insight reproduces hyperexponential fit to population data green fits salmon)



a simulation, starting at Year 0

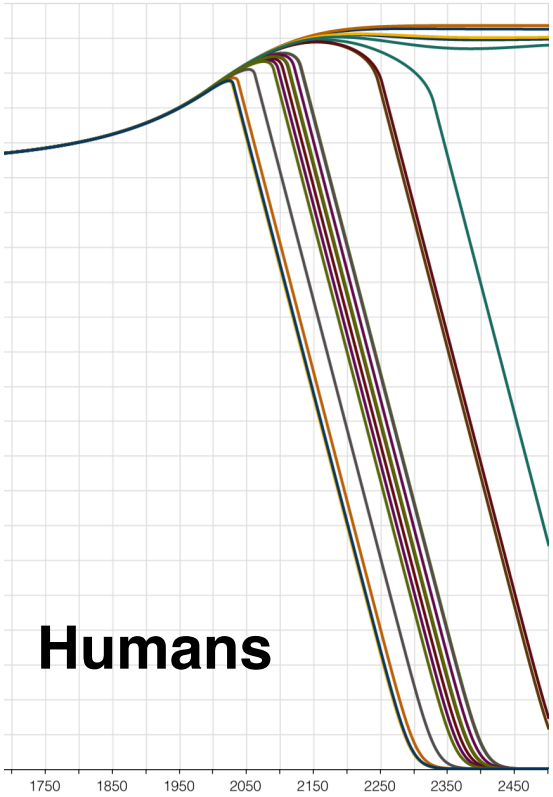


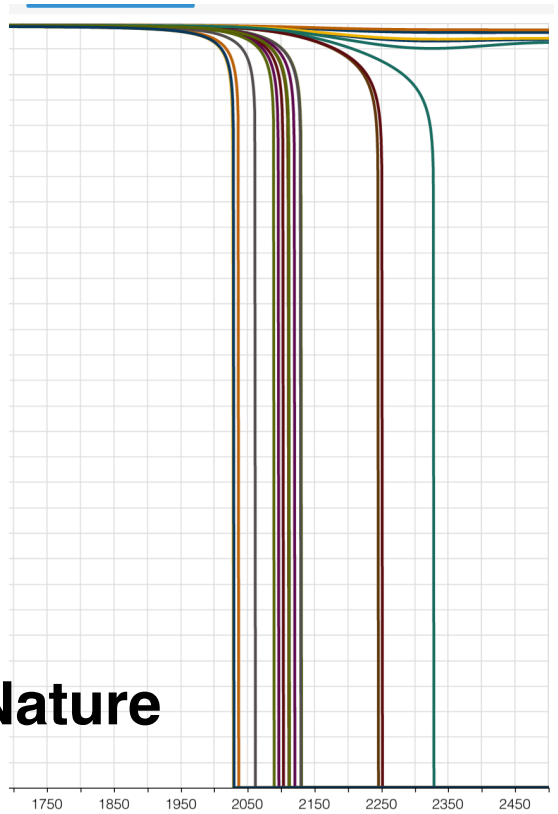
same, in log space

Sensitivity to affluence

I =PA

At high Affluence (consumption per capita), the population reaches carrying capacity early and collapses. At low affluence, a high population is sustainable.



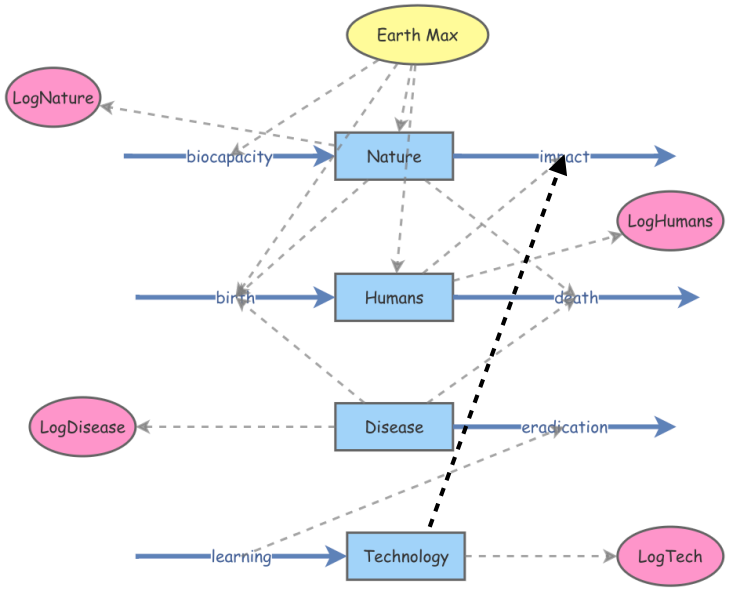


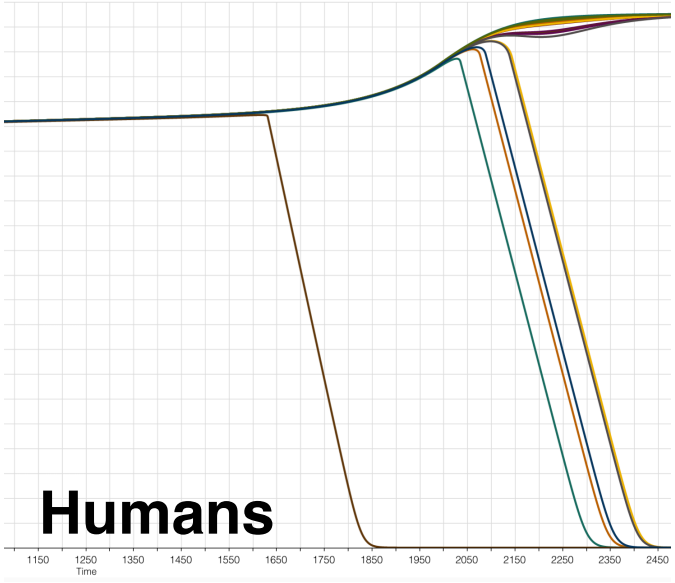
At high Affluence (consumption per capita), Nature is exhausted earlier. At low Affluence, Nature is not disturbed. Decrease in Nature by one log unit (90%) or more leads to collapse.

Sensitivity to affluence

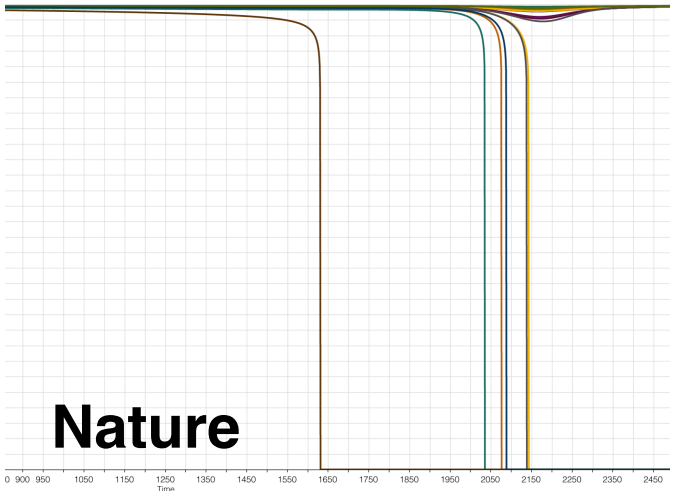
Using technology to reduce impact

I =PAT





If Technology is used to calculate impact (I=PAT), then collapse is less likely. Collapse threshhold (1 log unit) remains the same.



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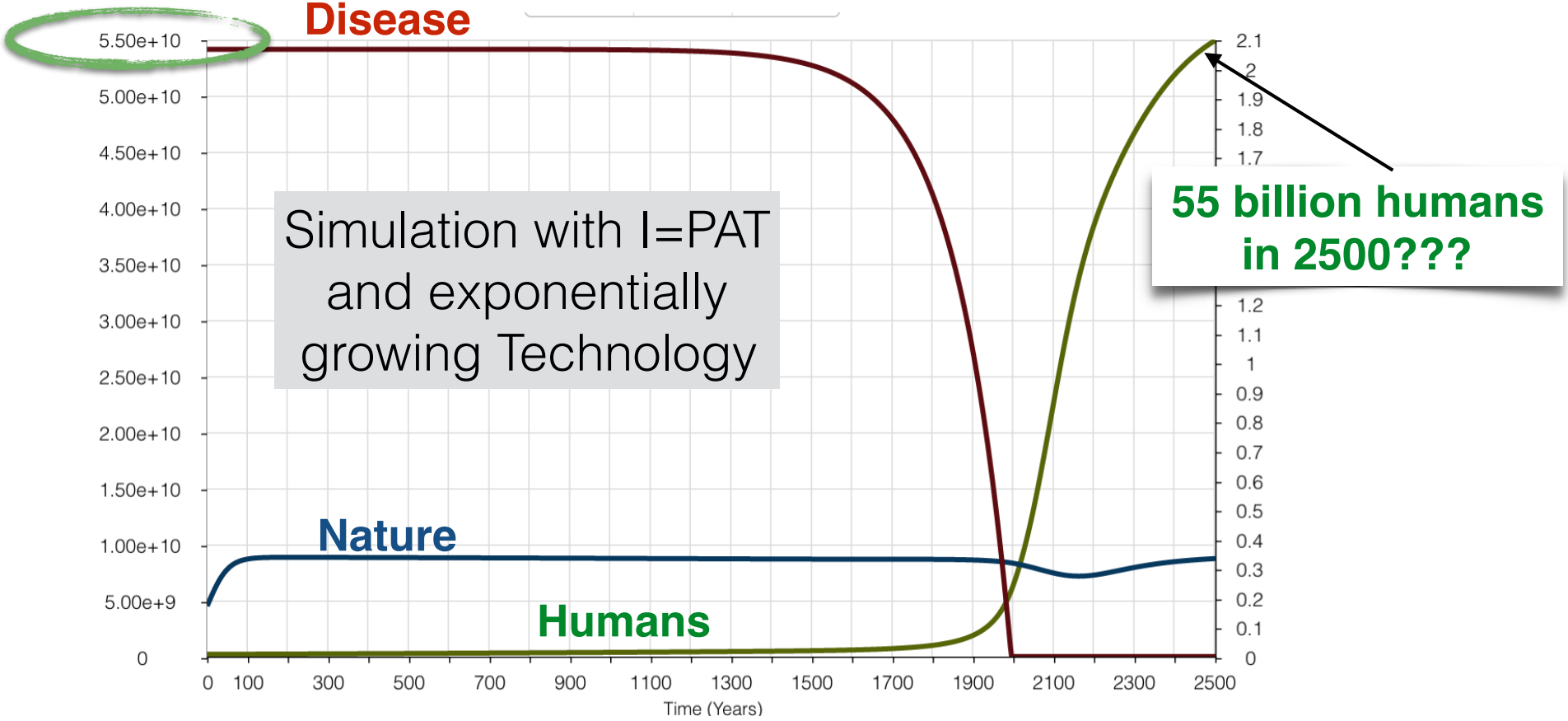
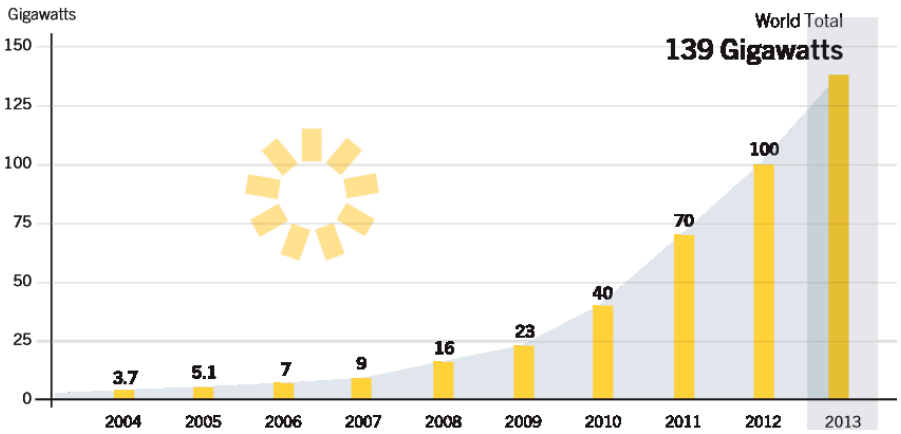
What is next for Technology?

Can population go *beyond the carrying capacity* sustainably?



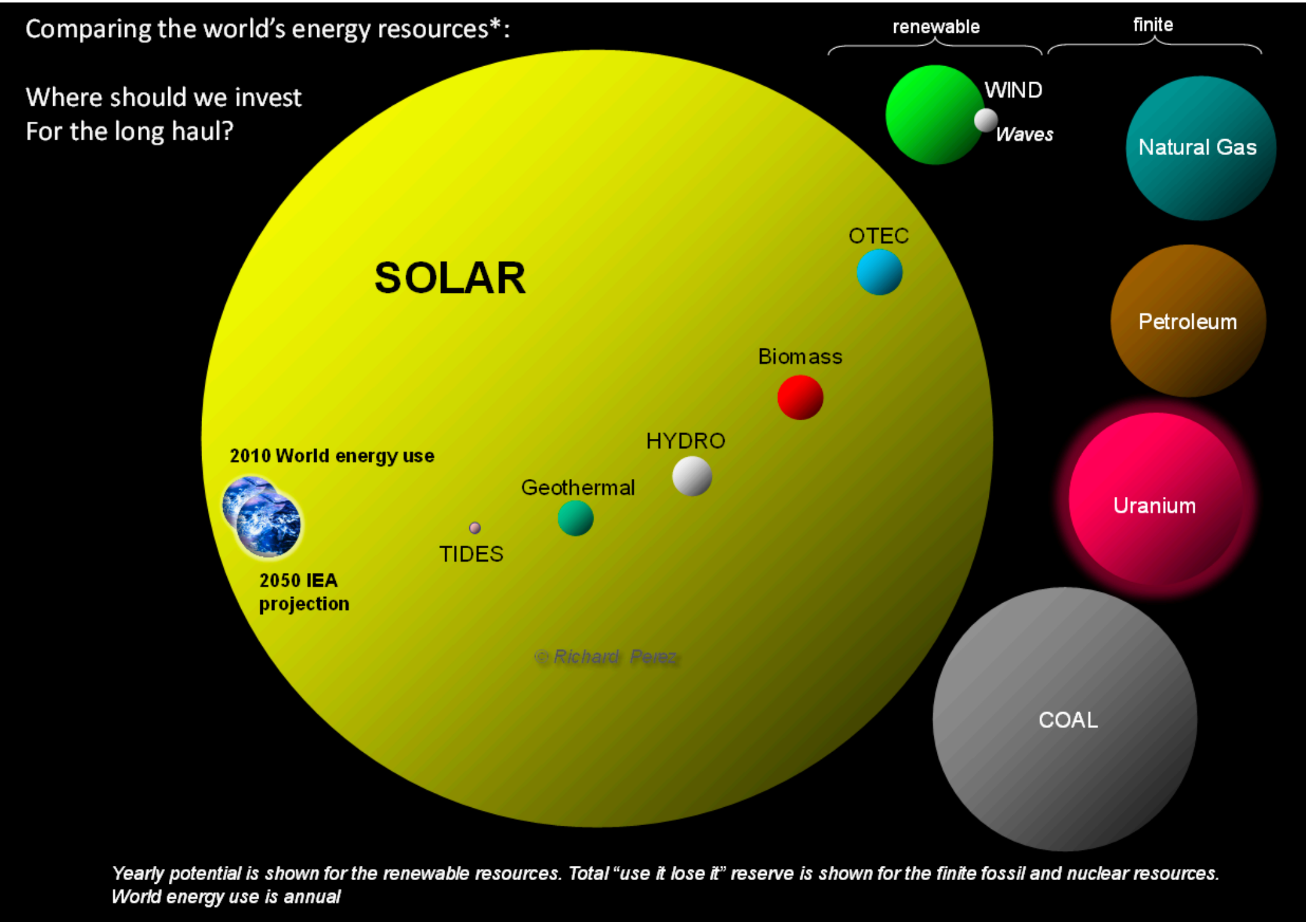
How population can go *beyond the carrying capacity:*

- **Abundant energy** can be converted into **anything**, including food, clothing, housing, geoengineering, liquid fuel, space flight.
- The **amount of solar energy available** for collection using Earth-abundant minerals (silicon, aluminum), is many times the total amount of energy currently being used.
- **Solar power is growing with a doubling time of less than two years** and is projected to reach 100% of the world's energy needs by 2030*.
- **Moore's Law** showed that exponential growth of technology can be maintained for decades if there is sufficient will.
- **Negative T** in I=PAT is possible if technology is used for geoengineering, i.e. replanting forests, carbon sequestration.



*my calculations

http://www.resilience.org/stories/2015-05-11/how-sustainable-is-pv-solar-power/


Comparing the world's energy resources*:
Where should we invest
For the long haul?
renewable
finite
WIND
Waves
Natural Gas
OTEC
SOLAR
Petroleum
Biomass
HYDRO
2010 World energy use
Geothermal
Uranium
TIDES
2050 IEA
projection
© Richard Perez
COAL
Yearly potential is shown for the renewable resources. Total "use it lose it" reserve is shown for the finite fossil and nuclear resources.
World energy use is annual

What is next for Technology?

Psychometrics: Cambridge Analytica

The success of this approach hinges on the accuracy of the company's psychological profiles. But how much can they know about someone's psyche on the basis of a few tweets or likes? Quite a lot, apparently. In a **2016 profile** for Das Magazin, a Berlin-based culture magazine, Kosinski talked about the predictive power of his model.

Here's how the authors summed it up:

> The strength of their [Kosinski and his Cambridge colleagues] modeling was illustrated by how well it could predict a subject's answers. Kosinski continued to work on the models incessantly: before long, he was able to evaluate a person better than the average work colleague, merely on the basis of ten Facebook "likes." Seventy "likes" were enough to outdo what a person's friends knew, 150 what their parents knew, and 300 "likes" what their partner knew. More "likes" could even surpass what a person thought they knew about themselves.

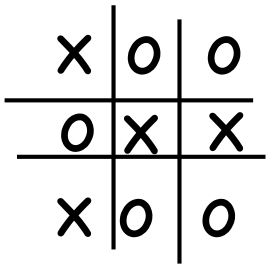
https://www.vox.com/policy-and-politics/2017/10/16/15657512/cambridge-analytica-trump-kushner-flynn-russia

The rules of the economy

- **Markets assume growth.**
- **Growth is bad.**
- **We can't live without markets.**

The economy is a game, a set of rules we all agree to.

What do we do when the rules prevent you from winning the game?



Science News *from research organizations*

No-growth economy could mean fewer crashes and higher wages, study shows

Date: November 10, 2017

Source: University of Sussex

Summary: An economy based on zero growth could be more stable -- experiencing fewer crashes -- and bring higher wages, suggests a new study.

Share:

An economy based on zero growth could be more stable -- experiencing fewer crashes -- and bring higher wages, suggests a new University of Sussex study.

Running counter to dominant economic thinking, the new research shows that economies can be stable with or without growth and are in fact likely to be less volatile if we stop chasing ever-increasing GDP.

The idea of a no-growth economy is not new -- British economist John Maynard Keynes in 1936 predicted an end to growth -- but it has gained traction in the past few years as people have increasingly come to view infinite growth as environmentally unsustainable.

Ecological Economics

Volume 145, March 2018, Pages 38-45

Methodological and Ideological Options

The Classical Circular Economy, Sraffian Ecological Economics and the Capabilities Approach

Nuno Ornelas Martins ✉

Ecological Economics

Volume 148, June 2018, Pages 15-21

Mainstream economics toolkit within the ecological economics framework

Ihar Dzeraviaha ✉

Economics is a set of rules.
We can change the rules.

Technology is a set of capabilities.
It grows autonomously.

Our fate is bimodal, and depends on affluence and technology.

There is a way to surpass the natural carrying capacity.