The incomprehensible reality of technological growth

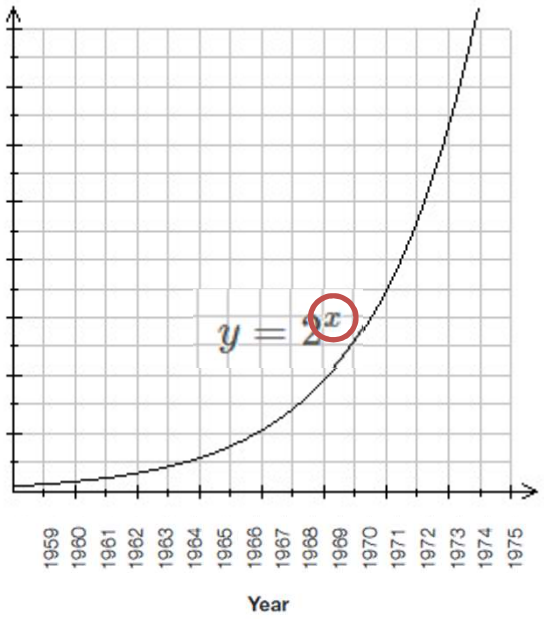
Understanding and preparing for the effects of exponential growth in technology

David Blondal
Desibel ehf
November 2017


Growth of
technology

Moore‘s law

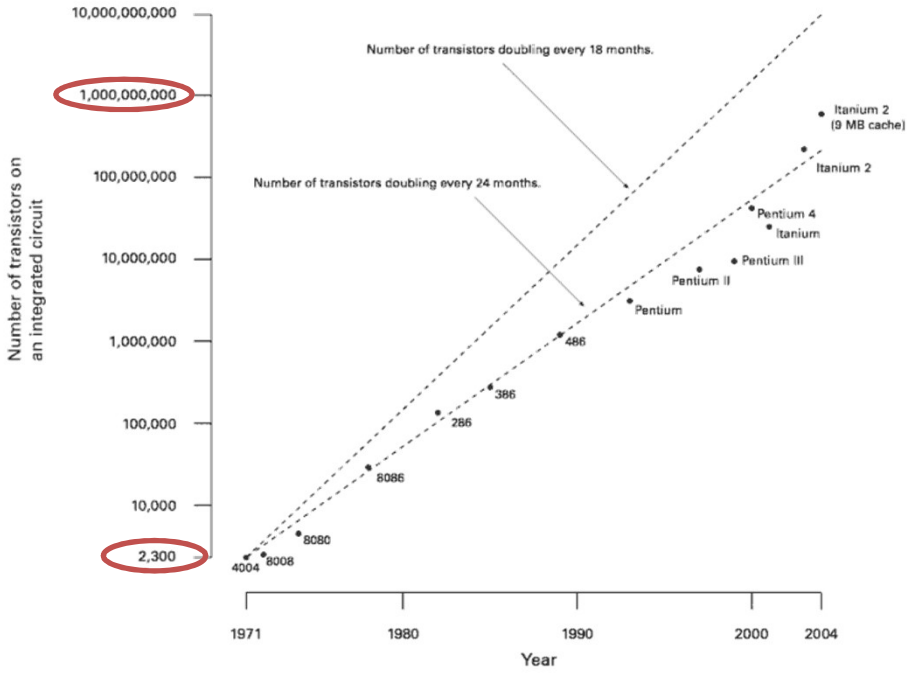
Only 4 measuring points



Initially only for the next 10 years

Moore‘s law valid for 50 years

(with a small adjustment)



Not possible to see how it will happen…

1997

Incredible Shrinking Transistor Nears Its Ultimate Limit: The Laws of Physics

New York Times

2003

The pursuit of Moore's Law is coming to an end not just because of physical constraints, but because microchips are more powerful than anyone really need them to be.

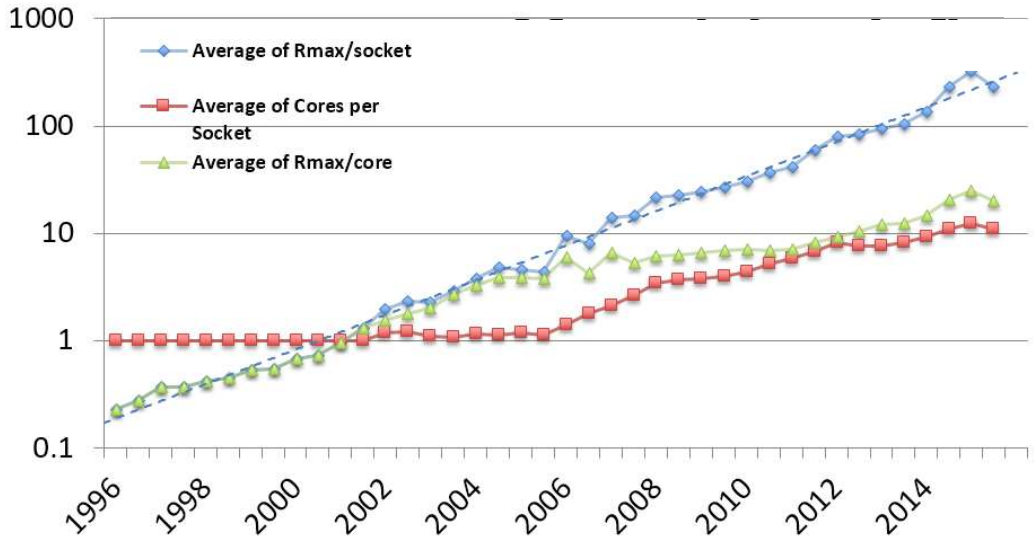
Economist

2017 (jan)

Moore's Law is expiring as it becomes physically impossible to cram more features on smaller chips.

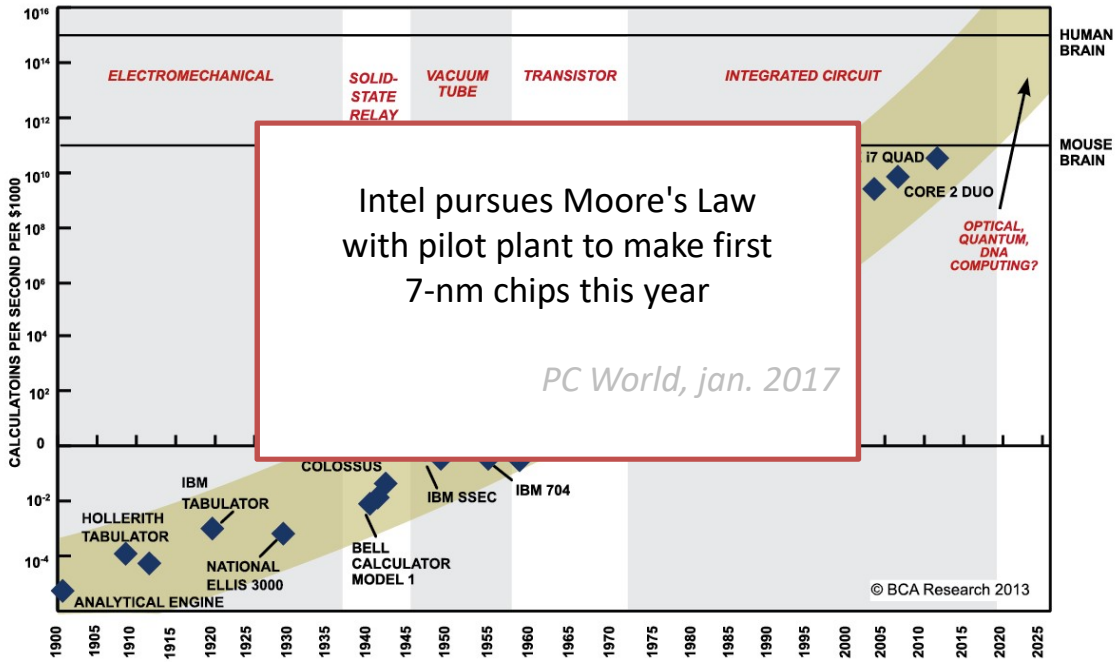
PC World

….but it has always **happened**!



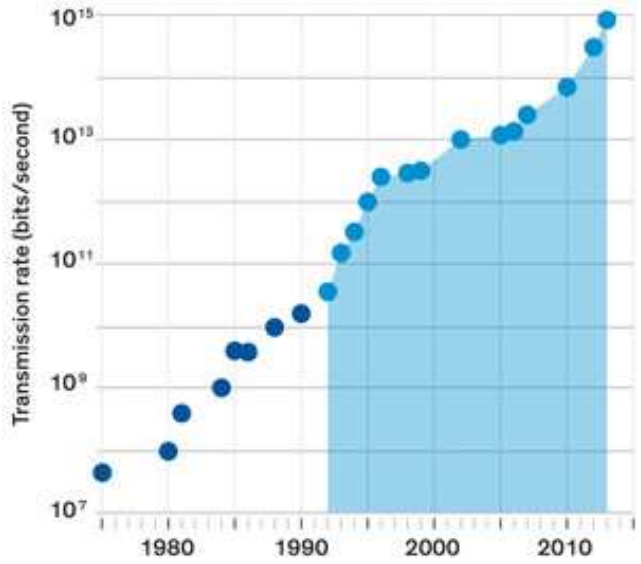
When one method stops growing, a new one is found

…and the trend has been for almost 120 years!



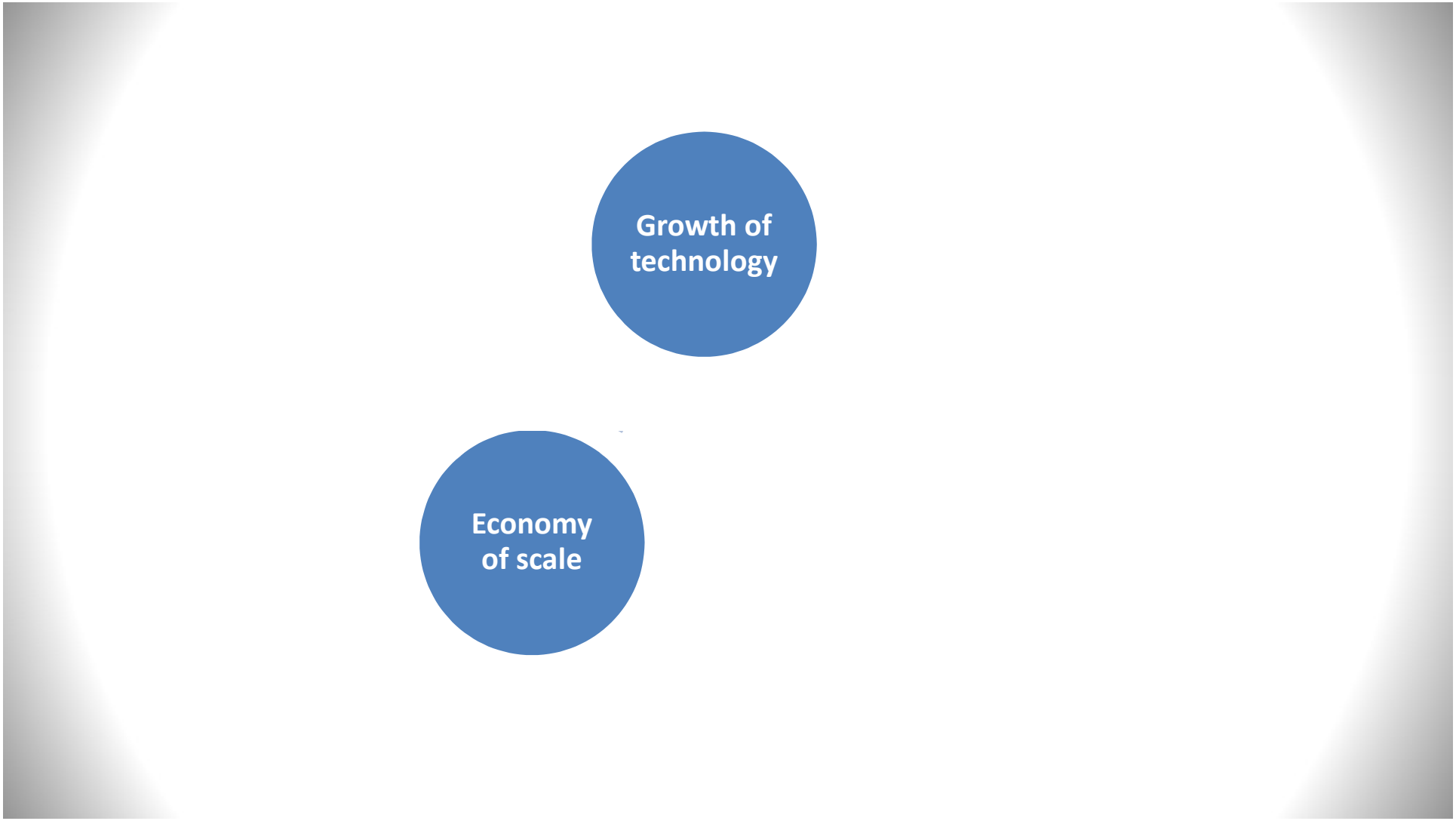
Intel pursues Moore's Law with pilot plant to make first 7-nm chips this year

PC World, jan. 2017



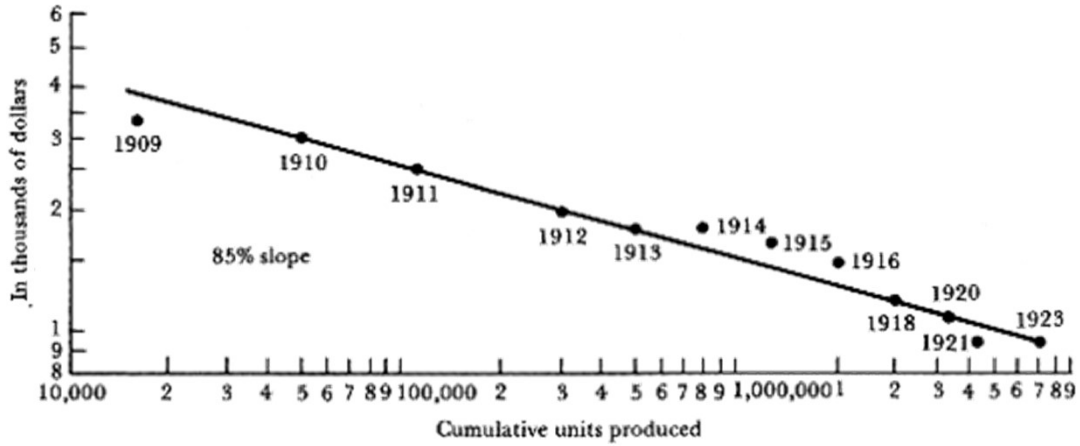
This trend is seen in many technological developments:

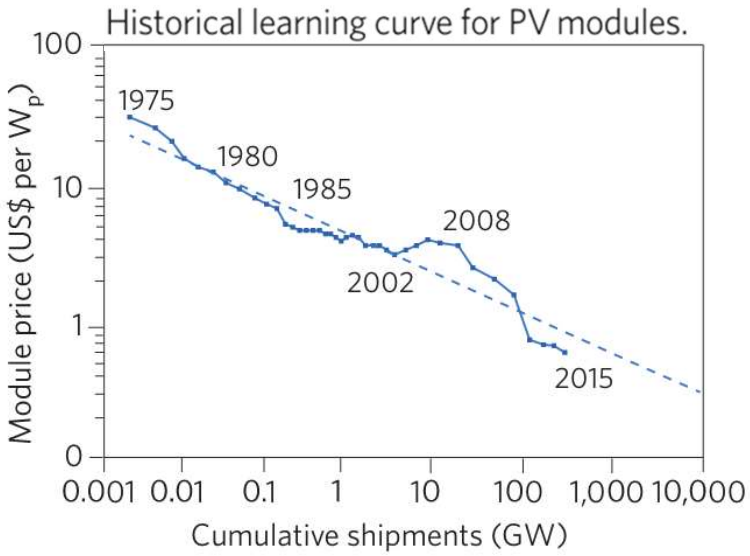
- Transistors in processors - Moore‘s law
- Size of computer memory
- Hard disk drive density - Kryder‘s law
- Fiber-optic capacity - Keck‘s law
- Internet bandwidth - Nielsen‘s law
- Network capacity – Buttler‘s law of Photonics
- Number of pixels in digital cameras
- Light output of LEDs - Haitz‘s law
- Energy use of computations - Koomey’s Law


Growth of technology
Economy of scale

Economy of scale – the learning curve

Ford Model T





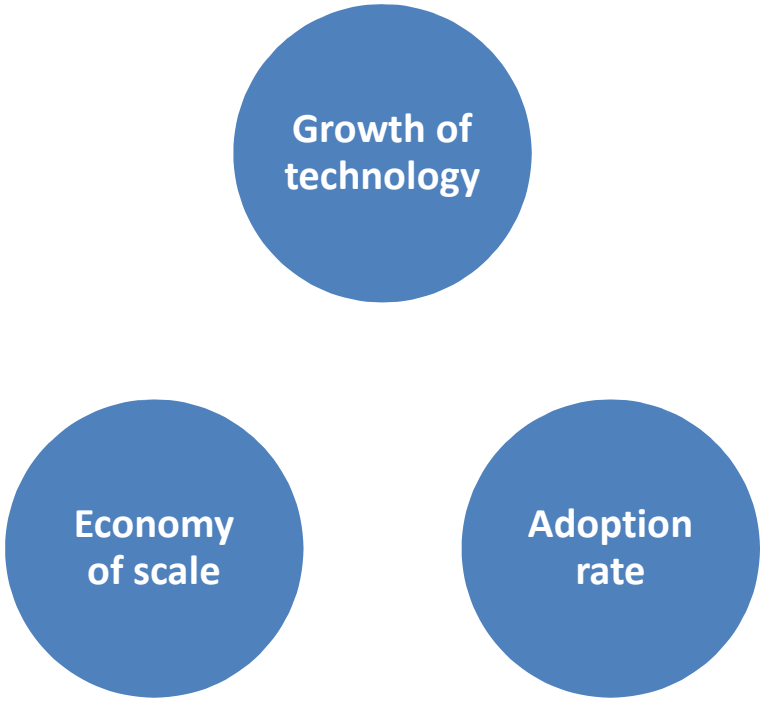
Economy of scale is witnessed in many fields:

- Ford Model T (1909)
- Time to assemble Boeing airplanes (1936)
- 24 products analyzed (1965)
- Digital cameras - Hendy‘s law
- DNA sequencing - Carlson curve
- Solar power – Swanson‘s law
- Wind power

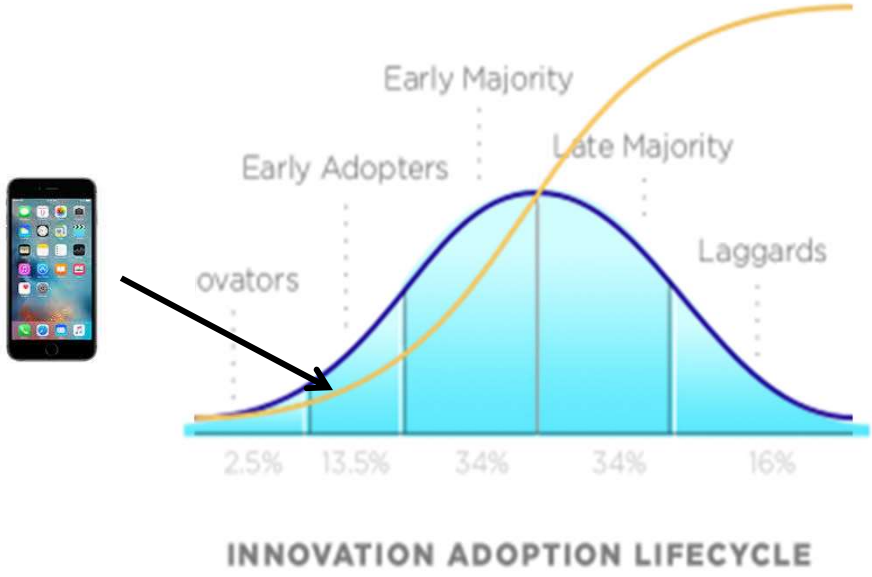
Learning rate
often around

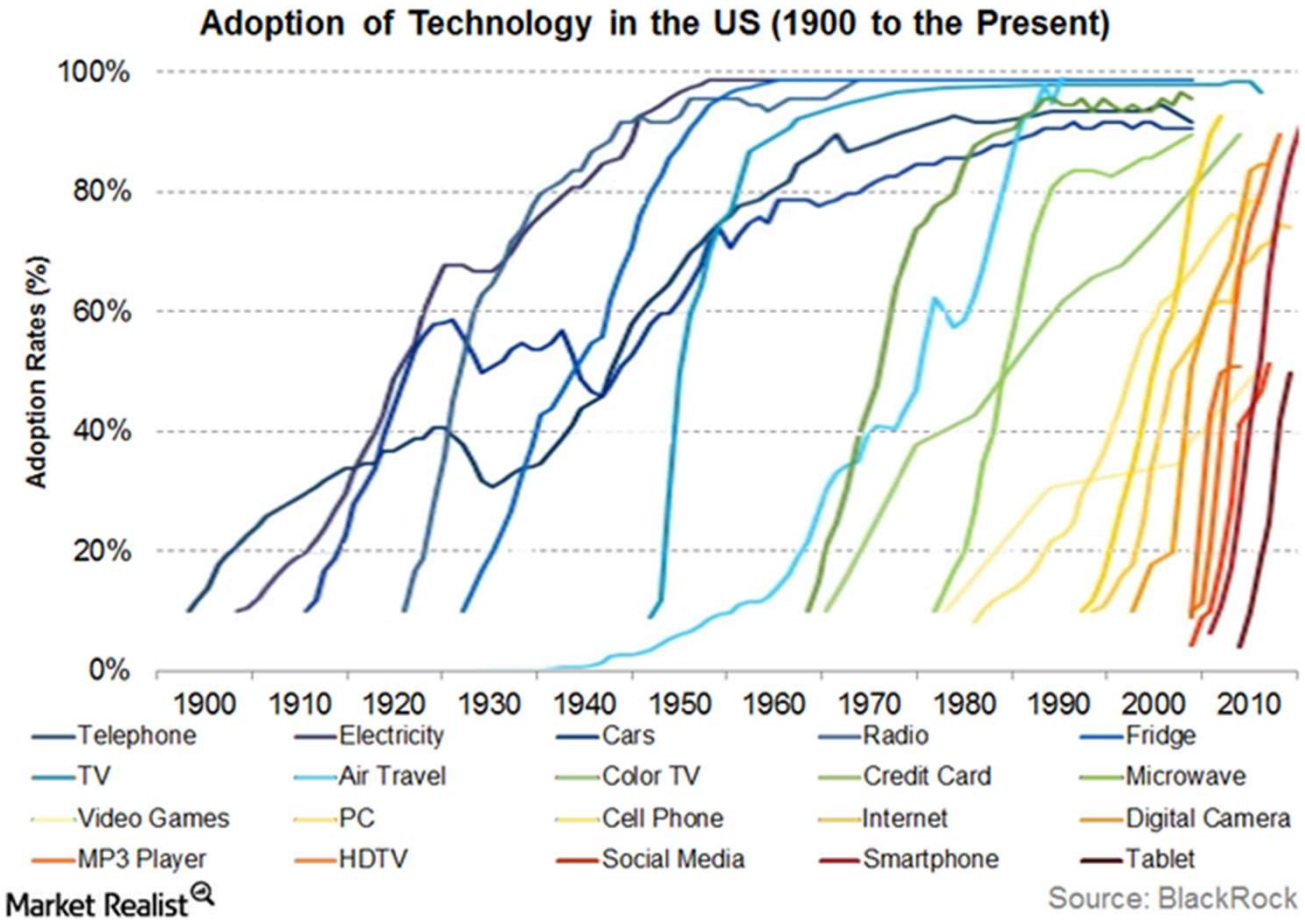
20%

(4-41%)


Growth of technology
Economy of scale
Adoption rate

Adoption of technology




Adoption of Technology in the US (1900 to the Present)
Adoption Rates (%)
100%
80%
60%
40%
20%
0%
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Telephone
Electricity
Cars
Radio
Fridge
TV
Air Travel
Color TV
Credit Card
Microwave
Video Games
PC
Cell Phone
Internet
Digital Camera
MP3 Player
HDTV
Social Media
Smartphone
Tablet
Market Realist
Source: BlackRock

Easter morning 1900: 5th Ave, New York City. Spot the automobile.

Source: US National Archives.

Easter morning 1913: 5th Ave, New York City. Spot the horse.

Source: George Grantham Bain Collection.

The reinforcing spiral of technology

Growth of technology

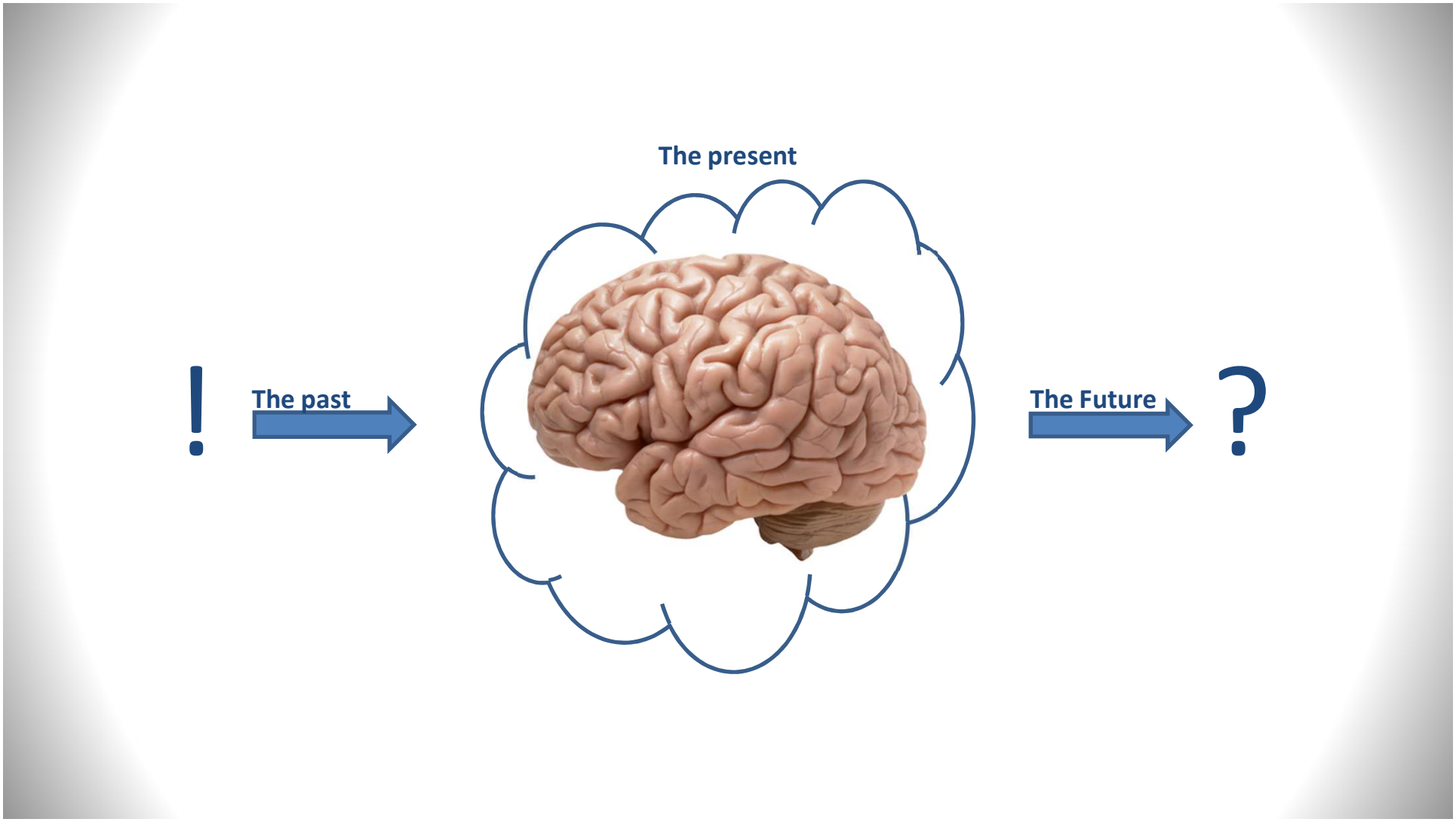
Exponential

Economy of scale

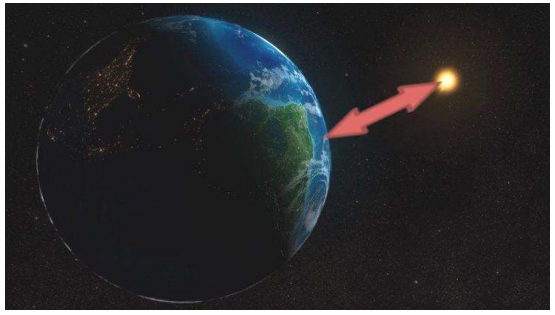
Exponential

Adoption rate

Exponential

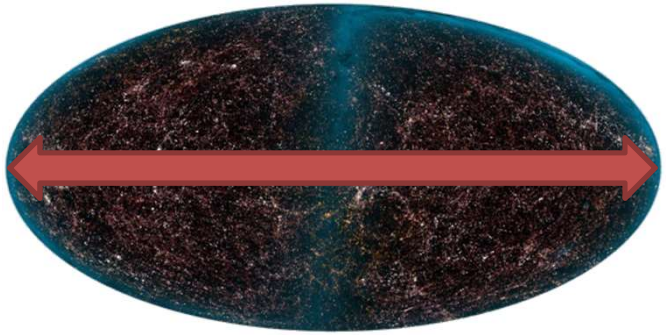

The present
!
The past
The Future
?

51
foldings



Distance from earth to the sun
(150 million km)

103
foldings



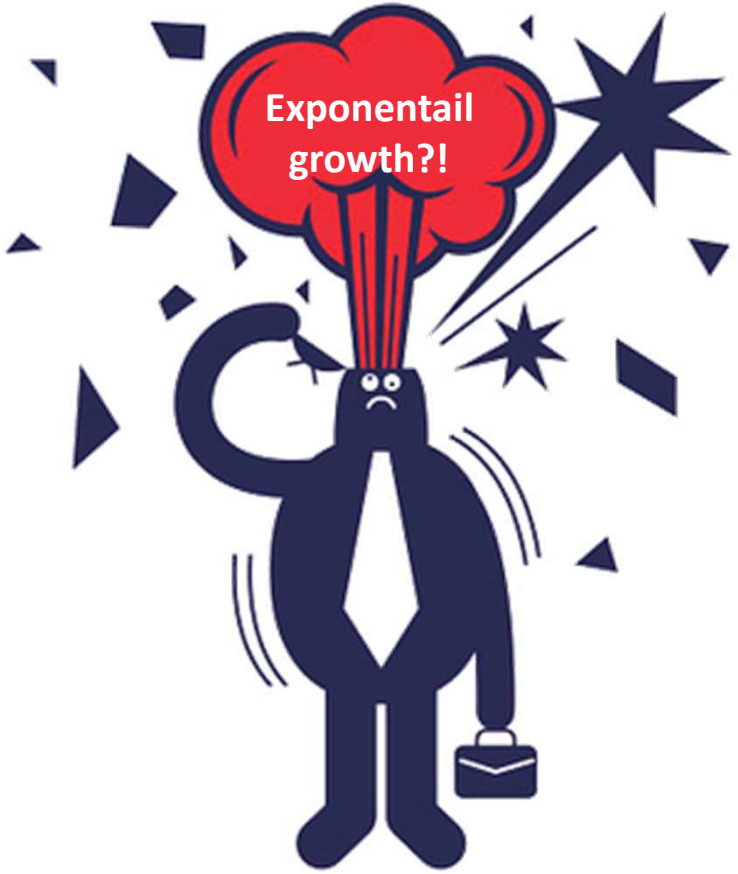
Size of the universe
(93billion light years)

Normal paper
folded
51 times

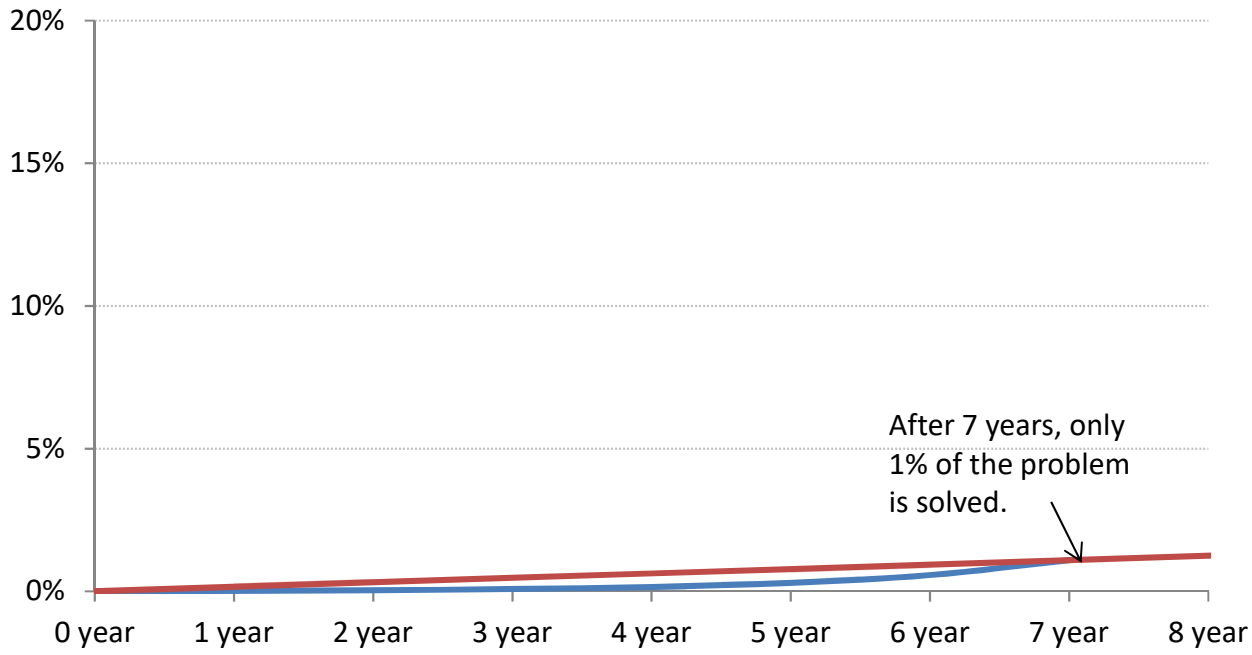
=

5.000 times
around the world

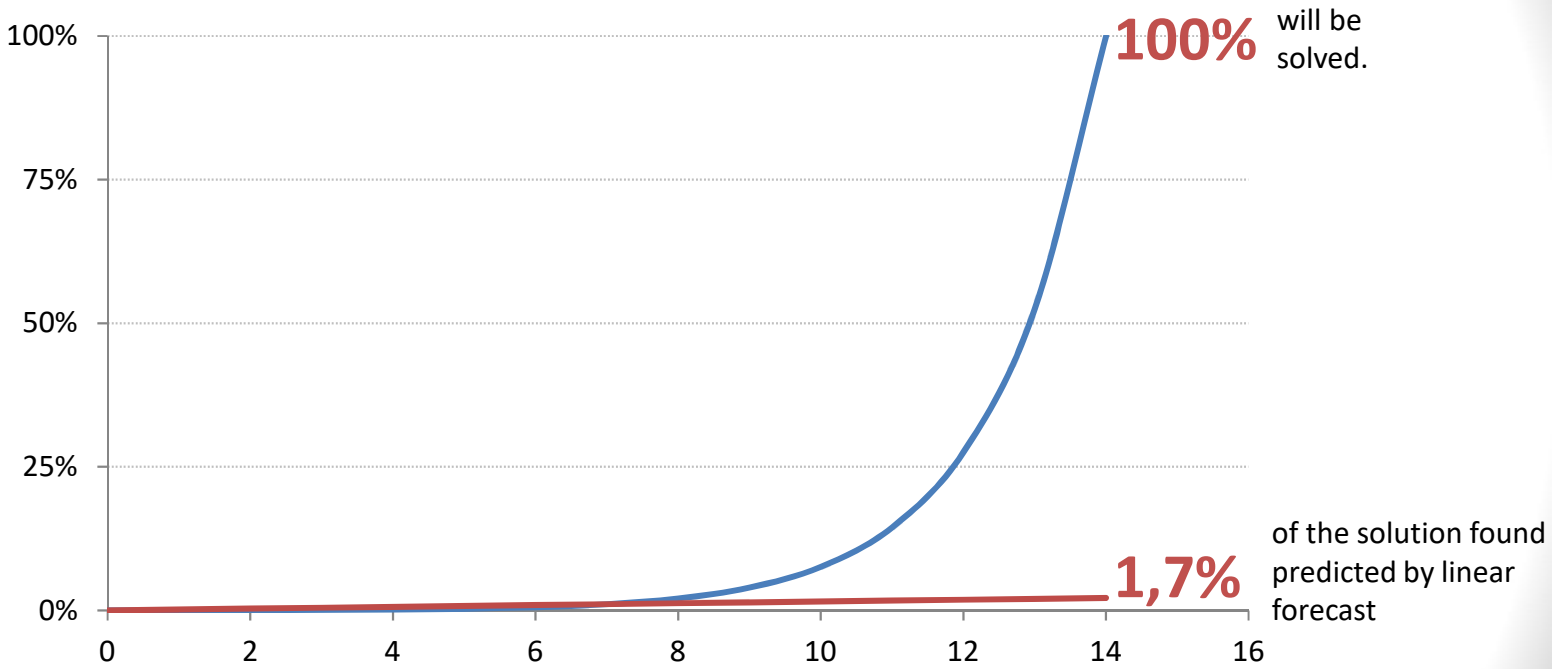
25 years
in an airplane

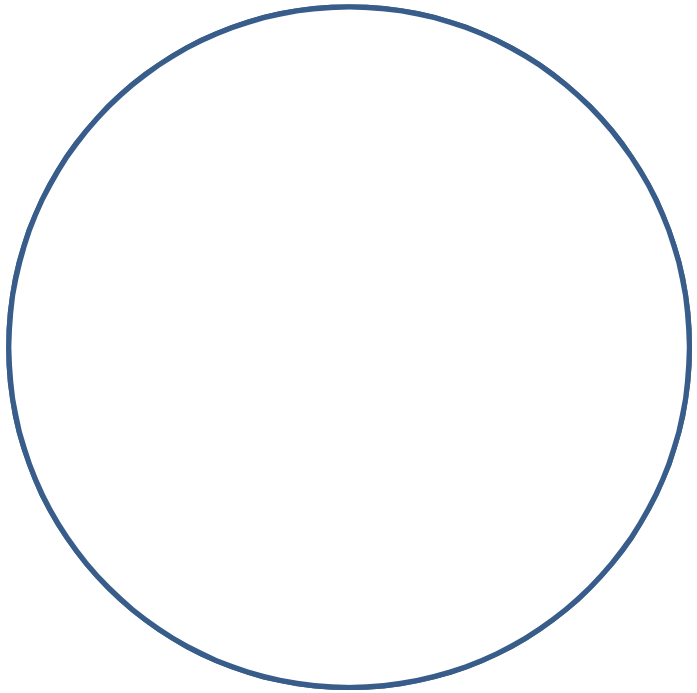

Exponentail
growth?!

Exponential growth look linear to begin with…

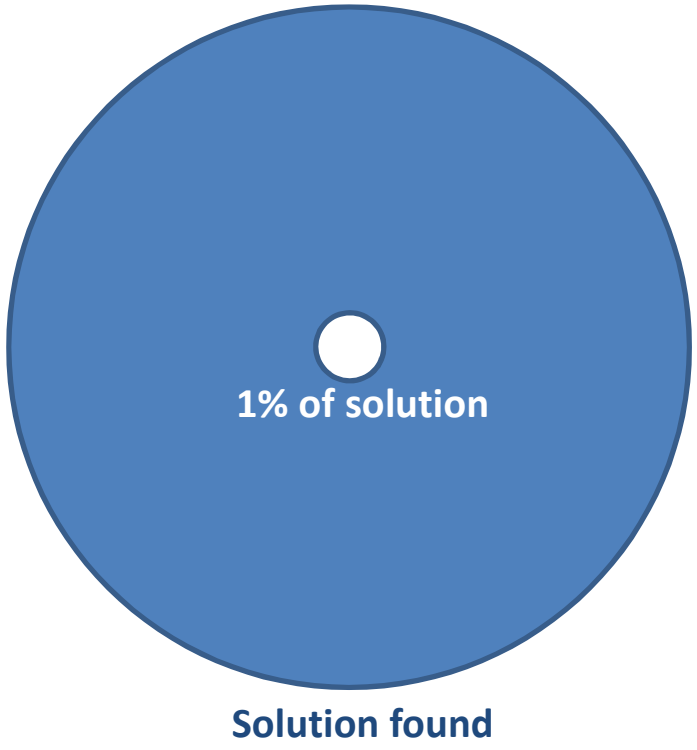


…which leads to risk of gross underestimations.

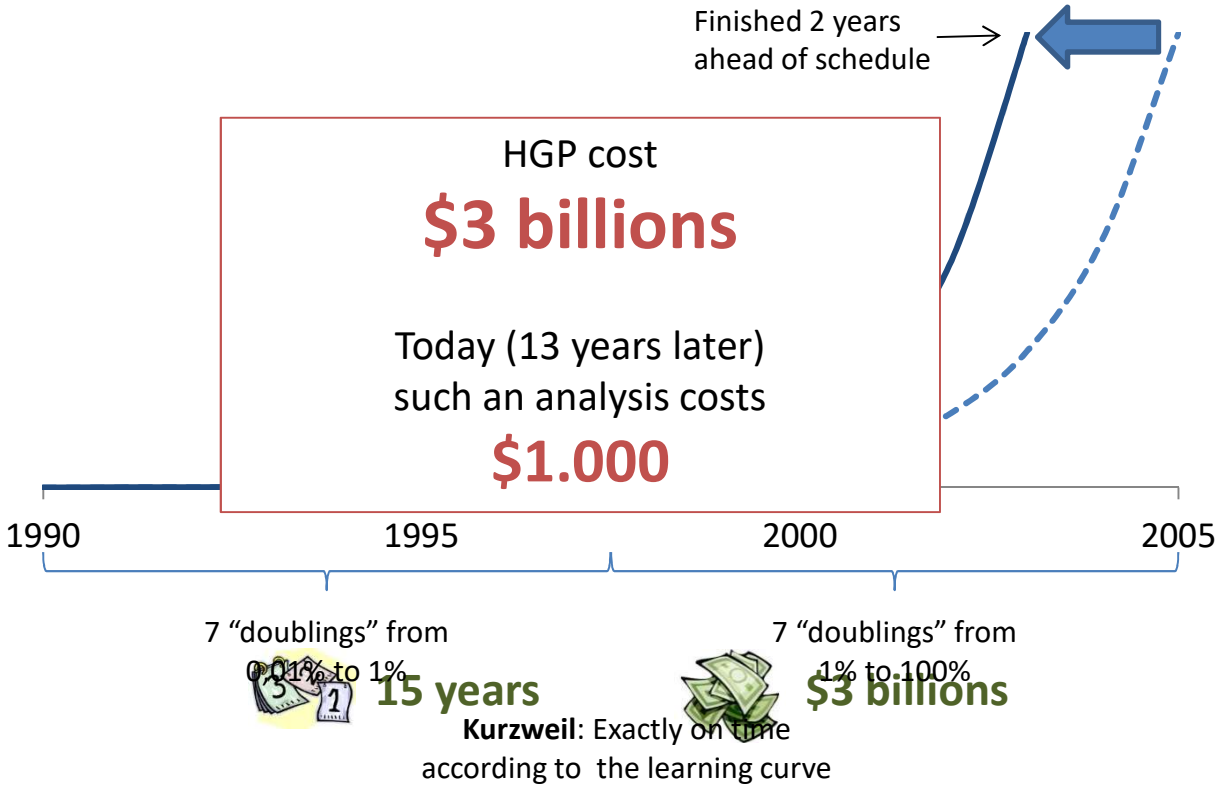




Solution found


1% of solution
Solution found

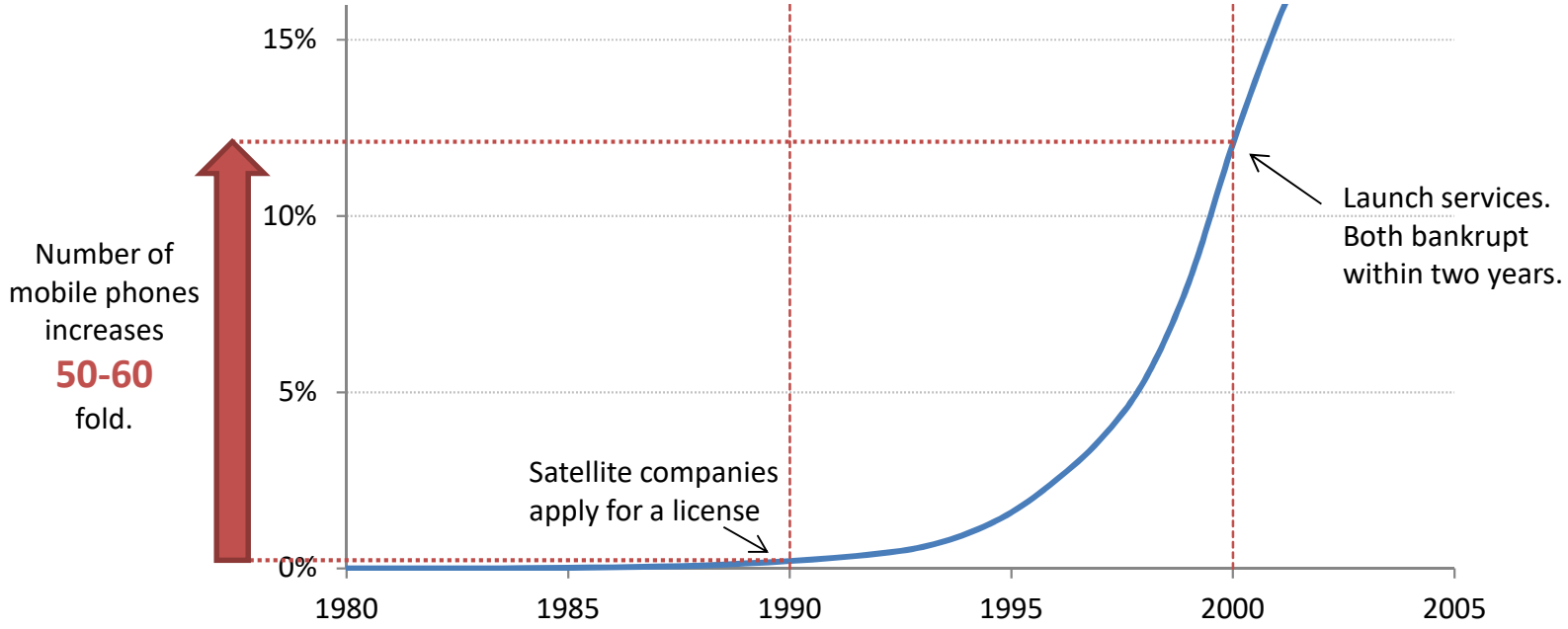
Human Genome Project



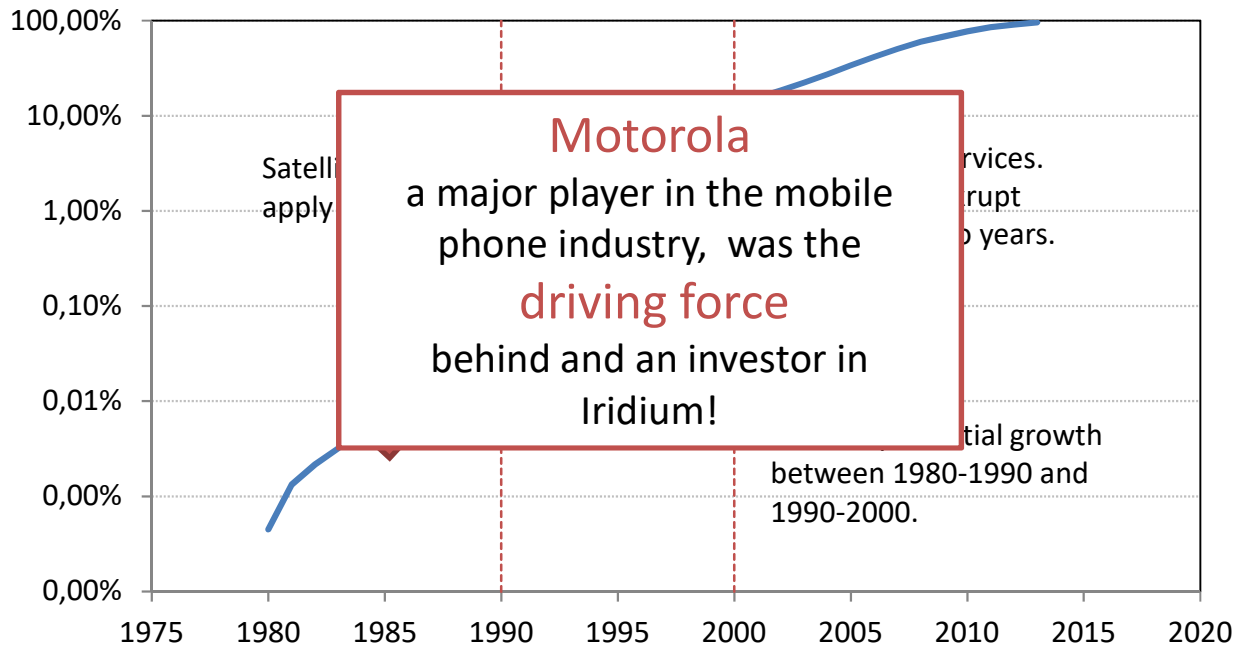
Globalstar

iridium

- Decade in development ignoring the growth of mobile phones
- $9b lost in their bankruptcies
- Iridium was one of the 20 largest US bankruptcies at that time.


15%
10%
5%
0%
1980
1985
1990
1995
2000
2005
Number of mobile phones increases
50-60
fold.
Satellite companies apply for a license
Launch services. Both bankrupt within two years.

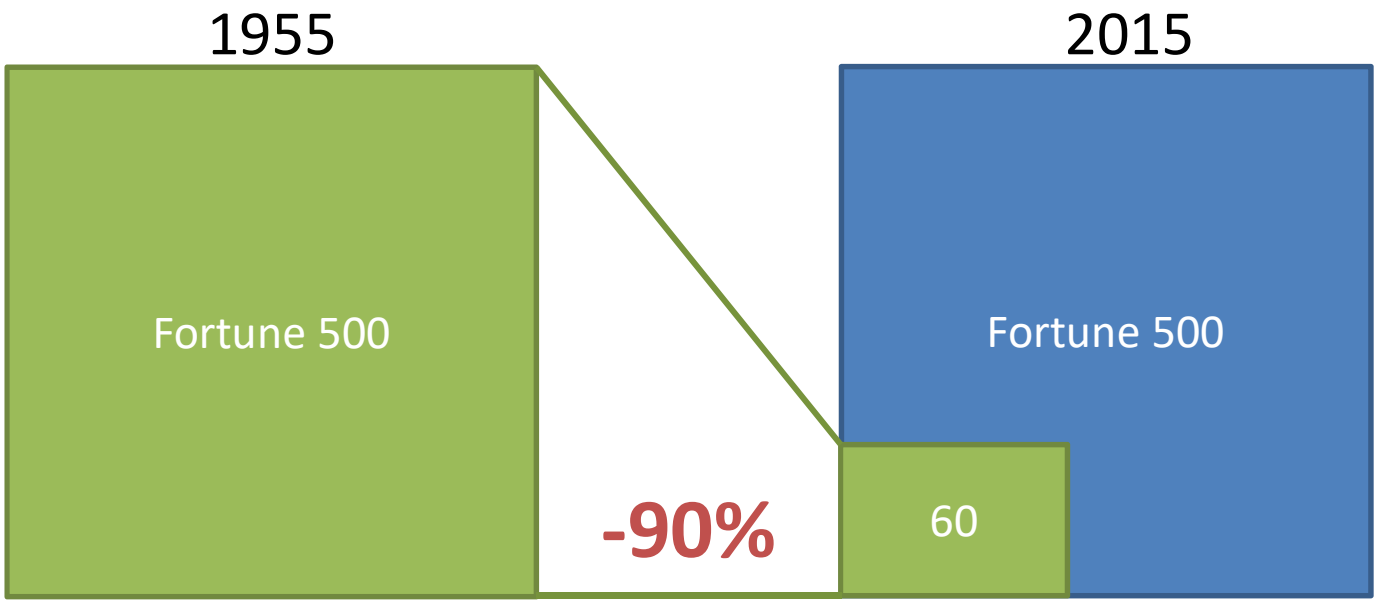
Was the fall of the satellite companies foreseeable?

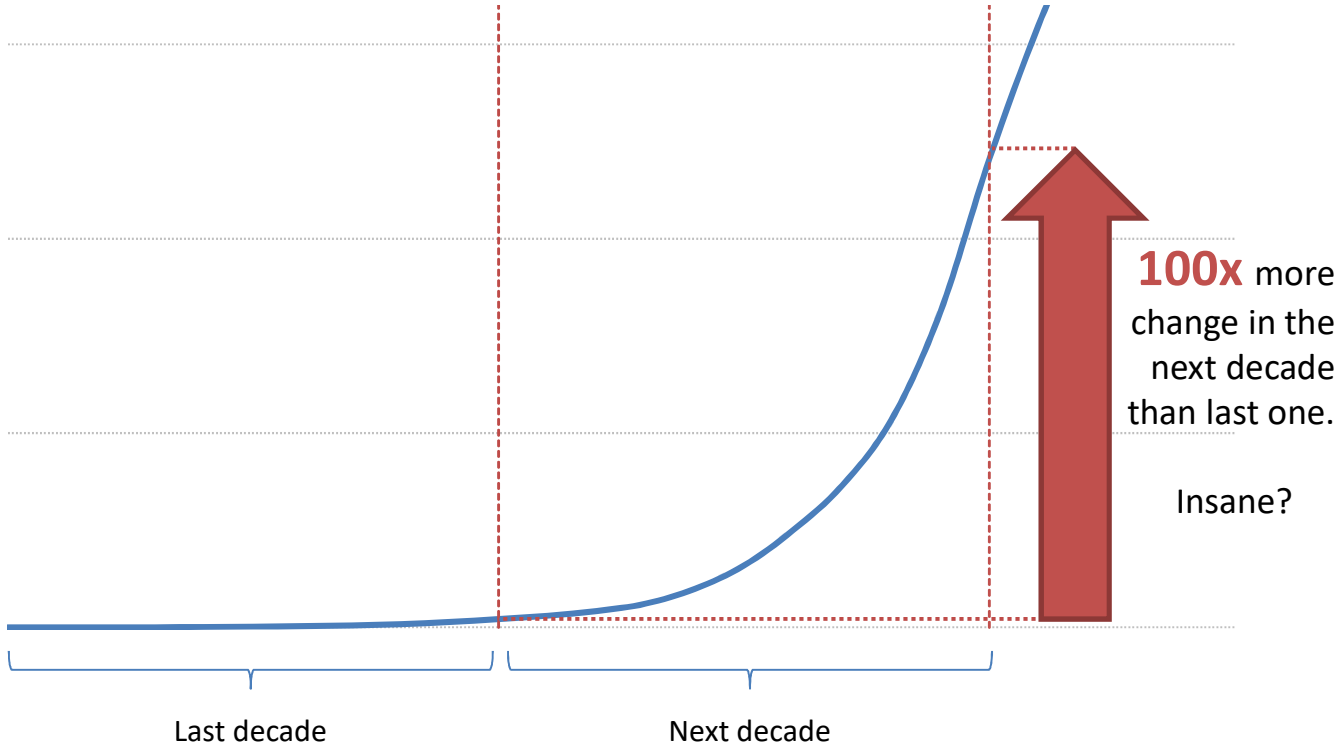


NOKIA

2007		2015
	**8 years!**	
$150b market value 40% market share		$0

Effect of technical development




100x more change in the next decade than last one.
Insane?
Last decade
Next decade

It is normally the

experts and insiders

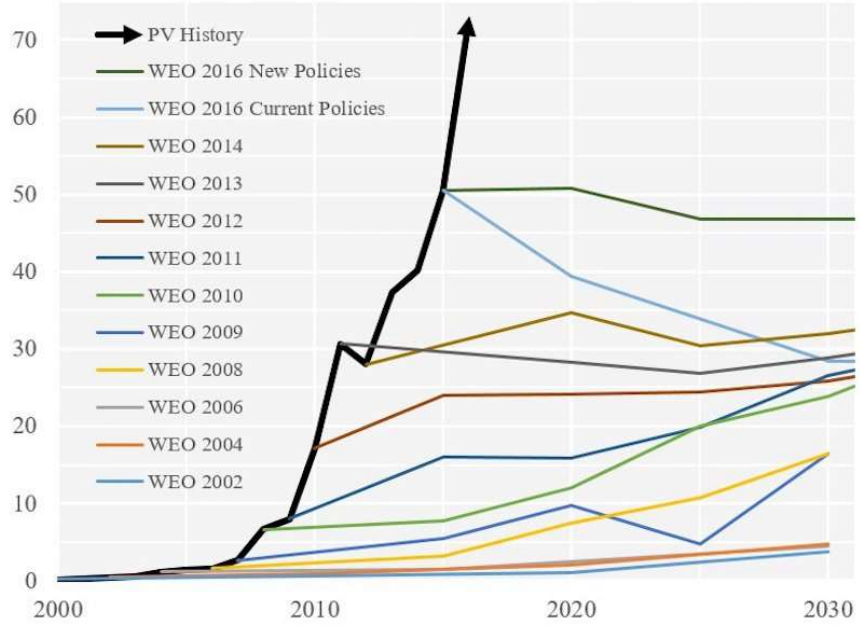
that

underestimate

exponential growth

Annual PV additions: historic data vs IEA WEO predictions

In GW of added capacity per year - sources World Energy Outlook and PVMA

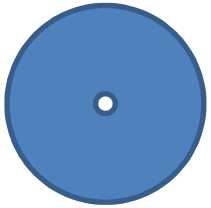


The Lesson

A

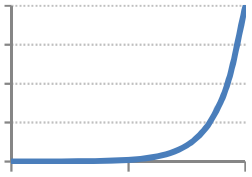
When you see a glimpse of the technology, it might be

about to arrive



B

The experience curve is the best way to forecast technological development and only needs **very few** years



C

Forecasts made with the experience curve seem

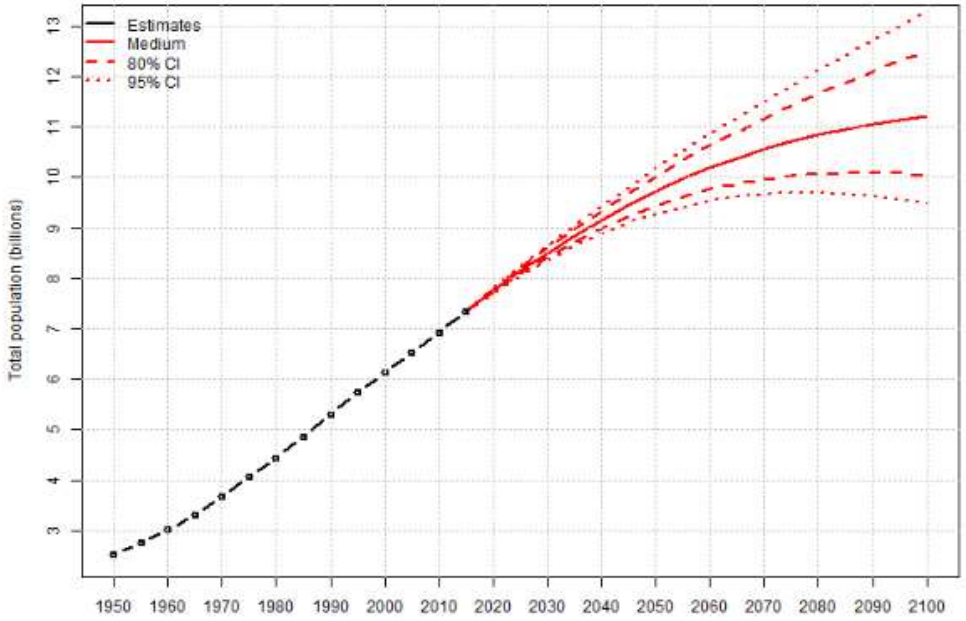
insane

D

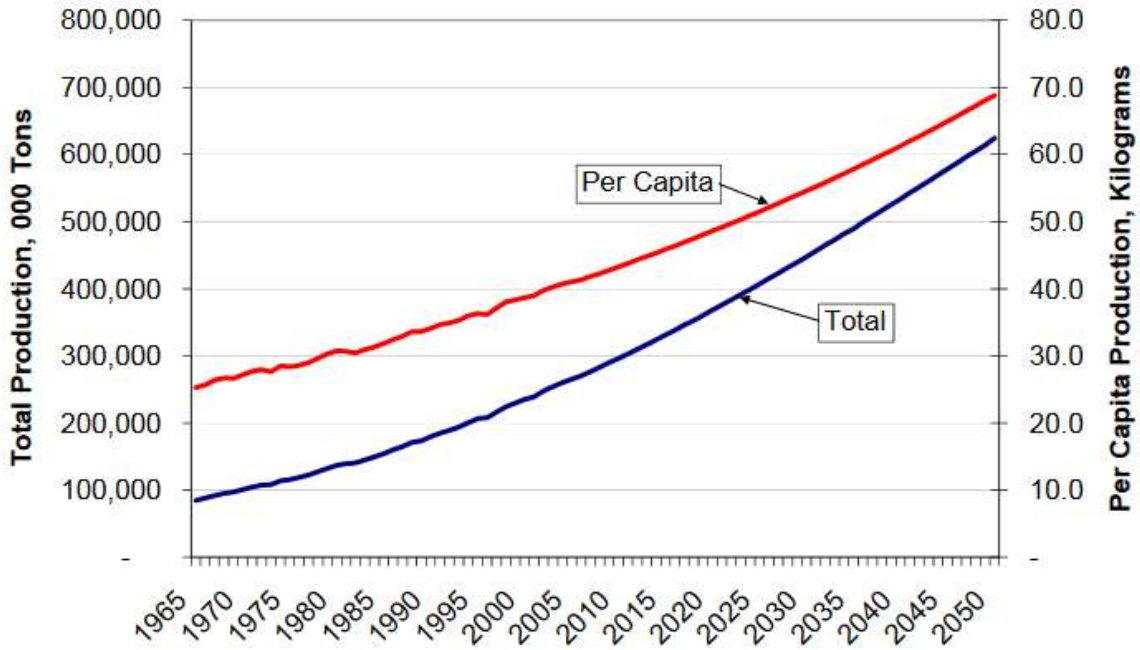
NEVER EVER

be on the wrong side of technical development

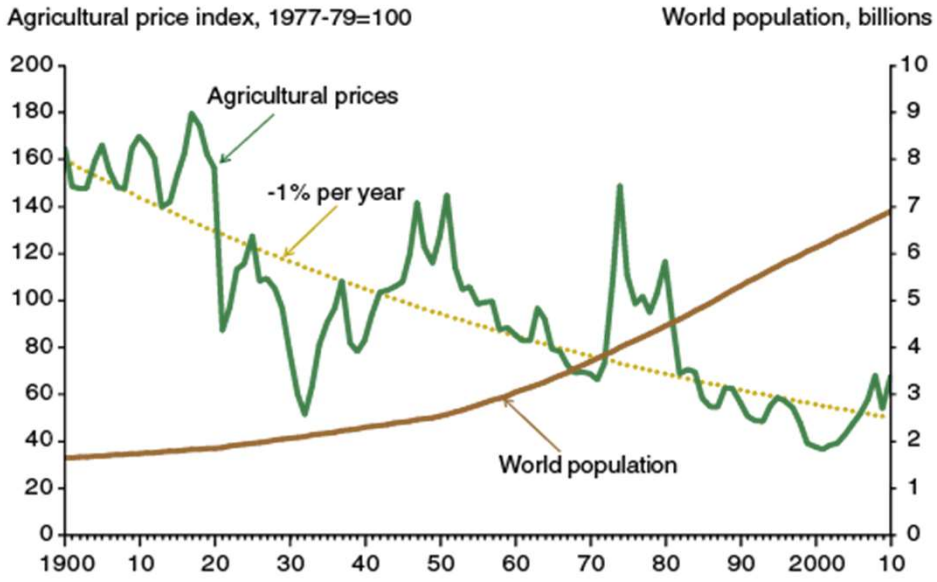
Global population is increasing



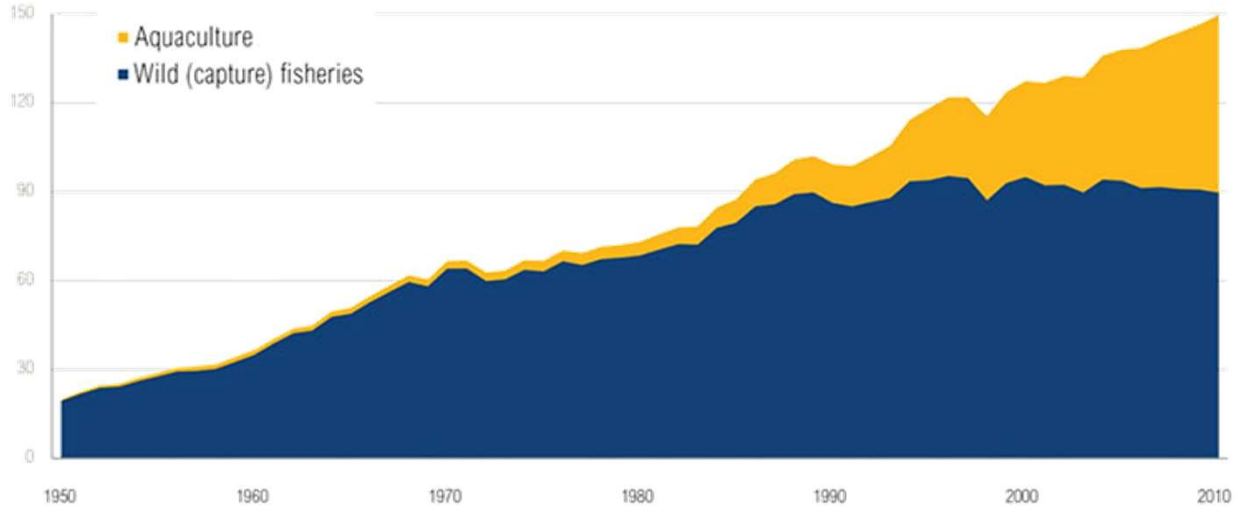
Meat production per capita is increasing…

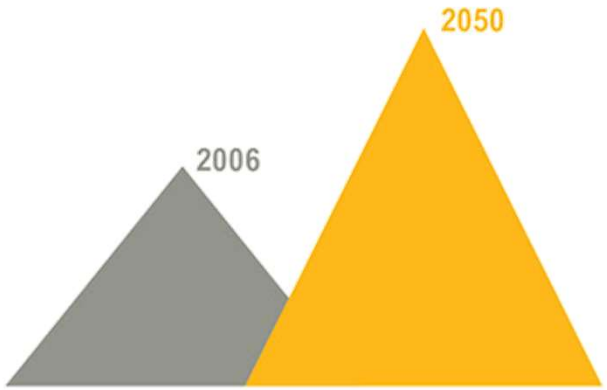


.. but prices keep going down



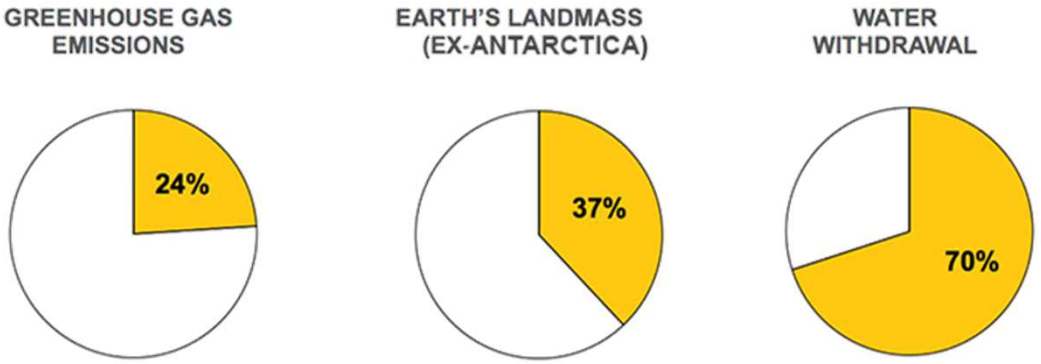
…as technical development supplies demand growth.

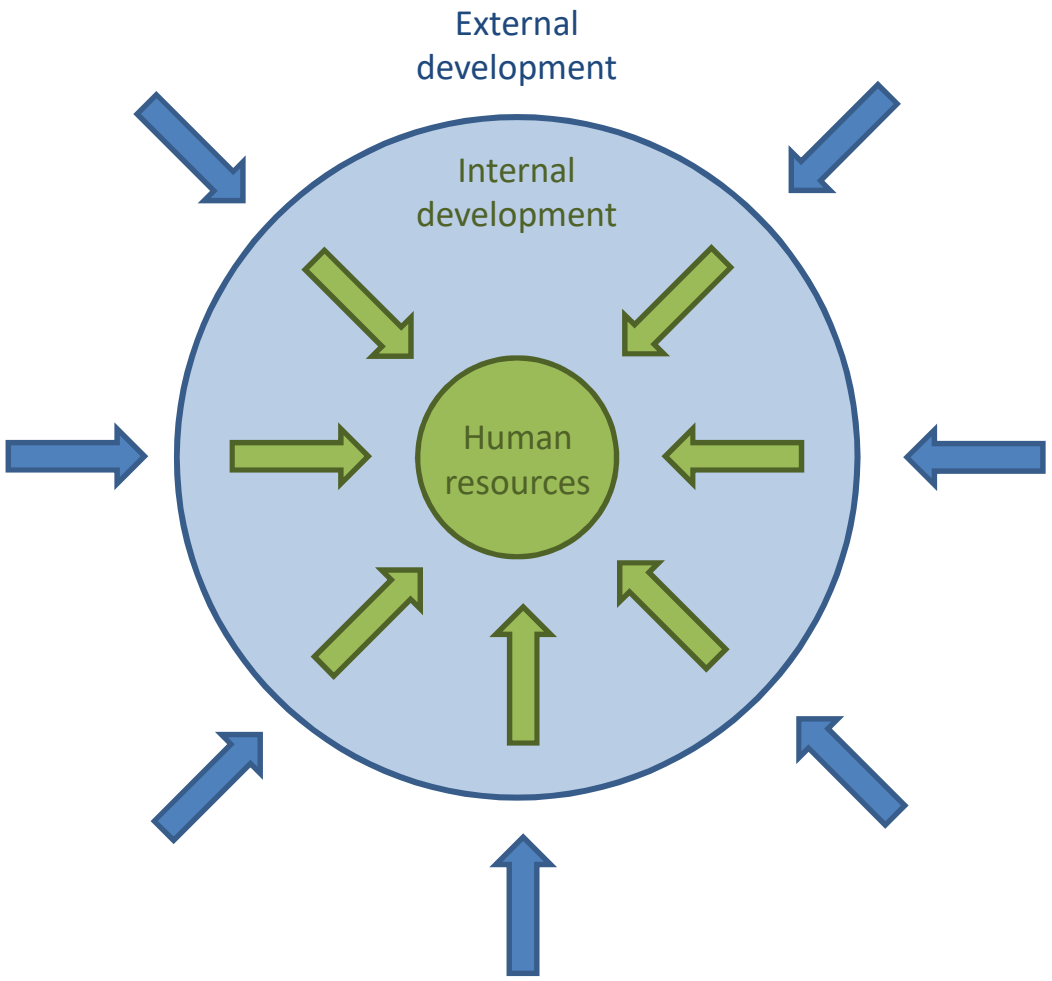




69% Required increase in food calories to feed 9.6 billion people by 2050

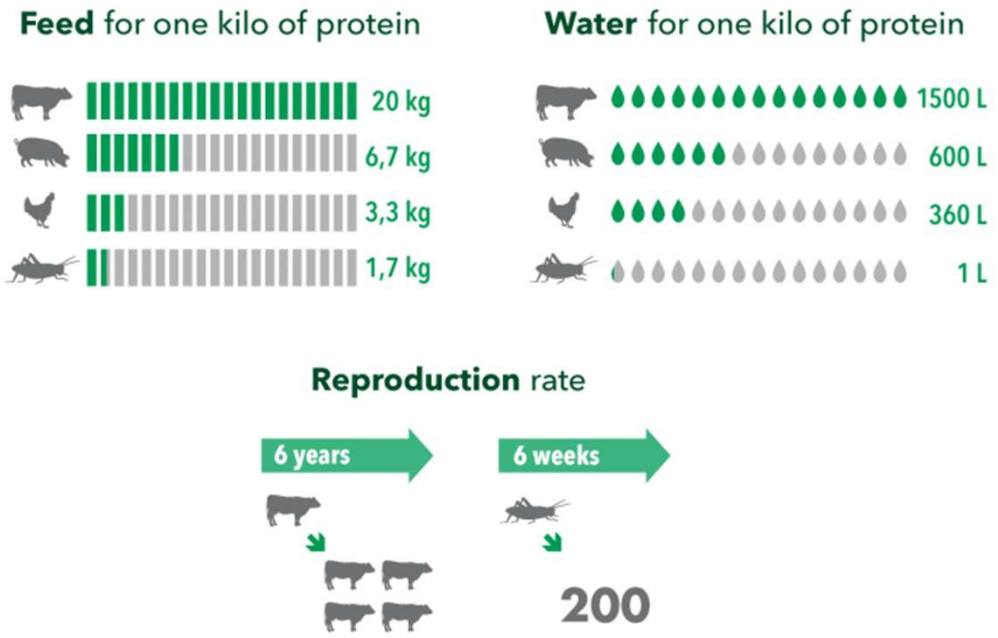
Resources are becoming scarce…




External development
Internal development
Human resources

Insects

Insects are highly efficient at creating protein..

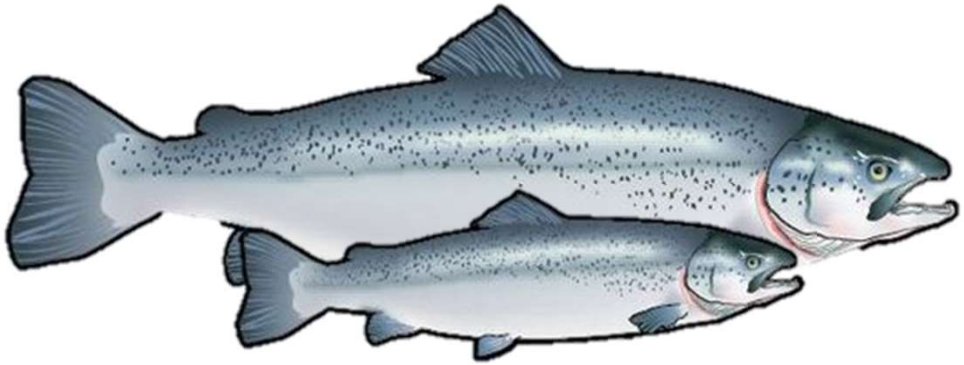


Insects

GMO increases efficiency

Insects

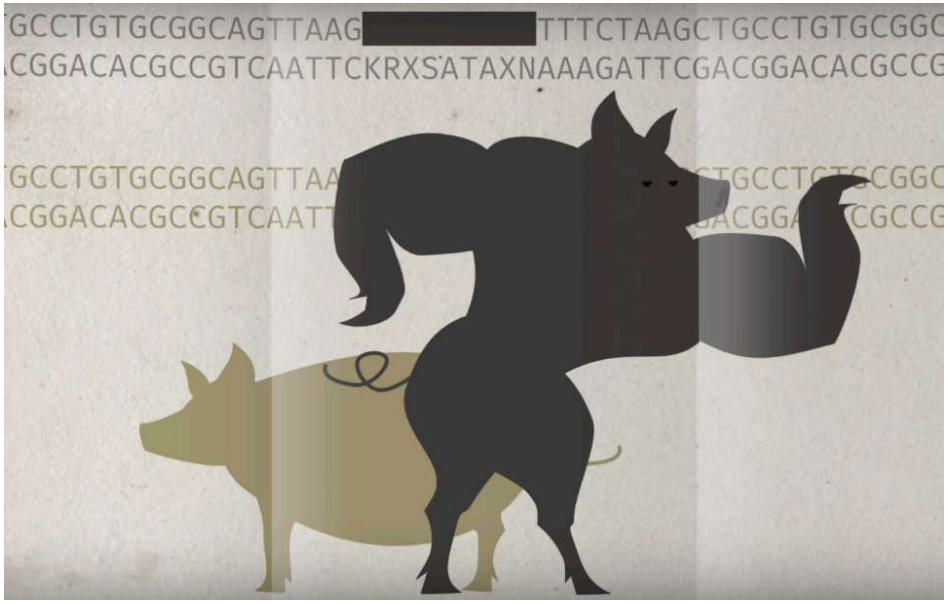
GMO



An 18 month old genetically engineered **AquAdvantage** Salmon (background – 61cm, 3,0kg) alongside an **Atlantic salmon** of the same age (foreground – 33cm, 1,3kg)

CRISPR will open up new dimensions

- Insects
- GMO



Rearranging plant protein

- Insects
- GMO
- Plant protein

One pound of cooked boneless chicken requires **7.5 pounds** of dry feed and **30 liters** of water.

The same amount of Beyond Meat requires only **1.1 pound** of ingredients and **2 liters** of water.

- Insects
- GMO
- Plant protein

Ground beef

$3,7

per pound
(2016)

Organic grass-fed beef

$6.99

per pound
(2016)

Beyond Burgers

$11.98

per pound
(2016)

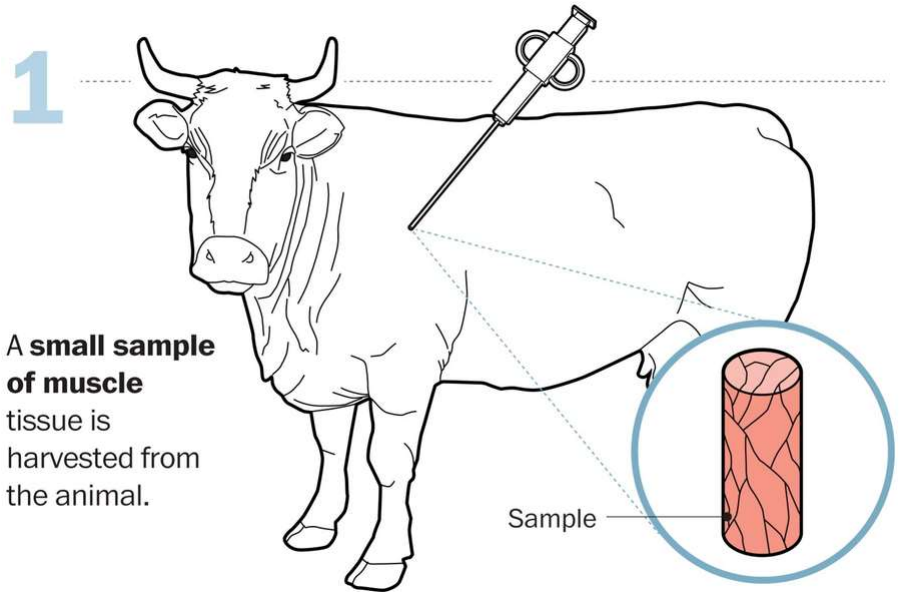
Impossible Burger

$20

per **burger**
(2015)

- Insects
- GMO
- Plant protein
- Cultivation

- Insects
- GMO
- Plant protein
- Cultivation



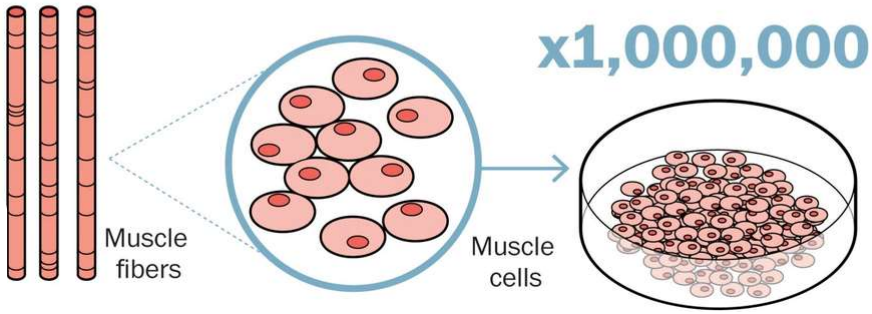
- Insects
- GMO
- Plant protein
- Cultivation

2

The tisue is cut into very small pieces, to separate the **muscle fibers** from **cells.**

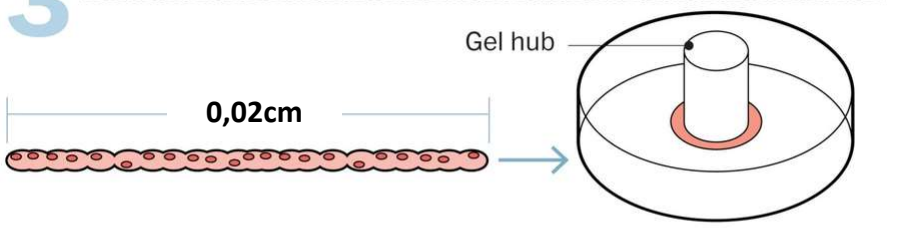
Individual cells are separated and placed in a culture. Cells start dividing on their own.

x1,000,000



- Insects
- GMO
- Plant protein
- Cultivation

3



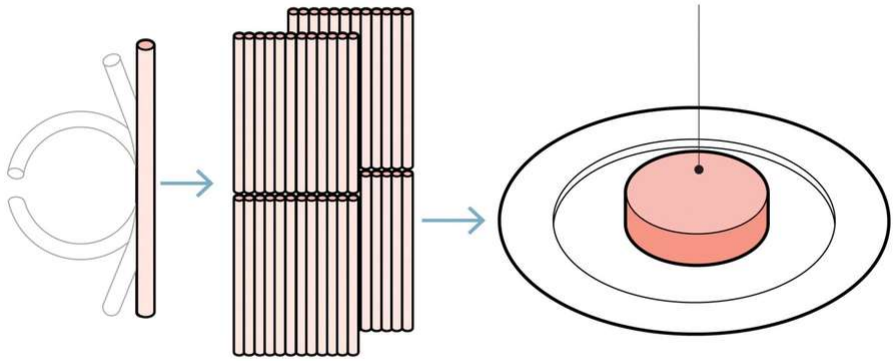
Cells **merge** naturally, arranging themselves into small fibers called **myotubes**.

Myotubes are grown around **gel hubs**, contracting and bulking up as they grow into a small ring of tissue.

- Insects
- GMO
- Plant protein
- Cultivation

4

x1,000,000,000,000,000,000 cells



From the tissue, the cells grow into **strands**. A single one can have more than a trillion cells.

Enough strands are **layered together** to produce a meat patty.

- Insects
- GMO
- Plant protein
- Cultivation

One
cell

=

175 million
hamburger

or

20 trillion
turkey nuggets

- Insects
- GMO
- Plant protein
- Cultivation

Production costs of cultivated burger

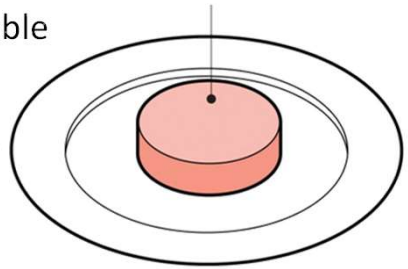
2013 **$325.000**

2016 **$11**

- Insects
- GMO
- Plant protein
- Cultivation

Seems to have many benefits:

- „Natural“ process
- Can produce meat from all animals with muscles
- No GMO
- No hormones, antibiotics or other medicine
- Make food more healthy
  - Take out heme iron that causes cancer
  - Omega 3 instead of fatty acids that increase cholesterol
- No animals mistreated
- Environmentally friendly and sustainable
- Can do yourself
- Unlimited production possibilities

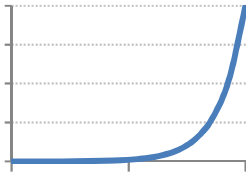


HOW TO PREPARE

Estimate time

- Analyze the technologies emerging and estimate the learning curve.

- Estimate when the disruption will occur (technologically and socially)



Be sustainable

- Sustainable and ecofriendly catching e.g. CO2 offsetting

- Define certification processes e.g. unified nonGMO labelling

Create strategy

- Analyze markets and identify future customers

- Create a joint brand?

These change will
most likely happen

faster

than you think is

possible