COMPUTING: NOW AND FOREVER

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University of Missouri
CI Day October 10, 2013

To Compute

com·pute *verb* \kəm-ˈpyüt\

: to find out (something) by using mathematical processes

com·put·ed | **com·put·ing**

Full Definition of COMPUTE

Cite! +1 Like

transitive verb

: to determine especially by mathematical means; *also* : to determine or calculate by means of a computer

AN ENCYCLOPÆDIA BRITANNICA COMPANY

Merriam-Webster

m-w.com

Why do we compute?

For any x what are the values of f(x)?

$$f(x) = 9\,x^2 + 3\,x^3 - 7$$

f(0) = 9*0 + 3*0 – 7 = -7
f(1) = 9*1 + 3*1 – 7 = 12 – 7 = 5
f(2) = 9*2^2 + 3*2^3 – 7 = 9*4 + 3*8 -7 = 36 + 24 – 7 = 53
f(3) = 9*3^2 + 3*3^3 – 7 = 9*9 + 3*27 – 7 = 81 + 81 – 7 = 162 – 7 = 155
f(4) = 9*4^2 + 3*4^3 – 7 = 9*16 + 3*64 – 7 = 144 + 192 – 7 = 336 – 7 = 329
f(5) = 9*5^2 + 3*5^3 – 7 = 9*25 + 3*125 – 7 = 225 + 375 -7 = 600 – 7 = 593
f(6) = 9*6^2 + 3*6^3 – 7 = 9*36 + 3*216 -7 = (180+54) + (600+48) -7 =
(200 + 30 +600 + 45) = 830 + 45 = 875

“Hal --- I am tired, please take over for me!”

$f(x) = 9x^2 + 3x^3 - 7$ in Excel

x	f(x) = 9*x^2 + 3*x^3 -7
0	9*A2^2 + 3*A2^3 -7
1	9*A3^2 + 3*A3^3 -7
2	9*A4^2 + 3*A4^3 -7
3	9*A5^2 + 3*A5^3 -7
4	9*A6^2 + 3*A6^3 -7
5	9*A7^2 + 3*A7^3 -7
6	9*A8^2 + 3*A8^3 -7
7	9*A9^2 + 3*A9^3 -7
8	
9	
10	
11	
12	
13	

x	f(x) = 9*x^2 + 3*x^3 -7
0	-7
1	5
2	53
3	155
4	329
5	593
6	965
7	1463
8	2105
9	2909
10	3893
11	5075
12	6473
13	8105

Brute Force Direct Approach

$f(x) = 9x^2 + 3x^3 - 7$

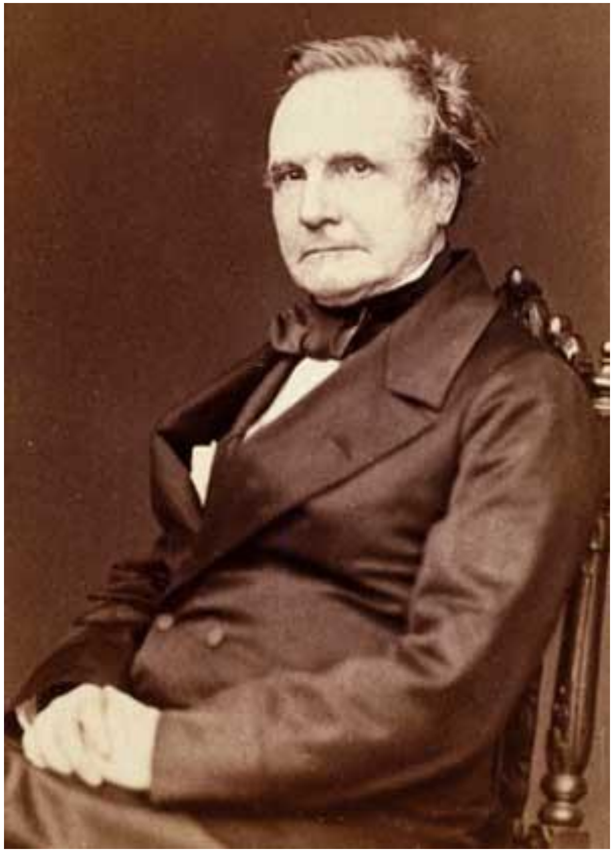
nth difference of an nth order polynomial is a constant

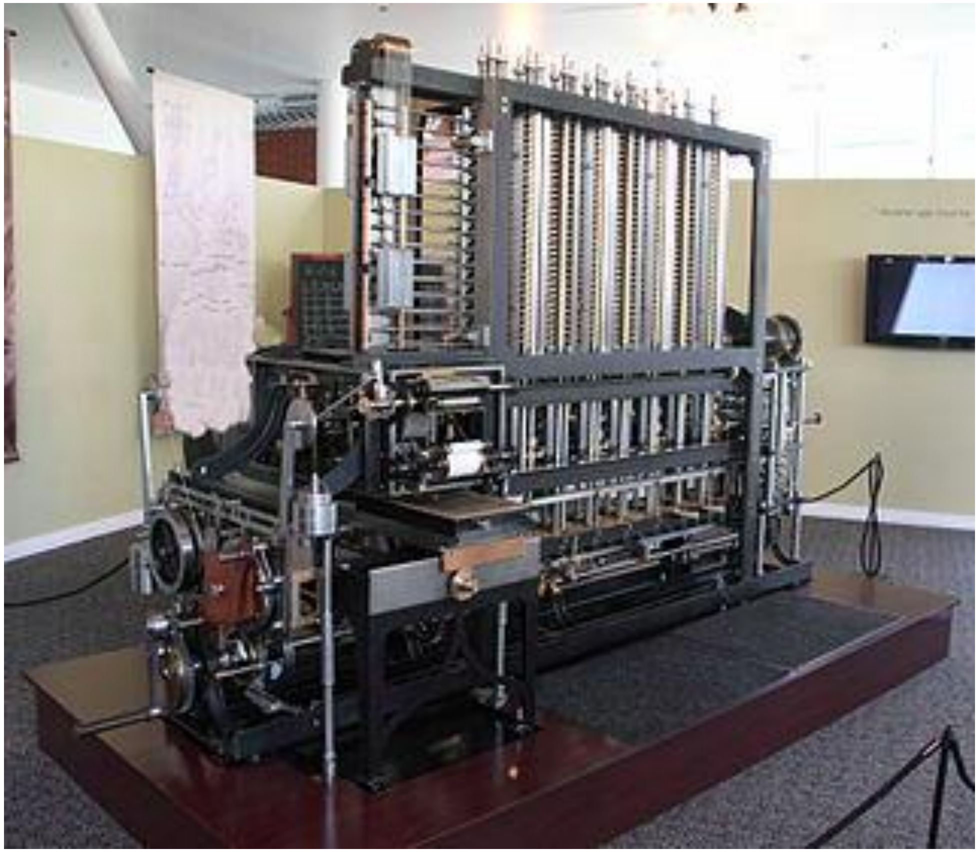
x	f(x) = 9*x^2 + 3*x^3 -7		Del1(x) = f(x+1) - f(x)		Del2(x) = Del1(x+1) - Del1(x)		Del3(x) = Del2(x+1) - Del2(x)
0	-7		12		36		18
1	5		48		54		18
2	53		102		72		18
3	155		174		90		18
4	329		264		108		18
5	593		372		126	+	18
6	965		498	+	144		18
7	1463	+	642		162		18
8	2105		804		180		18
9	2909		984		208		
10	3893		1192				
11	5085						
12							
13							

Indirect Algorithm Shortcut

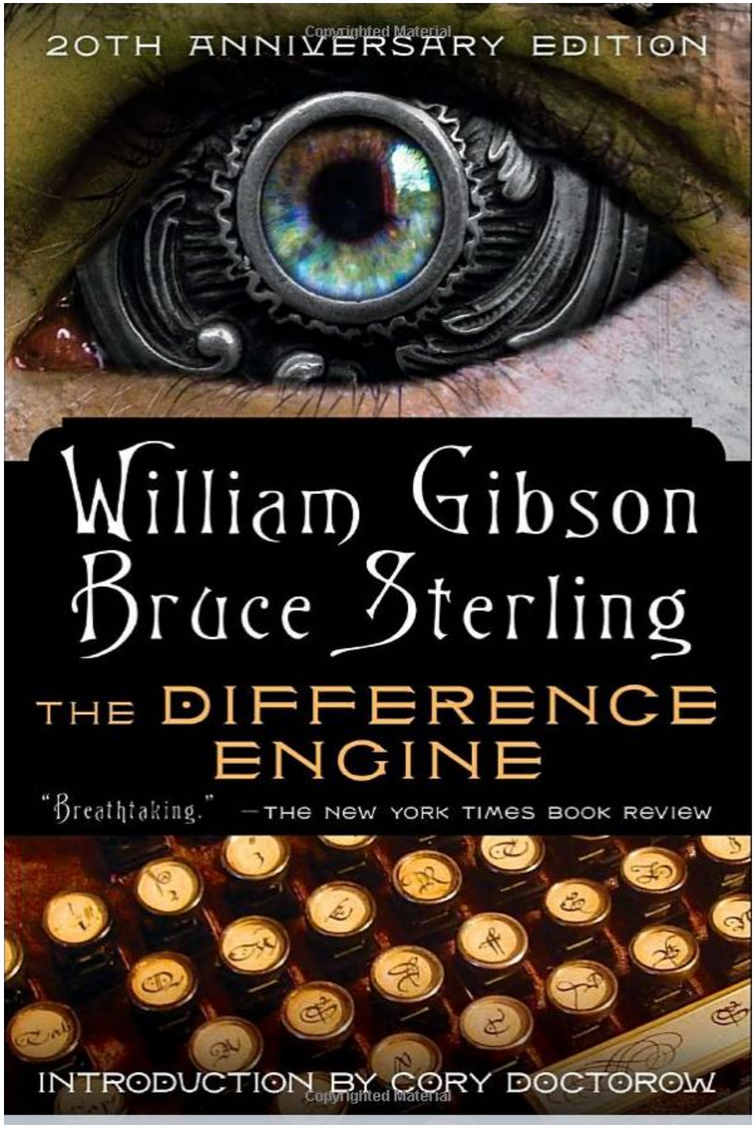
Knowing more fundamentals is better

Babbage’s Difference Machine





Cyber-Punk Literature

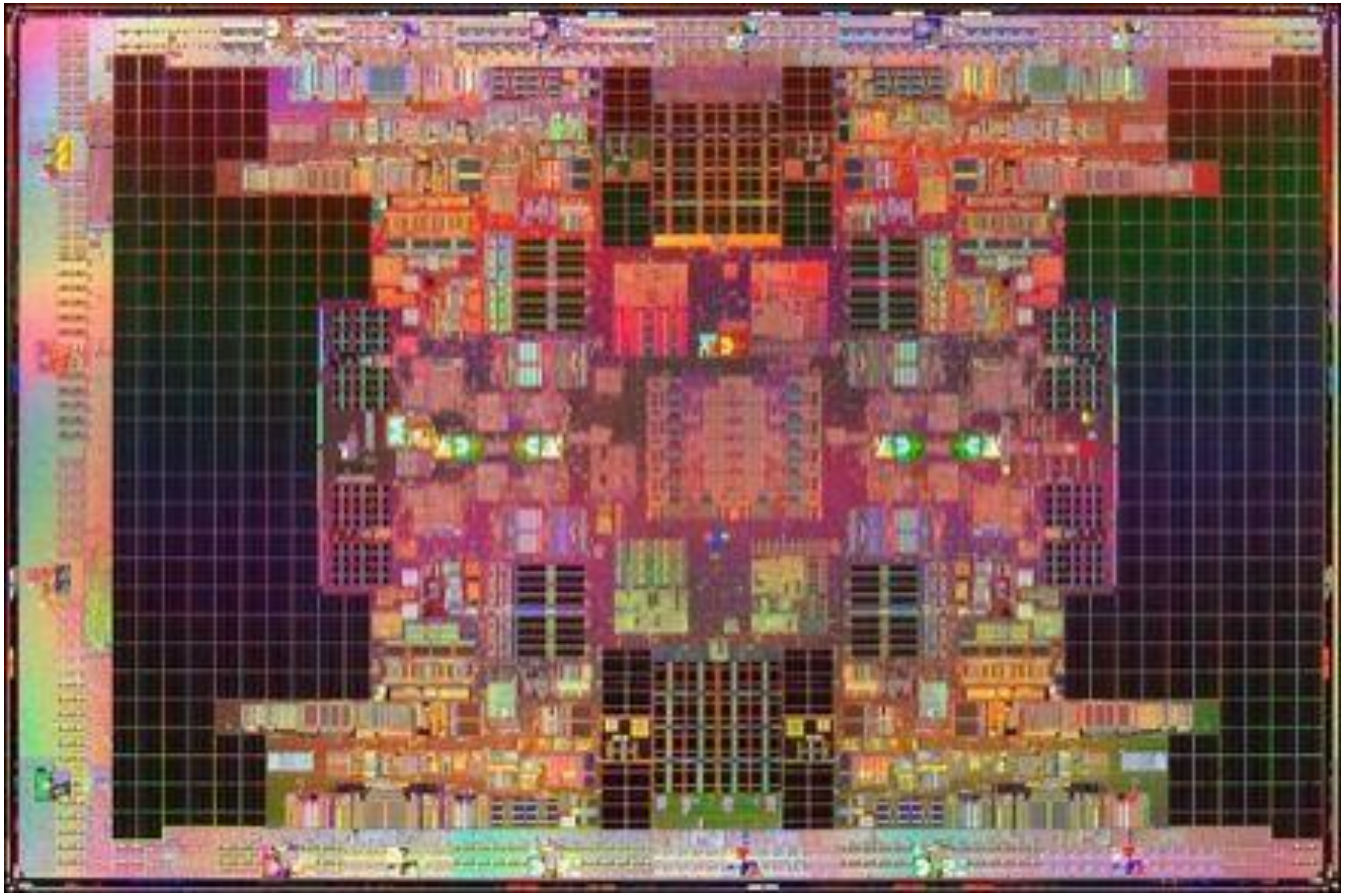


What material to use to make these gears ?

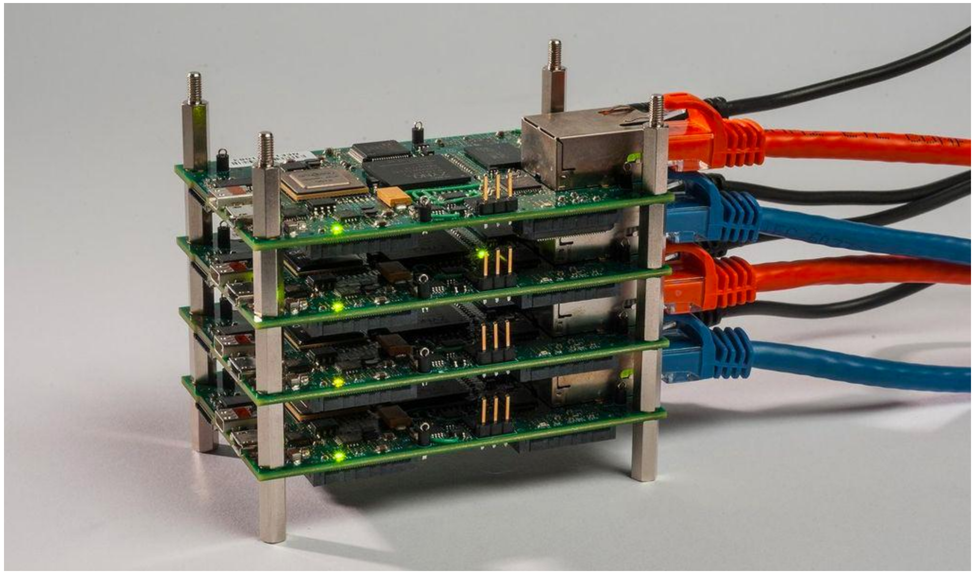
HCF

Forget about them

Very Large Scale Integration



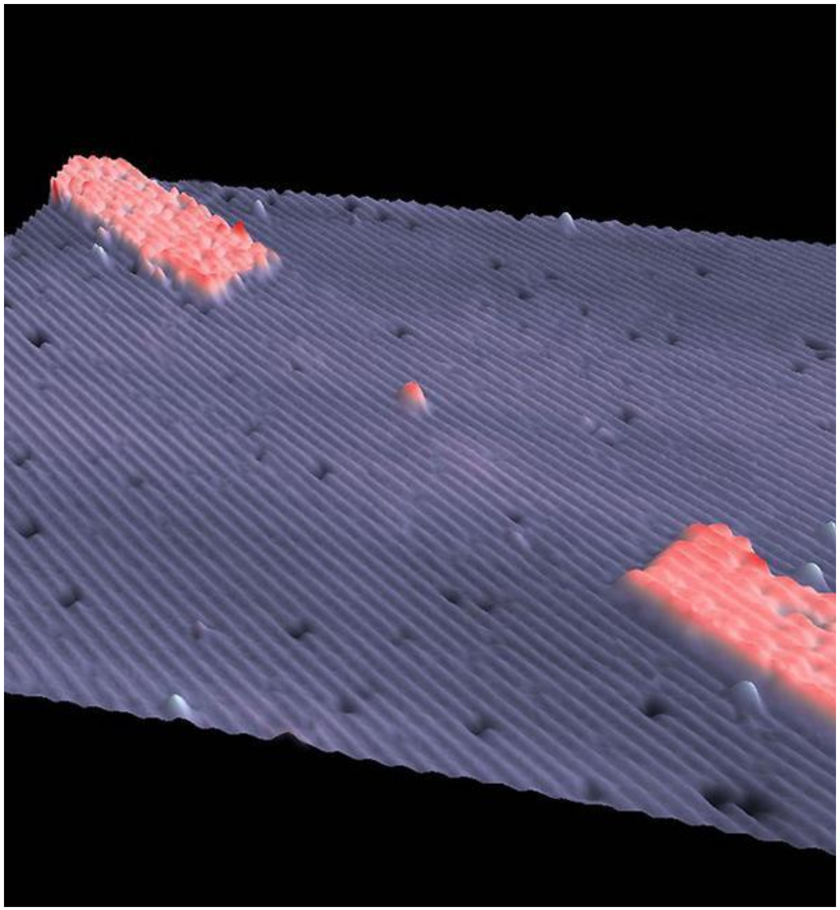
Beowulf (or Grendel)



Fast enough? Never

Tianhe-2, or Milky Way-2, clocked in at number one with a performance of 33.86 petaflops per second,

The smallest transistor



nature nanotechnology

NATURE NANOTECHNOLOGY | LETTER

A single-atom transistor

Martin Fuechsle, Jill A. Miwa, Suddhasatta Mahapatra, Hoon Ryu, Sunhee Lee, Oliver Warschkow, Lloyd C. L. Hollenberg, Gerhard Klimeck & Michelle Y. Simmons

Affiliations | Contributions | Corresponding author

Nature Nanotechnology **7**, 242–246 (2012) | doi:10.1038/nnano.2012.21
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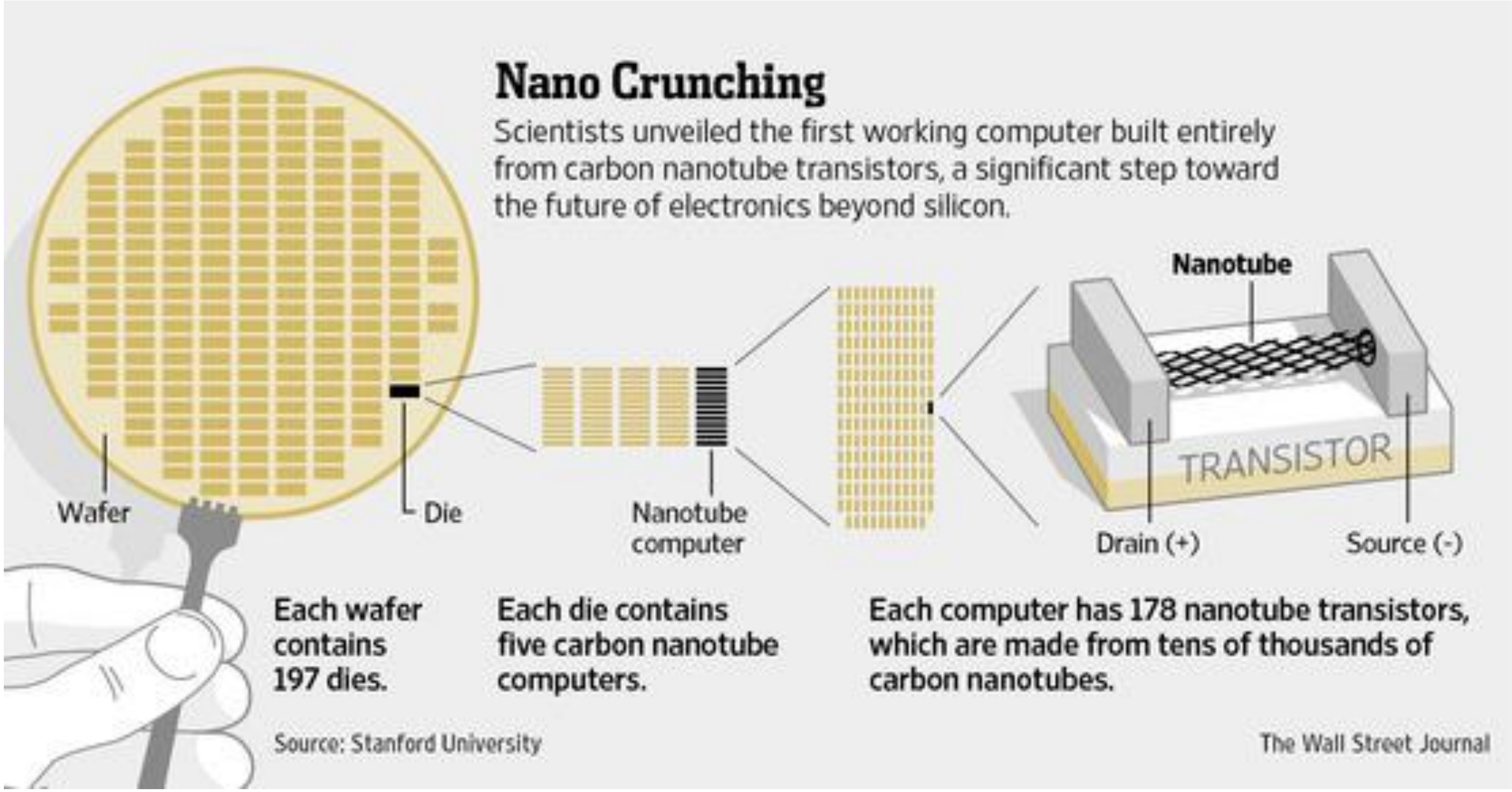
Abstract

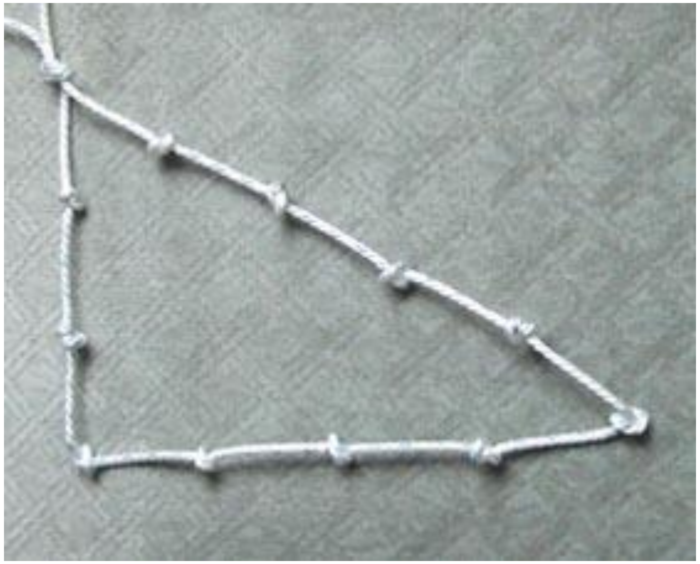
The ability to control matter at the atomic scale and build devices with atomic precision is central to nanotechnology. The scanning tunnelling microscope[1] can manipulate individual atoms[2] and molecules on surfaces, but the manipulation of silicon to make atomic-scale logic circuits has been hampered by the covalent nature of its bonds. Resist-based strategies have allowed the formation

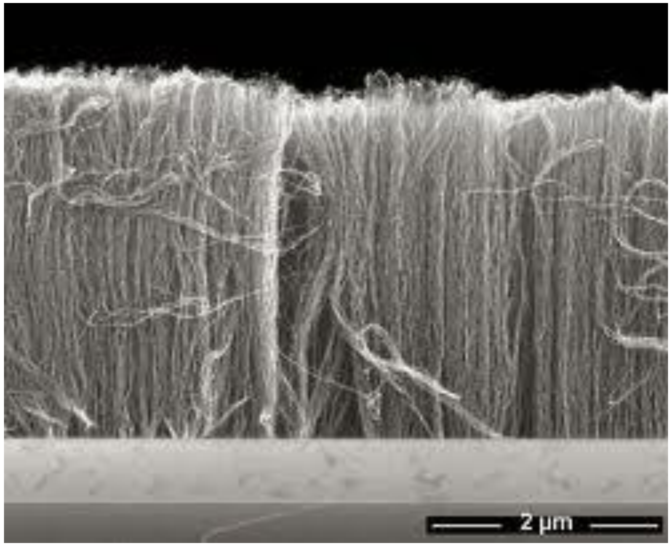
Carbon Nanotube Computer

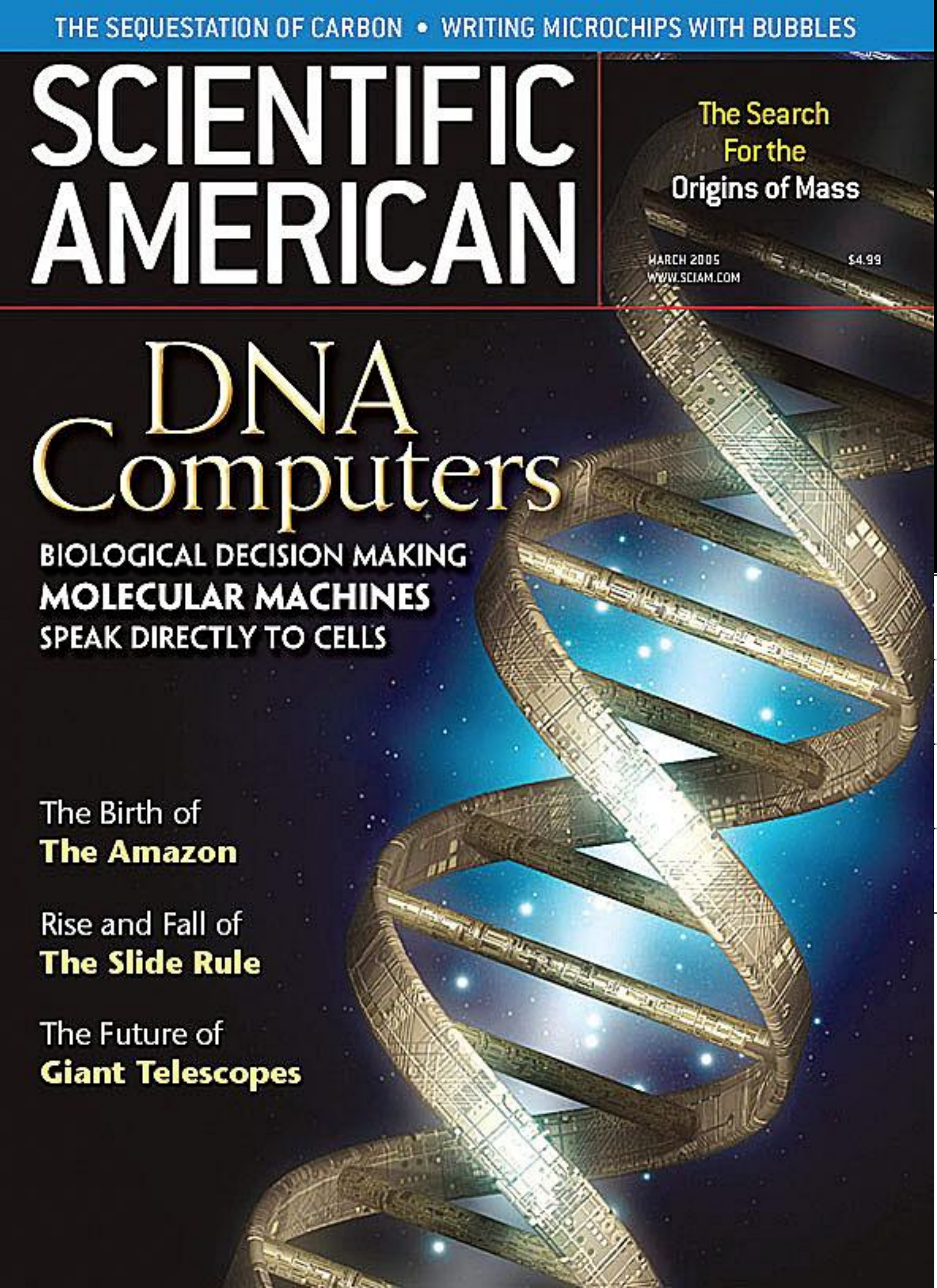


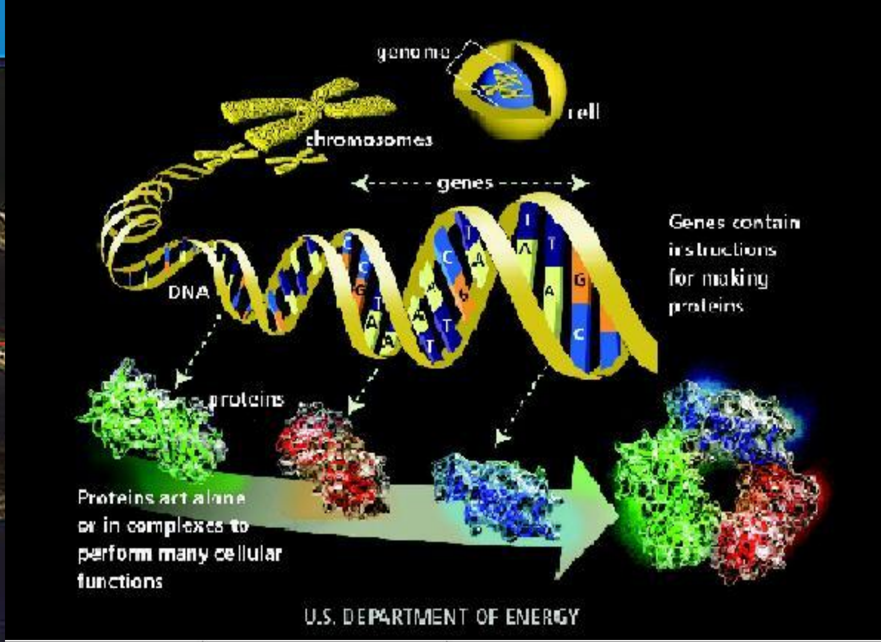
Upshots and Observations

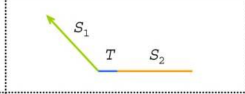
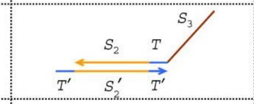
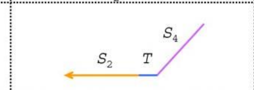
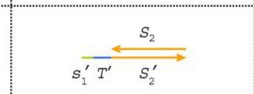
- We used to compute because "computing" was painfully hard work, subject to human error and, yet, very necessary
- We compute today for the these reasons and a plethora of other reasons that involve pleasure as well as utility/pain
- For the most part computing is still a brute force technology – human intuition and insight are very different
  - Knowing more is better and powerful
  - Quantum Mechanics/Quantum Information Theory
- Progress in Computing and progress in materials science go hand-in-hand
  - From the knots in ropes to brass gears, to silicon crystals to carbon nanotubes one drives the other
  - Be aware of biological science









input $w_{1,2}$ (1x)		S_1 T S_2 <ACCTCTCATCTATCACCACCTCTTTATCAATCTAC<
gate:output $g_{2:2,3}$ (10x)		S_2 T S_3 <TCTTTATCAATCTACCCACCTCCCACAACCTTCAT< >GGTGGAGAAATAGTTAGATGGGTGG> T' S_2' T'
fuel $w_{2,4}$ (10x)		S_2 T S_4 <TCTTTATCAATCTACCCACCACATCCCCCATTACC<
threshold $th_{1,2:2}$ (0.5x)		S_2 <TCTTTATCAATCTAC< >AGTGGTGGAGAAATAGTTAGATG> s_1' T' S_2'

from Scientific American, August 1998

For any x what are the values of f(x)?

$$f(x) = 9\,x^2 + 3\,x^3 - 7$$

Wolfram's Mathematica
2 GHz Intel Core i7
MacBook Air

```
In[1]:= f[x_] := 9*x^2 + 3*x^3 - 7
        Table[{x, f[x]}, {x, 0, 100}];
        Timing[%]

Out[3]= {5. × 10^-6, {{0, -7}, {1, 5}, {2, 53}, {3, 155}, {4, 329}, {5, 593}, {6, 965},
  {7, 1463}, {8, 2105}, {9, 2909}, {10, 3893}, {11, 5075}, {12, 6473}, {13, 8105},
  {14, 9989}, {15, 12 143}, {16, 14 585}, {17, 17 333}, {18, 20 405}, {19, 23 819},
  {20, 27 593}, {21, 31 745}, {22, 36 293}, {23, 41 255}, {24, 46 649}, {25, 52 493},
  {26, 58 805}, {27, 65 603}, {28, 72 905}, {29, 80 729}, {30, 89 093}, {31, 98 015},
  {32, 107 513}, {33, 117 605}, {34, 128 309}, {35, 139 643}, {36, 151 625}, {37, 164 273},
  {38, 177 605}, {39, 191 639}, {40, 206 393}, {41, 221 885}, {42, 238 133}, {43, 255 155},
  {44, 272 969}, {45, 291 593}, {46, 311 045}, {47, 331 343}, {48, 352 505}, {49, 374 549},
  {50, 397 493}, {51, 421 355}, {52, 446 153}, {53, 471 905}, {54, 498 629}, {55, 526 343},
  {56, 555 065}, {57, 584 813}, {58, 615 605}, {59, 647 459}, {60, 680 393},
  {61, 714 425}, {62, 749 573}, {63, 785 855}, {64, 823 289}, {65, 861 893},
  {66, 901 685}, {67, 942 683}, {68, 984 905}, {69, 1 028 369}, {70, 1 073 093},
  {71, 1 119 095}, {72, 1 166 393}, {73, 1 215 005}, {74, 1 264 949}, {75, 1 316 243},
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  {81, 1 653 365}, {82, 1 714 613}, {83, 1 777 355}, {84, 1 841 609}, {85, 1 907 393},
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  {96, 2 737 145}, {97, 2 822 693}, {98, 2 910 005}, {99, 2 999 099}, {100, 3 089 993}}}
```

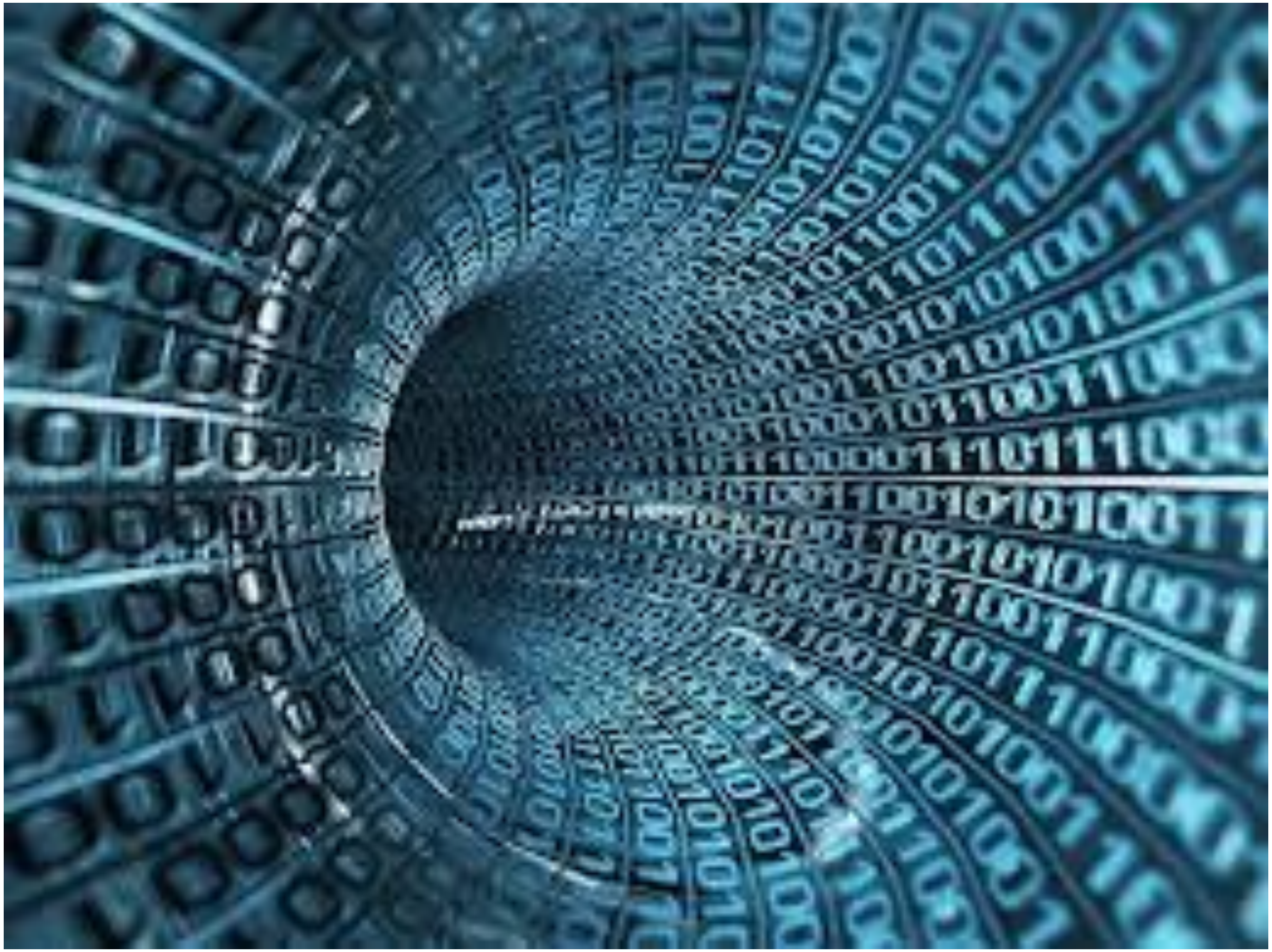
Computing Writ Large

The ACM *Computing Curricula 2005*[1] defined "computing" as follows:

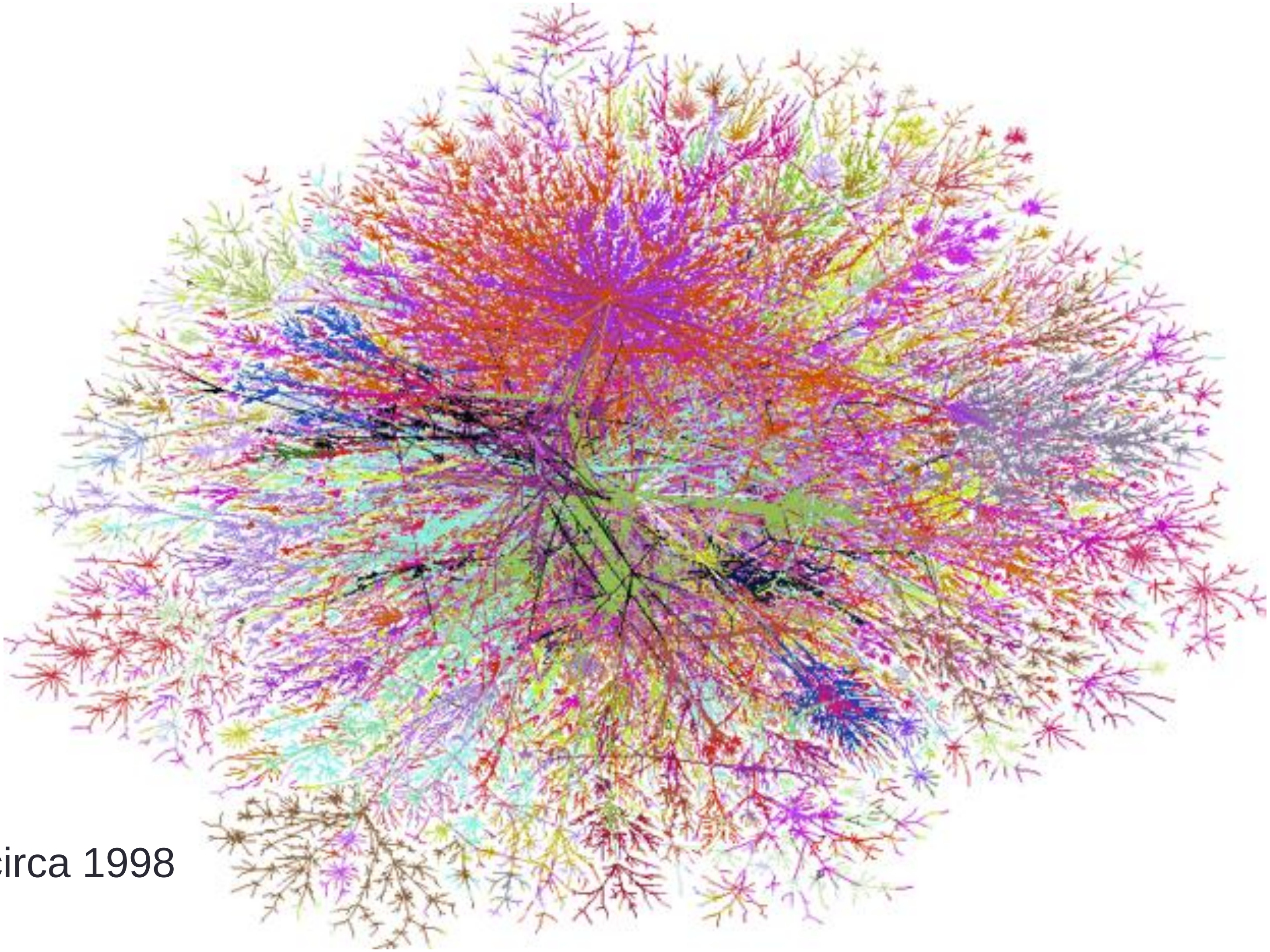
> "In a general way, we can define computing to mean any goal-oriented activity requiring, benefiting from, or creating computers. Thus, computing includes designing and building hardware and software systems for a wide range of purposes; processing, structuring, and managing various kinds of information; doing scientific studies using computers; making computer systems behave intelligently; creating and using communications and entertainment media; finding and gathering information relevant to any particular purpose, and so on. The list is virtually endless, and the possibilities are vast."

and it defines five sub-disciplines of the *computing* field: Computer Science, Computer Engineering, Information Systems, Information Technology, and Software Engineering.[2]

BIG Data and Really BIG data

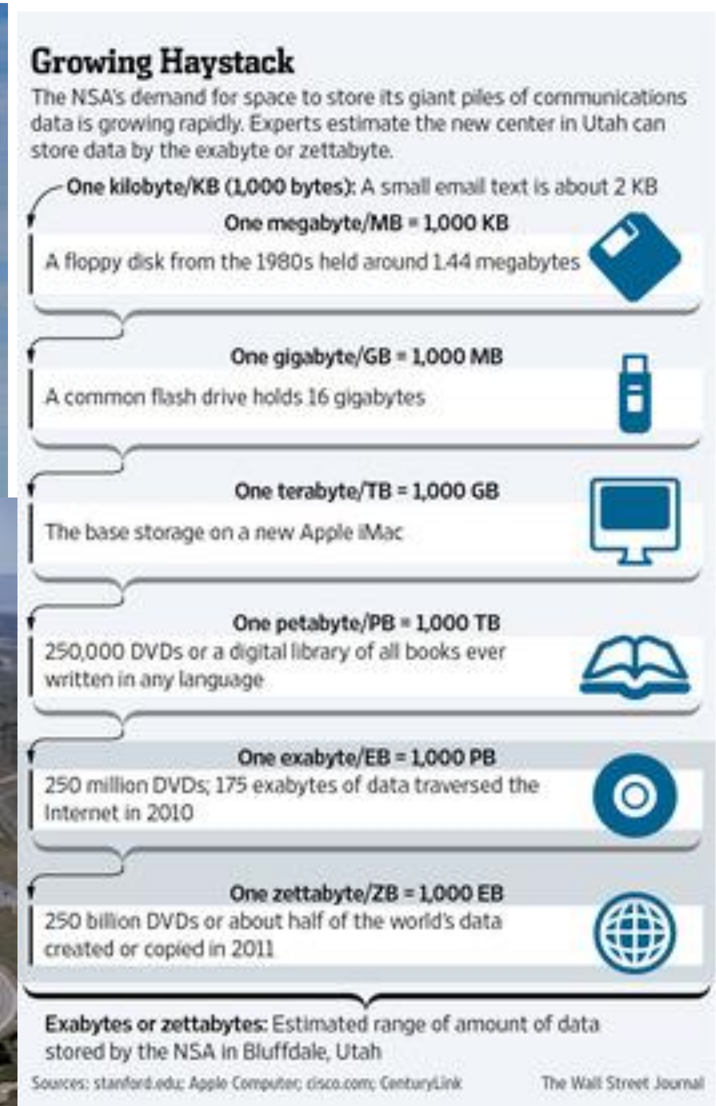


2.5 Quintillion bytes of data every day

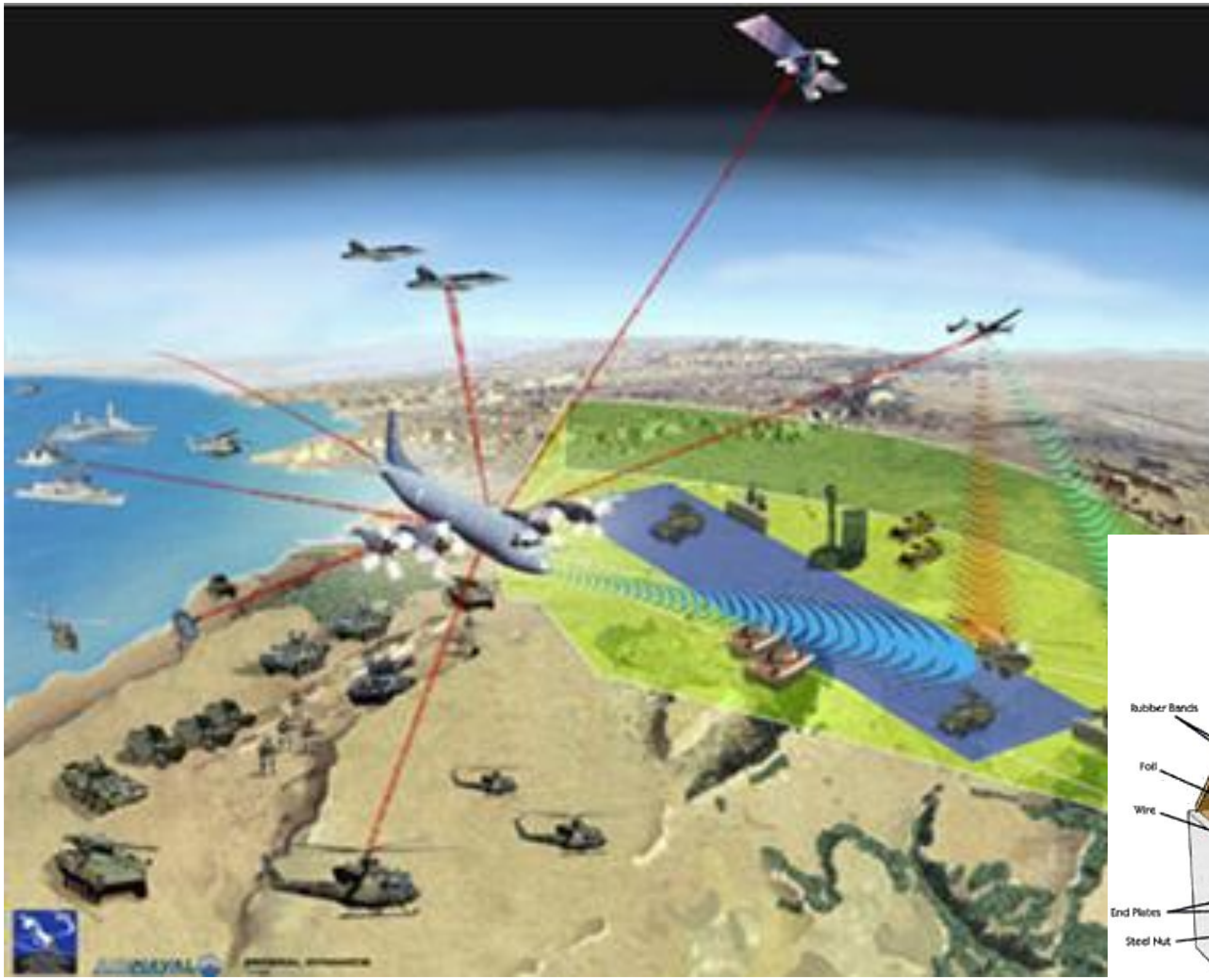


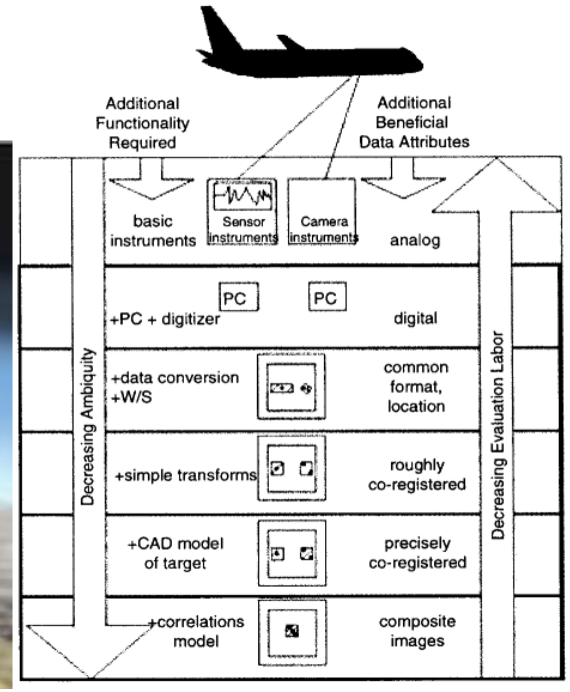
Internet circa 1998

Beyond Yottabytes to “Hellabytes” of Data

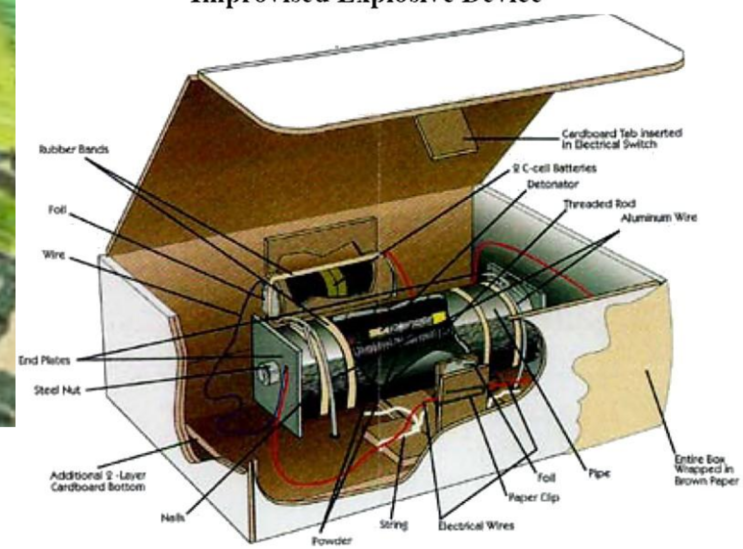


Data Fusion

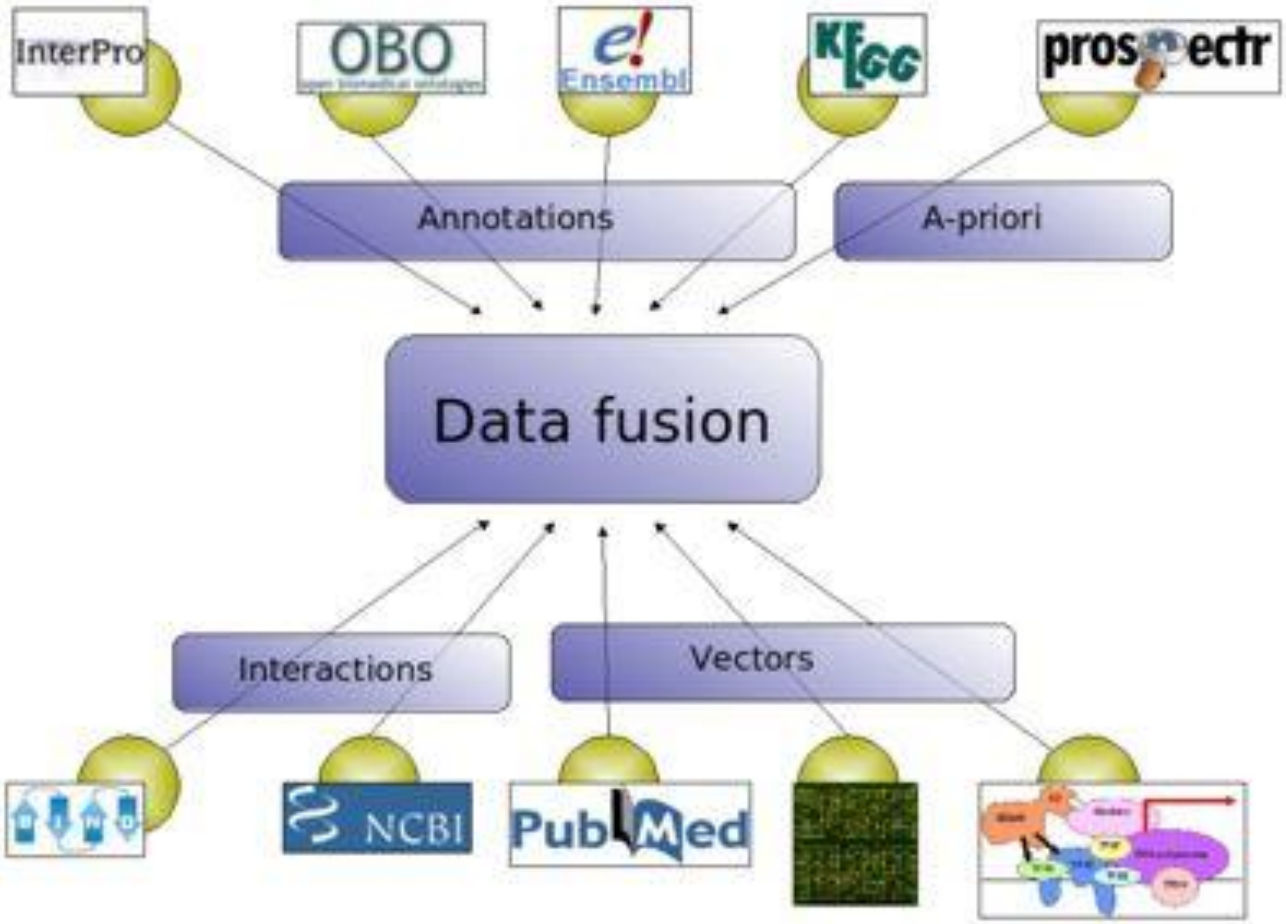




Improvised Explosive Device



Military to Civilian Transition



Google Translation: “Statistical Machine Translation”

What is Google Translate?

Google Translate is a free translation service that provides instant translations between dozens of different languages. It can translate words, sentences and web pages between any combination of our supported languages. With Google Translate, we hope to make information universally accessible and useful, regardless of the language in which it's written.

How does it work?

When Google Translate generates a translation, it looks for patterns in hundreds of millions of documents to help decide on the best translation for you. By detecting patterns in documents that have already been translated by human translators, Google Translate can make intelligent guesses as to what an appropriate translation should be. This process of seeking patterns in large amounts of text is called "statistical machine translation". Since the translations are generated by machines, not all translation will be perfect. The more human-translated documents that Google Translate can analyse in a specific language, the better the translation quality will be. This is why translation accuracy will sometimes vary across languages.

What languages does Google Translate support?

Supported languages:
71

Google Translate currently supports:

Afrikaans	Dutch	Hindi	Malay	Spanish
Albanian	English	Hungarian	Maltese	Swahili
Arabic	Esperanto	Icelandic	Norwegian	Swedish
Belarusian	Estonian	Indonesian	Persian	Thai
Bosnian	Filipino	Irish	Polish	Turkish
Bulgarian	Finnish	Italian	Portuguese	Ukrainian
Catalan	French	Japanese	Romanian	Vietnamese
Chinese	Galician	Korean	Russian	Welsh
Croatian	German	Latvian	Serbian	Yiddish
Czech	Greek	Lithuanian	Slovak	
Danish	Hebrew	Macedonian	Slovenian	

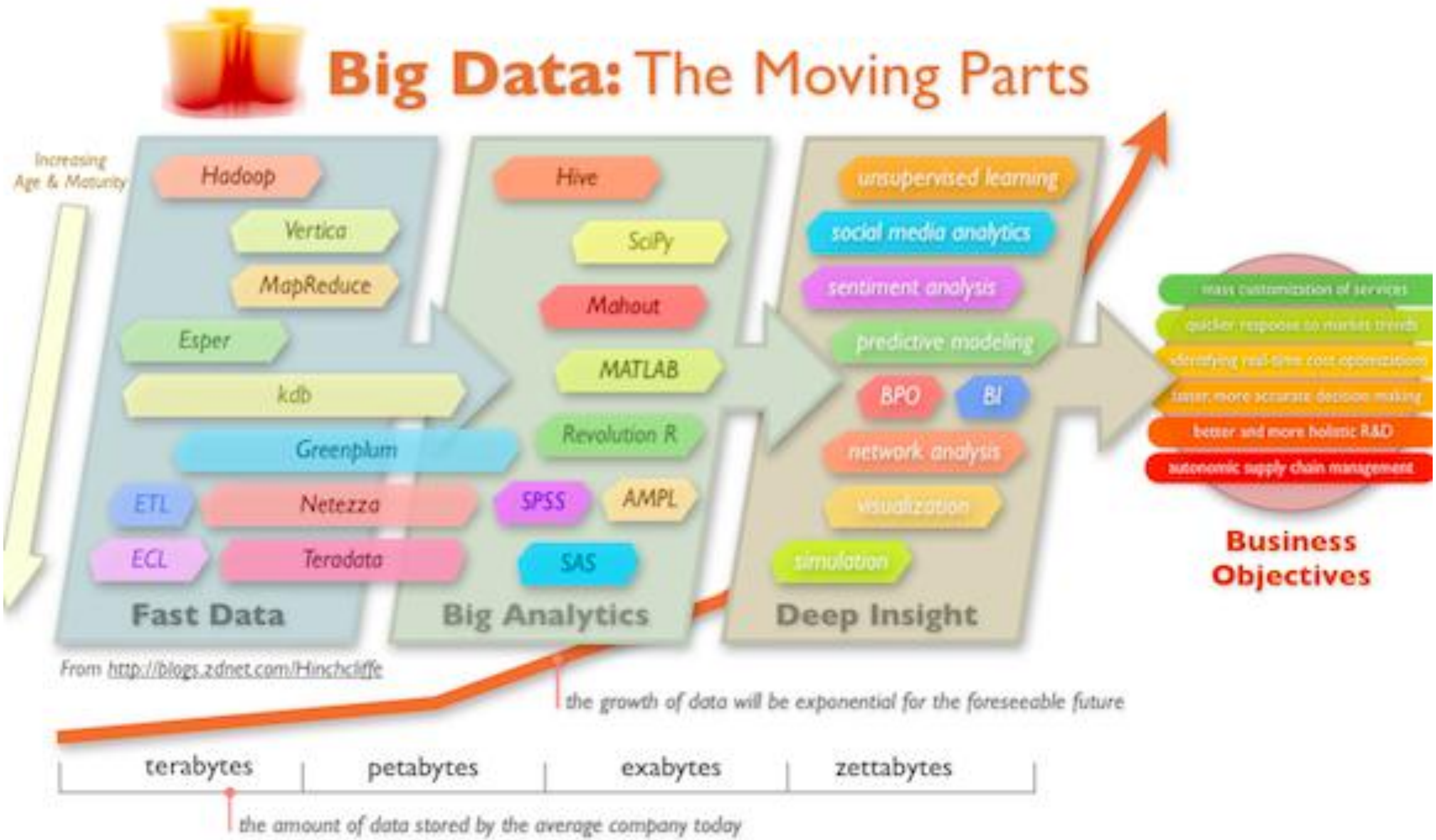
Current alpha languages are:

Armenian	Cebuano	Hmong	Lao	Telugu
Azerbaijani	Georgian	Javanese	Latin	Urdu
Basque	Gujarati	Kannada	Marathi	
Bengali	Haitian Creole	Khmer	Tamil	

Google Translate tests other languages, called "alpha languages", that may have less-reliable translation quality than our supported languages. We are always working to support other languages and will introduce them as soon as the translation quality meets our standards.

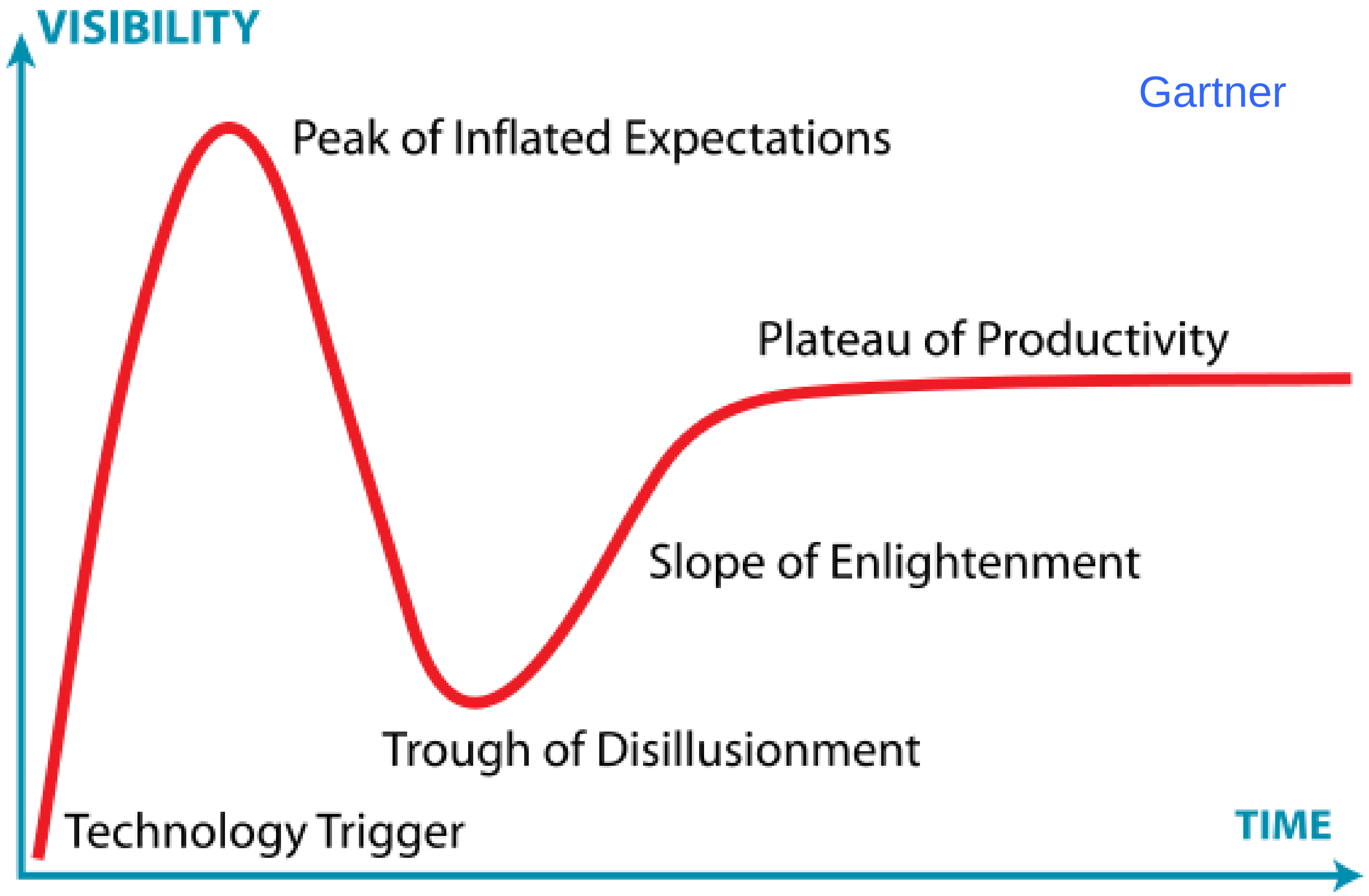
HCF

From Terabytes to Zettabytes

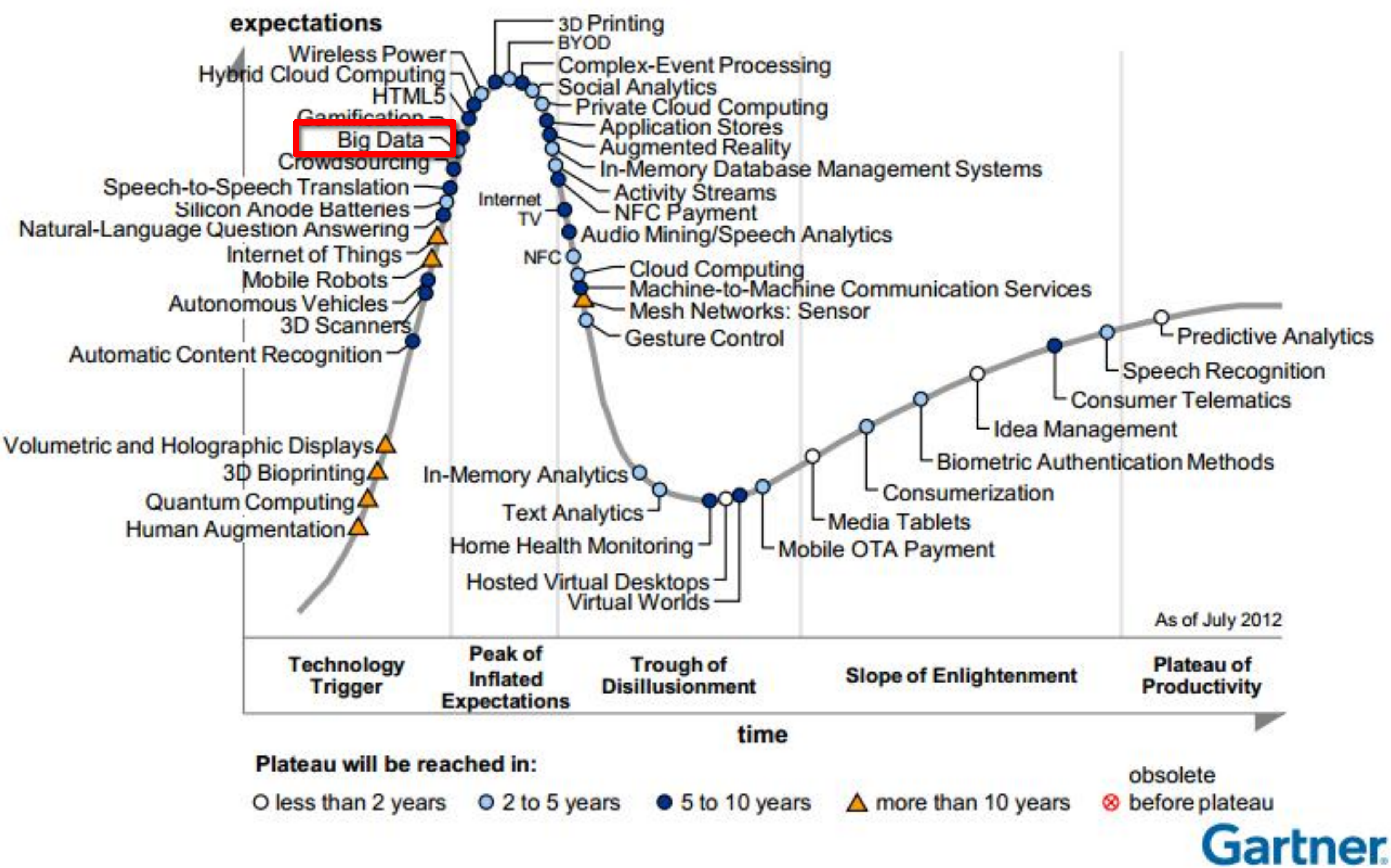


Generalized HYPE CYCLE

Gartner

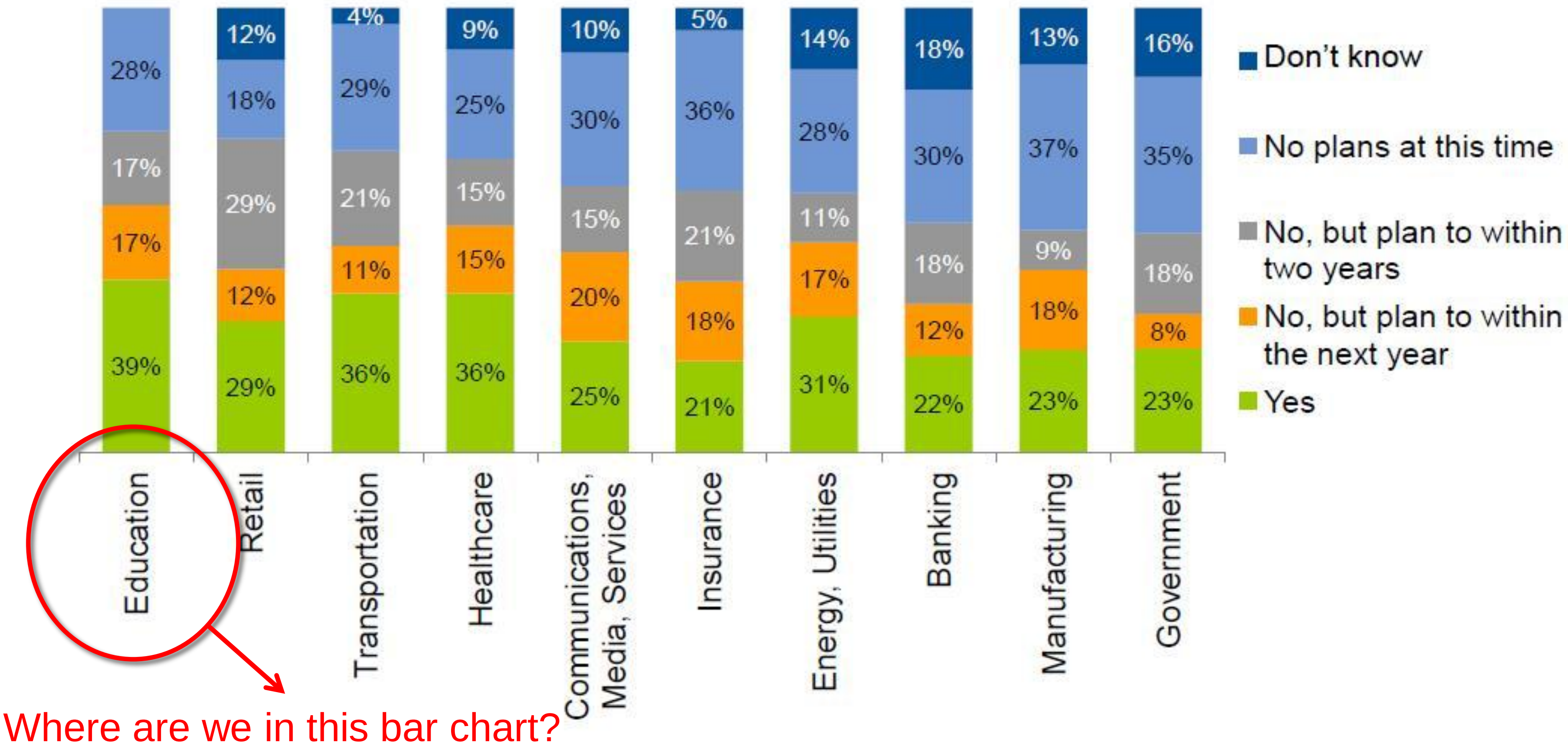


Emerging Technologies Hype Cycle 2012



Big Data Investments by Industry

Has your organization already invested in technology specifically designed to address the big data challenge?



Source: Gartner (July 2012)

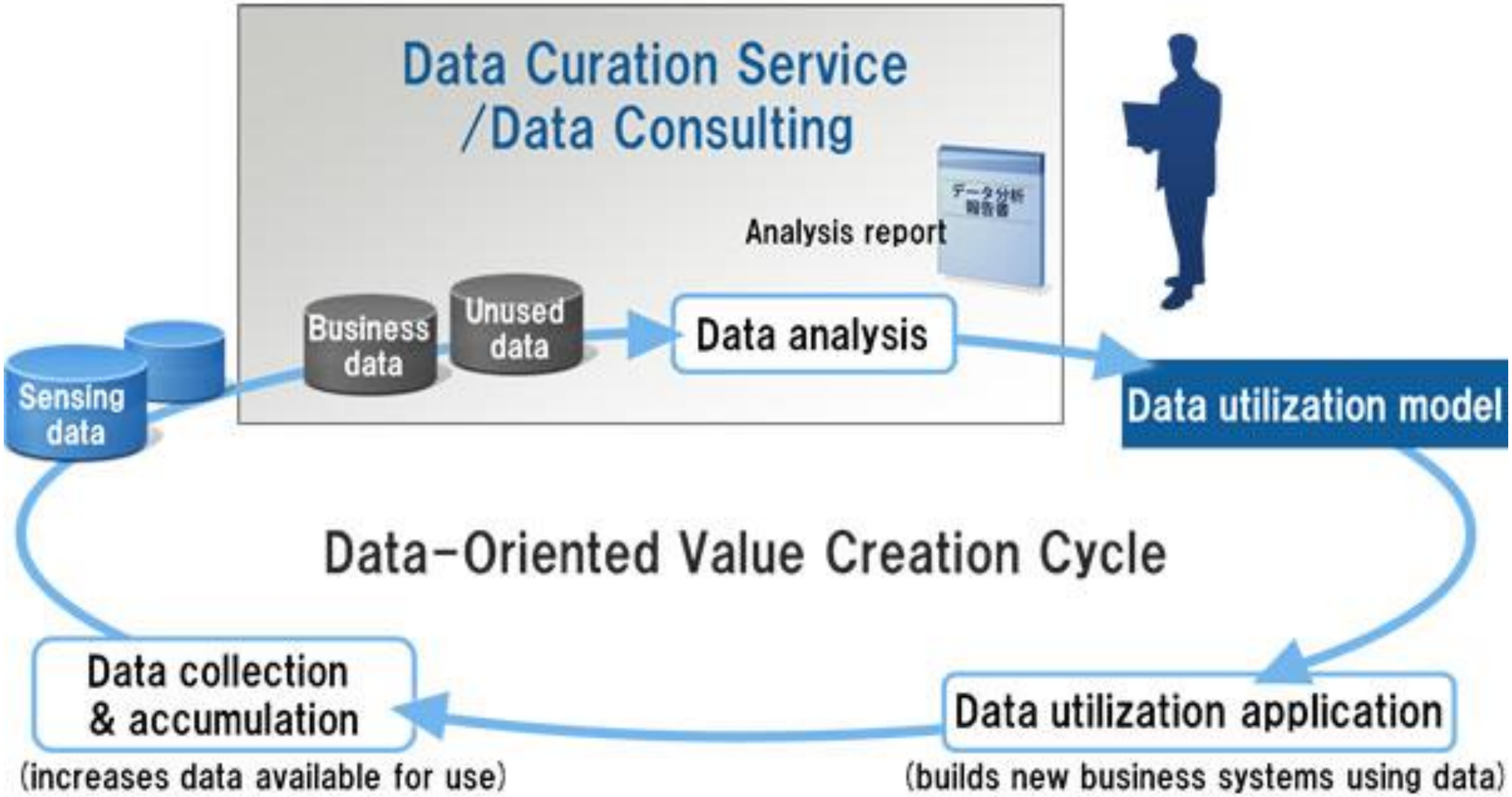
Gartner

Big "Dirty" Data: GIGO

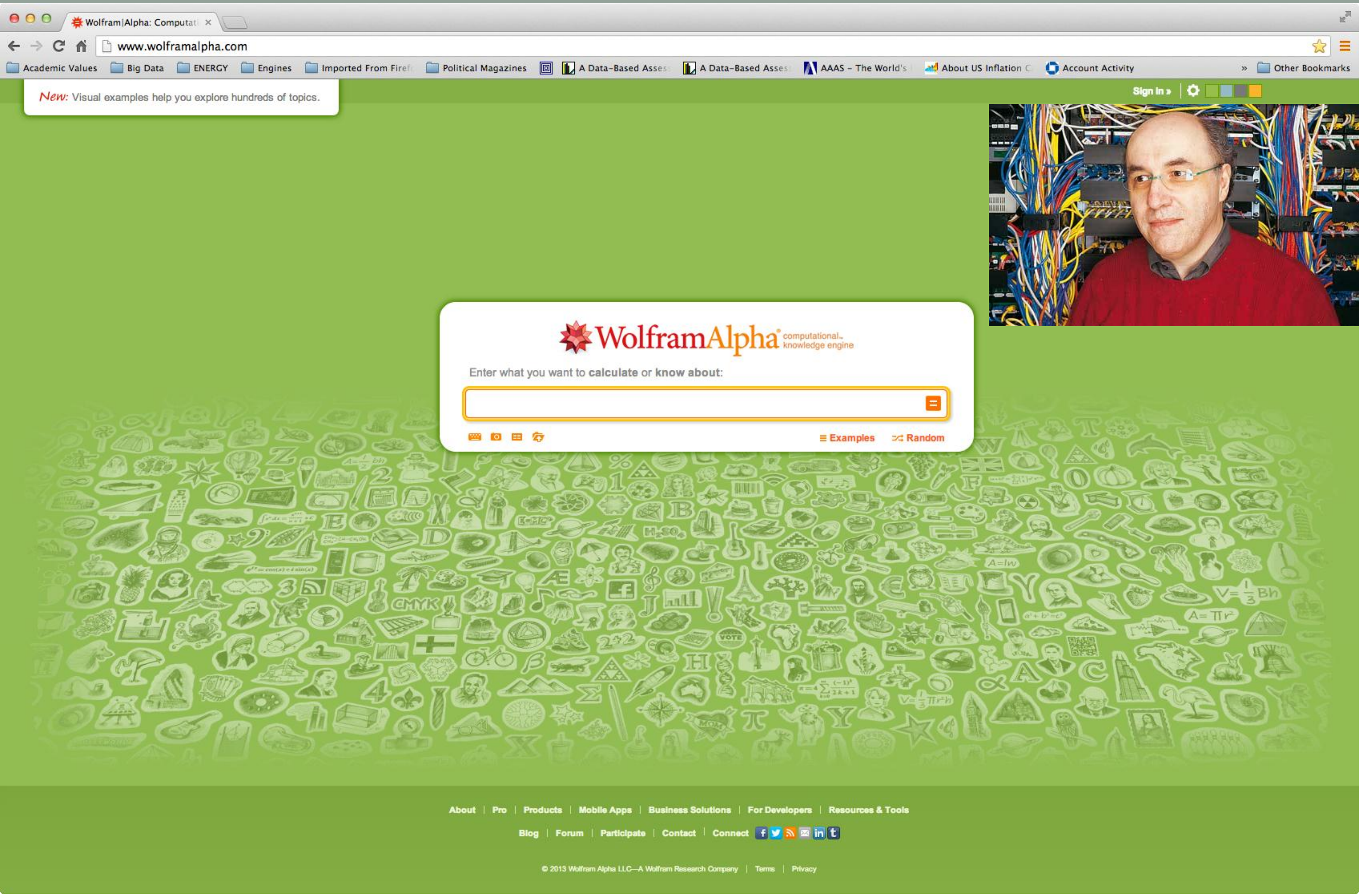
Big Data Catches All

The catchall term of big data skills came in fifth as the most popular among hiring managers in addition to Hadoop. Big data is a collection of data sets so large and complex that it becomes difficult to process using on-hand database management tools or traditional data processing applications. The challenges include capture, curation, storage, search, sharing, transfer, analysis and visualization.

Data Curation



www.Fujitsu.com


Wolfram|Alpha: Computat
www.wolframalpha.com
Academic Values
Big Data
ENERGY
Engines
Imported From Firef
Political Magazines
A Data-Based Asses
A Data-Based Asses
AAAS – The World's
About US Inflation C
Account Activity
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New: Visual examples help you explore hundreds of topics.
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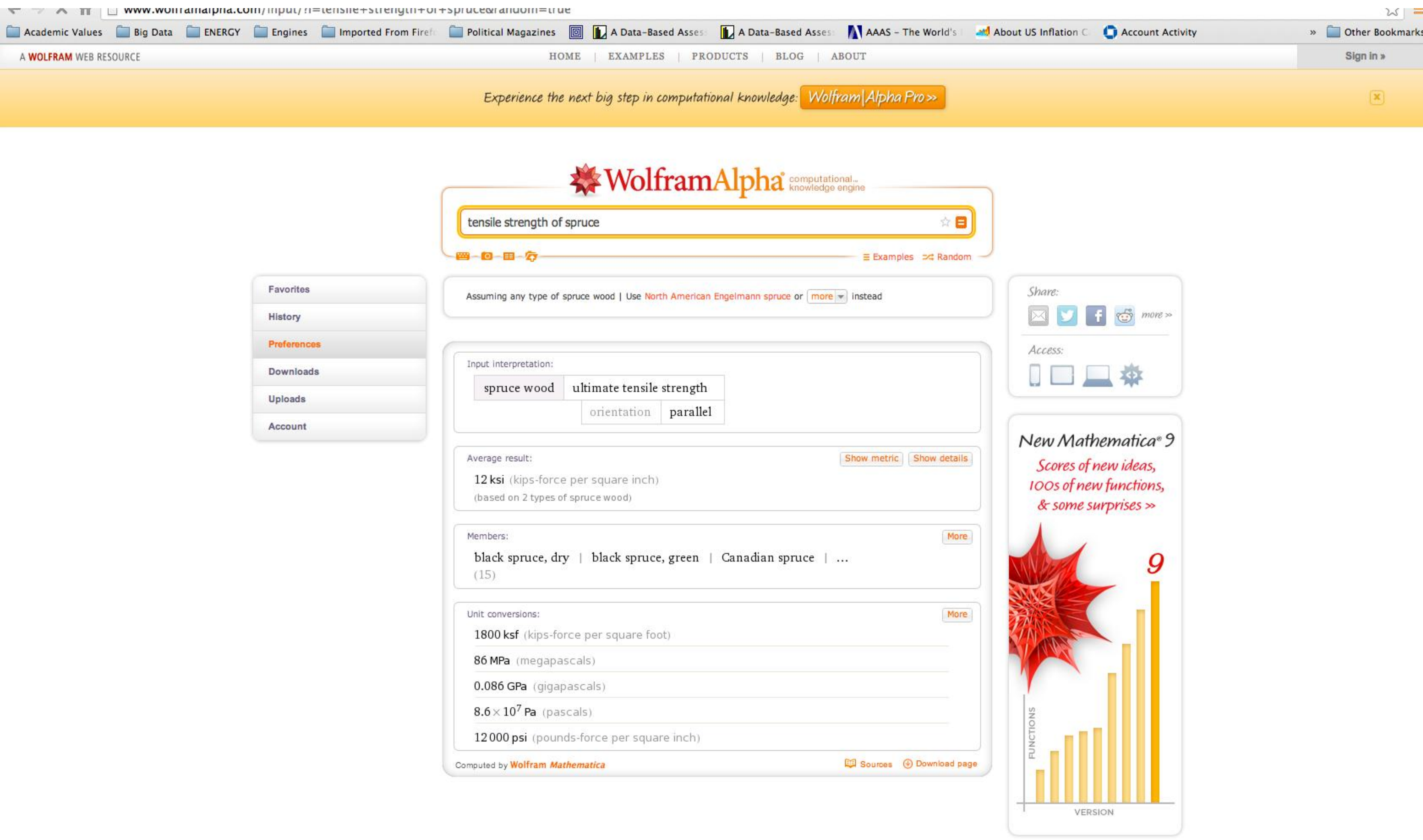
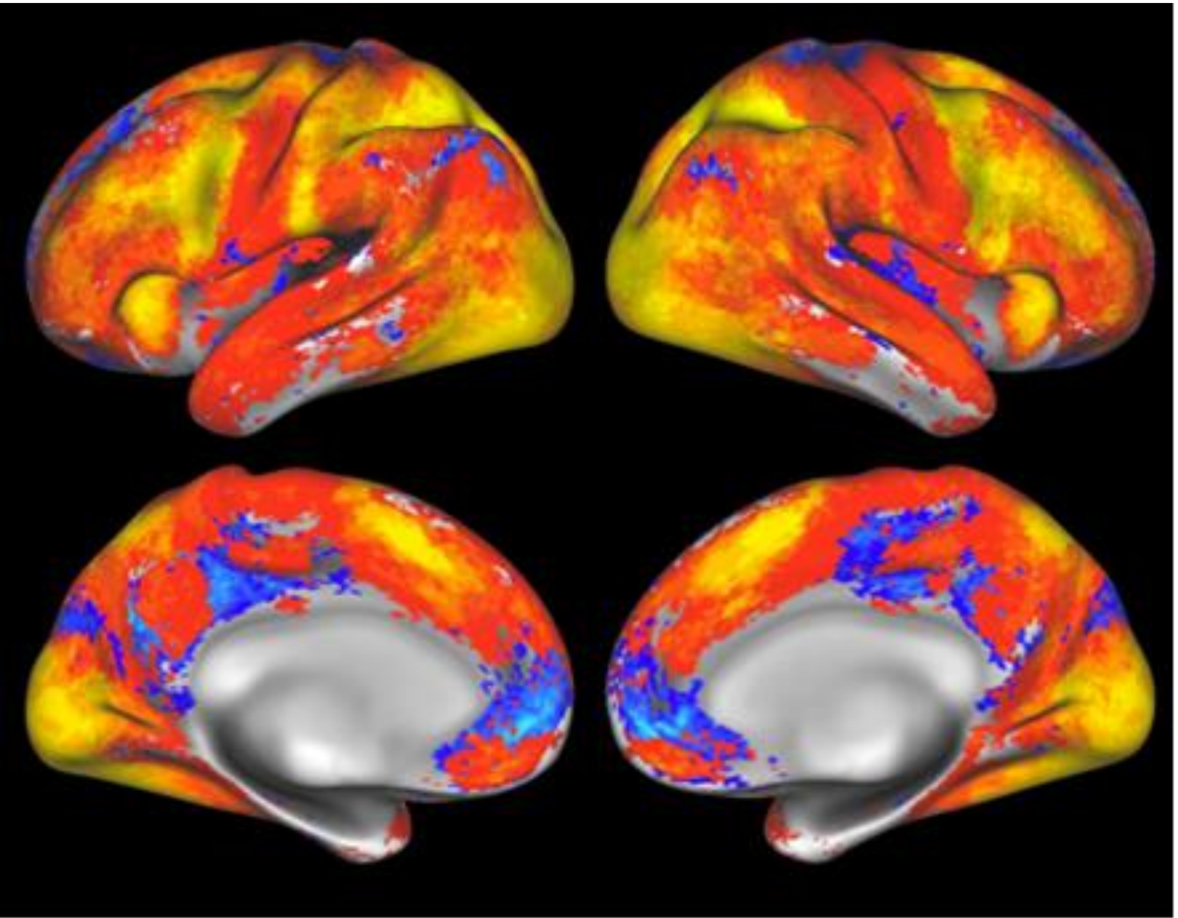
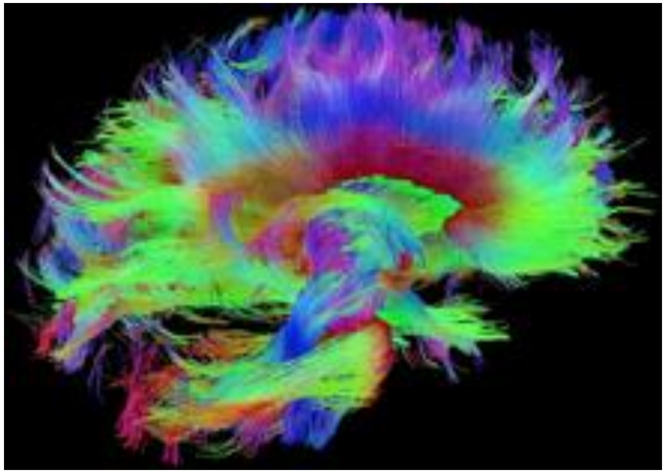
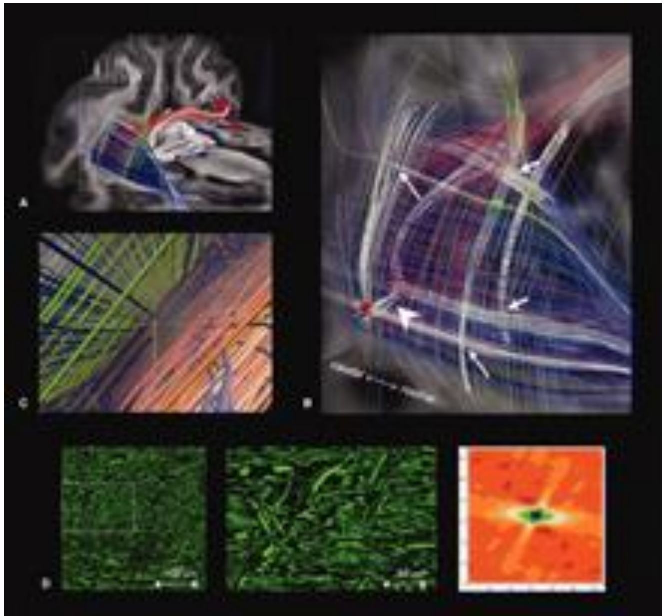
Alpha's Data must be Reliable ERGO Curation



Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative



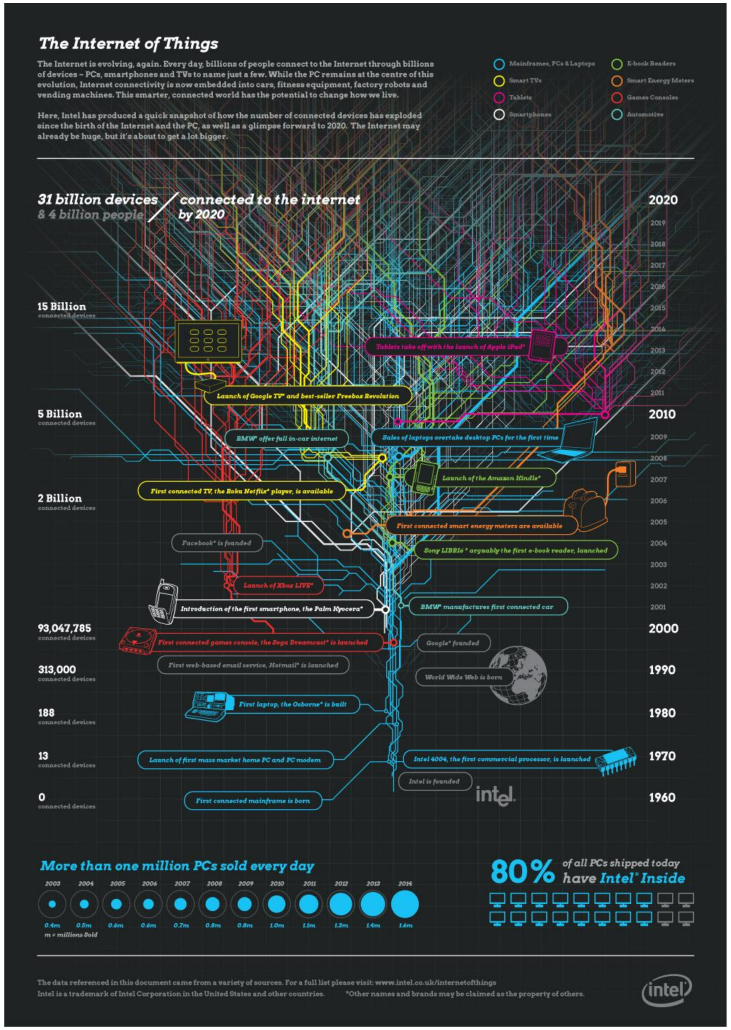




EU Diving Deeply into the HBP

Advanced Manufacturing, 3D Printing and Robotics

The Internet of Everything



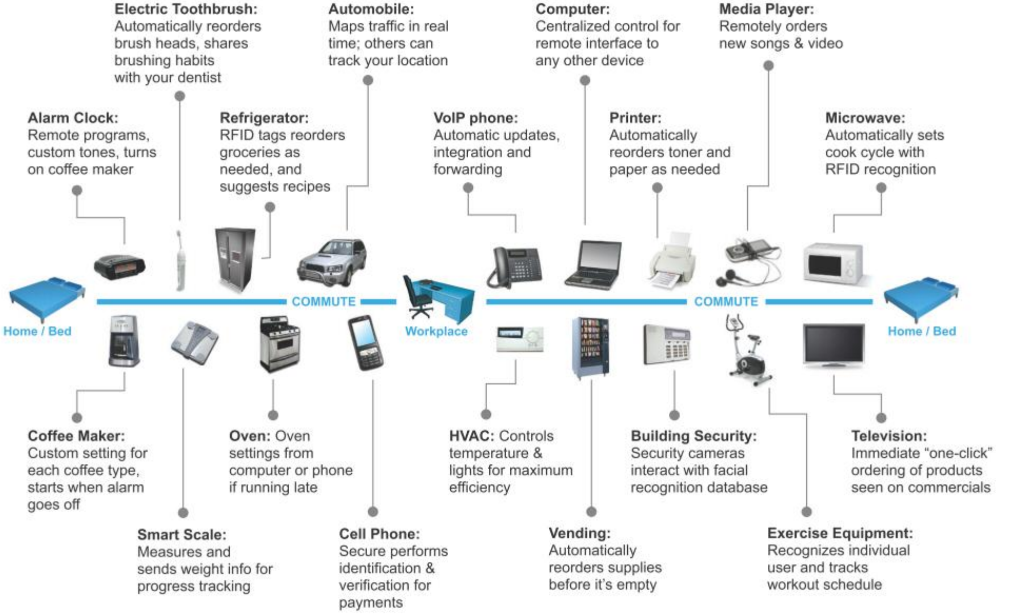
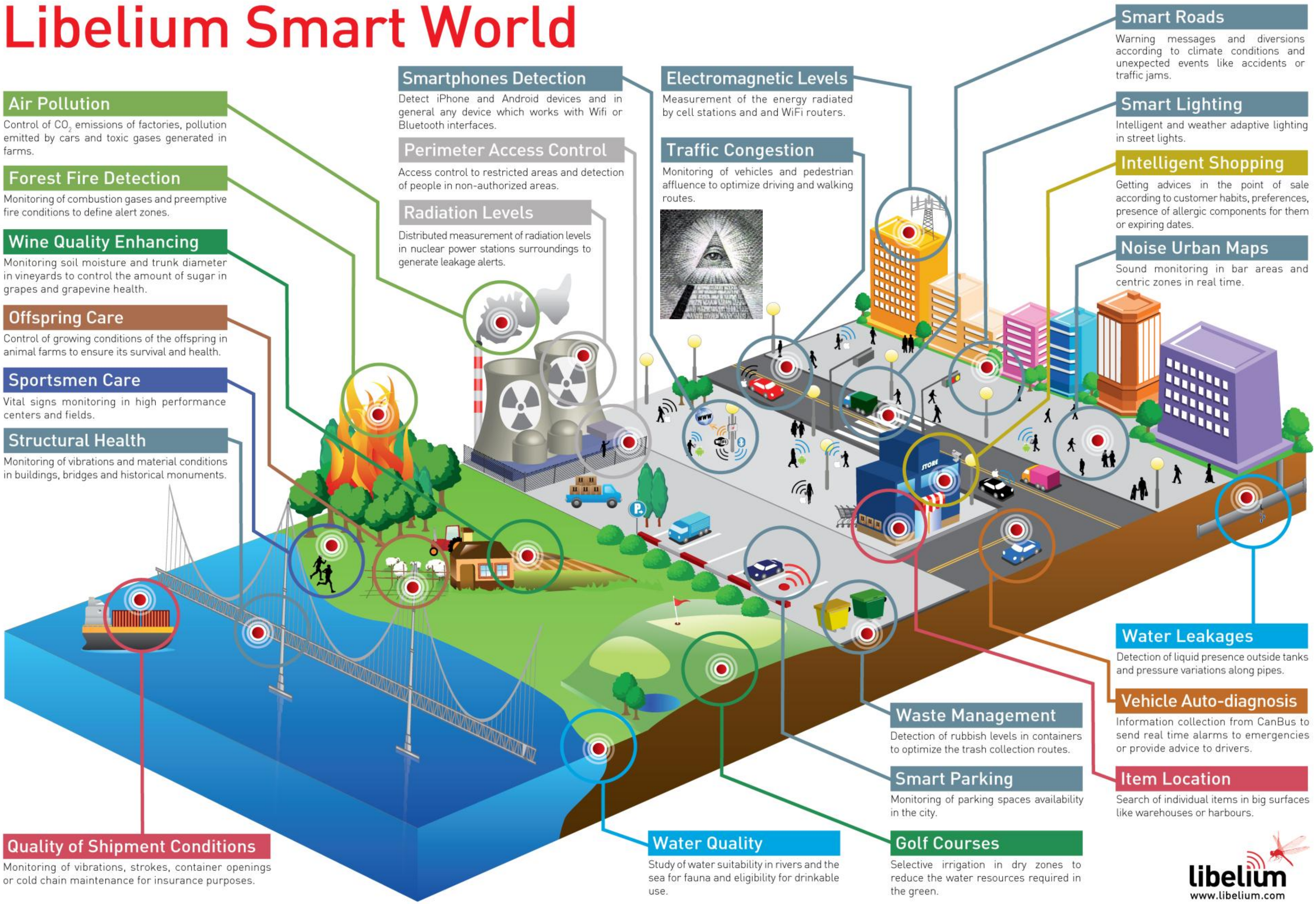


Figure 3. The Internet of Things

Libelium Smart World



“Post Capitalist” Entrepreneurship

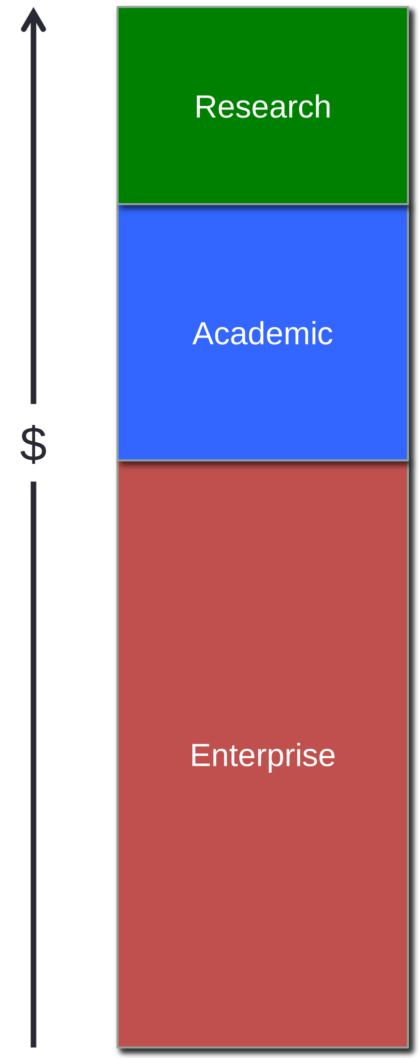
Capital Intensive

HCF

Capital Negligible

What does this all mean for UM?

- Invest wisely and invest *sufficiently* in computing across the board
  - Lots of input on decision making – faculty and staff working in cooperation
  - *It is an investment not an expense*
- Examine what we do at the cutting edge –
  - Where are we at the cutting edge?
  - What are we doing there?
  - Why are we there?
  - How do we go further faster than others?
- Integrate learning with discovery at all levels
- Be ready to capitalize on new trends, but don't jump too quickly



Keep your eyes peeled for the future

Thank you!