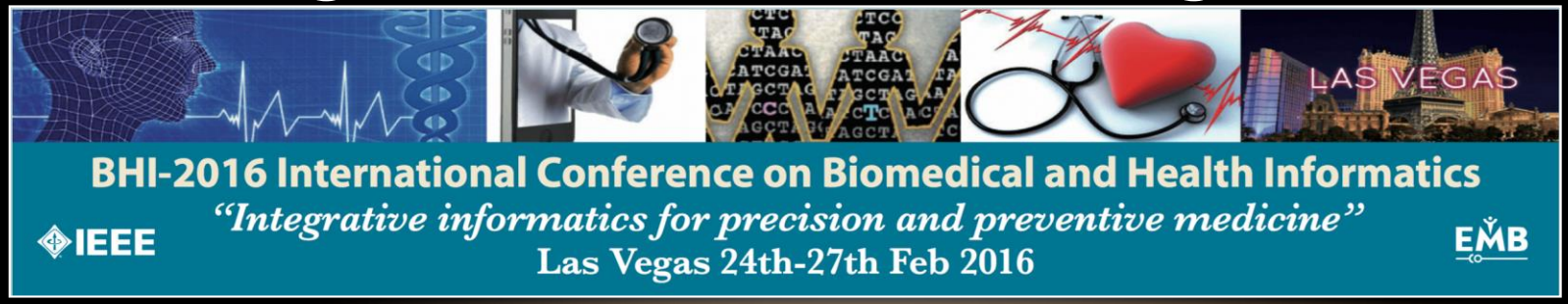
Medical Intelligence:

Big Data, Predictive Analytics, Machine Learning, and Artificial Intelligence



Anthony C. Chang, MD, MBA, MPH

Chief Intelligence and Innovation Officer
Children's Hospital of Orange County

Medical Director, Sharon Disney Lund Medical Intelligence and Innovation Institute

Honors Cooperative Program in Biomedical Informatics/ Artificial Intelligence

STANFORD
SCHOOL OF MEDICINE

Artificial Intelligence


Copyright Pierangelo Boog


PIENSE
THINK
ΣΚΕΨΟΥ
DENKE
PENSER
$2,000
$13,400
$5,000
Ken
WATSON
BRAD
Albinism 98%
Albino 10%
Porphyria 7%
CBC


A
A
РОССИЯ


HBR.ORG
Harvard Business Review
JUNE 2015
44 The Big Idea
You Need an Innovation Strategy
Gary P. Pisano
98 Organization
Luxury's Talent Factories
Andrew Shipilov and Frédéric Godart
110 Managing Yourself
Conquering Digital Distraction
Larry Rosen and Alexandra Samuel
Meet Your New Employee
How to manage the man-machine collaboration
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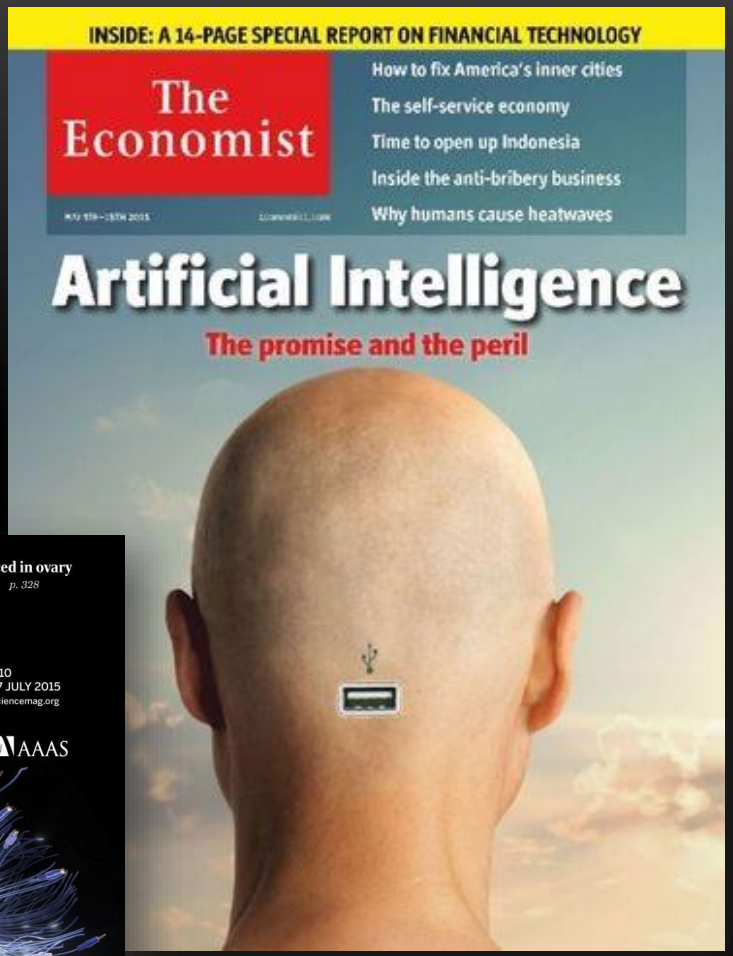
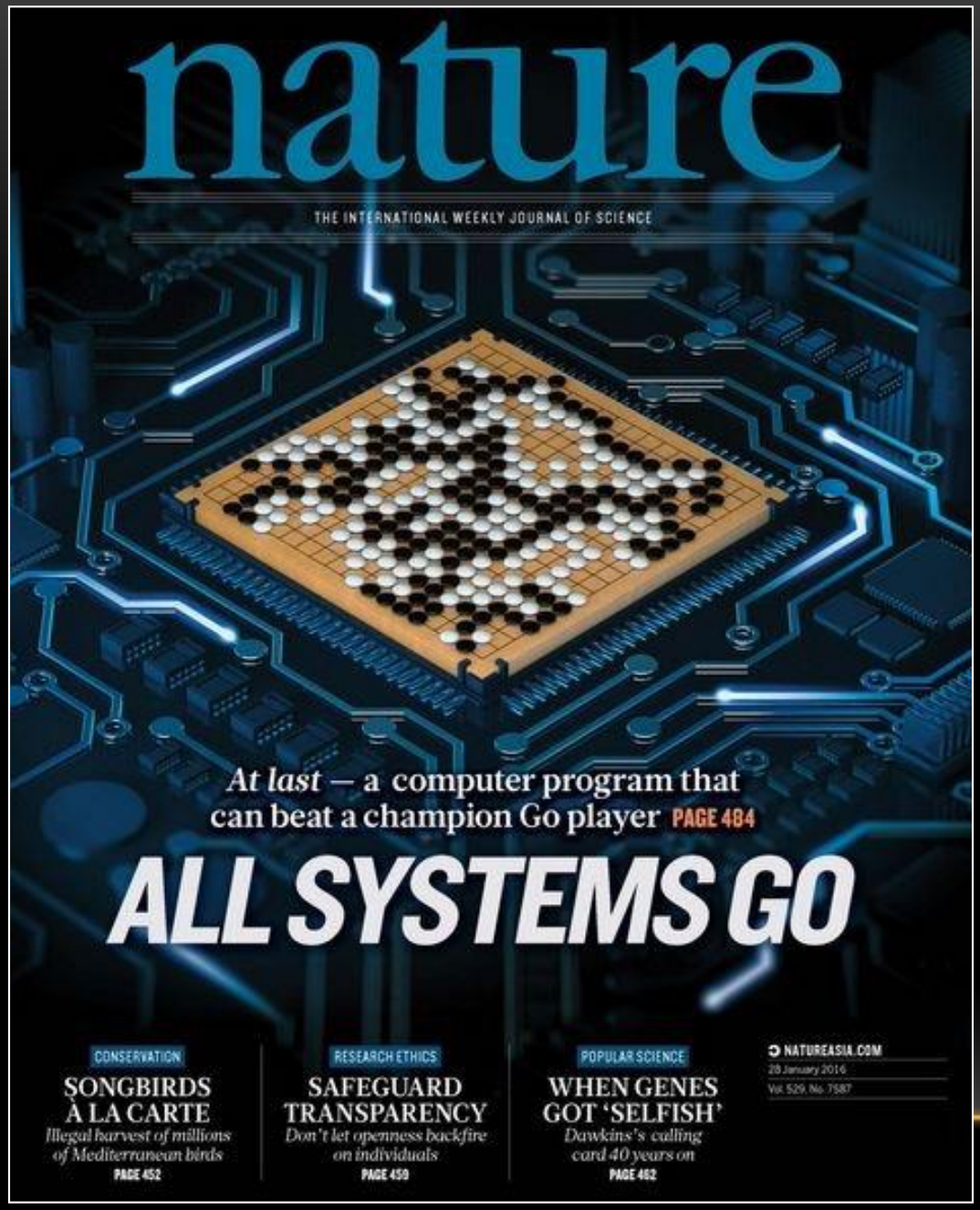
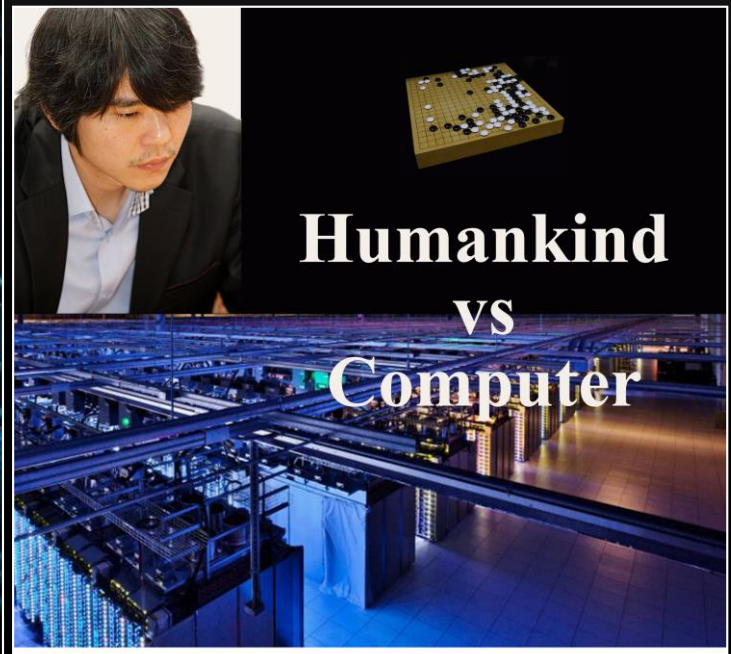
What it takes to end an AIDS epidemic p. 226
Polar bears suffer through lean summers p. 295
Sperm produced in ovary of mutant fish p. 328
Science
$10
17 JULY 2015
sciencemag.org
AAAS
SPECIAL ISSUE
ARTIFICIAL INTELLIGENCE


INSIDE: A 14-PAGE SPECIAL REPORT ON FINANCIAL TECHNOLOGY
The Economist
How to fix America's inner cities
The self-service economy
Time to open up Indonesia
Inside the anti-bribery business
Why humans cause heatwaves
Artificial Intelligence
The promise and the peril


WRITTEN AND DIRECTED BY
ALEX GARLAND THE WRITER OF
28 DAYS LATER
EX_MACHINA
THERE IS NOTHING MORE HUMAN
THAN THE WILL TO SURVIVE
COMING SOON
www.exmachinafilm.com
/ExMachinaMovie





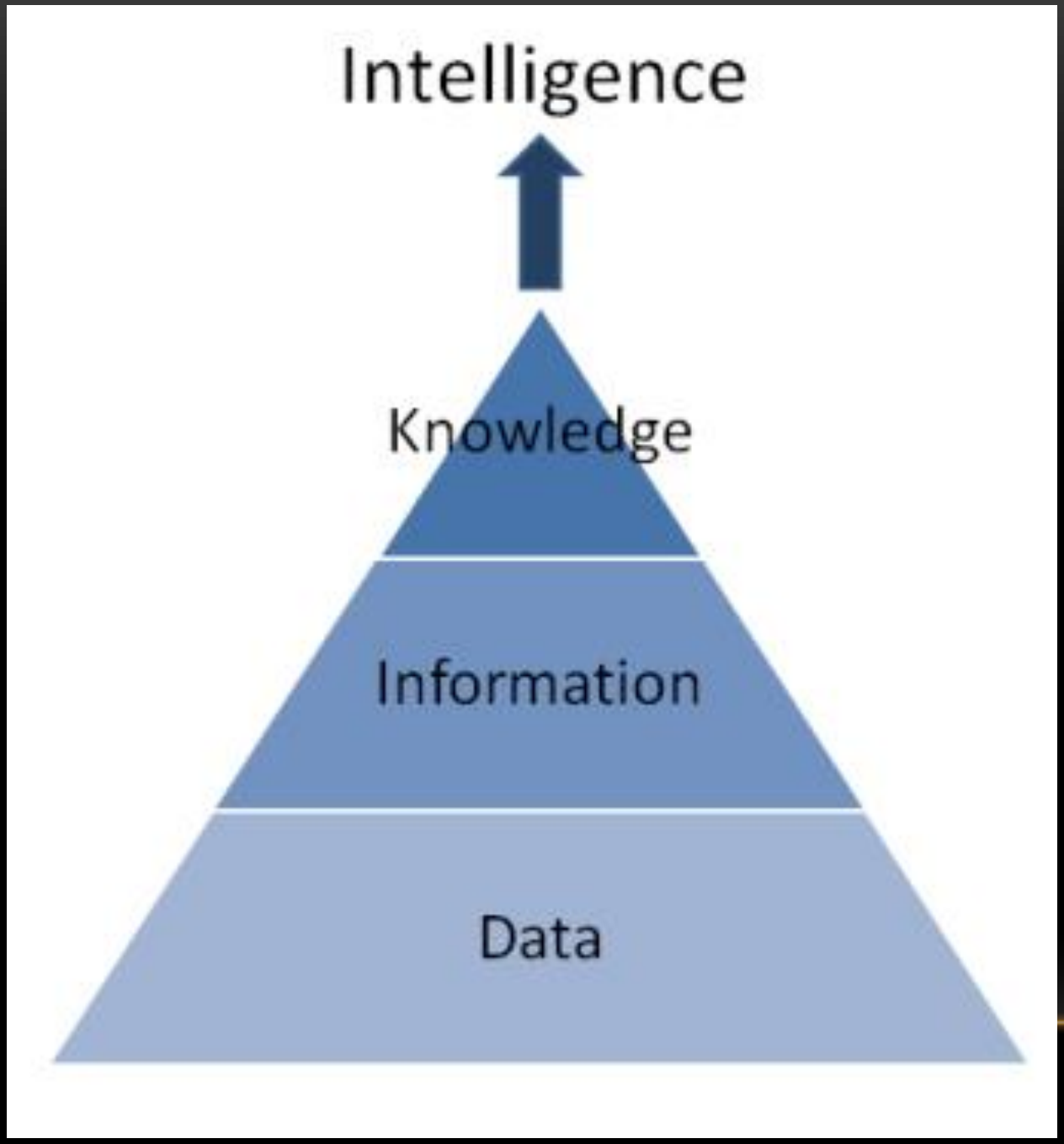
AlphaGo vs Lee Sedol

人類と人工知能の叡智をかけた
史上最強の五番勝負が始まる。

勝つのは、李世乭か？ Googleか？

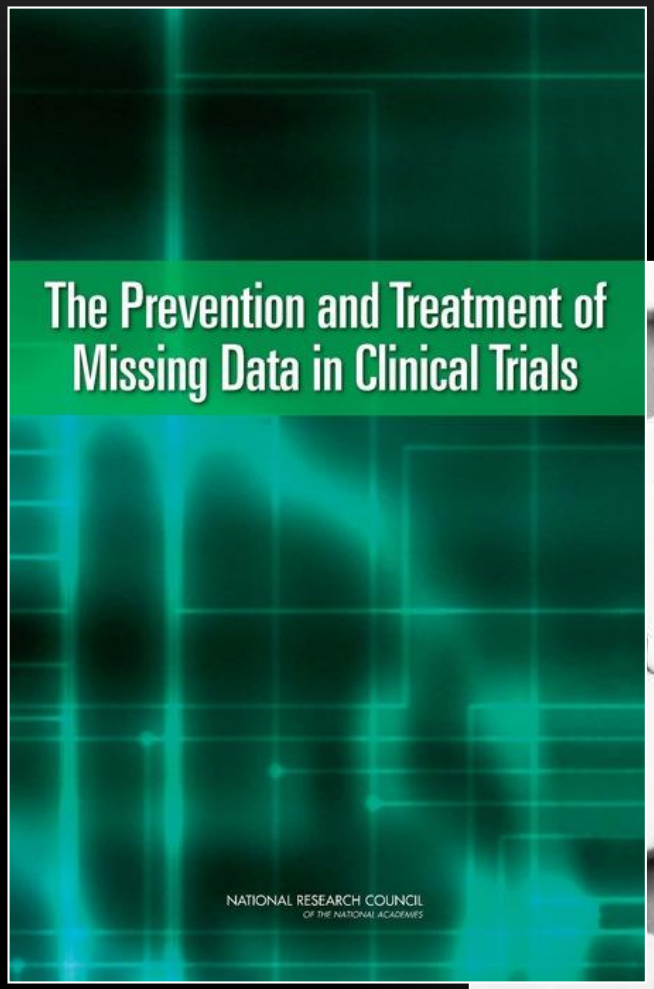
賞金100万ドル

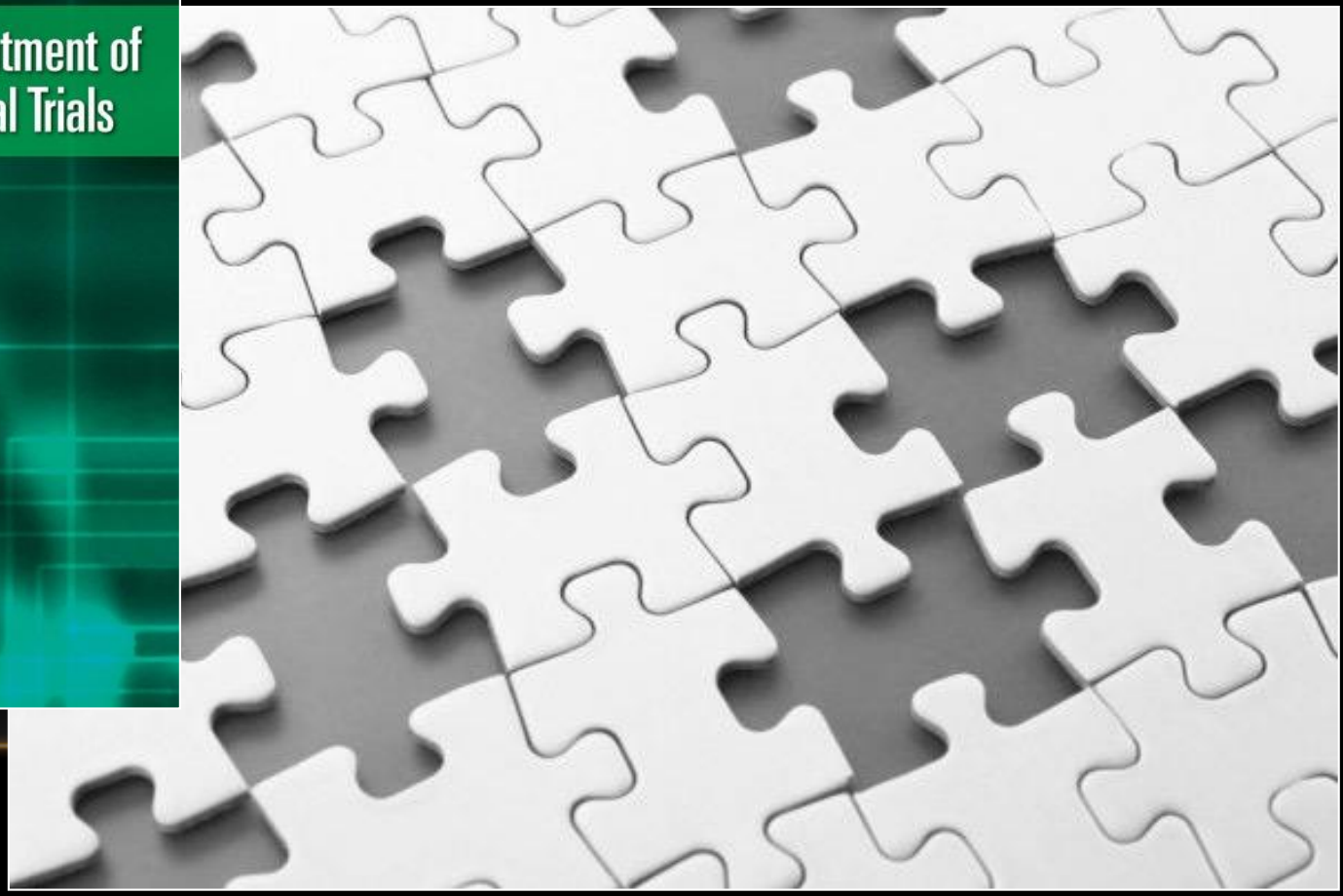
対局日程：3月9、10、12、13、15日／対局場：韓国ソウル


Intelligence
Knowledge
Information
Data

- Artificial Intelligence
- **Artificial Intelligence in Medicine (“Medical Intelligence”)**

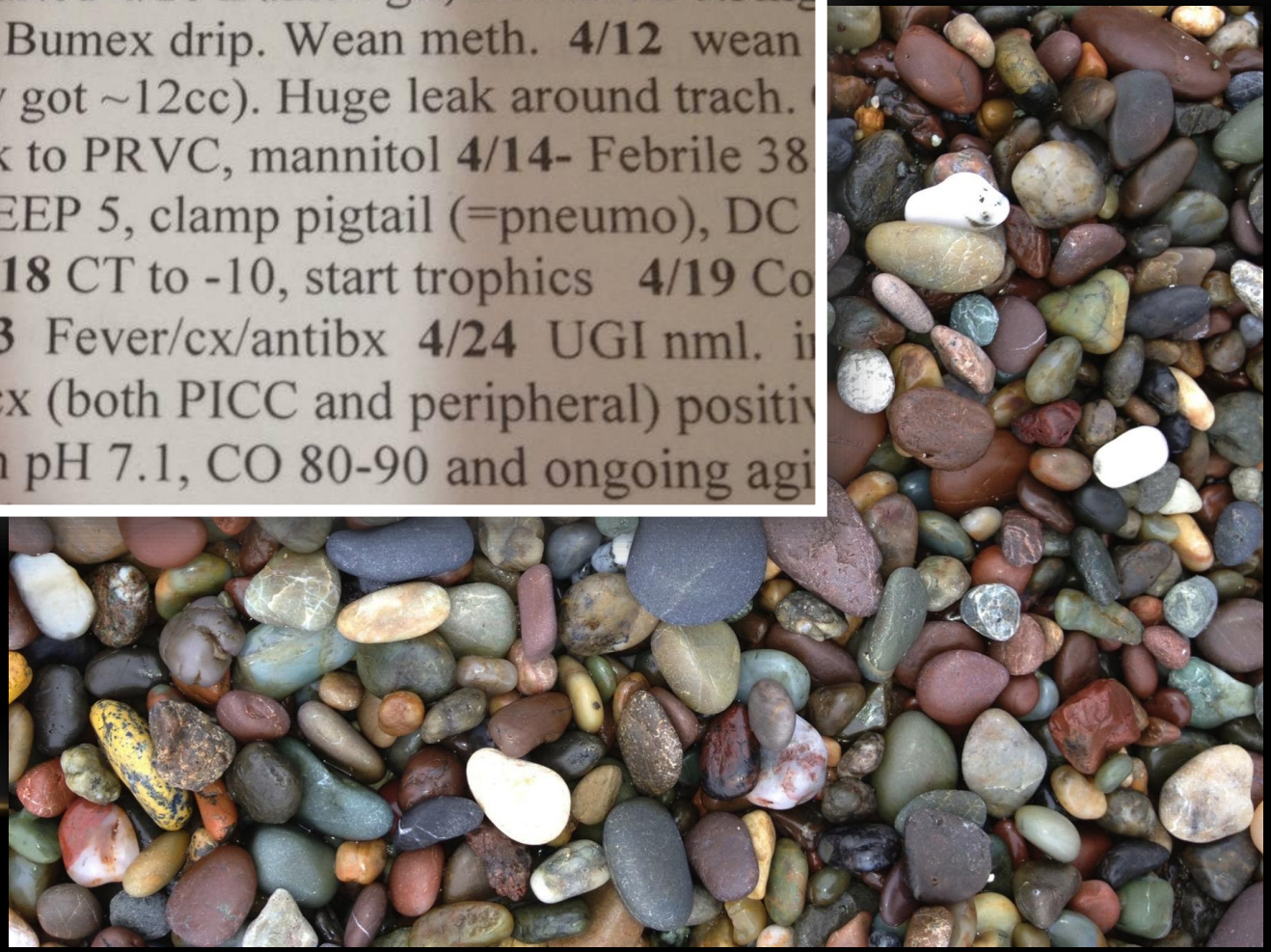
Missing Data





Unstructured Data

9 Family meeting: parents okay with trach, PD and broviac
mplications, diuril started **4/10** Bumex gtt, Decadron 0.3mg
1 wean TiVol. Incr Bumex drip. Wean meth. **4/12** wean
DB. Feeds held (only got ~12cc). Huge leak around trach.
lg air leak, vent back to PRVC, mannitol **4/14-** Febrile 38
4/16 DC Bicitra, PEEP 5, clamp pigtail (=pneumo), DC
nex to scheduled. **4/18** CT to -10, start trophics **4/19** Co
s. Diuril to PO. **4/23** Fever/cx/antibx **4/24** UGI nml. i
n decadron. Blood cx (both PICC and peripheral) positiv
ratory acidosis with pH 7.1, CO 80-90 and ongoing agi



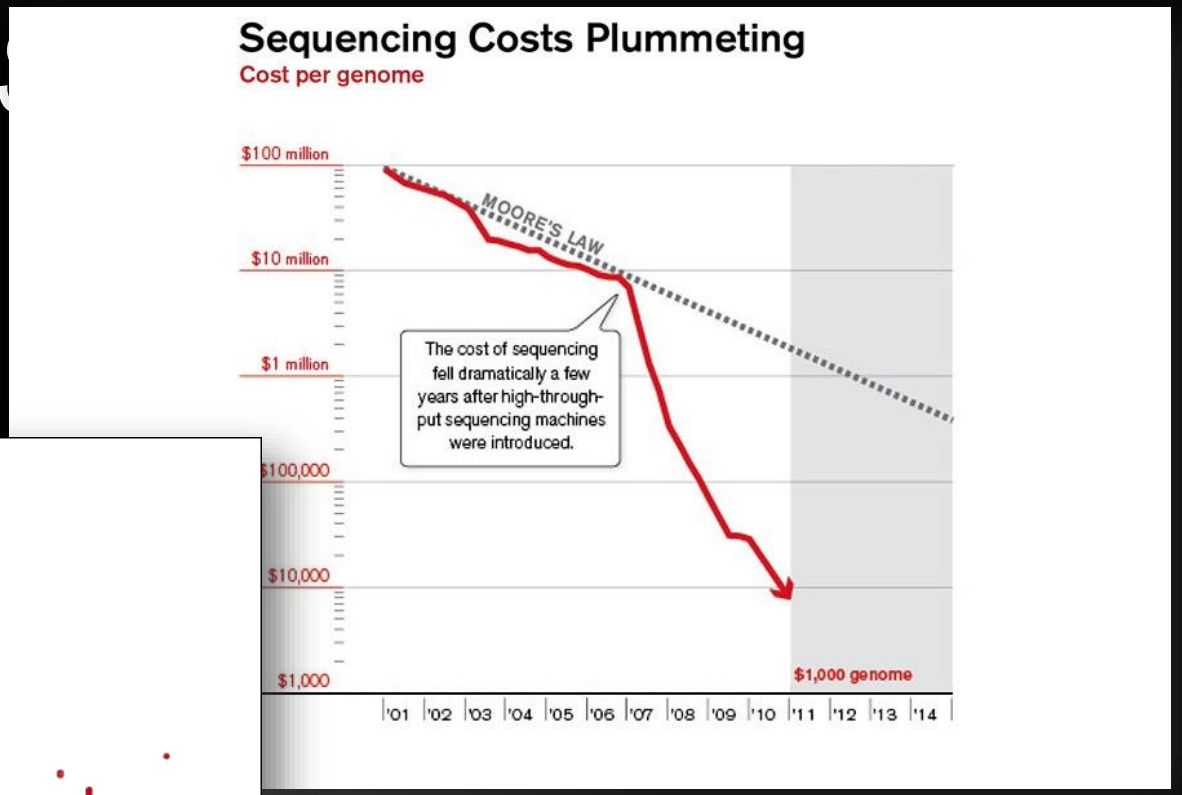
Excessive Data

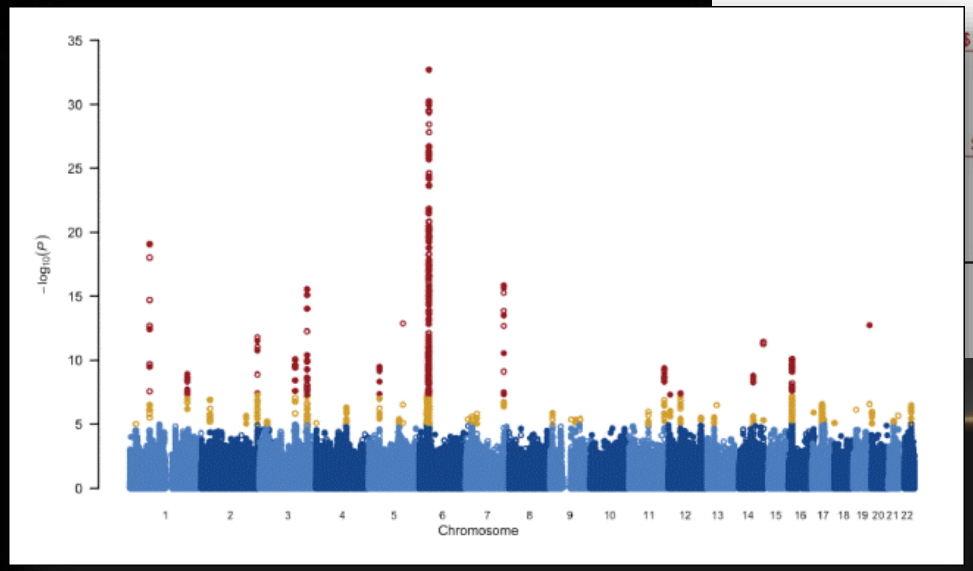
Future Data


New Health Sciences Data Sources
Drug Research
Social Media
Patient Records
Gene Sequencing
Test Results
Claims
Home Monitoring
Mobile Apps

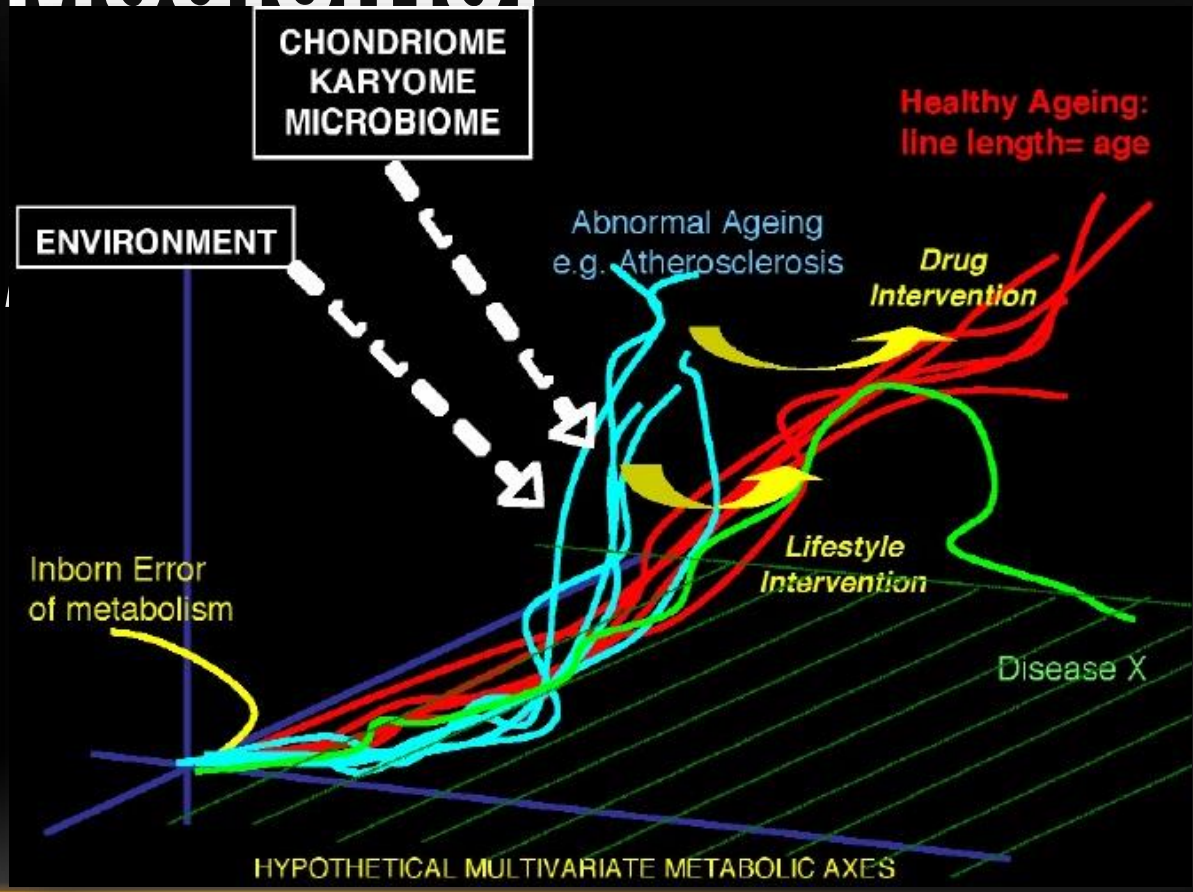
Genomic Medicine:

Next Generation



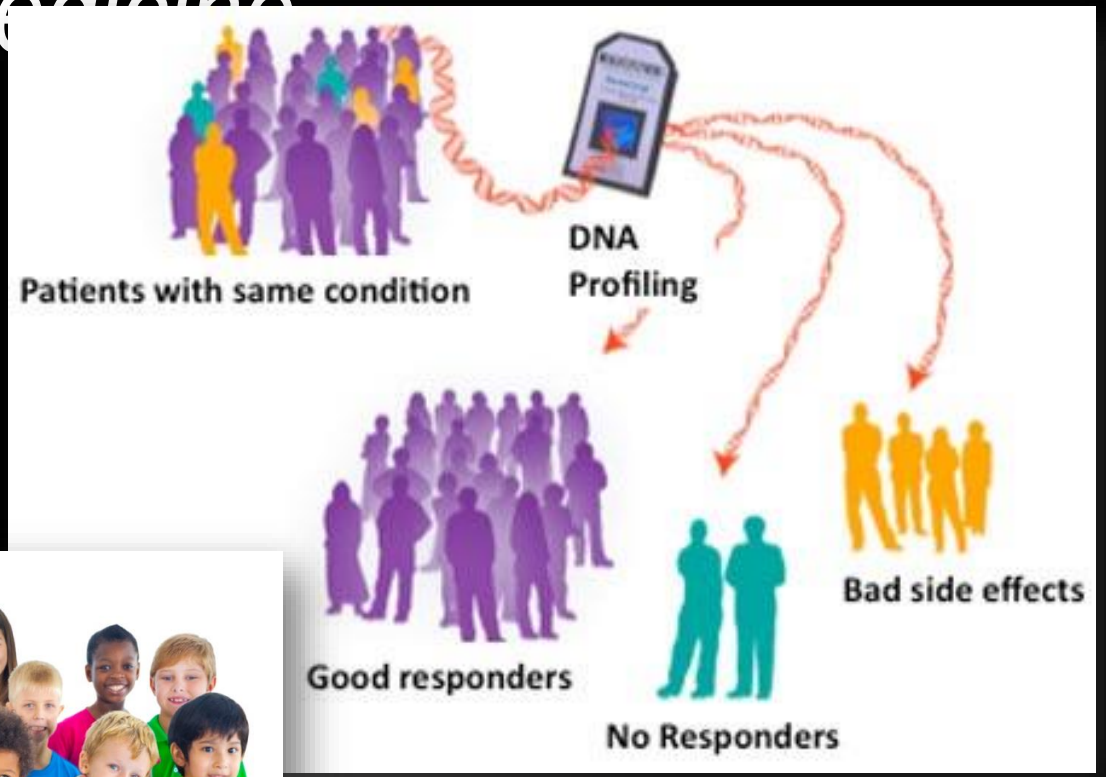


Precision Medicine:



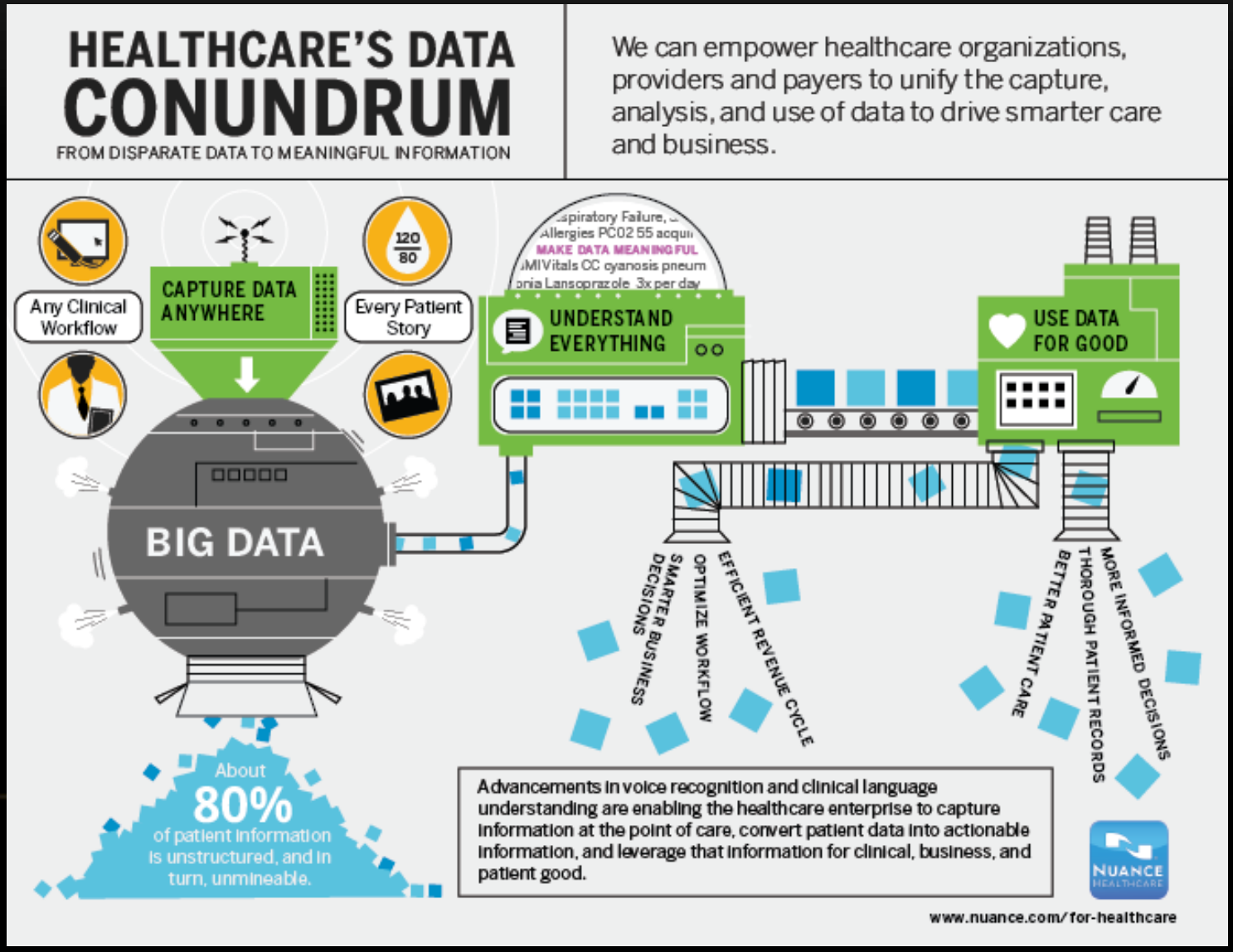
Nicholson J et al. *Discovery Medicine*, 7/2009.

- **PharmacoGenomics:** *Personalized Medicine*



Internet of EveryThing *Patient*

Little Information



Knowledge and Intelligence Network

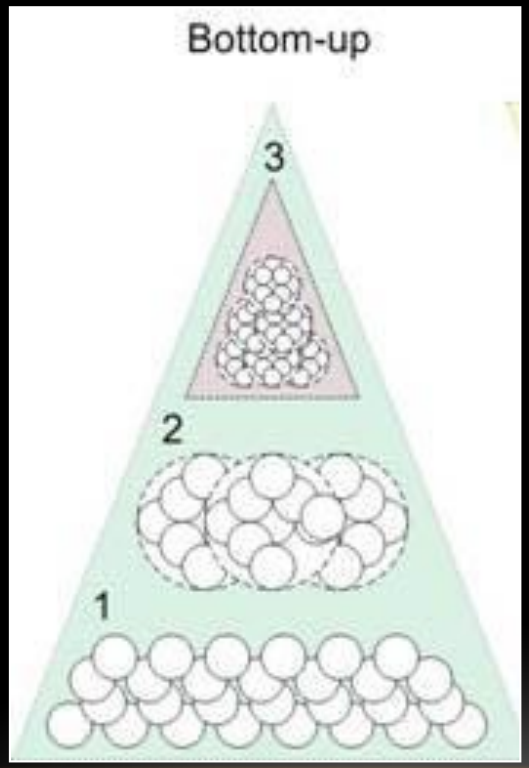
Disparate types of information are linked into multiscalar, multilateral, multidimensional relationships

Disparate Information

- The end of theory: The data deluge makes the scientific method (randomized controlled trials) *obsolete*.

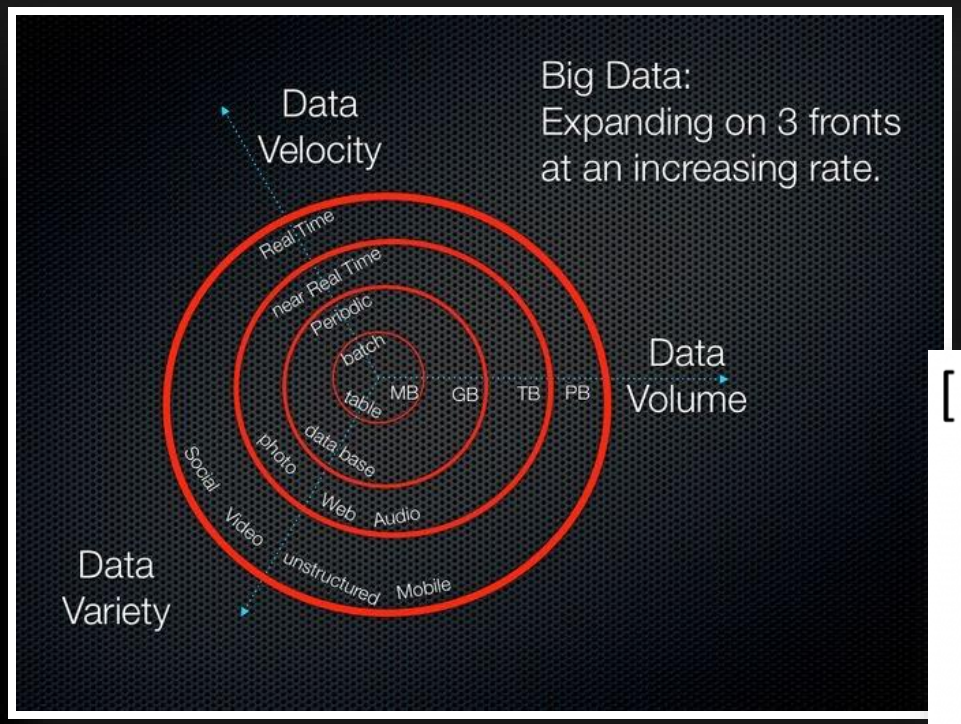
  Chris Anderson, *Wired*

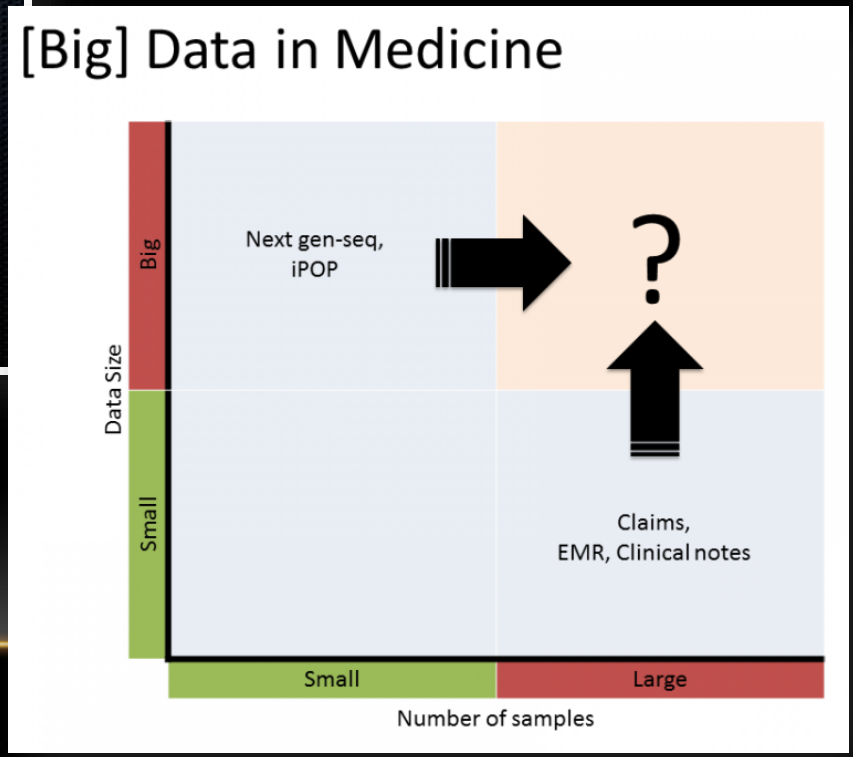
Algorithms



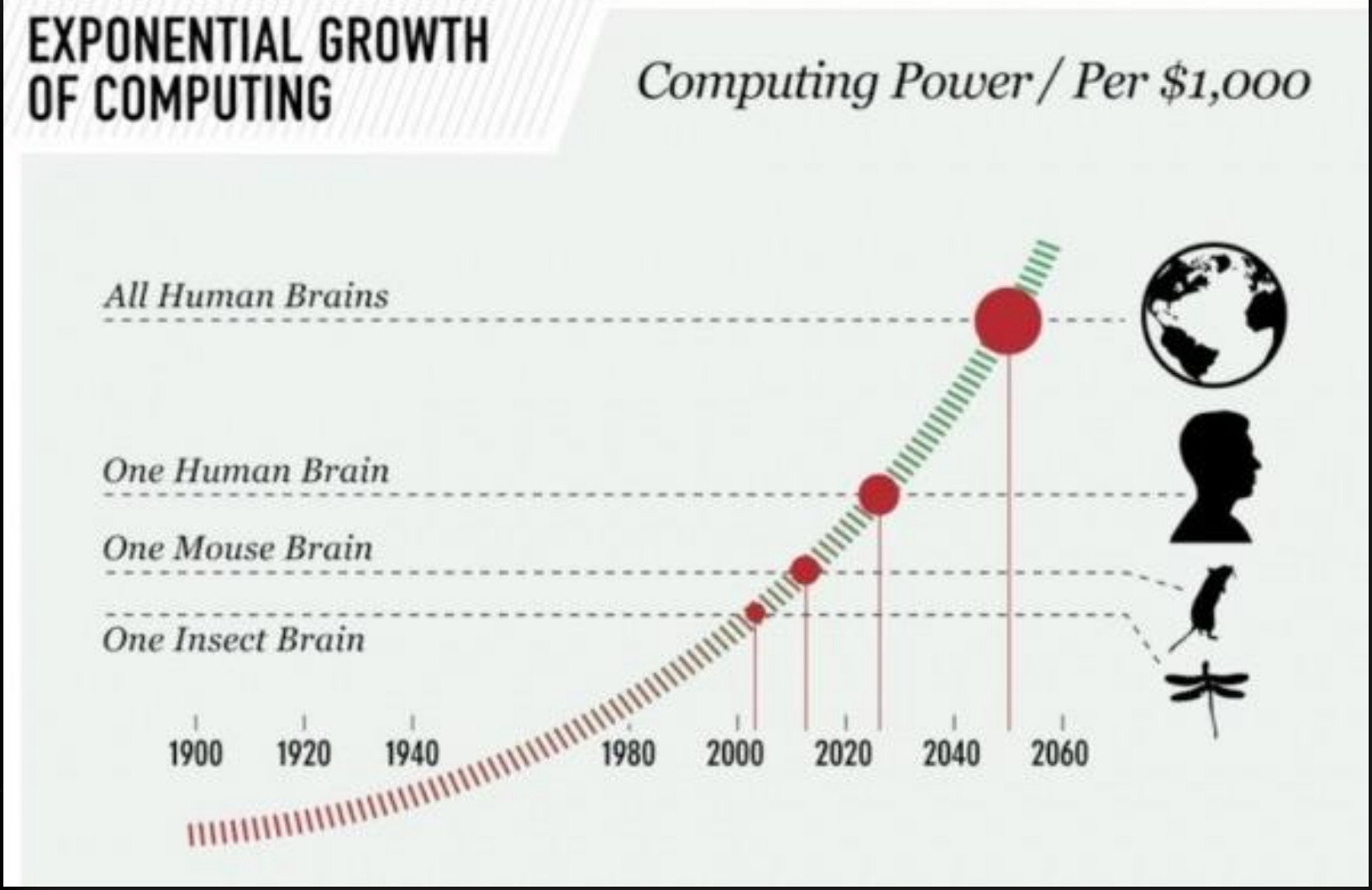

```r
rm(list=ls())
library(dplyr)
library(gplots)
library(survival)
library(maxstat)
library(glmnet)
library(qvalue)


#source("https://bioconductor.org/biocLite.R")
#biocLite()
#biocLite(c("qvalue"))

# Setting the working directory here
setwd("~/HW2/")

# Reading in data

clinical<-read.table("~/HW2/HNSC.clin.merged.txt",
                     sep="\t",
                     fill=T,
                     #                     skipNul=T,
                     row.names=1,
                     colClasses="character")

# Setting up assigned variables
variables<-
 c("patient.bcr_patient_barcode","patient.days_to_death","patient.days_to_
 last_followup","patient.vital_status")
clinical<-clinical[variables,]

# Transposing column and row
clinical<-t(clinical)
clinical<-data.frame(clinical,row.names=NULL,stringsAsFactors = FALSE)

# Converting to numeric
clinical$patient.days_to_death<-as.numeric(clinical$patient.days_to_death)
clinical$patient.days_to_last_followup<-as.numeric(clinical
 $patient.days_to_last_followup)

```

Big Data

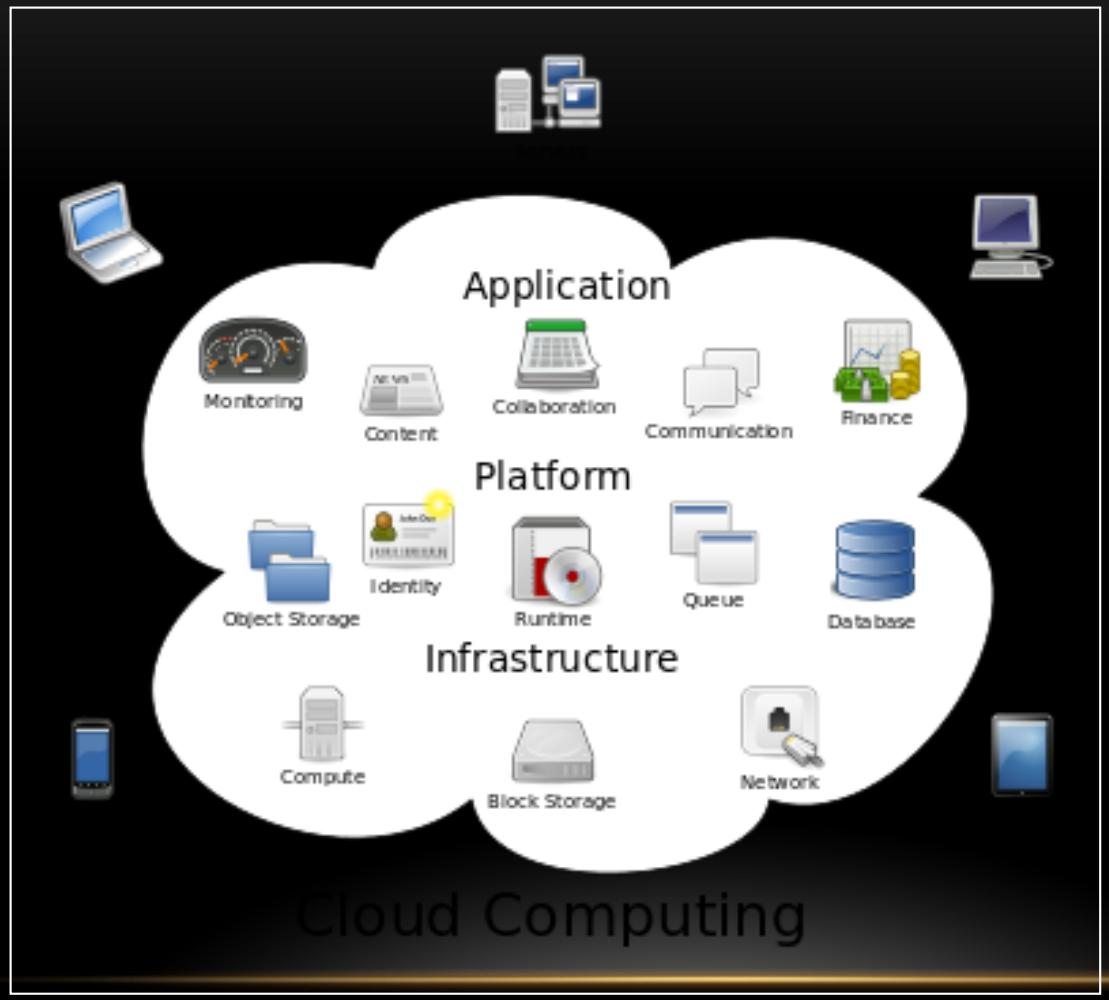

Big Data:
Expanding on 3 fronts
at an increasing rate.
Data
Velocity
Real Time
near Real Time
Periodic
batch
table
data base
photo
Social
Video
Web
Audio
unstructured
Mobile
MB
GB
TB
PB
Data
Volume
Data
Variety


[Big] Data in Medicine
Data Size
Big
Small
Next gen-seq,
iPOP
?
Claims,
EMR, Clinical notes
Small
Large
Number of samples

Computational Power



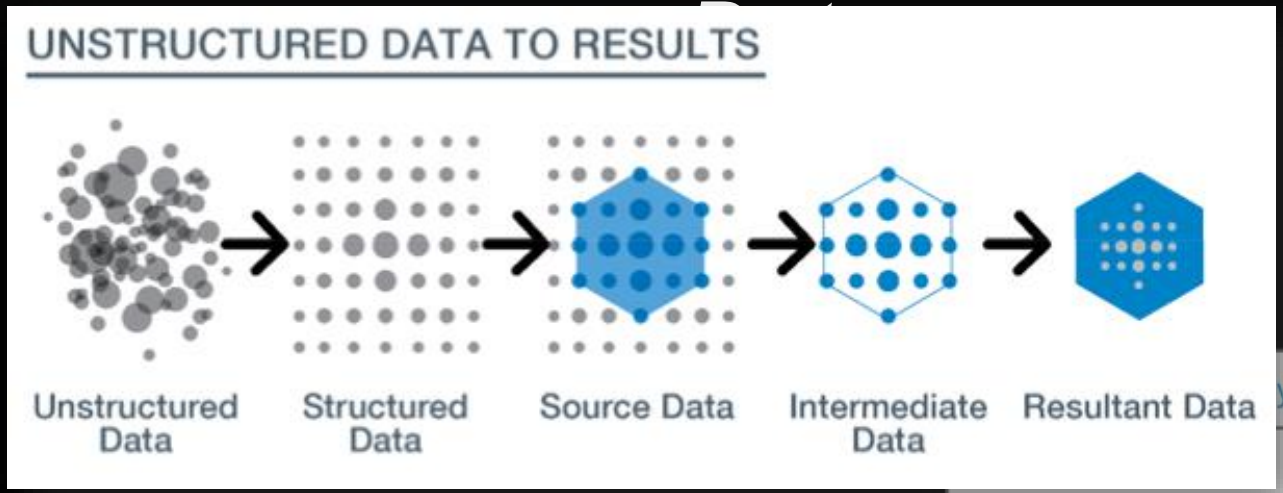
Cloud Computing

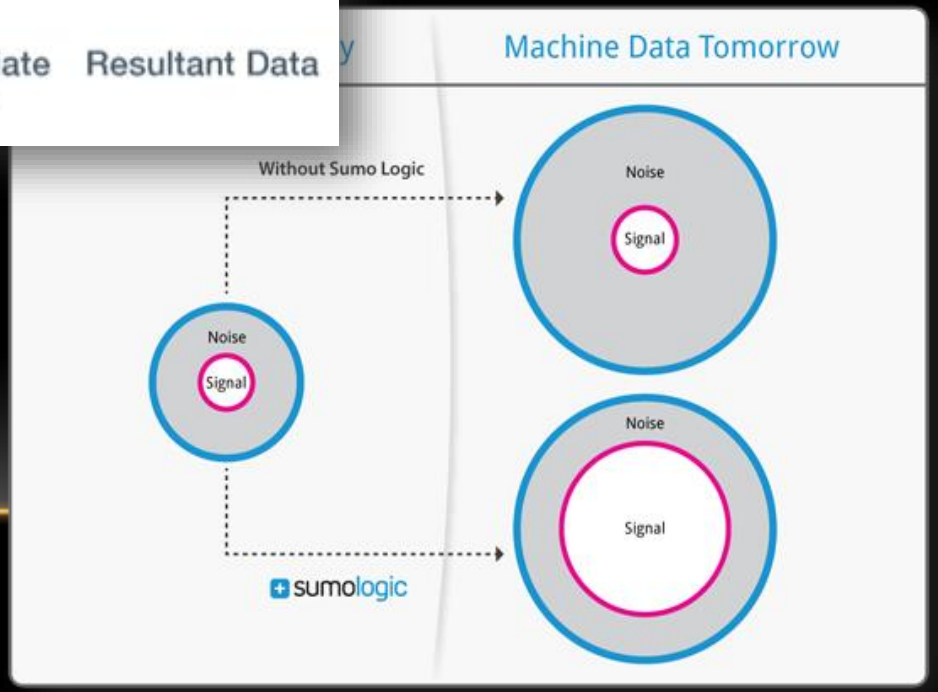


Cognitive Computing:

Data Mining:

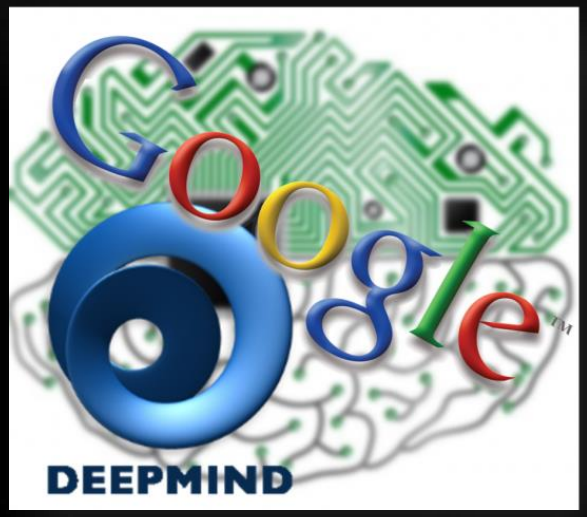
New Knowledge from Big

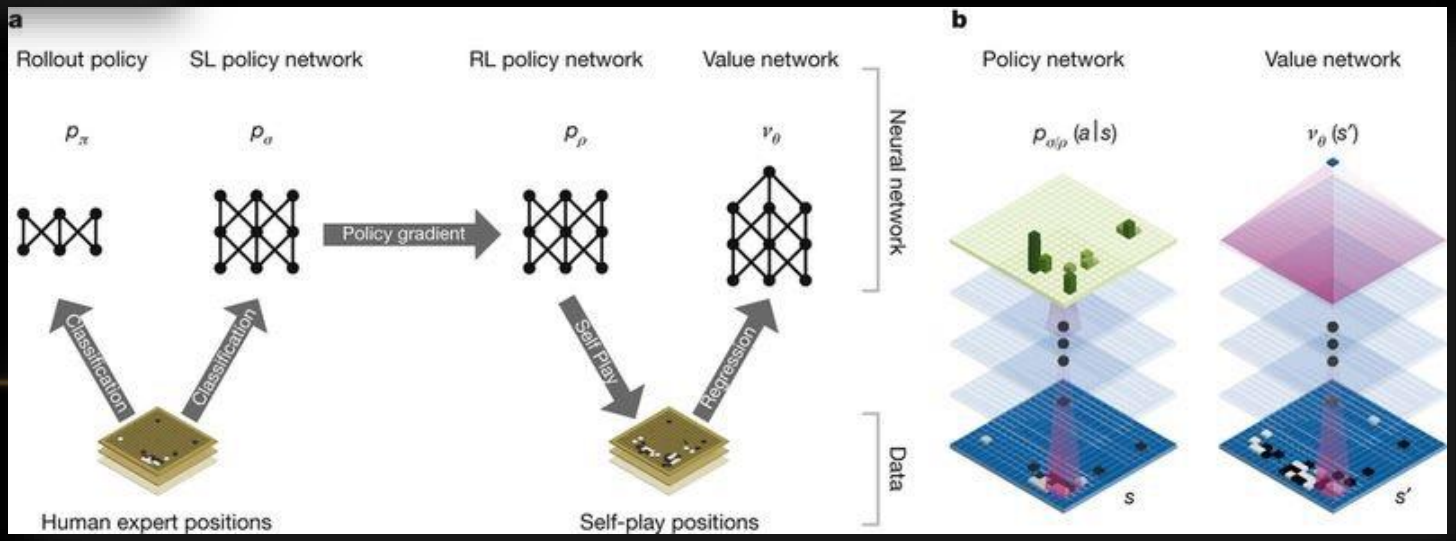




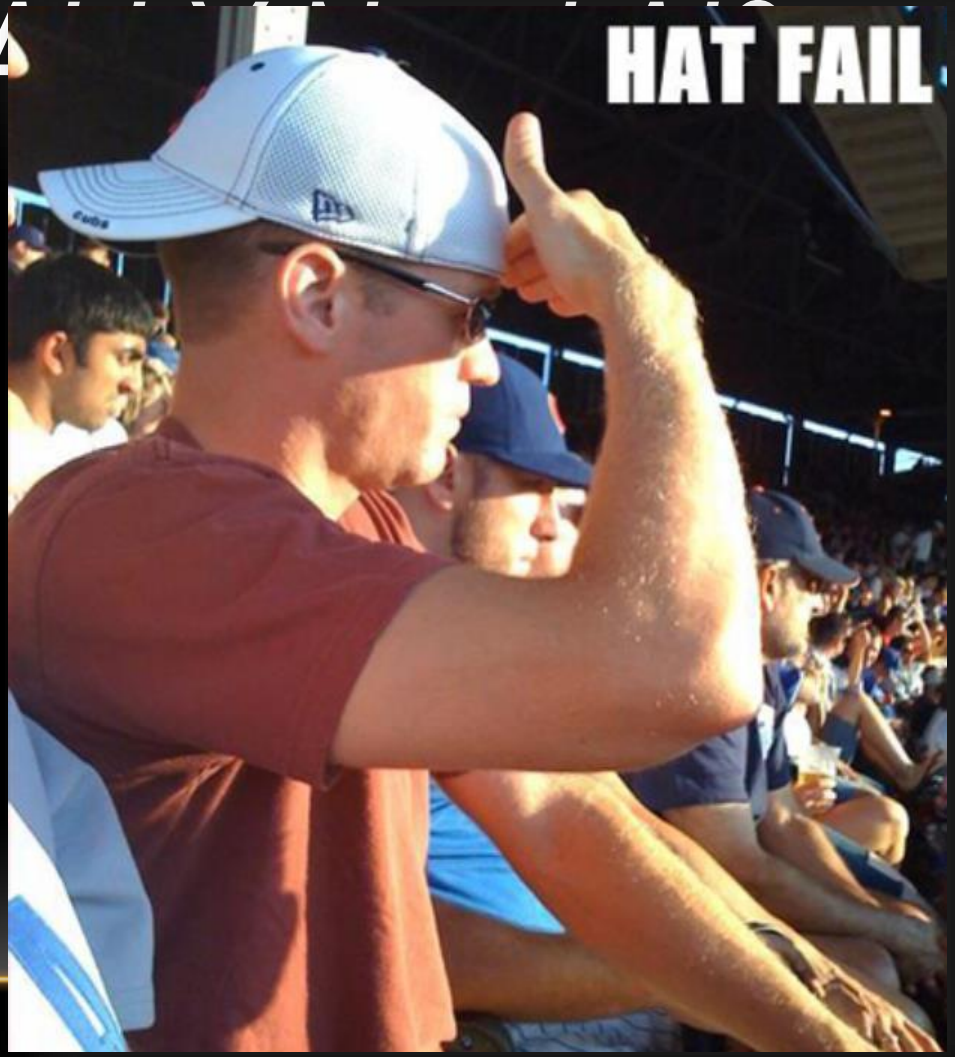
Deep Learning:

Machine Learning/ Neural Networks

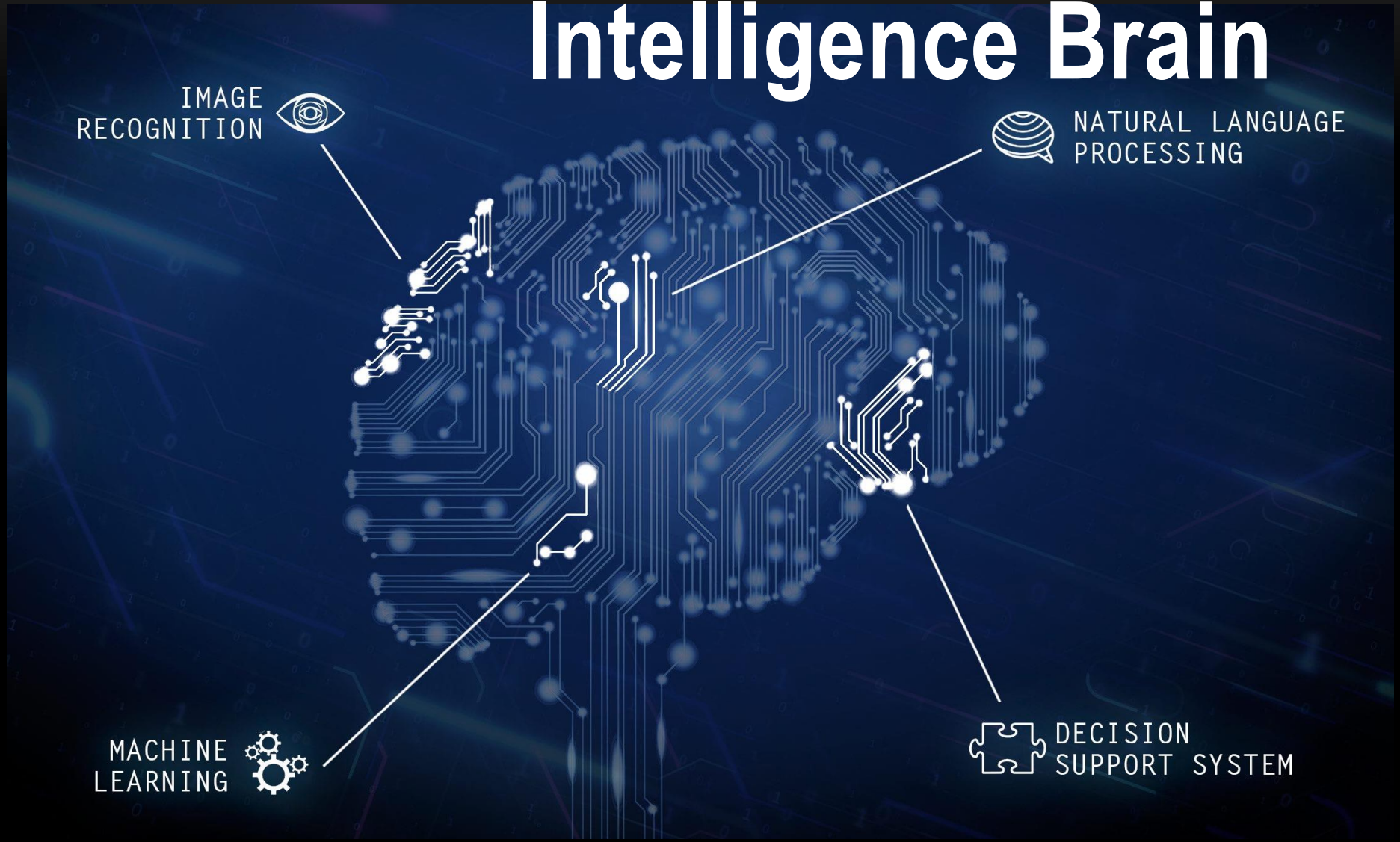




- *Do We Humans REA*



The Artificial Intelligence Brain



EME STREAMING ANALYTICS ARCHITECTURE

Patient Bedside Monitoring Network

Hospital Network

ICU Monitors

Med Surg Monitors

OR Monitors

ED Monitors

Telemetry System

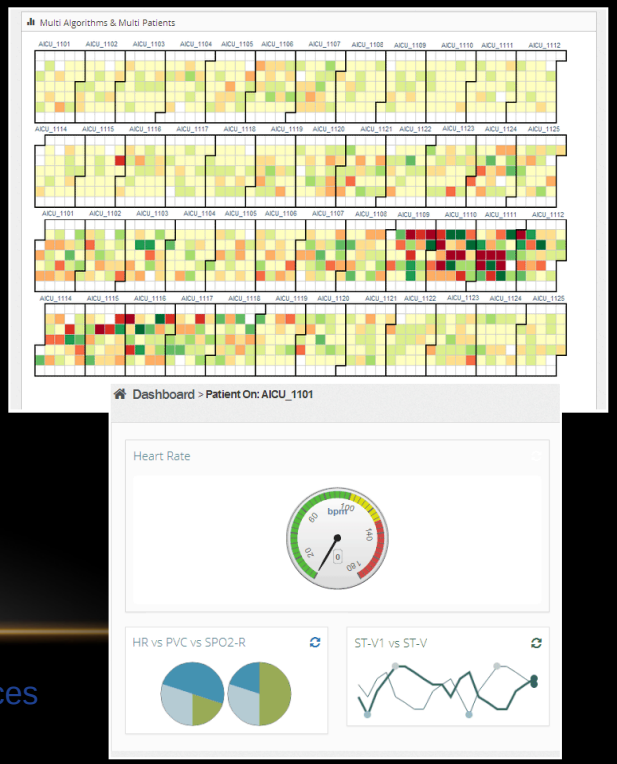
Excel Medical BedMasterEx & BedComm

IBM Infosphere Streams

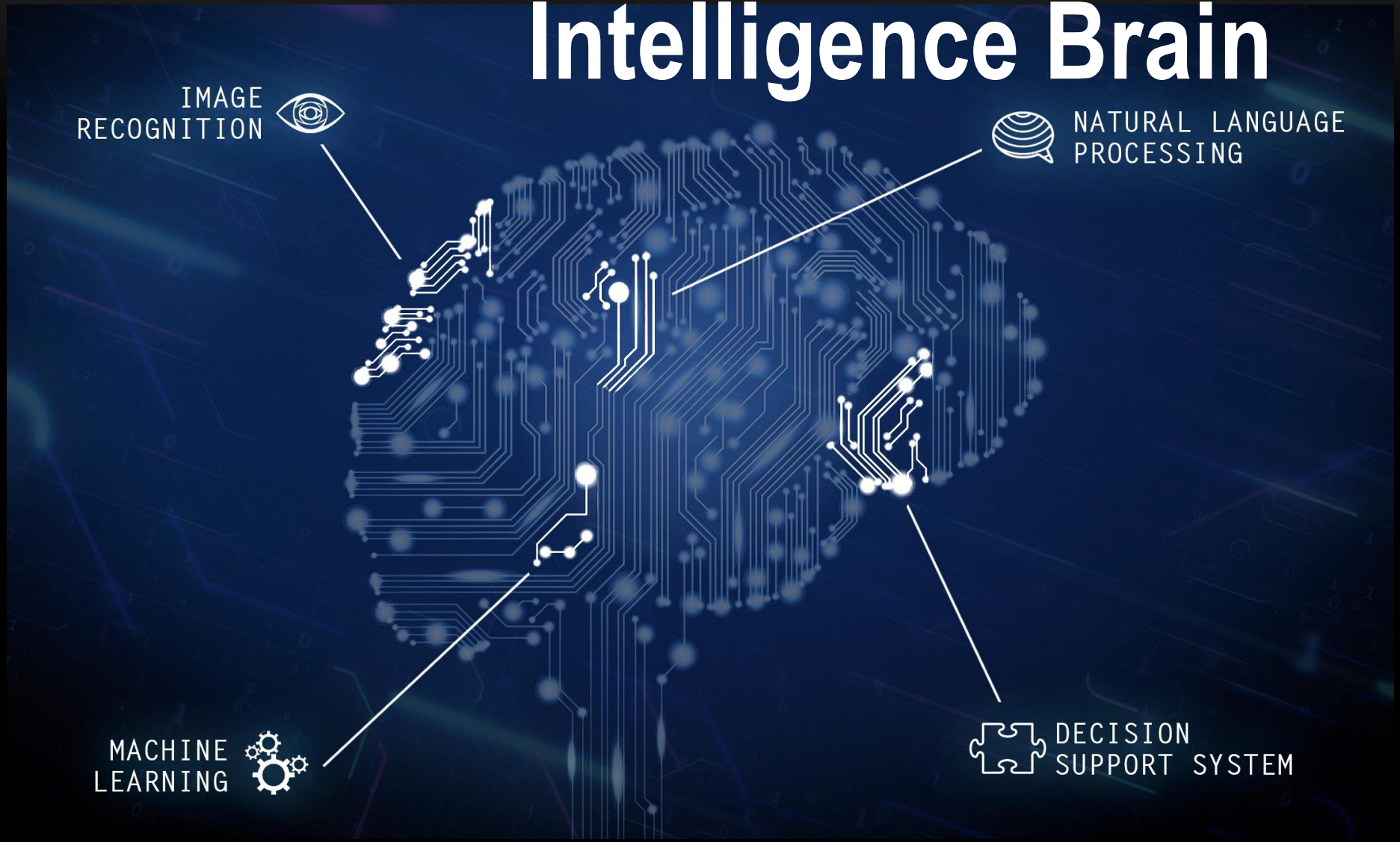
Ancillary Monitoring Devices (vents, oximeters, video, etc)

Hospital EMR and other data sources

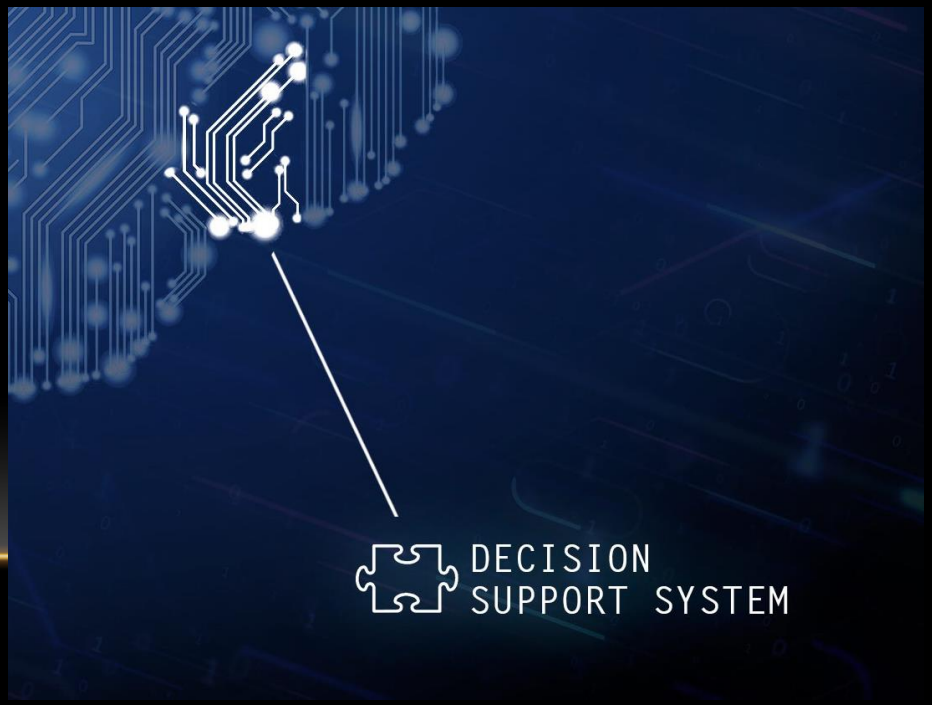
Various dashboards or notifications for clinicians & investigators



The Artificial Intelligence Brain



The Artificial Intelligence Brain



Acquiring

BedComm

BMEX Runtime

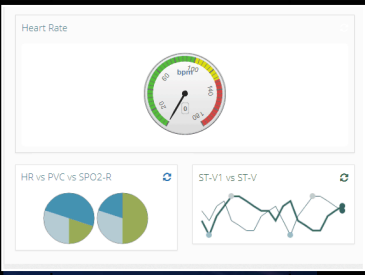
SQL Server

real-time / replay

Adaptation Layer

SQL/NoSQL/HTTP

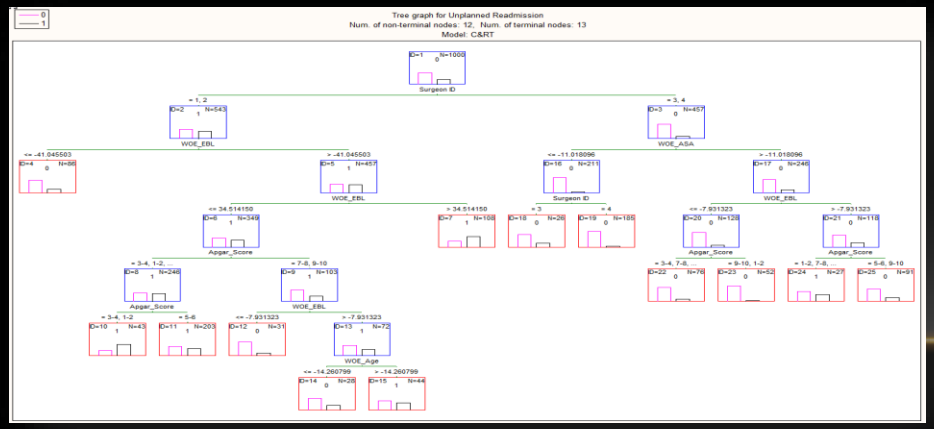
Delivery Layer



BedMasterEx

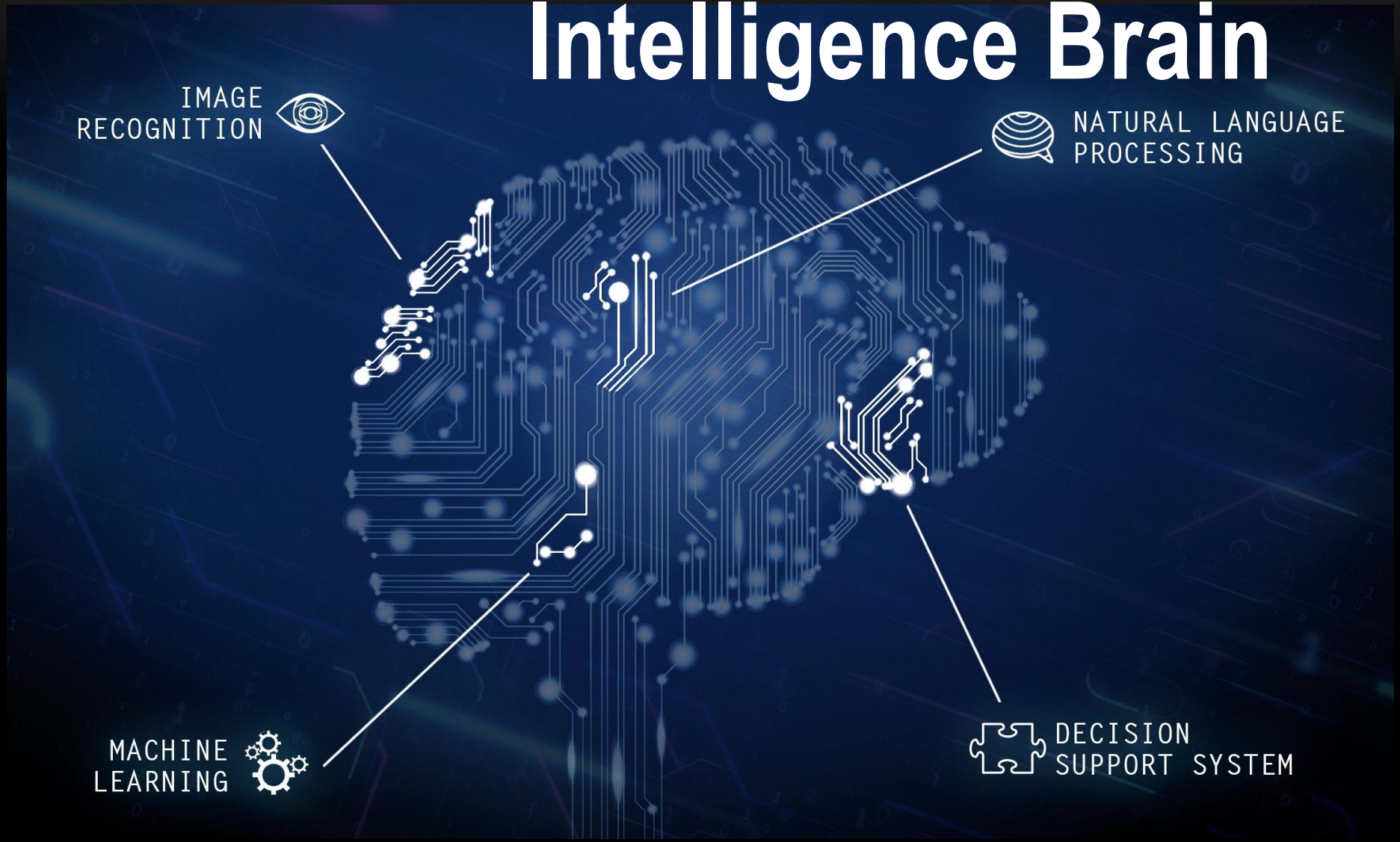
IBM

InfoSphere Streams

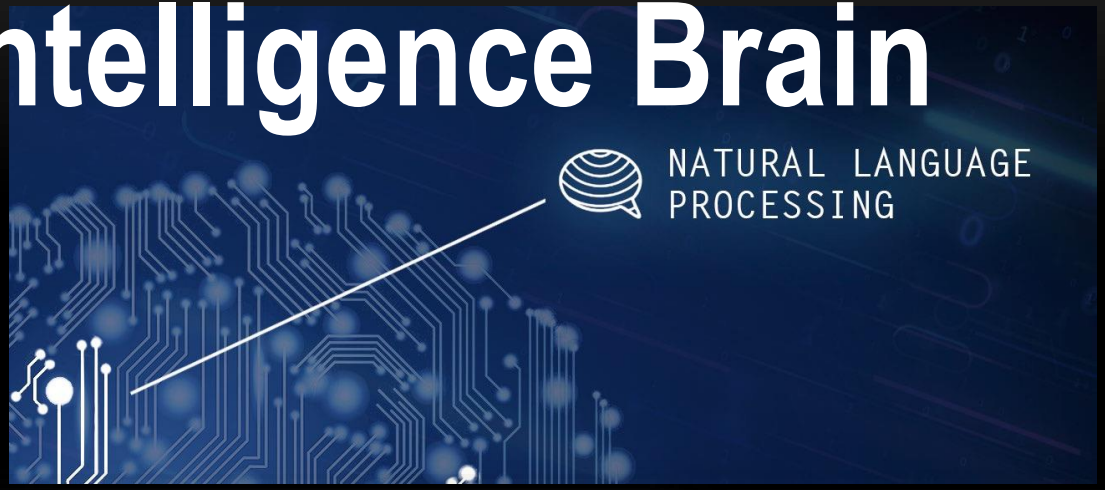


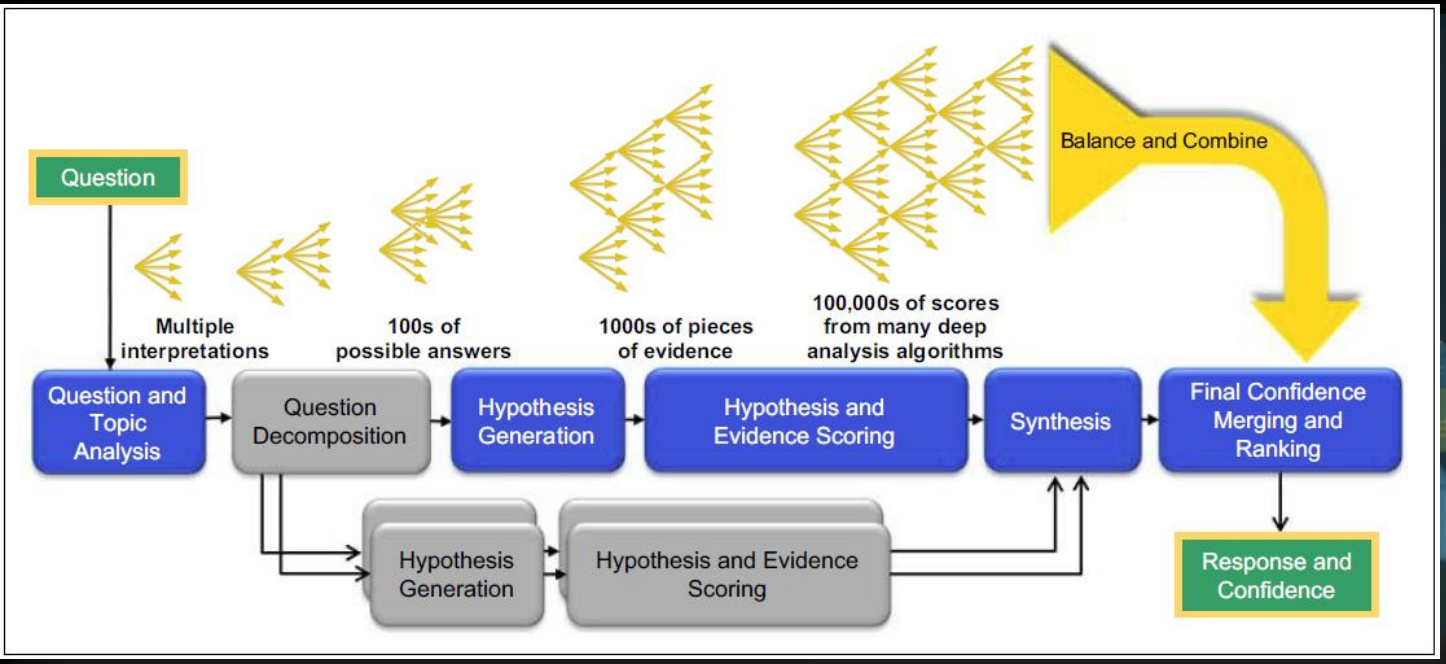
DECISION SUPPORT SYSTEM

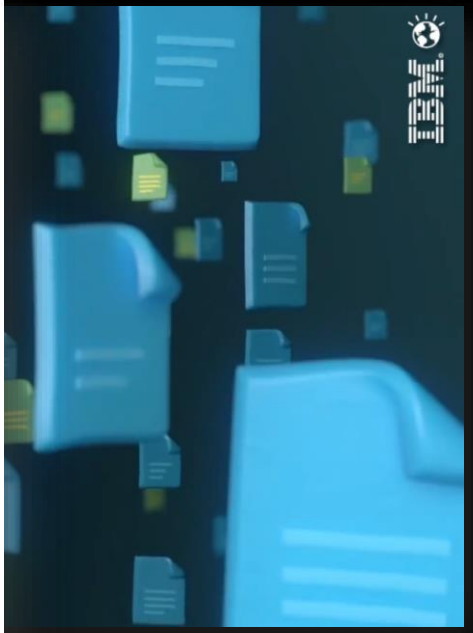
The Artificial Intelligence Brain



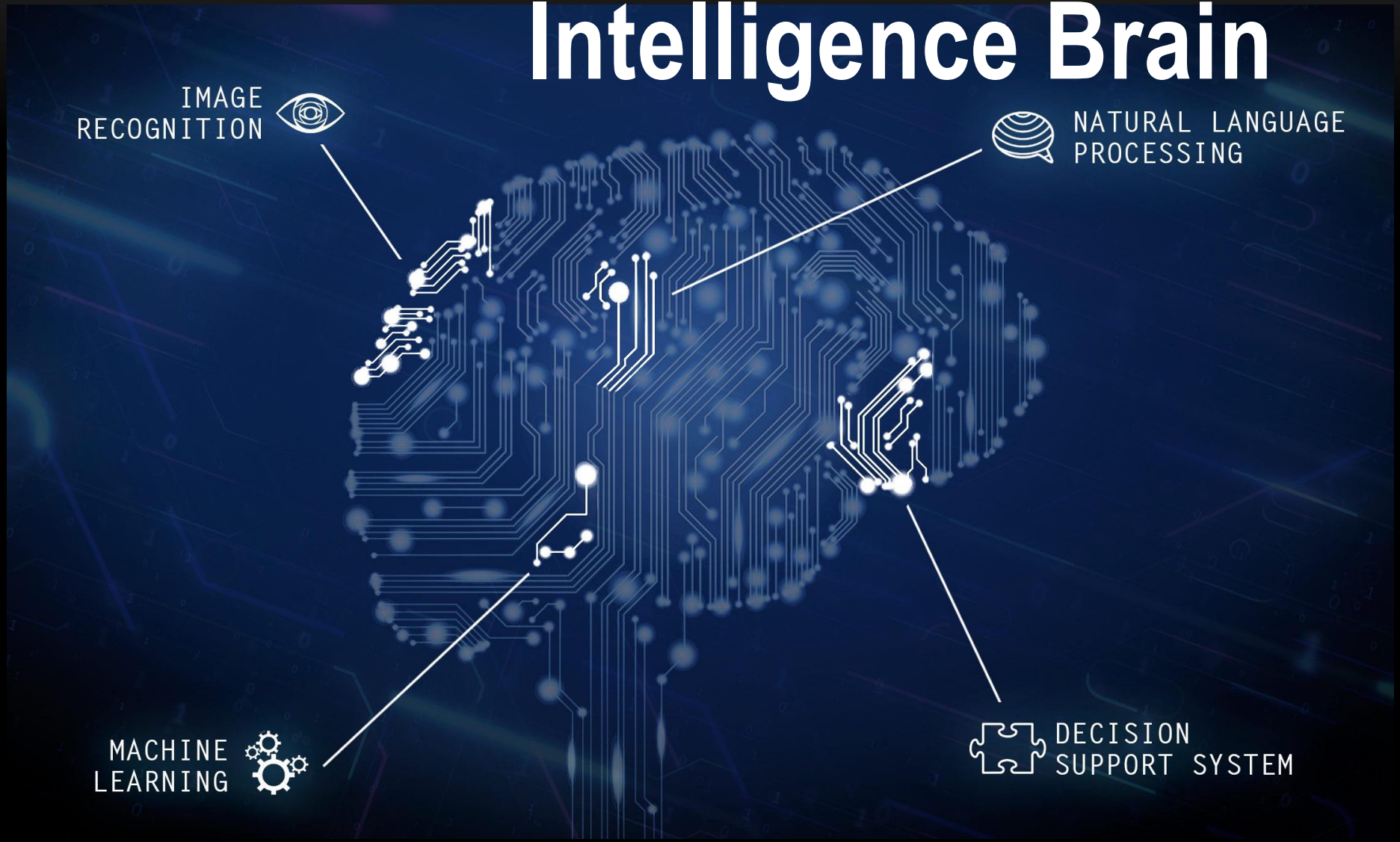
The Artificial Intelligence Brain

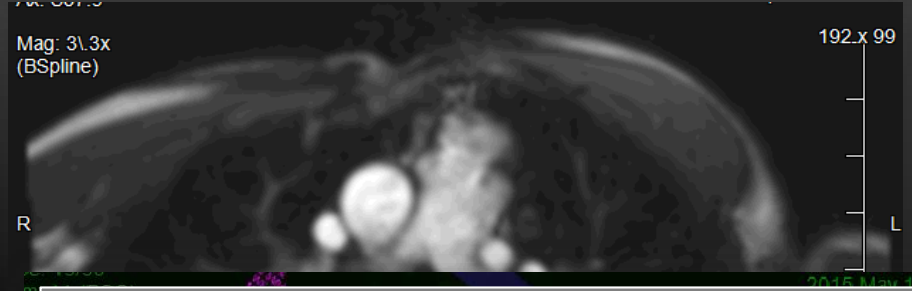


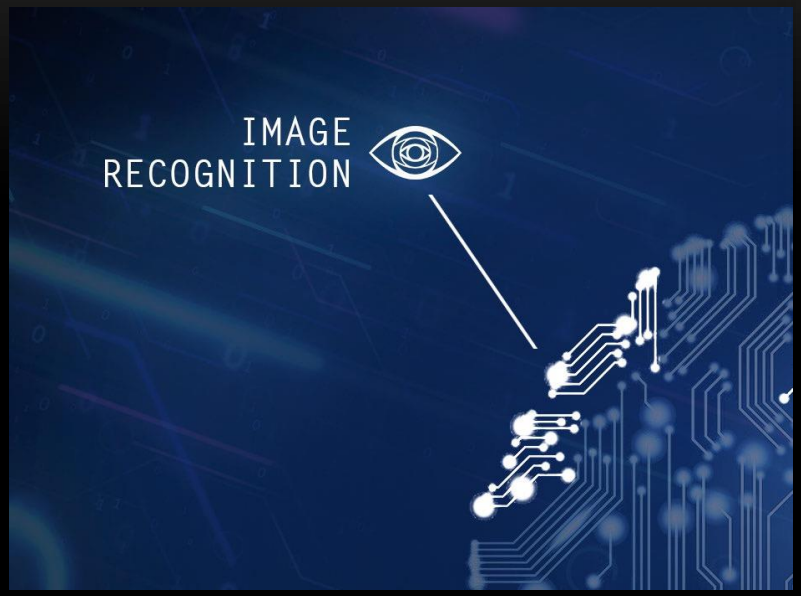




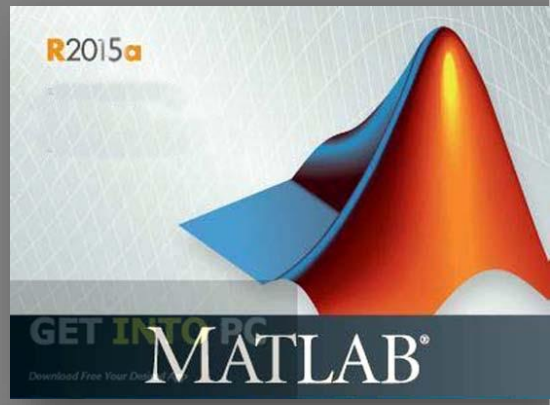
The Artificial Intelligence Brain



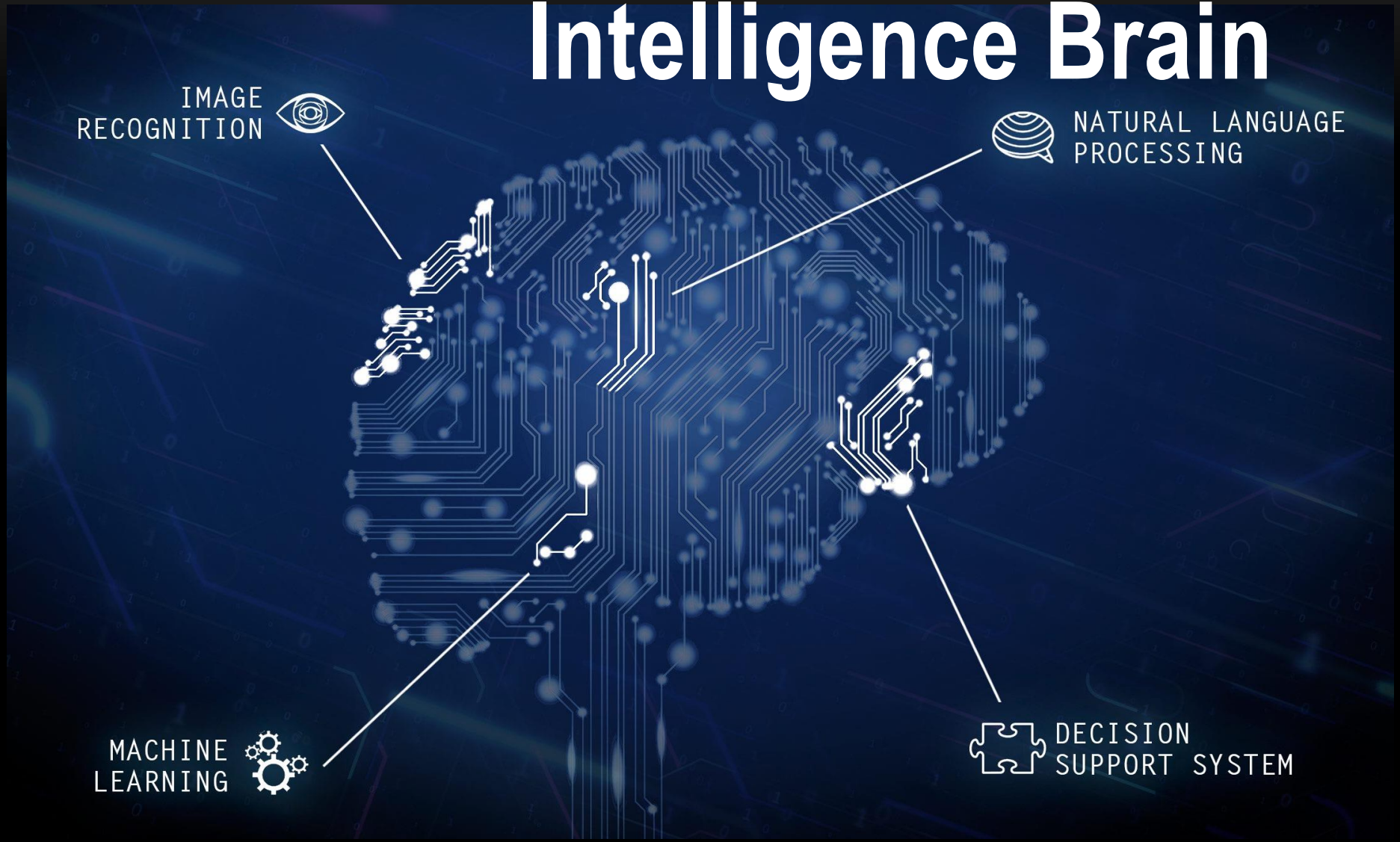


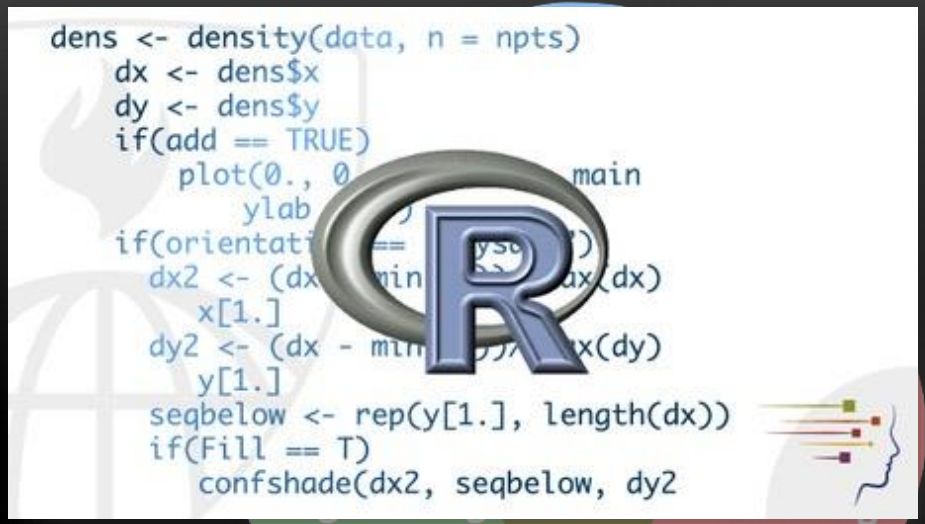


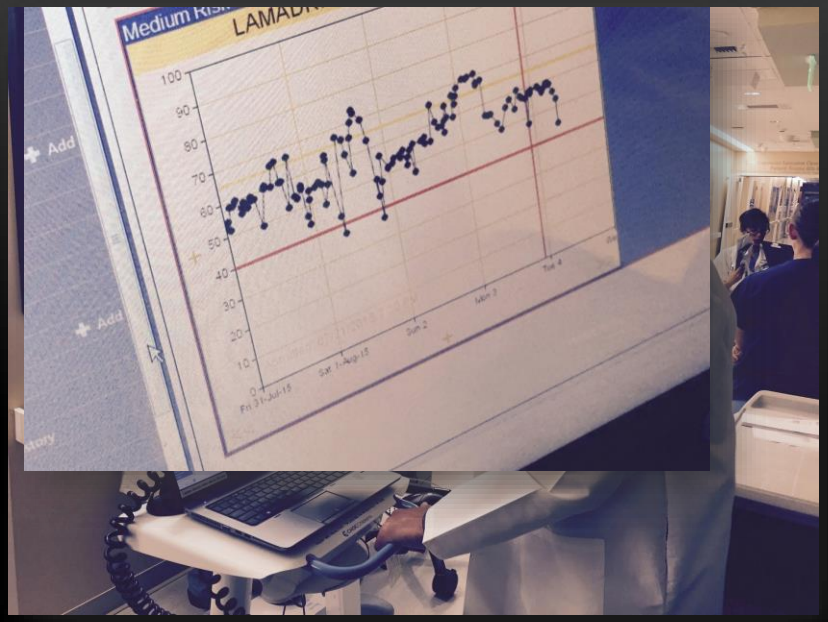

```
function newImg = myconv2(img, kernel)

newImg = zeros(size(img));

imgRow = size(img,1);
imgCol = size(img,2);

shift = (size(kernel,1)-1)/2; % maximum of how far we may go past border of img

for row = 1:imgRow
    for col = 1:imgCol
        newImgVal = 0;
        for x = -shift:shift
            for y = -shift:shift
                newRow = row - x;
                if (newRow < 1)
                    continue;
                elseif (newRow > imgRow)
                    continue;
                end

                newCol = col - y;
                if (newCol < 1)
                    continue;
                elseif (newCol > imgCol)
                    continue;
                end

                newImgVal = newImgVal + img(newRow, newCol)*kernel(x+shift+1,y+shift+1);
            end
        end
        newImg(row,col) = newImgVal;
    end
end
```

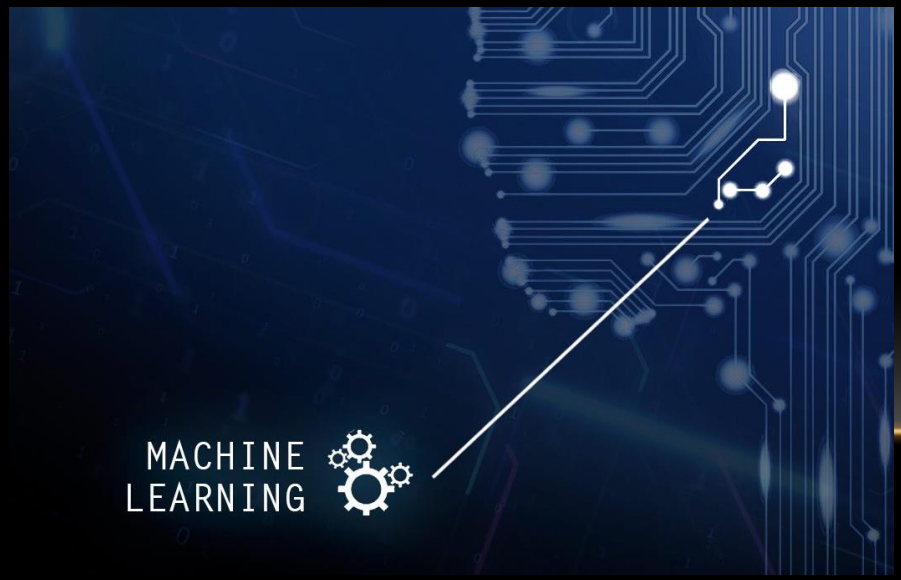


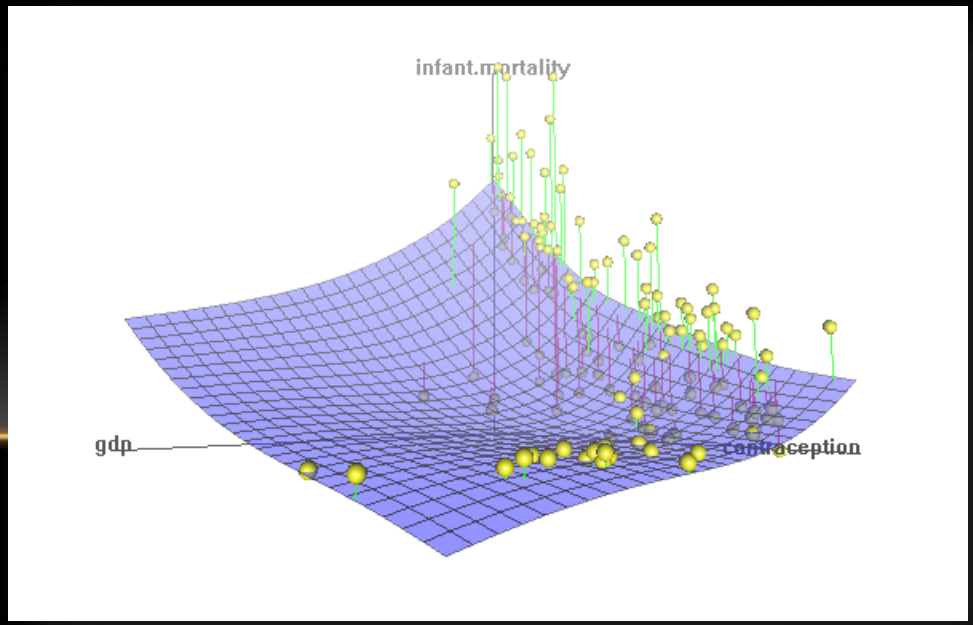
The Artificial Intelligence Brain

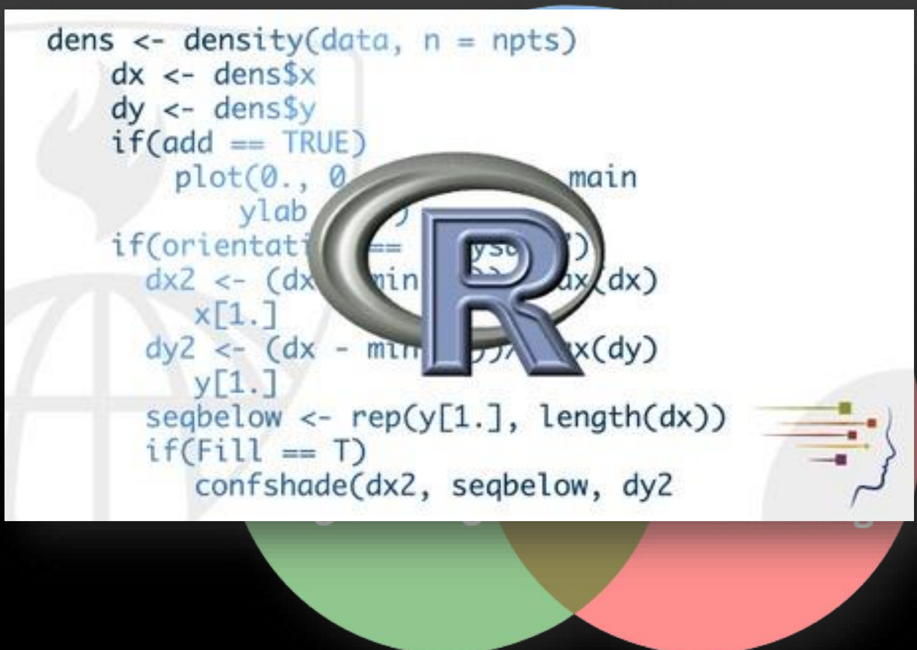


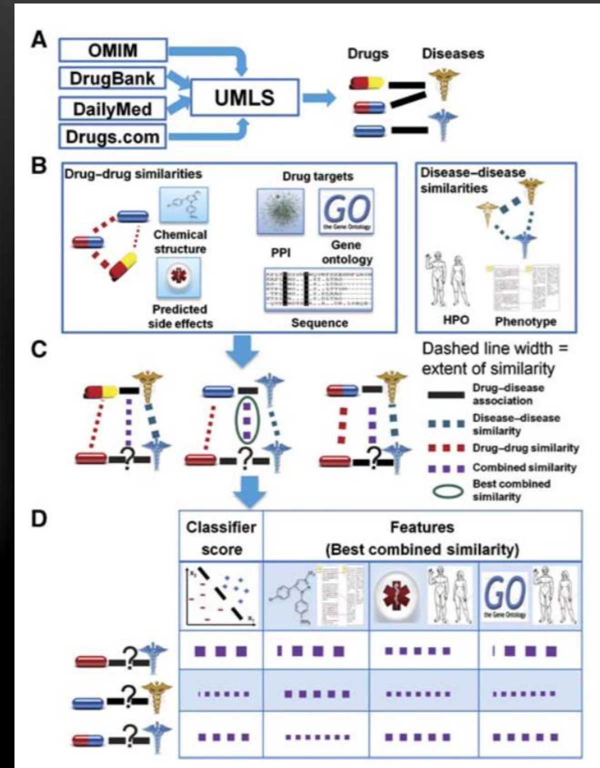

dens <- density(data, n = npts)
dx <- dens$x
dy <- dens$y
if(add == TRUE)
main
ylab
dx)
x[1.]
dy)
y[1.]
seqbelow <- rep(y[1.], length(dx))
if(Fill == T)
confshade(dx2, seqbelow, dy2

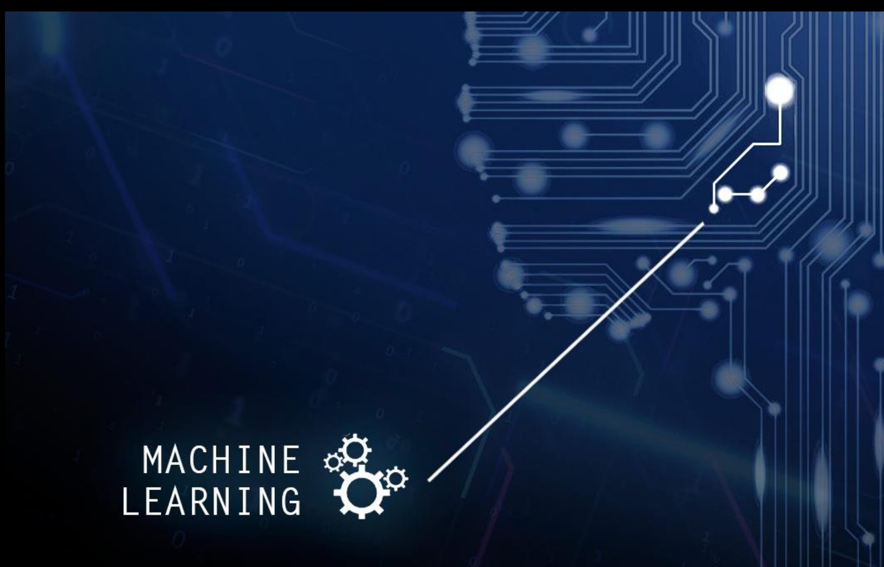

Medium
LAMADR
100
90
80
70
60
50
40
30
20
10
0

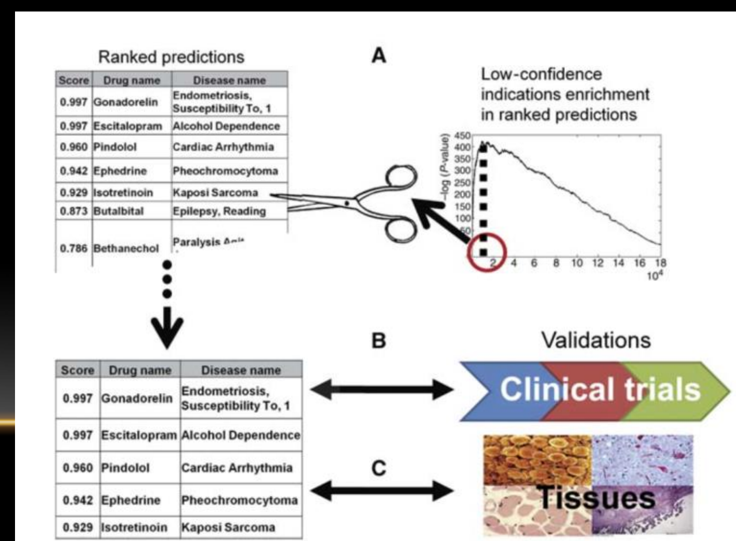

MACHINE
LEARNING


infant.mortality
gdp
contraception

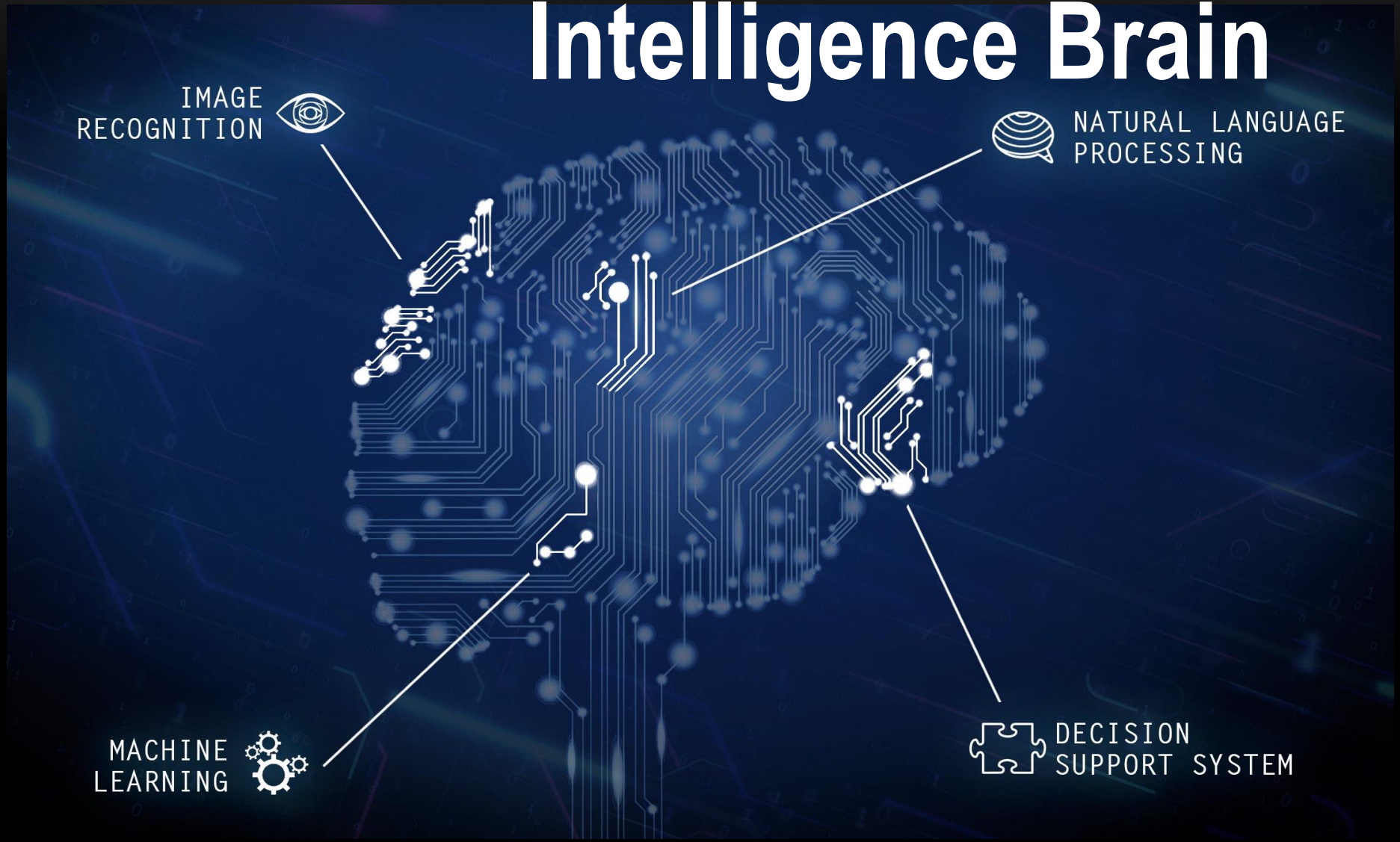

dens <- density(data, n = npts)
dx <- dens$x
dy <- dens$y
if(add == TRUE)
plot(0., 0
main
ylab
if(orientati
dx2 <- (dx
x[1.]
dy2 <- (dx - mi
y[1.]
seqbelow <- rep(y[1.], length(dx))
if(Fill == T)
confshade(dx2, seqbelow, dy2


A
OMIM
DrugBank
DailyMed
Drugs.com
UMLS
Drugs
Diseases
B
Drug–drug similarities
Chemical structure
Predicted side effects
Drug targets
PPI
GO
Gene ontology
Sequence
Disease–disease similarities
HPO
Phenotype
C
Dashed line width = extent of similarity
Drug–disease association
Disease–disease similarity
Drug–drug similarity
Combined similarity
Best combined similarity
D
Classifier score
Features (Best combined similarity)

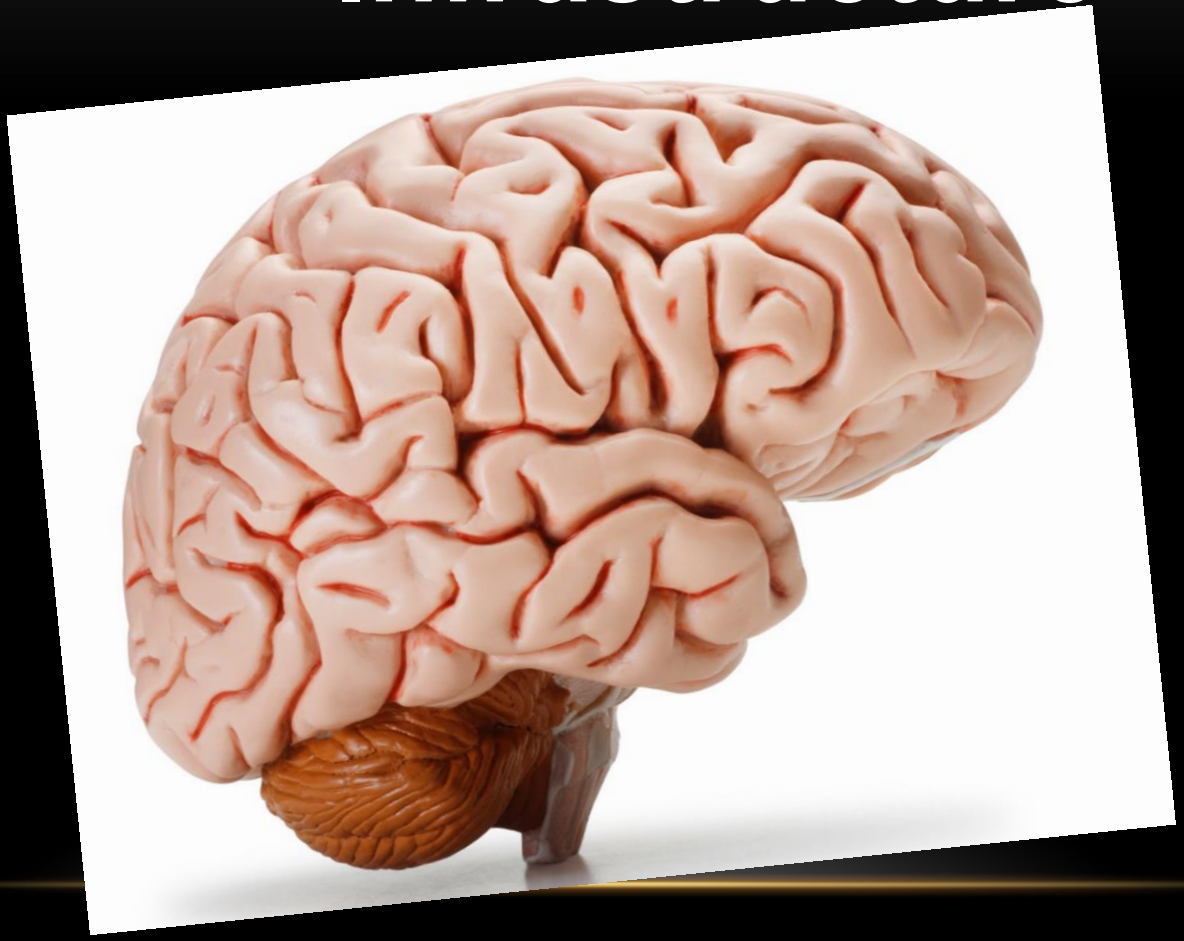

MACHINE
LEARNING


Ranked predictions
Score Drug name Disease name
0.997 Gonadorelin Endometriosis, Susceptibility To, 1
0.997 Escitalopram Alcohol Dependence
0.960 Pindolol Cardiac Arrhythmia
0.942 Ephedrine Pheochromocytoma
0.929 Isotretinoin Kaposi Sarcoma
0.873 Butalbital Epilepsy, Reading
0.786 Bethanechol Paralysis
A
Low-confidence indications enrichment in ranked predictions
-log (P-value)
B
Validations
Clinical trials
C
Tissues
Score Drug name Disease name
0.997 Gonadorelin Endometriosis, Susceptibility To, 1
0.997 Escitalopram Alcohol Dependence
0.960 Pindolol Cardiac Arrhythmia
0.942 Ephedrine Pheochromocytoma
0.929 Isotretinoin Kaposi Sarcoma

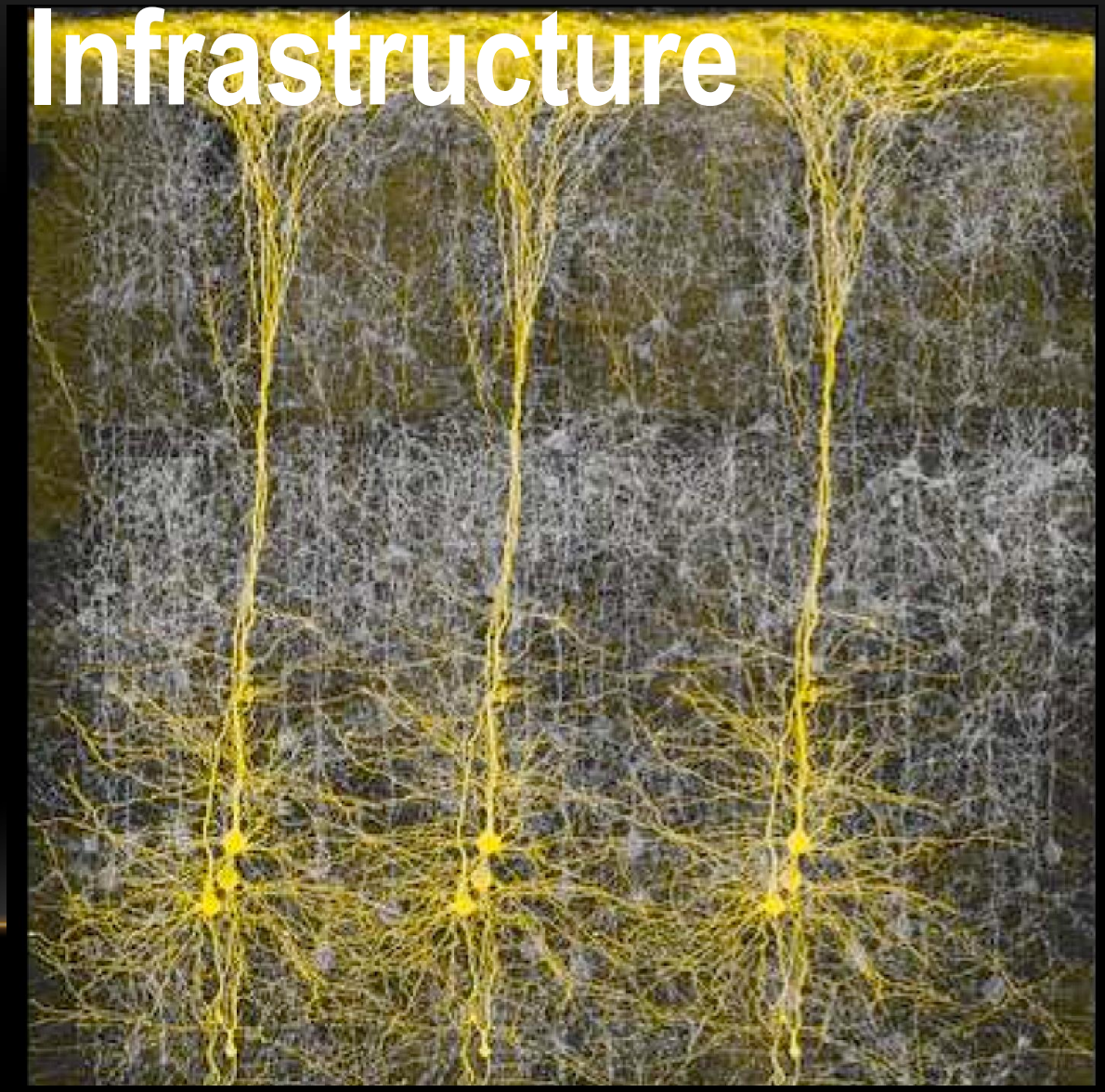
The Artificial Intelligence Brain



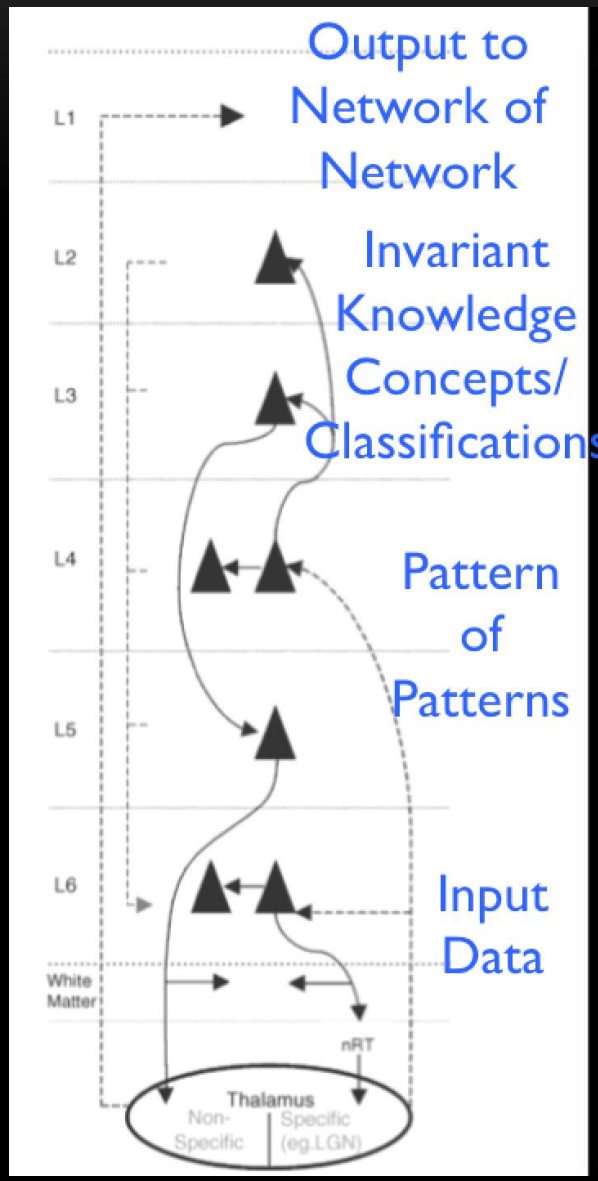
Cortical Infrastructure

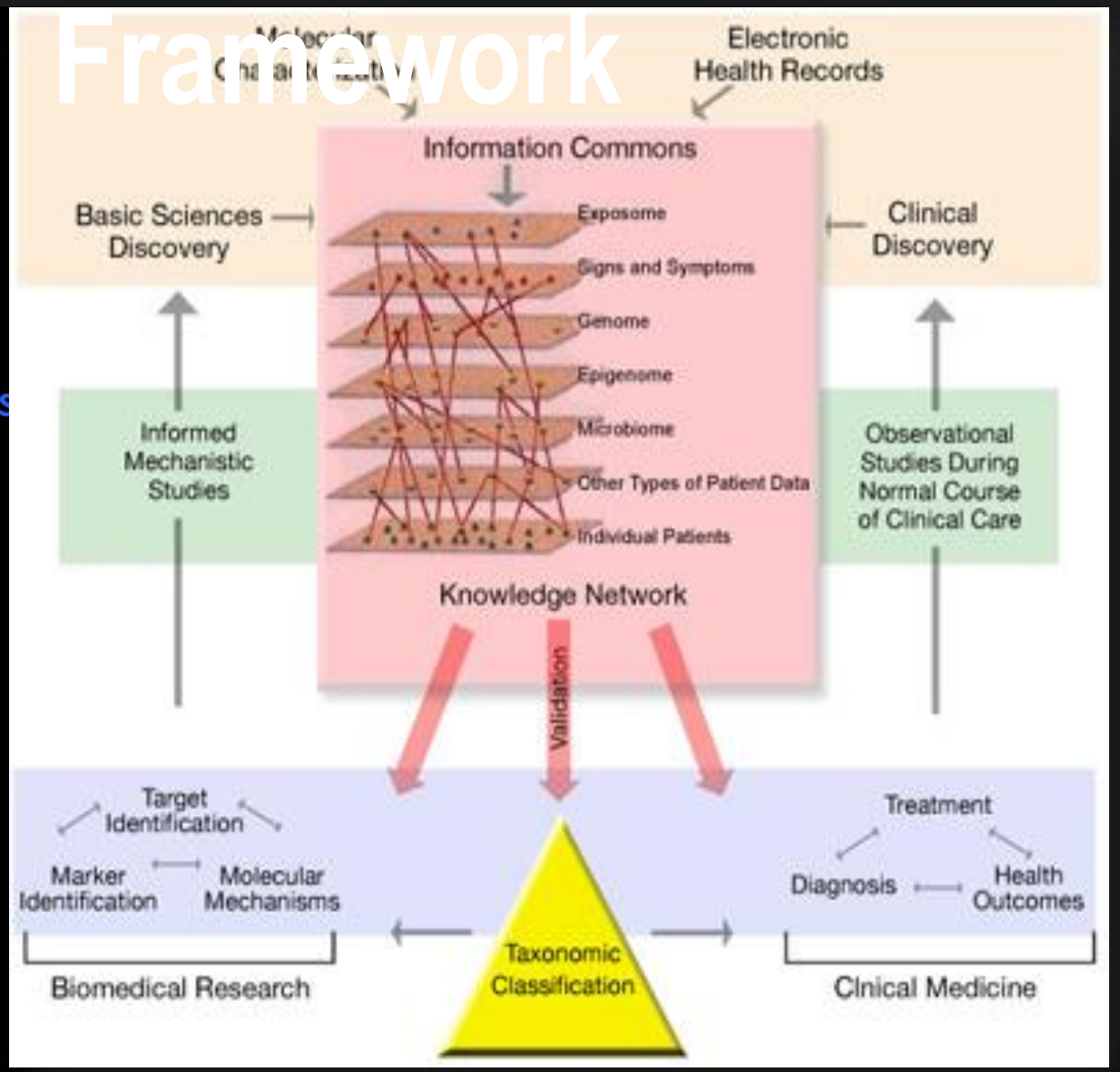


Cortical Infrastructure



BioIntelligence Framework

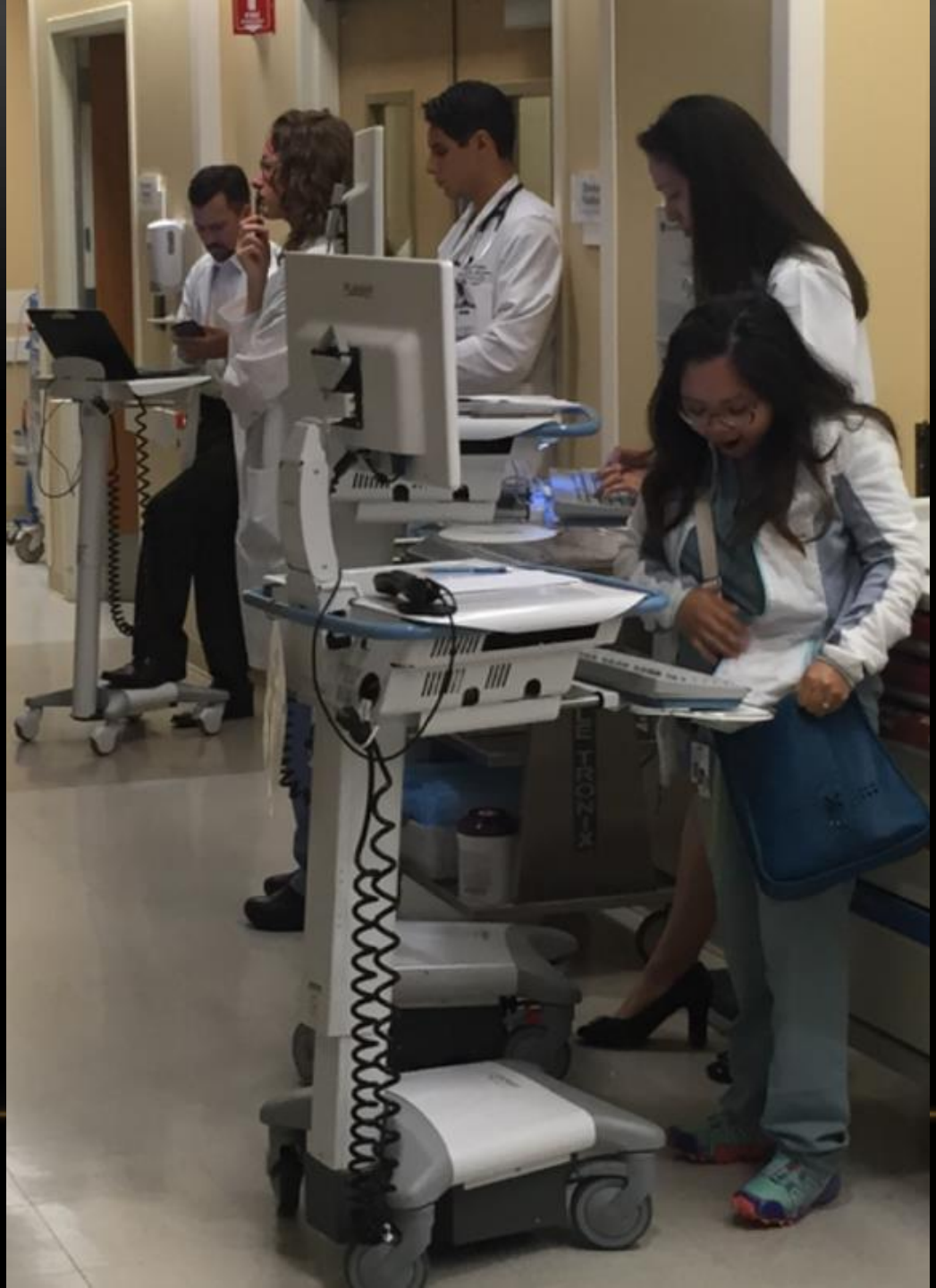




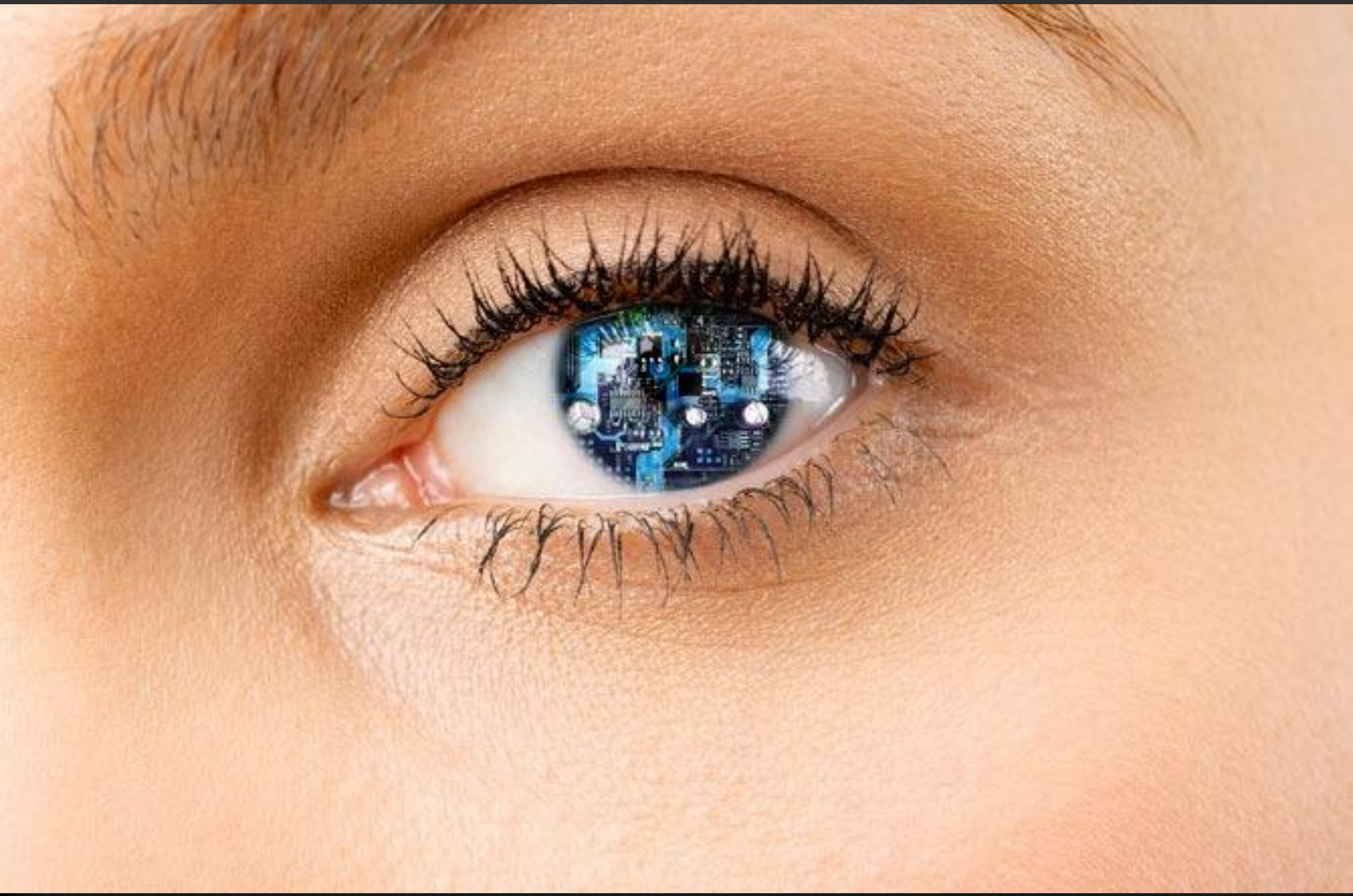
BioIntelligence Framework:

A Living Expert Neural Network

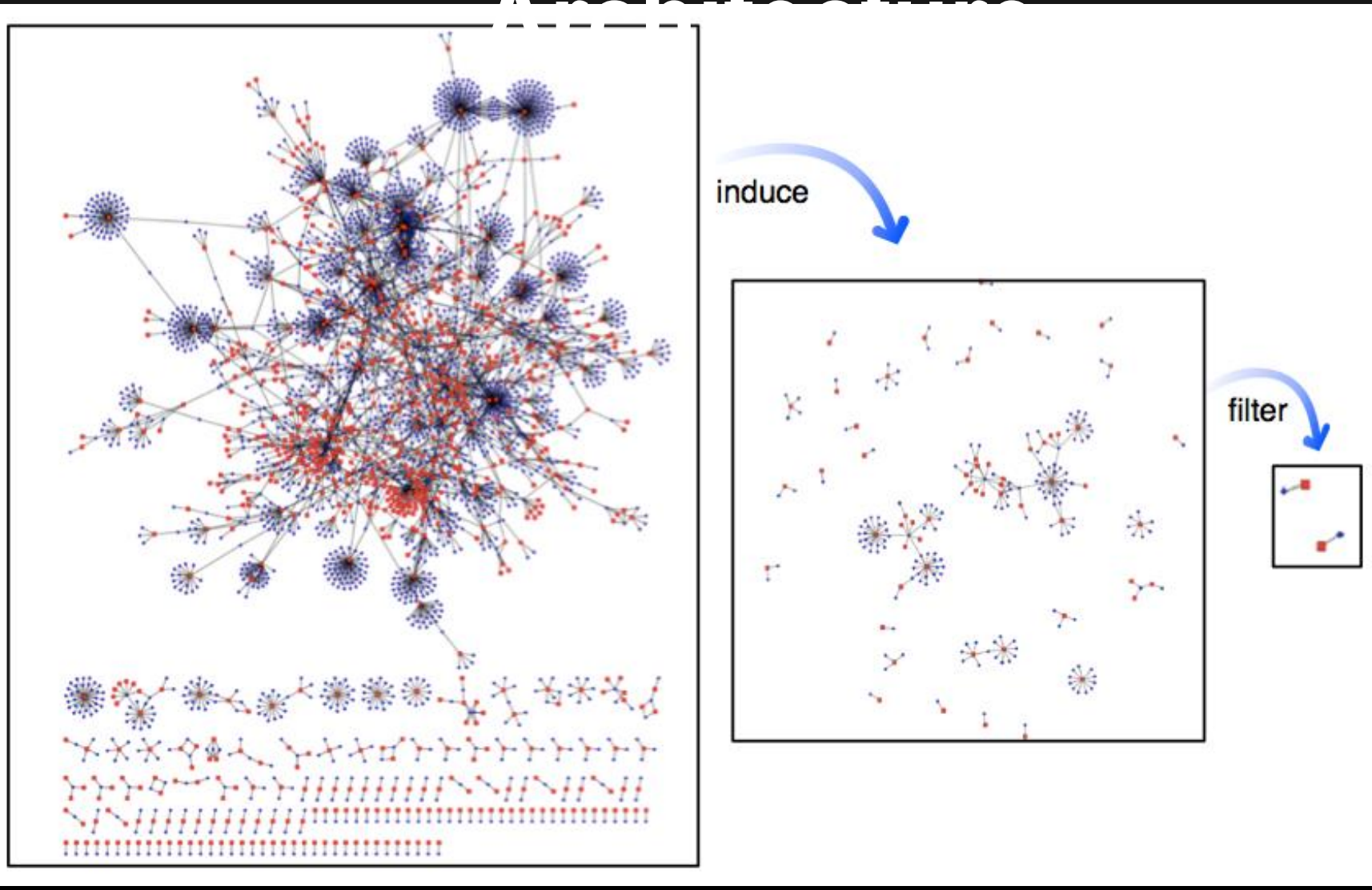
Making the visible *invisible*



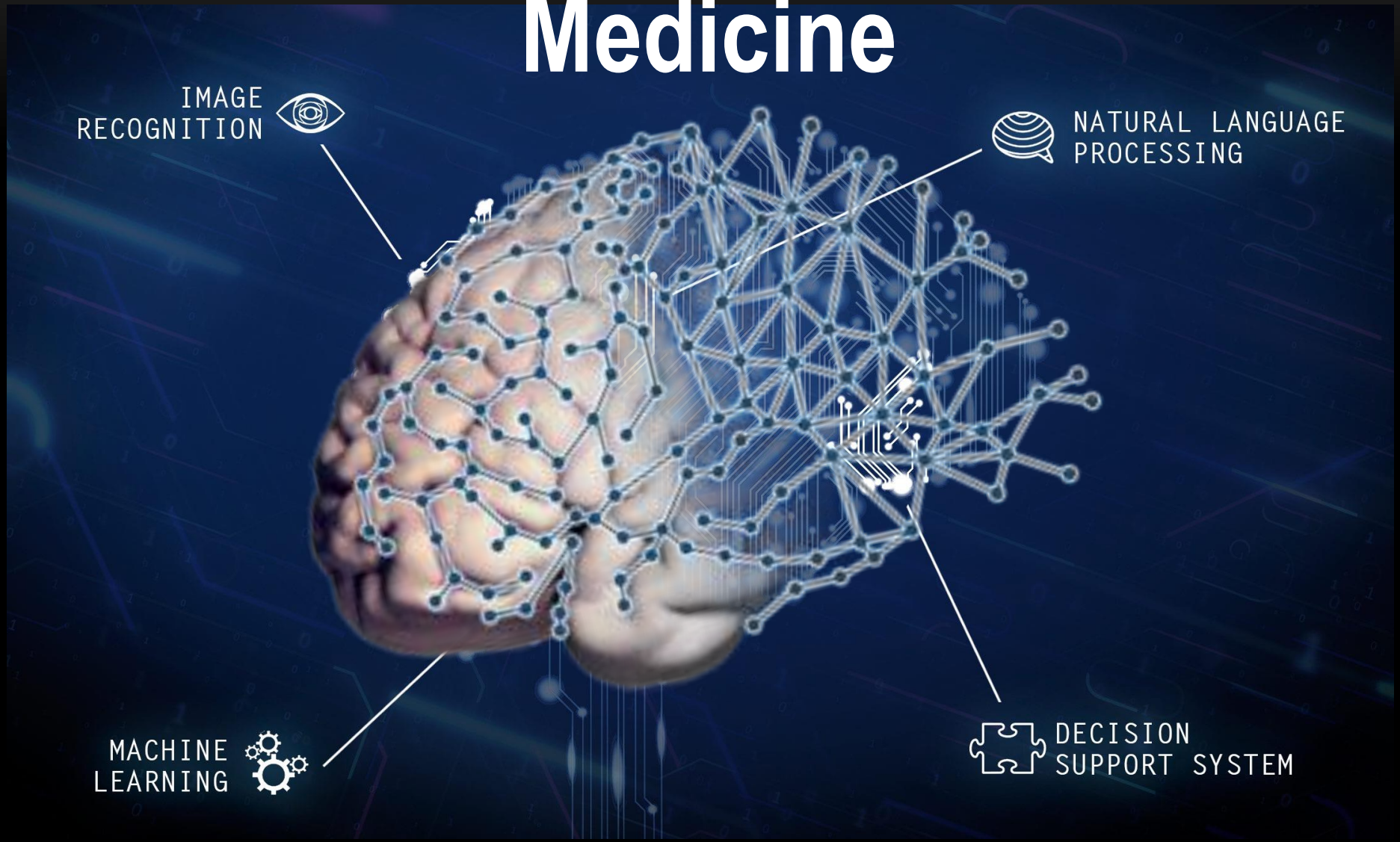
Making the invisible *visible*



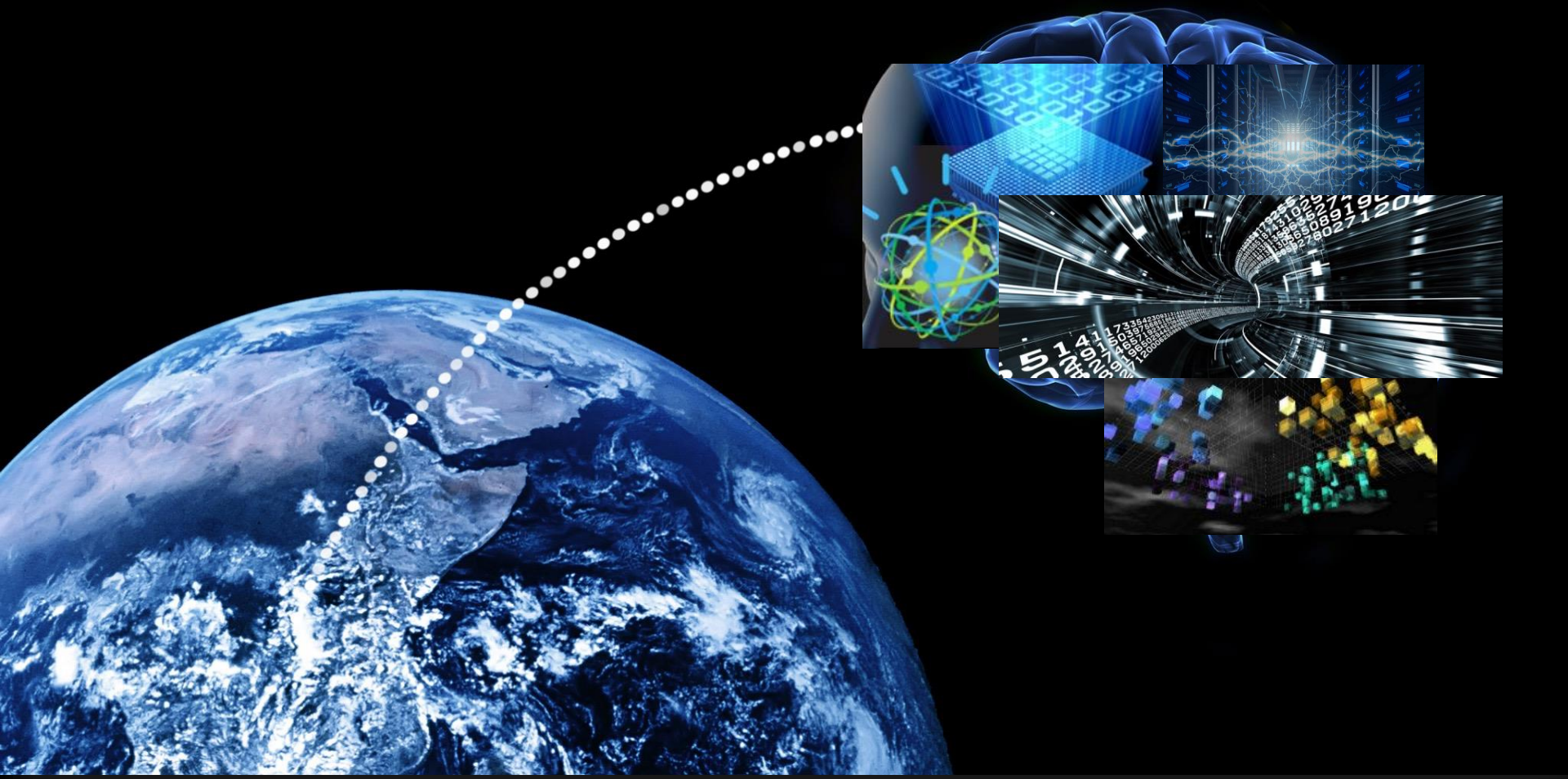
HyperGraph Architecture



Intelligence-Based Medicine



Intelligence-Based Medicine



Intelligence-as-a-

Collective

VERY SPECIAL THANKS TO:

Sharon Disney Lund Medical Intelligence and Innovation Institute (MI3)

The Innovation Institute

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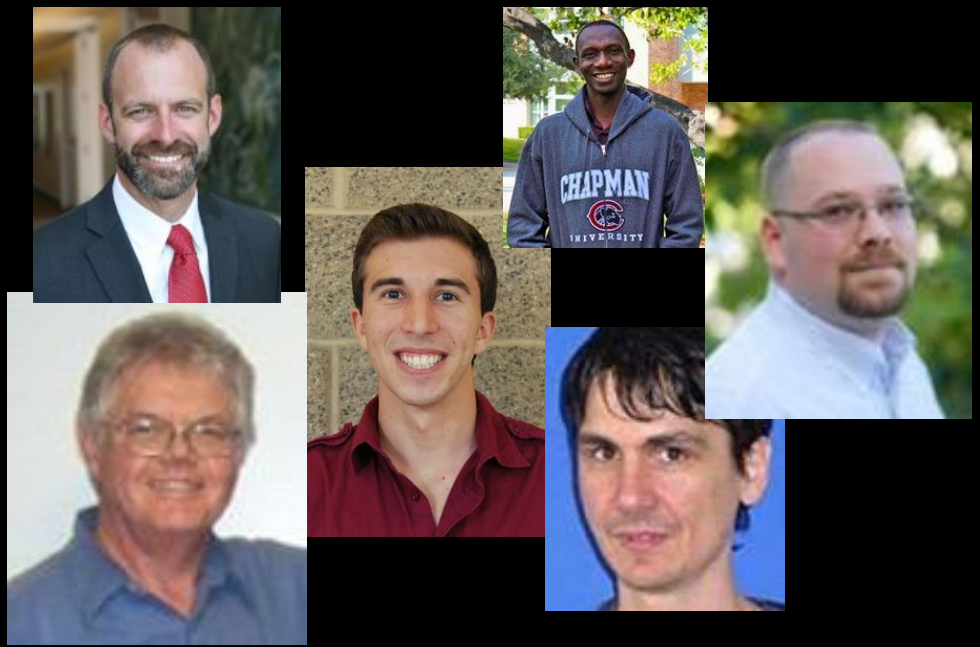
and

Scientist-in-Residence and Computer Science Department

CHAPMAN UNIVERSITY



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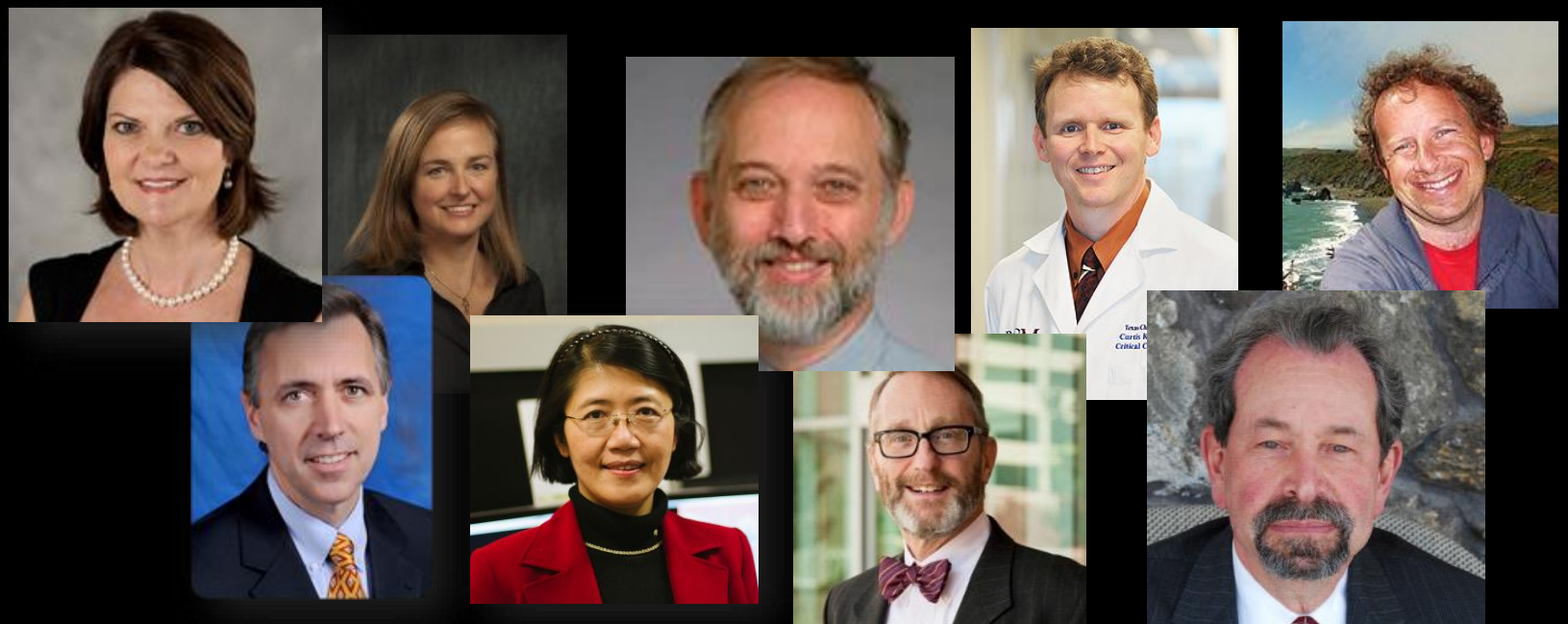

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