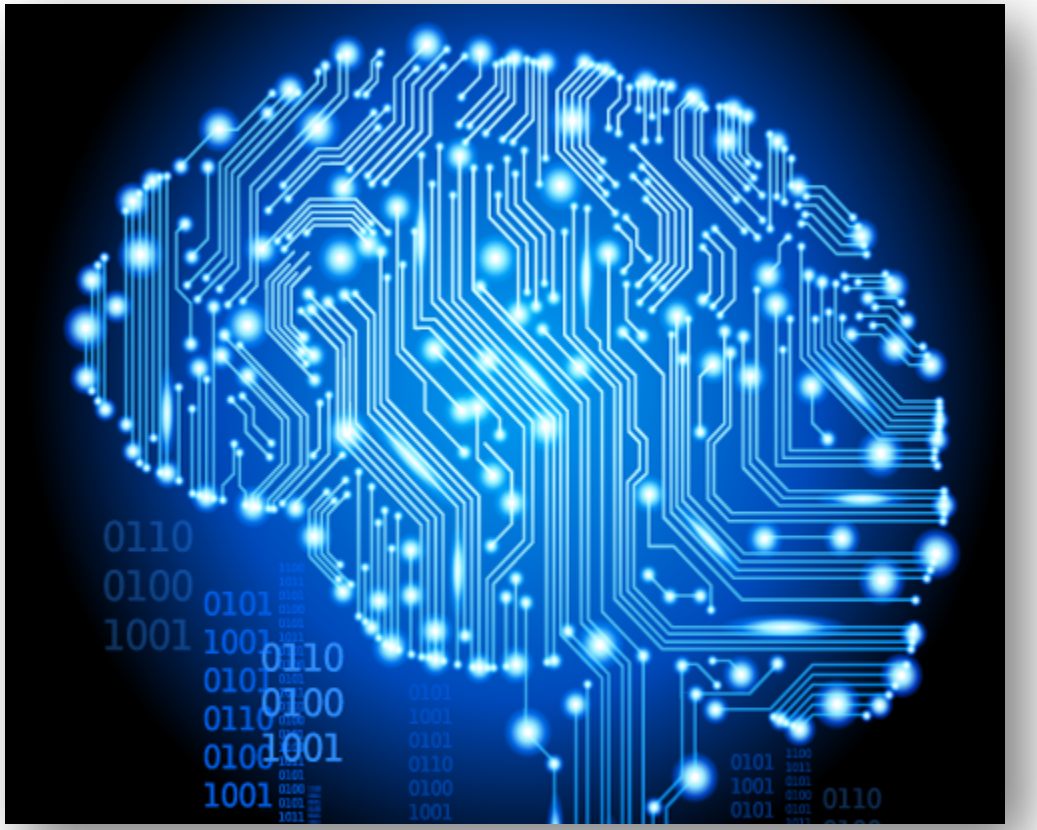
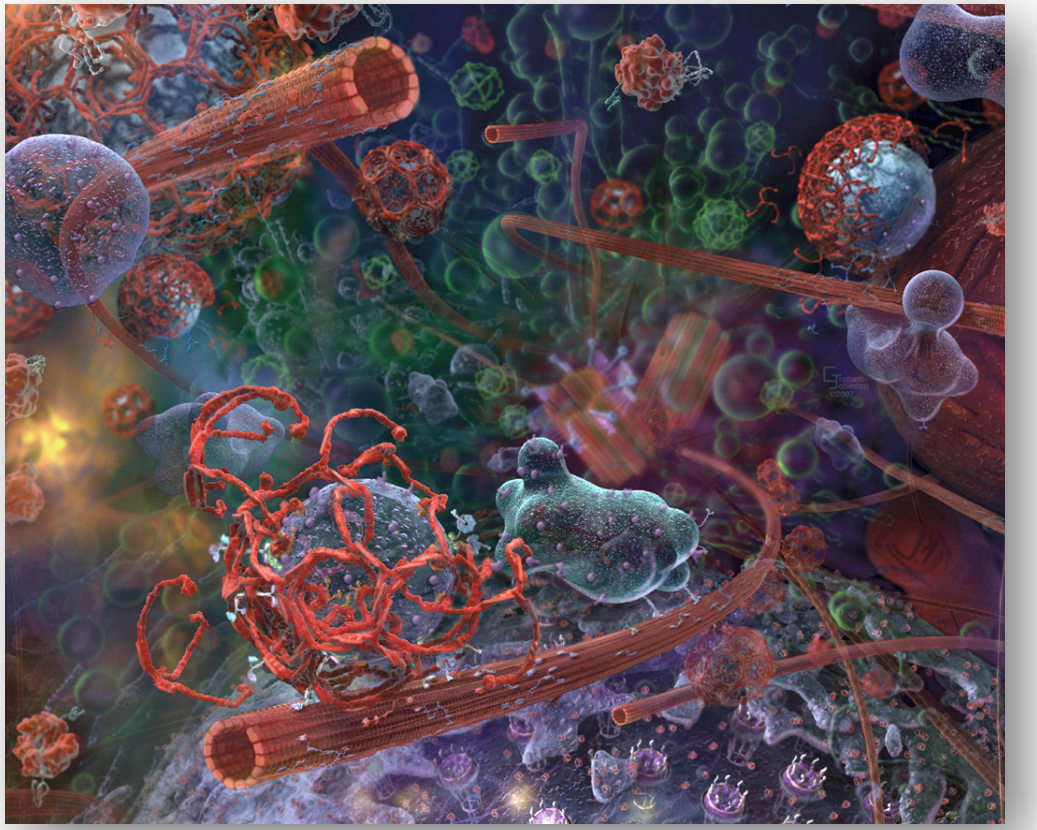
# Utilizing Deep Learning for Cellular cryo-tomography





Niels Volkmann
Sanford Burnham Prebys Medical Discovery Institute
NRAMM Deep Learning Workshop, April 2018

# ARTIFICIAL INTELLIGENCE

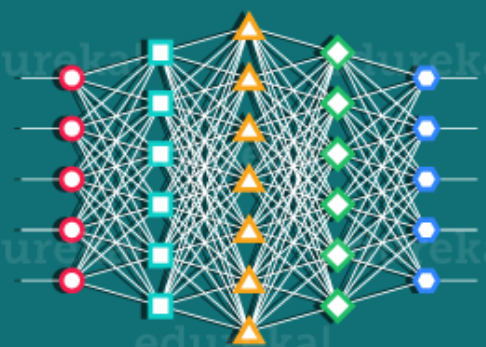
Engineering of making Intelligent Machines and Programs

# MACHINE LEARNING

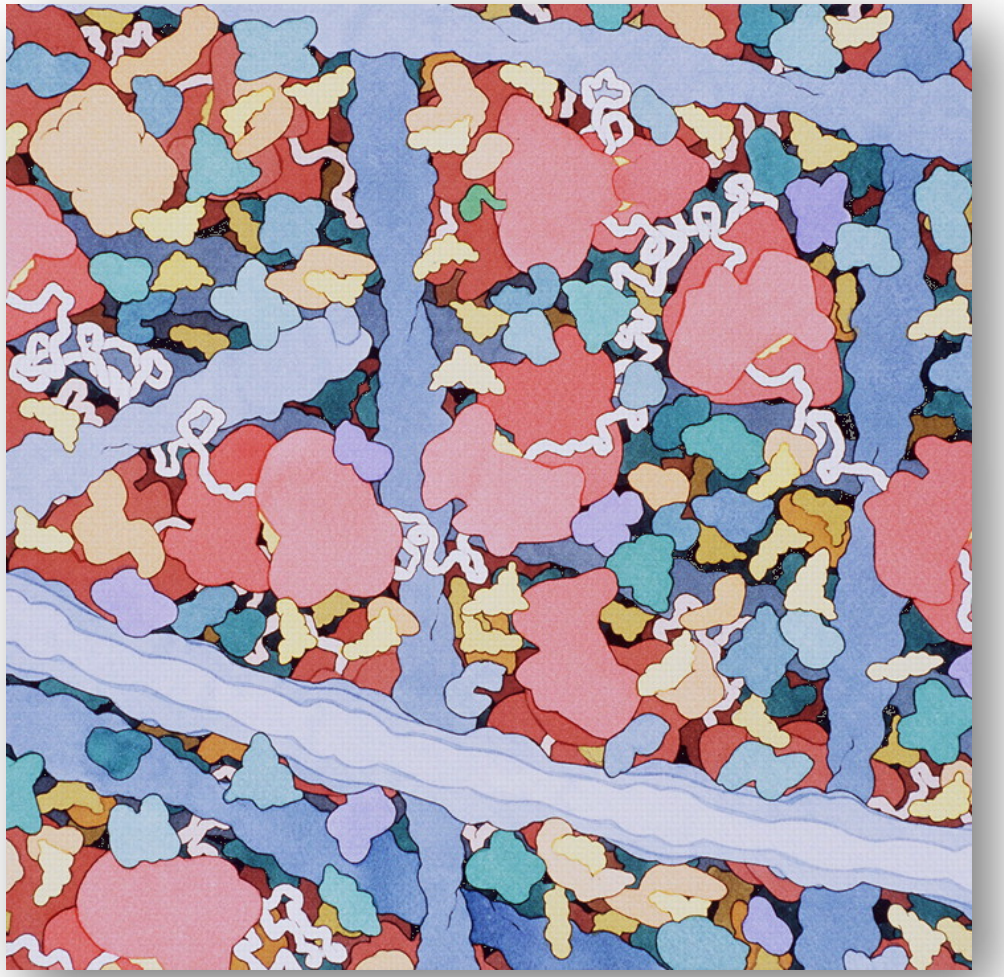
Ability to learn without being explicitly programmed

# DEEP LEARNING

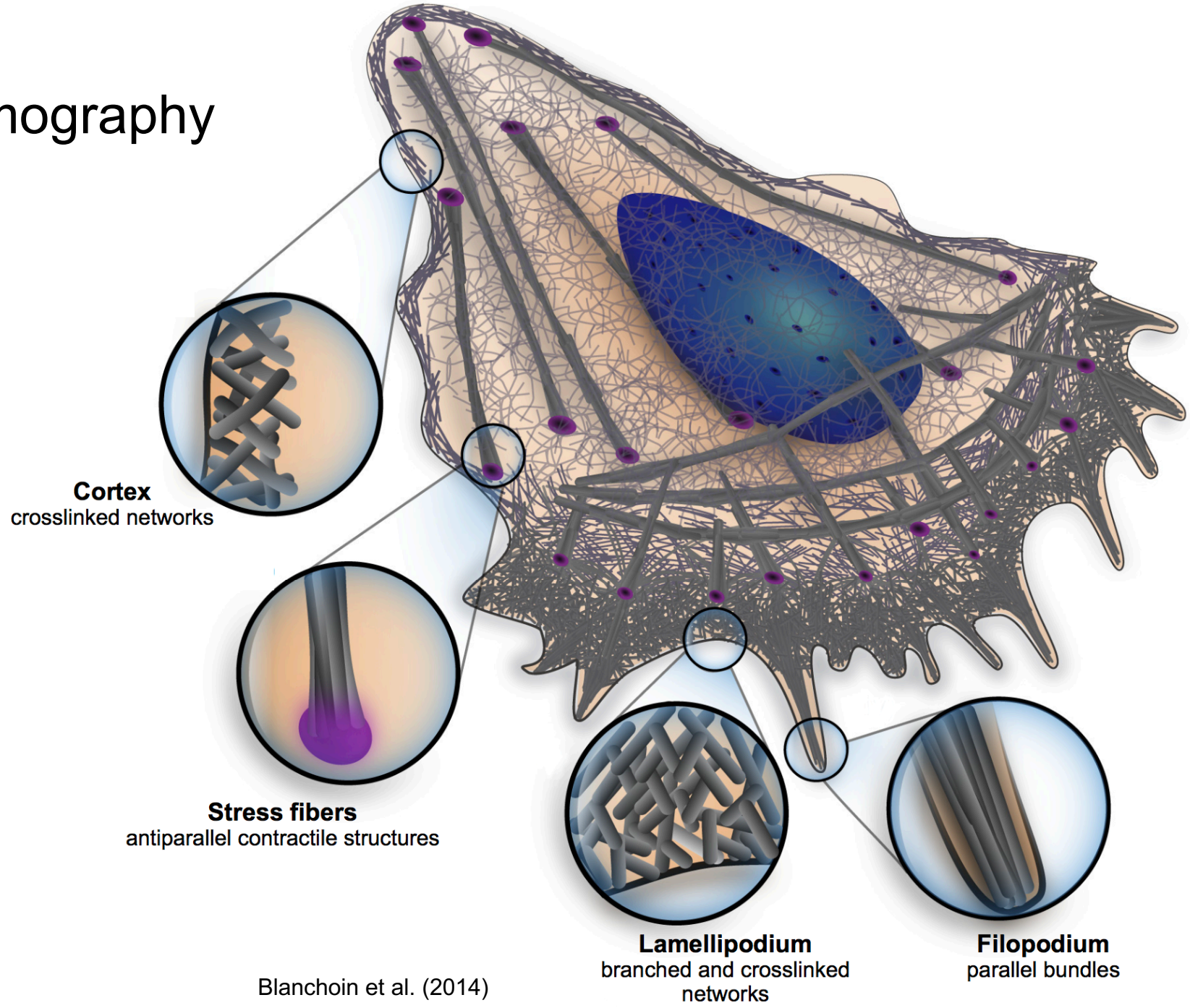
Learning based on Deep Neural Network



# Cellular Tomography

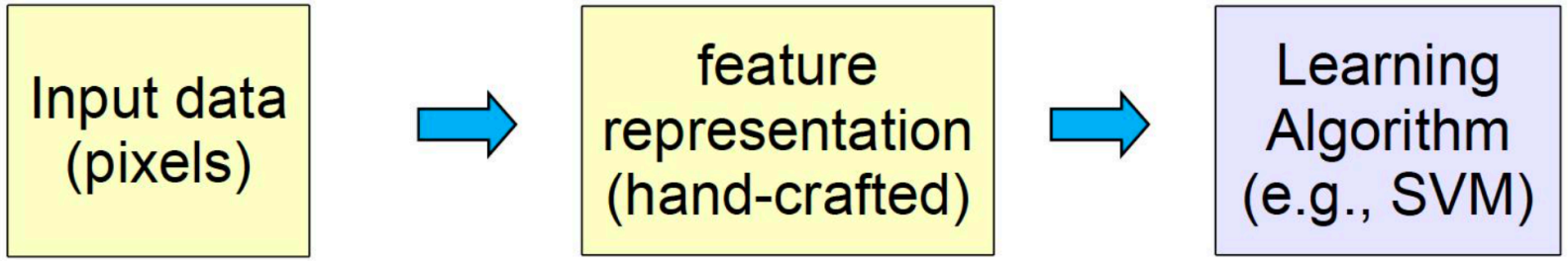


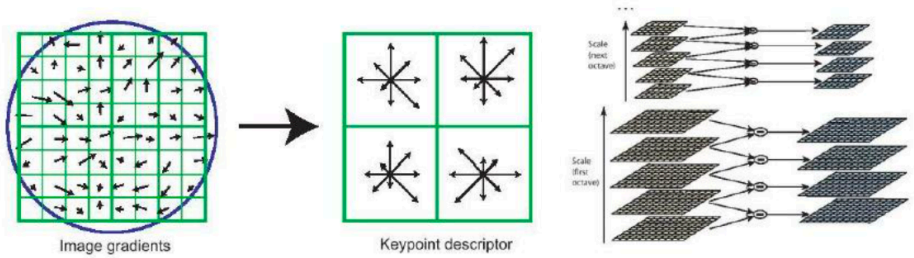
# Cellular Tomography



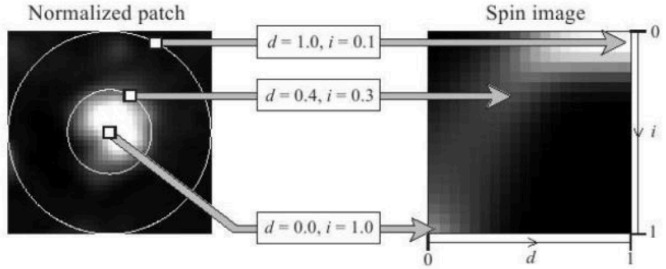

Blanchoin et al. (2014)

# Traditional Machine Learning Approach

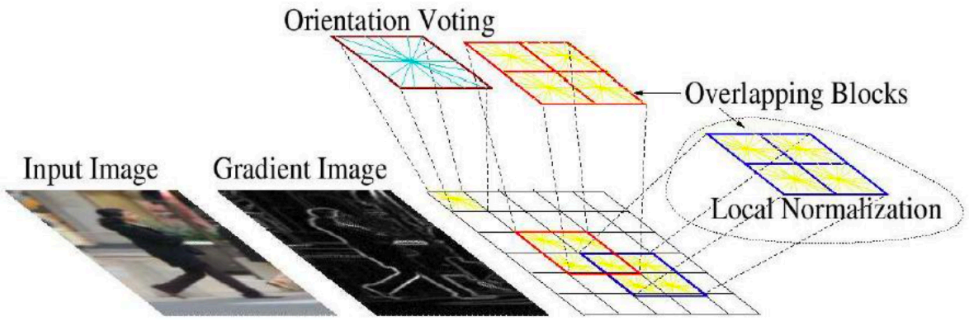


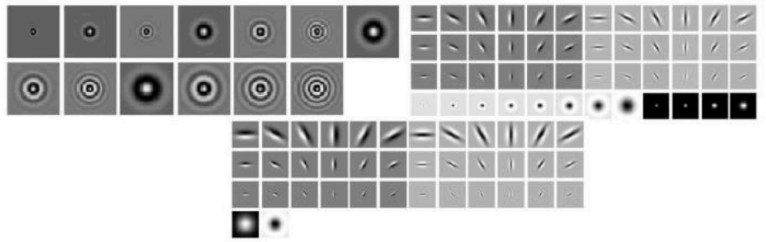

SIFT




Spin image

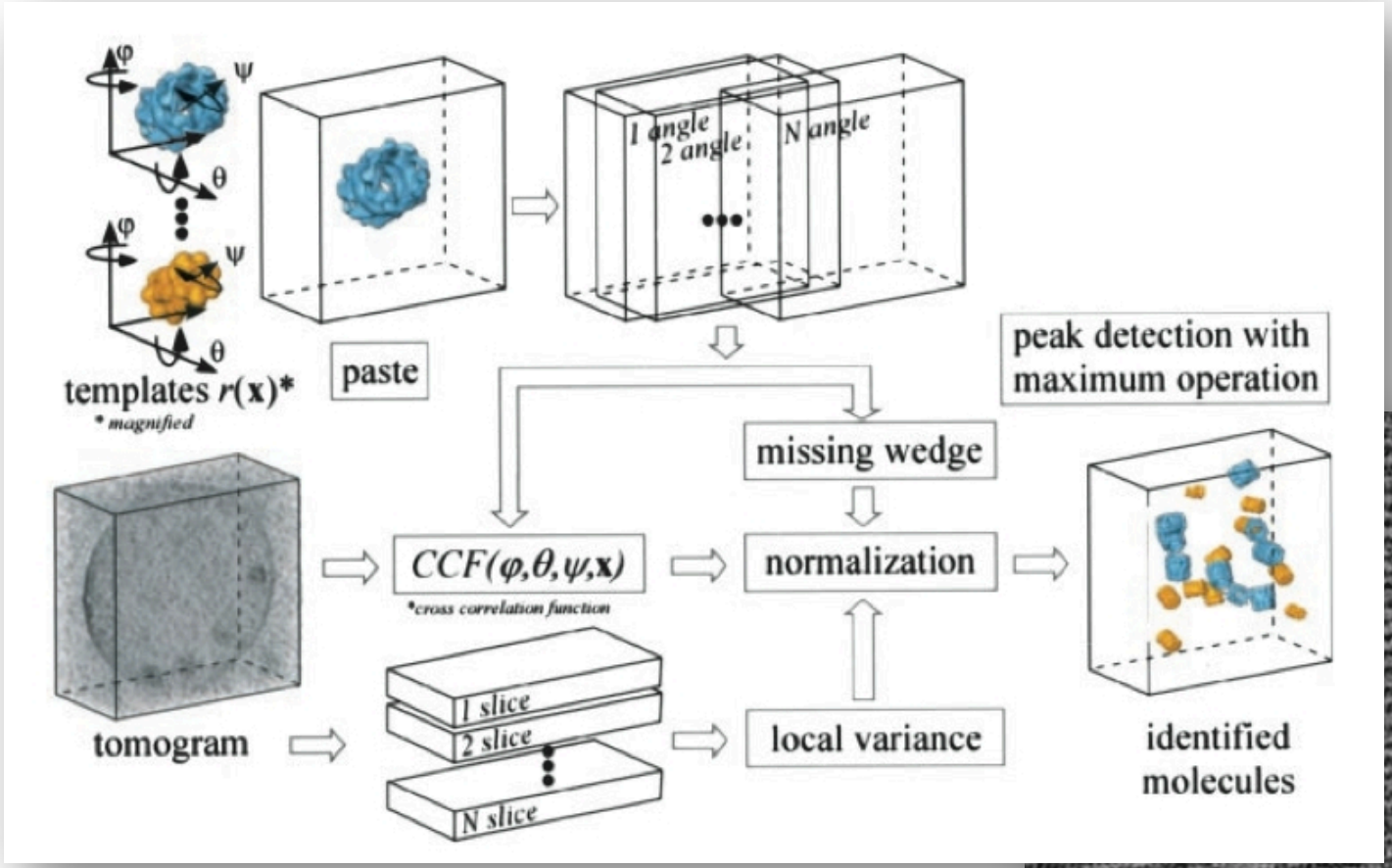



HoG

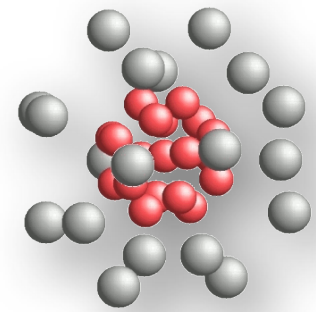


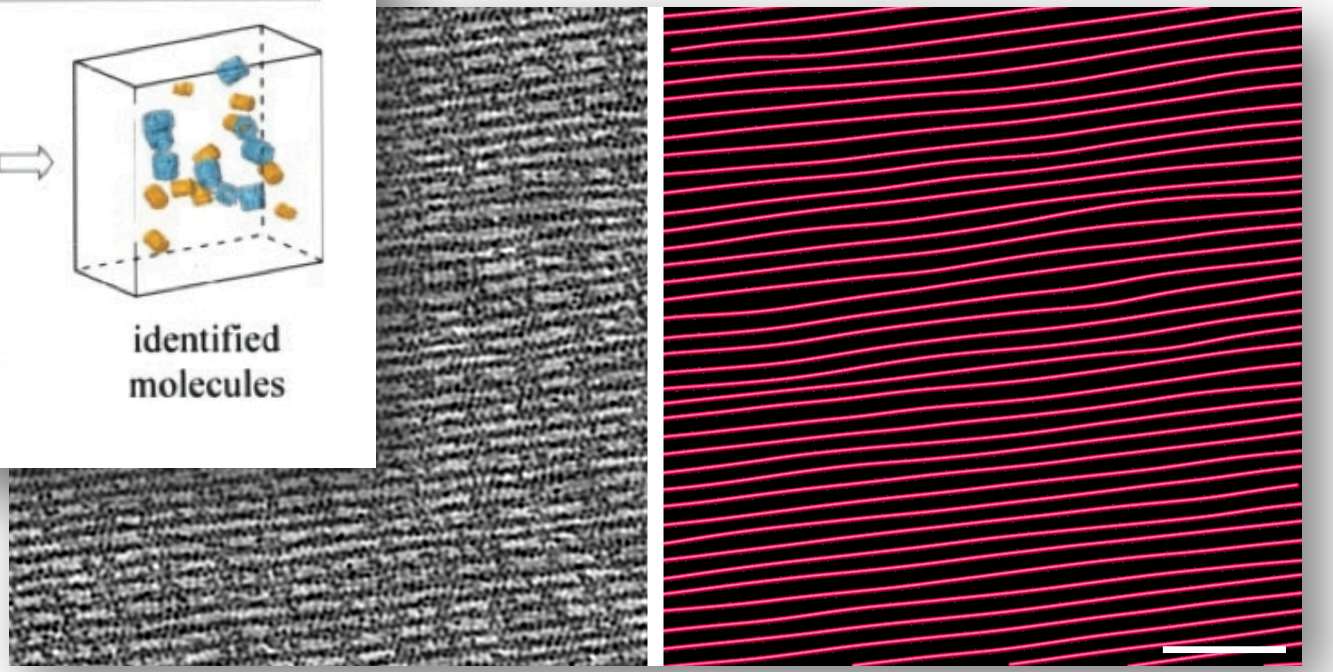
Textons

# Template-based Approaches

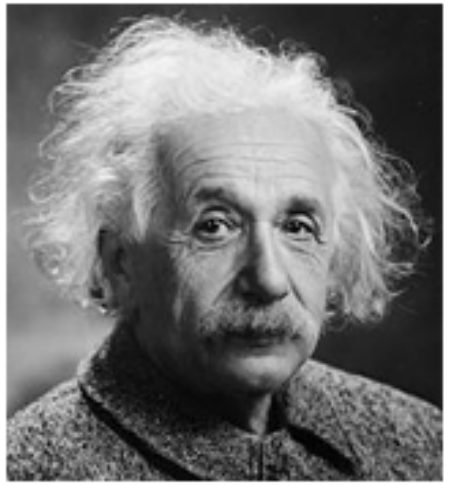


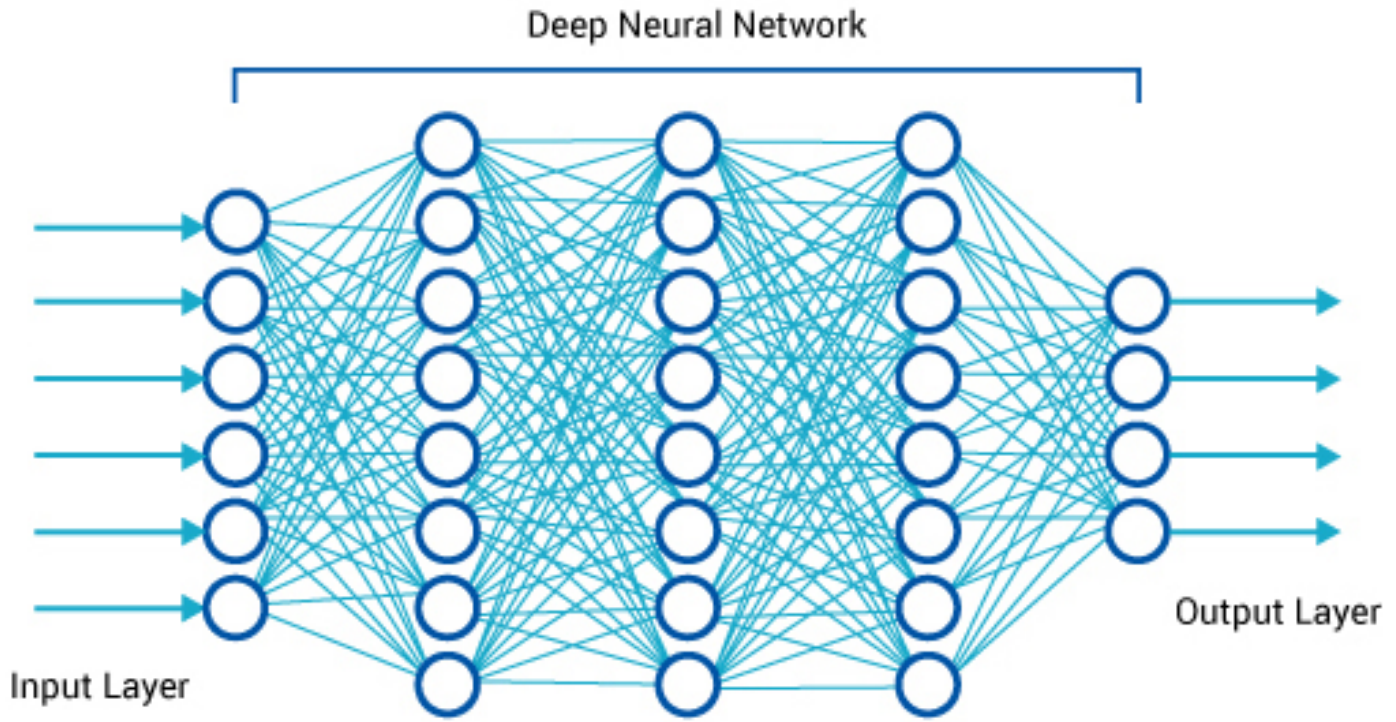

from Frangakis et al. PNAS 2002





Xu et al. LNCS 2015

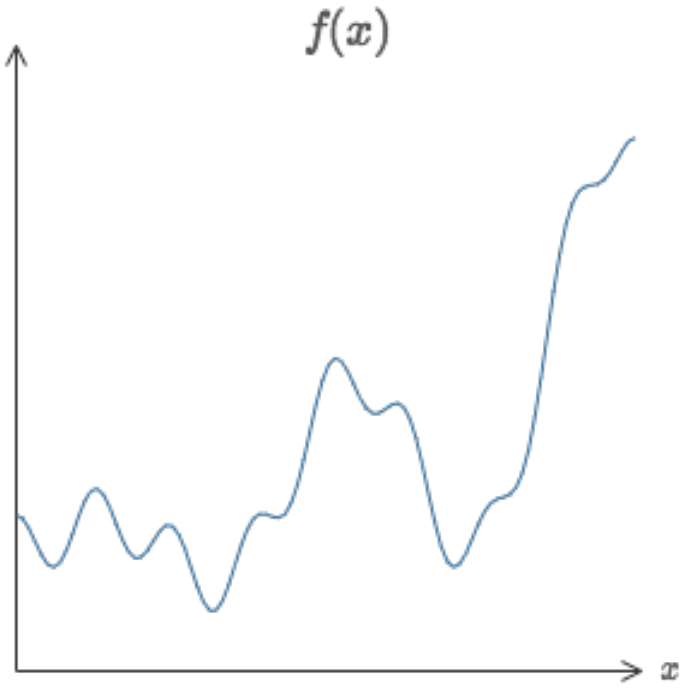


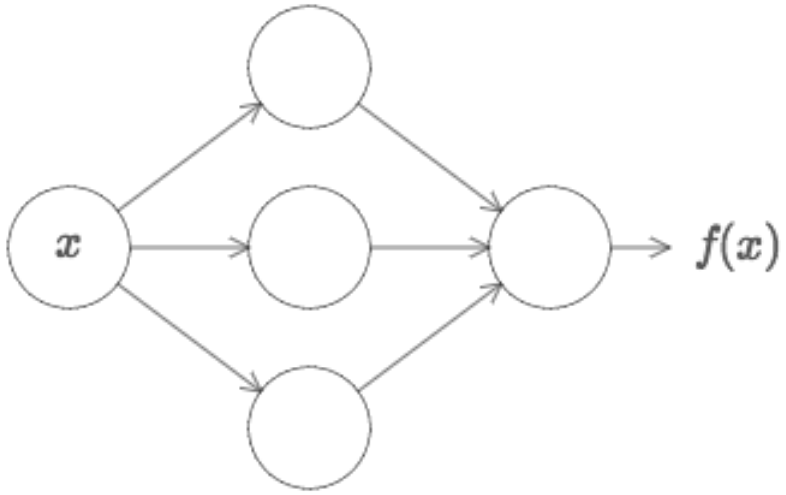


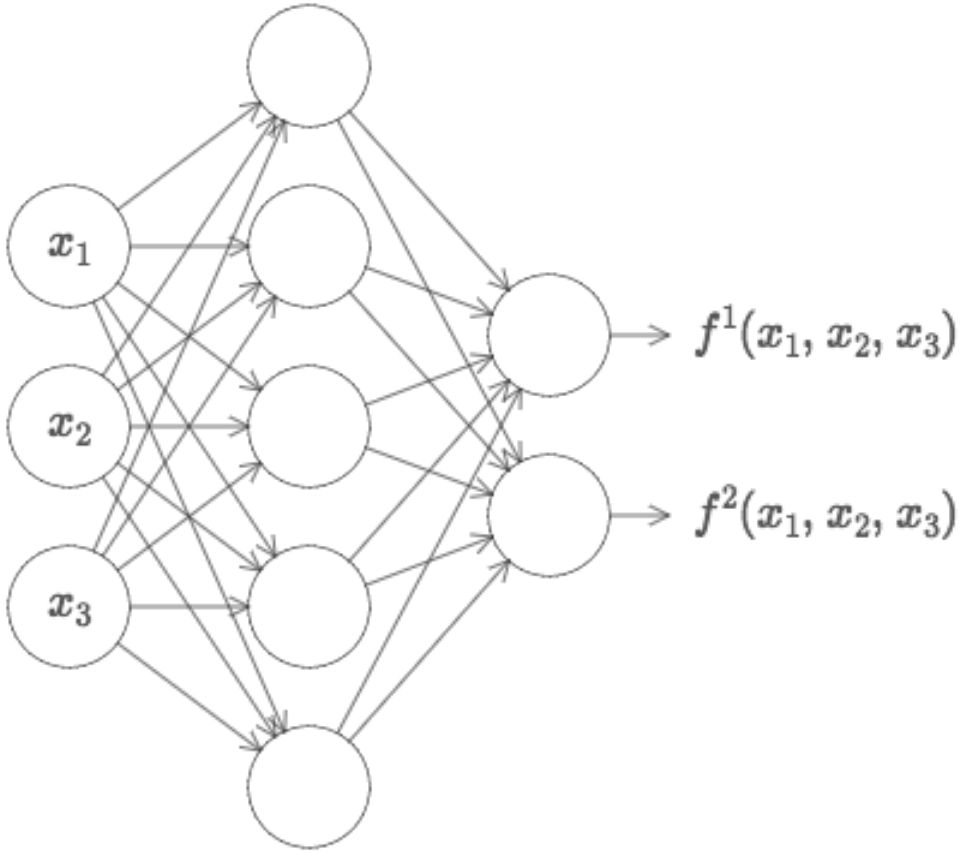

IT'S EINSTEIN!

edges | combinations of edges | object models

# Universal Approximation Theorem

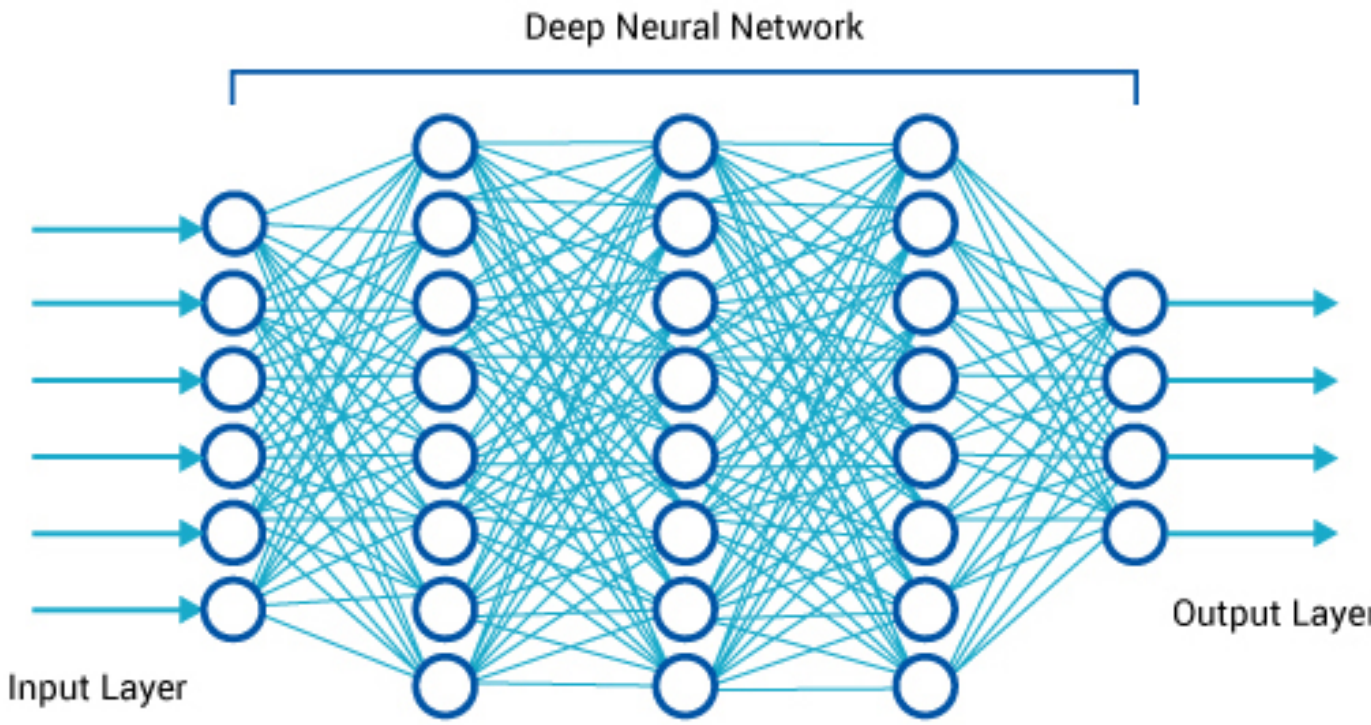


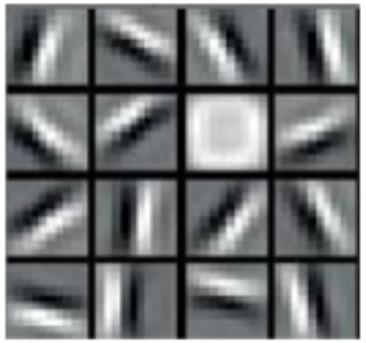




Kurt Hornik (1991) *Neural Networks*, 4, 251–257.


@teenybiscuit




THAT'S NOT EINSTEIN!!



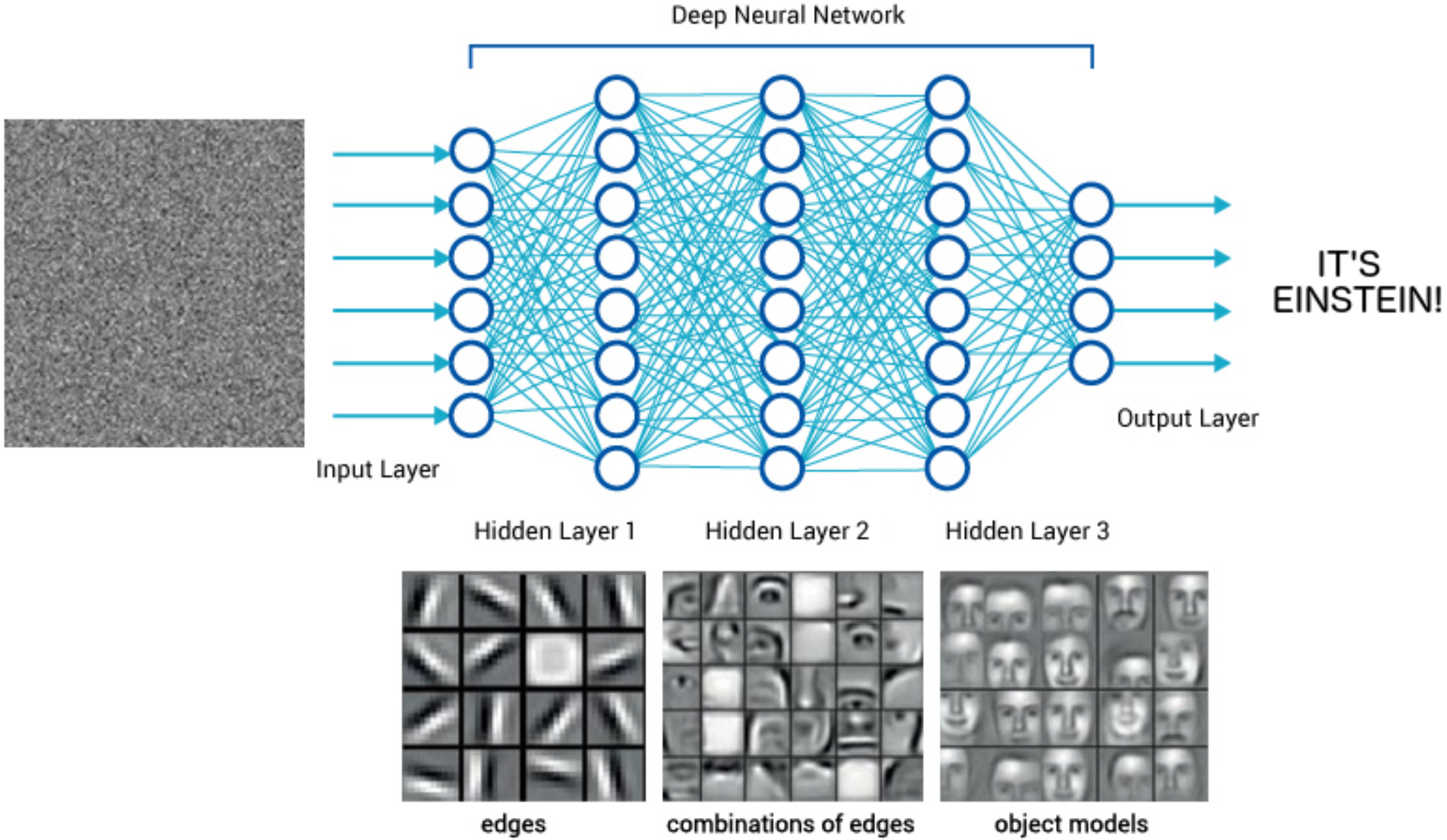
edges

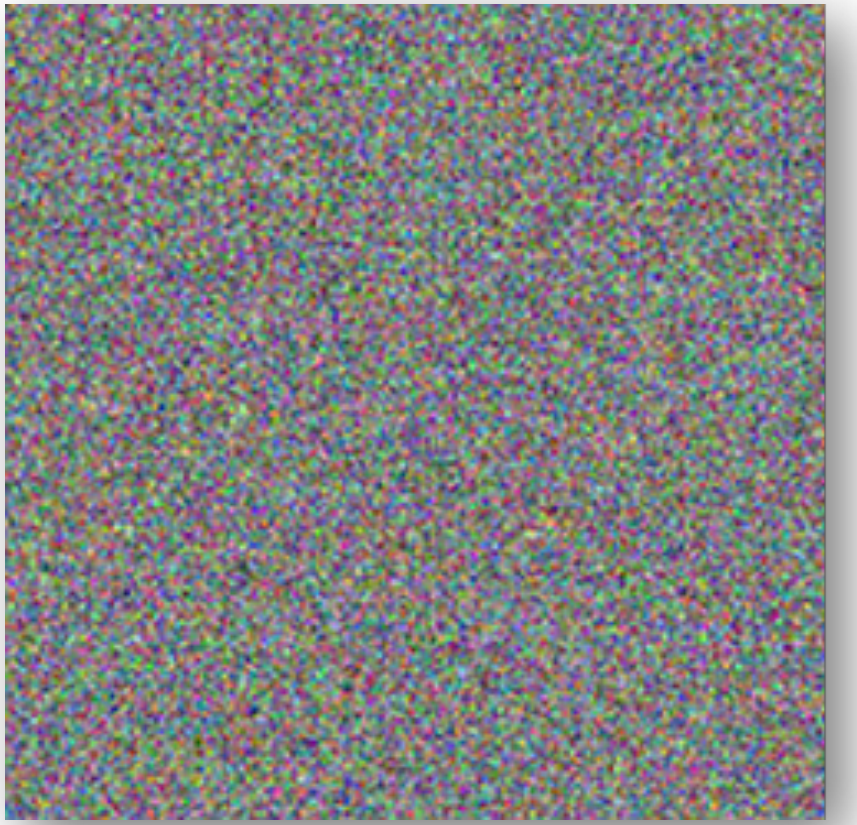
combinations of edges

object models

Panda

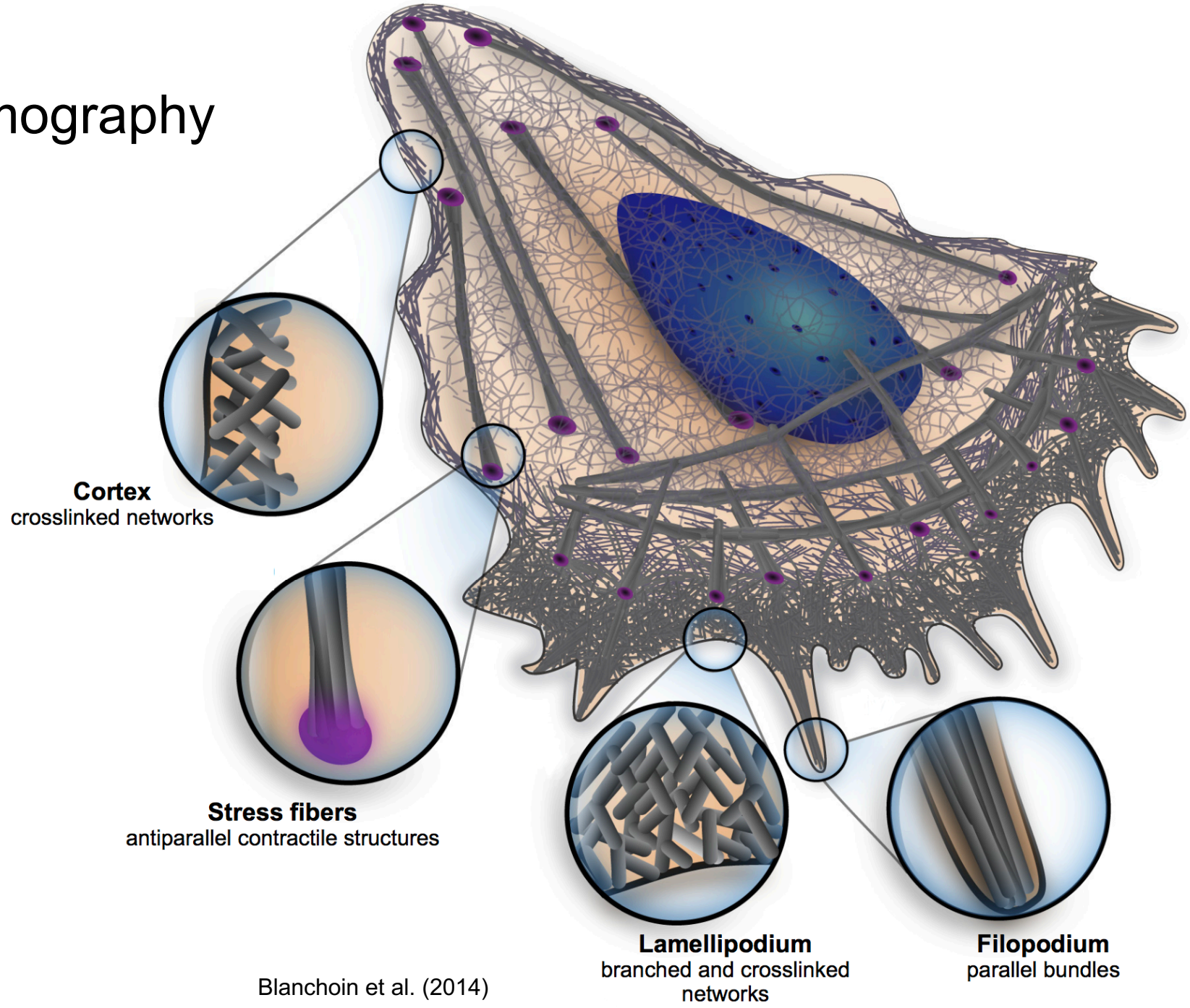
Gibbon


Deep Neural Network
IT'S EINSTEIN!
Input Layer
Output Layer
Hidden Layer 1
Hidden Layer 2
Hidden Layer 3
edges
combinations of edges
object models

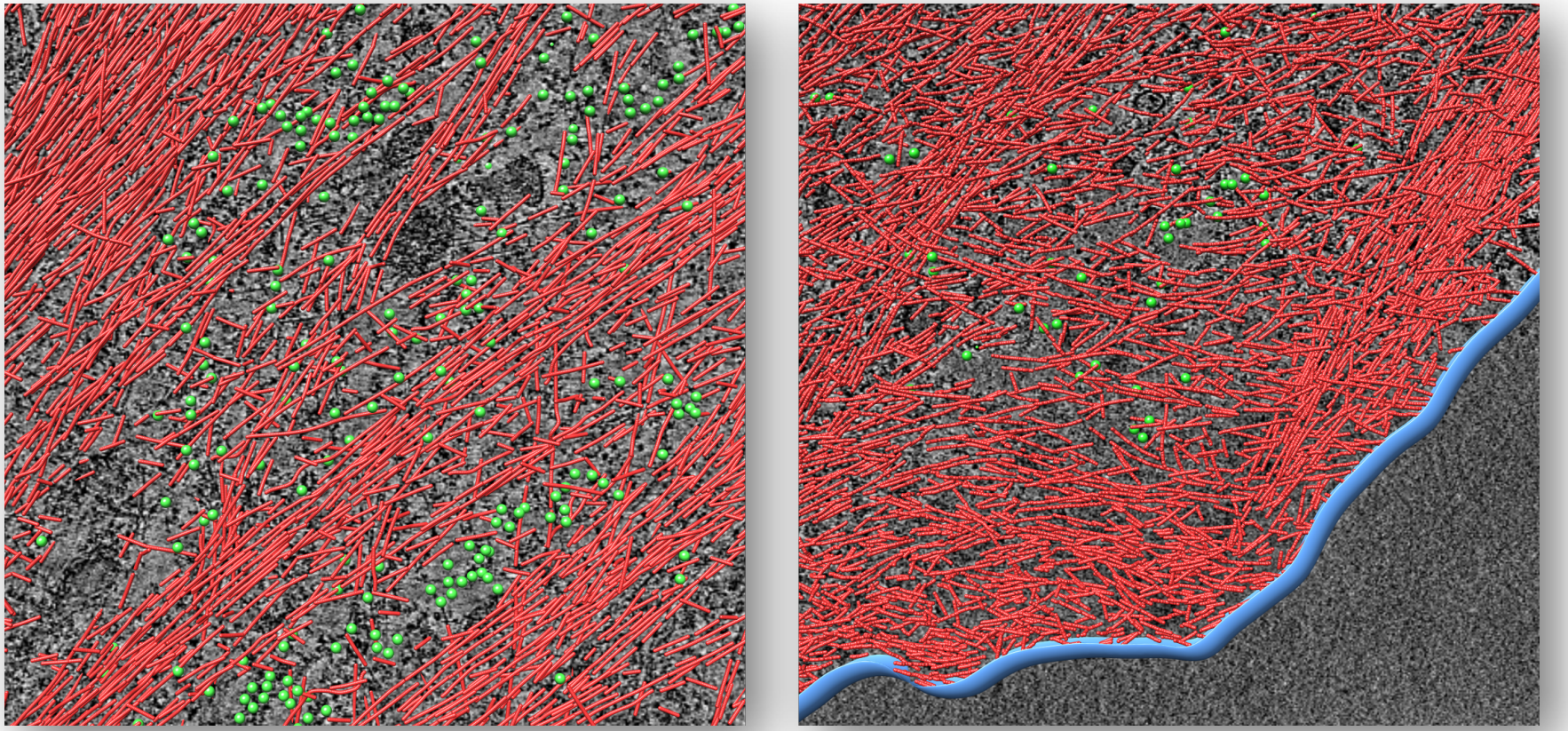


Mordvintsev et al. 2015

# Cellular Tomography



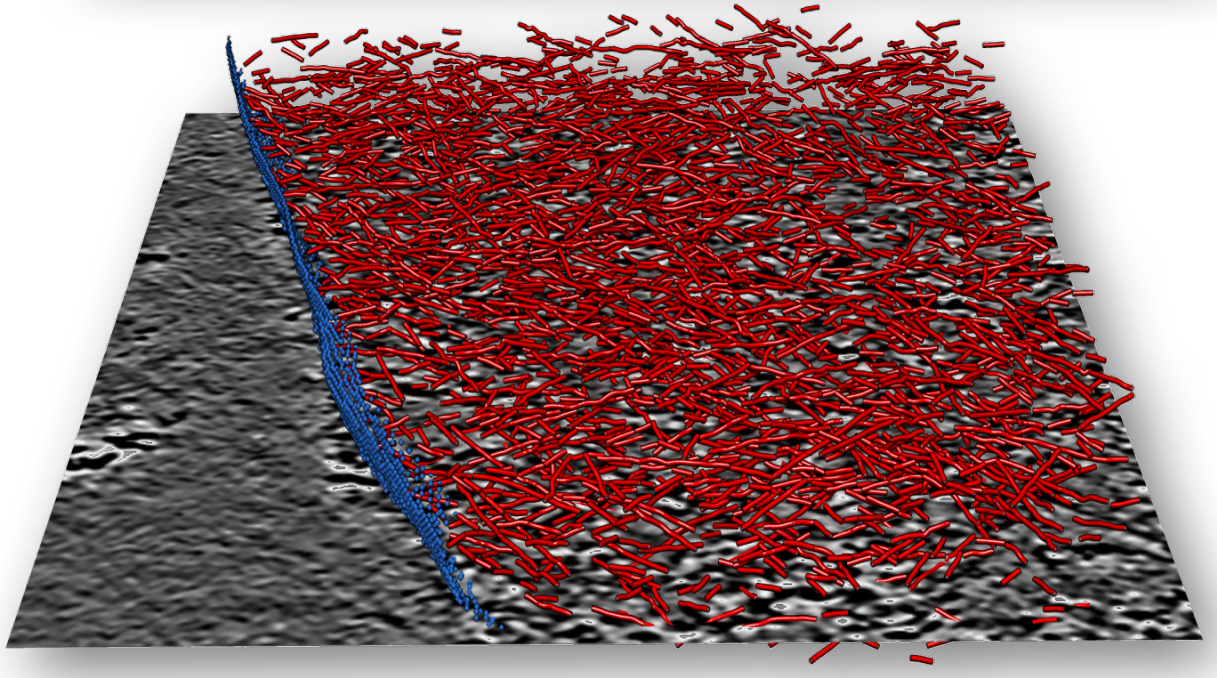

Blanchoin et al. (2014)

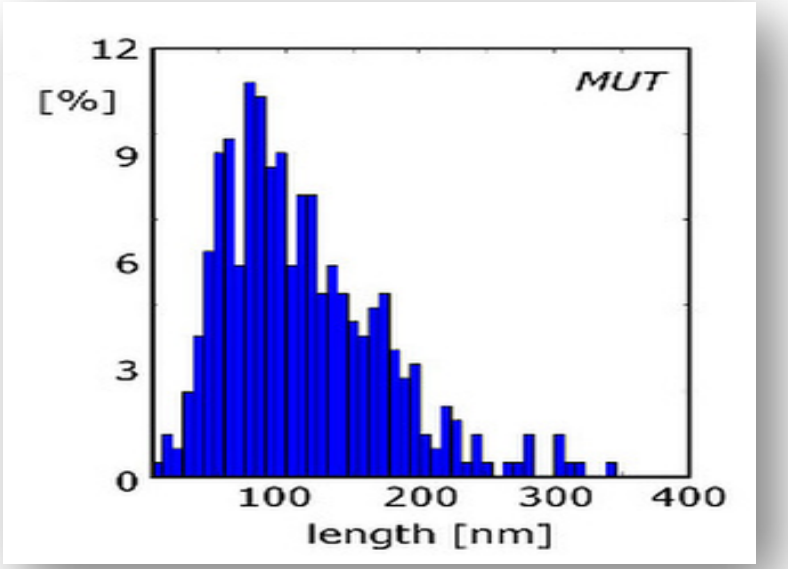


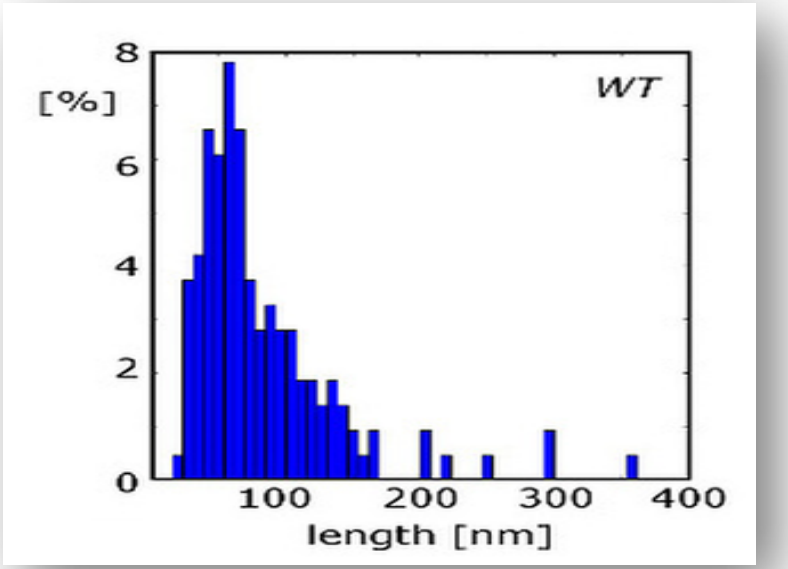
Anderson et al. 2016

- volume fraction of actin filaments in bundles:
  - wt: 0.233 +/- 0.073 (0.153)
  - mut: 0.362 +/- 0.116 (0.242)

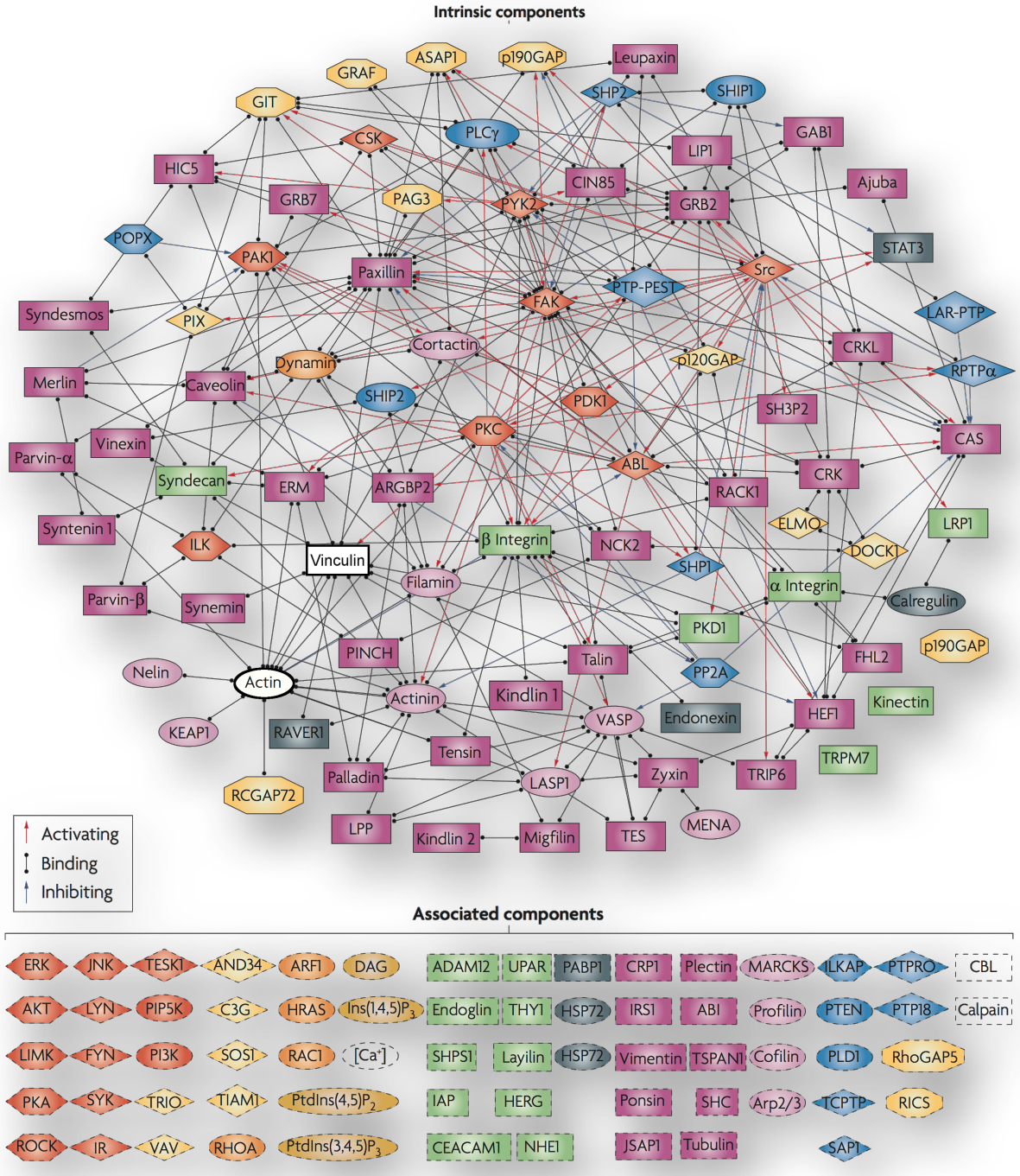
- volume fraction of actin filaments in protrusions:
  - wt: 0.287 +/- 0.095 (0.191)
  - mut: 0.384 +/- 0.084 (0.256)

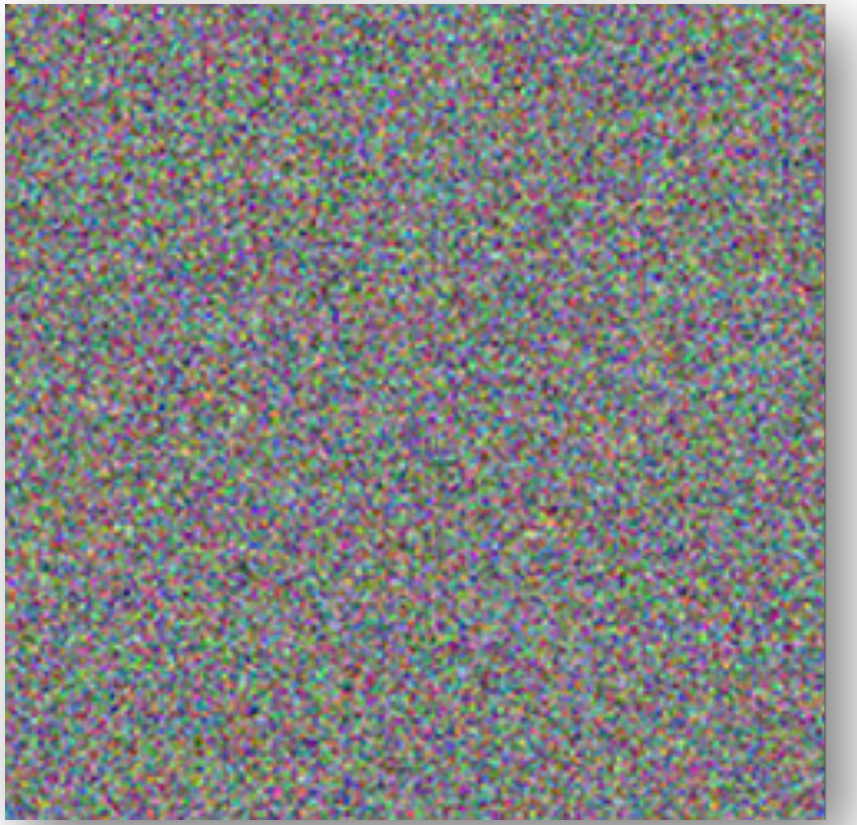





Anderson et al. 2016


Intrinsic components
ASAP1
p190GAP
Leupaxin
GRAF
SHP2
SHIP1
GIT
PLCγ
GAB1
CSK
LIP1
HIC5
CIN85
Ajuba
GRB7
PAG3
PYK2
GRB2
POPX
STAT3
PAK1
Paxillin
Src
PTP-PEST
Syndesmos
FAK
LAR-PTP
PIX
Cortactin
CRKL
Dynamin
p120GAP
RPTPα
Merlin
Caveolin
SHIP2
PDK1
SH3P2
PKC
CAS
Vinexin
Parvin-α
ABL
CRK
Syndecan
ERM
ARGBP2
RACK1
Syntenin 1
ELMO
LRP1
ILK
β Integrin
NCK2
DOCK1
Vinculin
SHP1
Filamin
α Integrin
Parvin-β
Synemin
Calregulin
PKD1
PINCH
FHL2
p190GAP
Talin
Nelin
PP2A
Actin
Actinin
Kindlin 1
Kinectin
HEF1
KEAP1
RAVER1
VASP
Endonexin
Tensin
TRPM7
Palladin
Zyxin
TRIP6
LASP1
RCGAP72
MENA
LPP
Kindlin 2
Migfilin
TES
Activating
Binding
Inhibiting
Associated components
ERK
JNK
TESK1
AND34
ARF1
DAG
ADAM12
UPAR
PABP1
CRP1
Plectin
MARCKS
ILKAP
PTPRO
CBL
AKT
LYN
PIP5K
C3G
HRAS
Ins(1,4,5)P3
Endoglin
THY1
HSP72
IRS1
ABI
Profilin
PTEN
PTP18
Calpain
LIMK
FYN
PI3K
SOS1
RAC1
[Ca2+]
SHPS1
Layilin
HSP72
Vimentin
TSPAN1
Cofilin
PLD1
RhoGAP5
PKA
SYK
TRIO
TIAM1
PtdIns(4,5)P2
IAP
HERG
Ponsin
SHC
Arp2/3
TCPTP
RICS
ROCK
IR
VAV
RHOA
PtdIns(3,4,5)P3
CEACAM1
NHE1
JSAP1
Tubulin
SAP1



Mordvintsev et al. 2015

# Acknowledgements:

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Karen Anderson
Mark Swift