



# Interpretable Deep Learning for Biomedicine

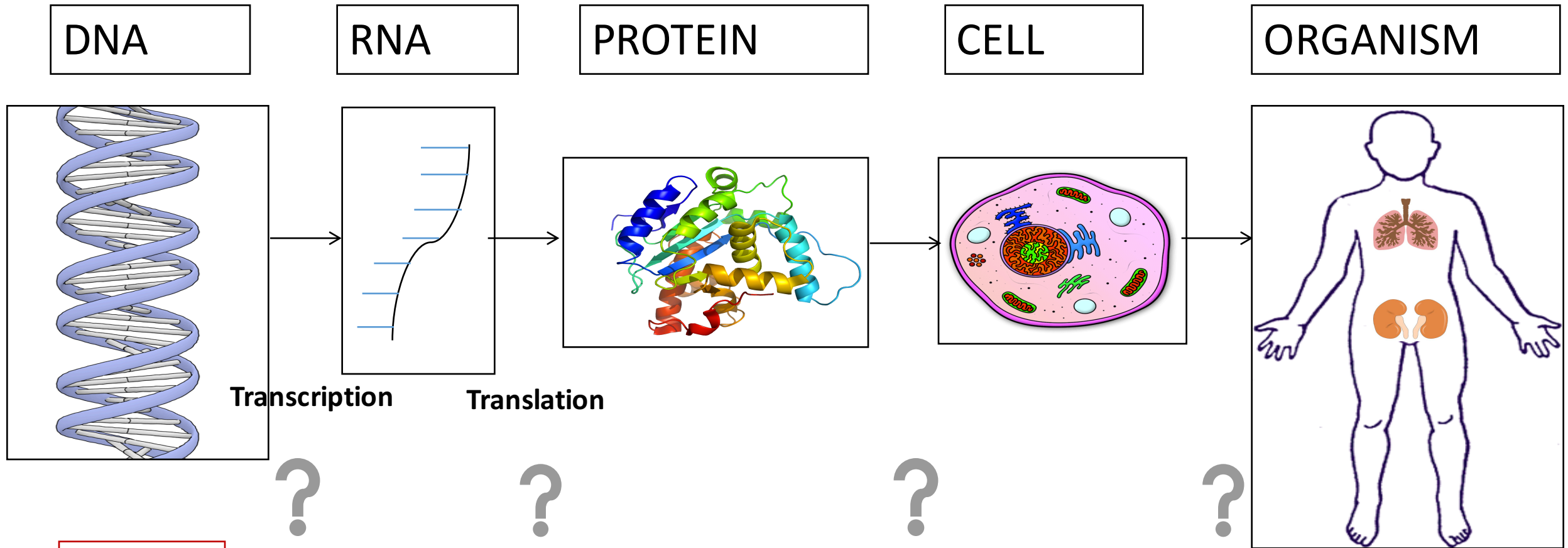
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**@ UVA Blitzarama 2018 Workshop**

# Biology in a Slide: Aim to Understand/Cure Disease



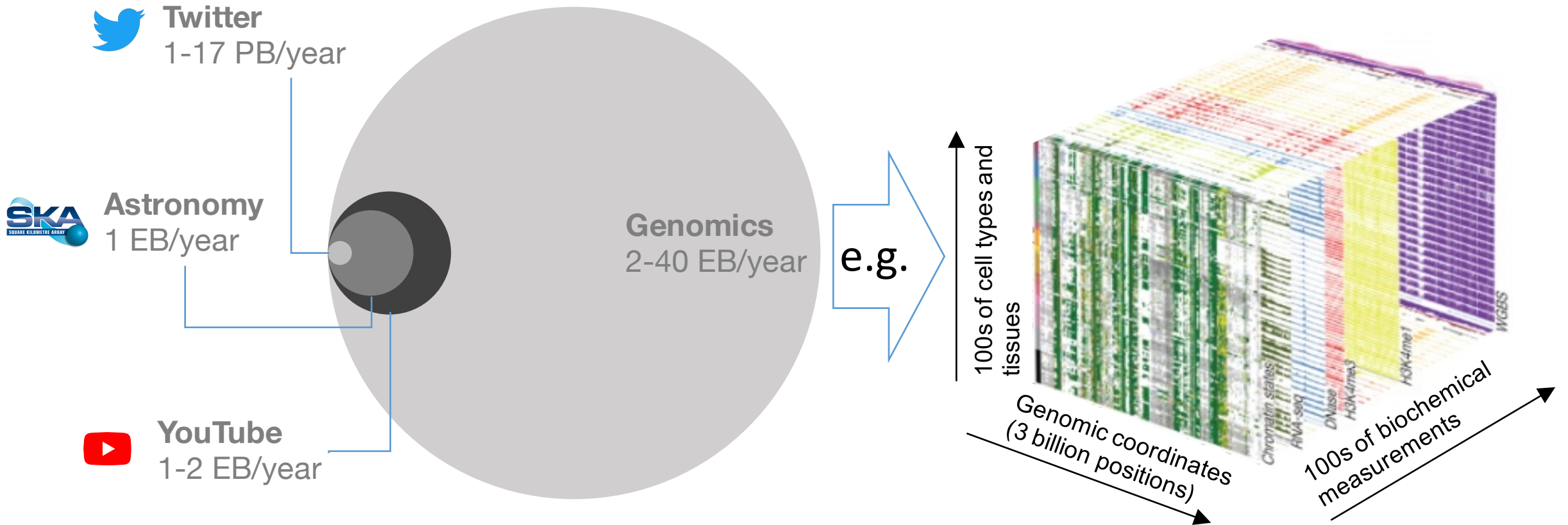
CATGACTG  
CATGCCTG

**Genetic Variant**



**Disease**

# Big Data: Large-scale genomics measurements

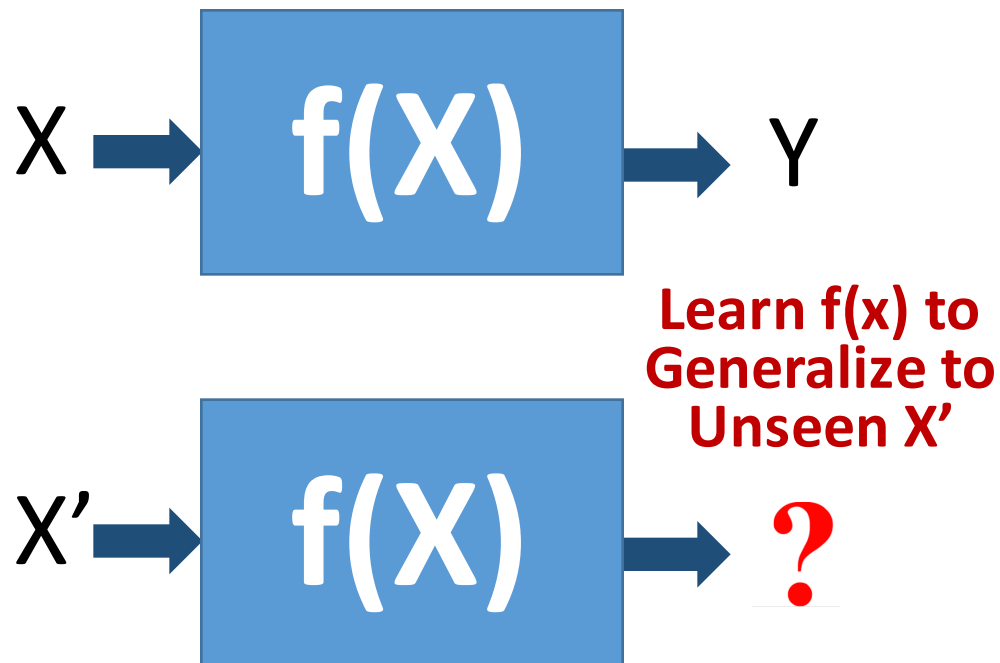


Adapted from Stephens ZD et al  
PLOS Biol 2015

<http://deepchrome.org>

# Computational Challenges: Data-Driven

- Need **inductive reasoning**
  - Generalizations from observed data to unseen data



- Able to provide **biological explanations**
- **Well-engineered software systems** providing a unified architecture to build upon
- Provide **accuracy and trust**
- **Scalable** and **Explanatory**

# Our Solution: Deep Learning

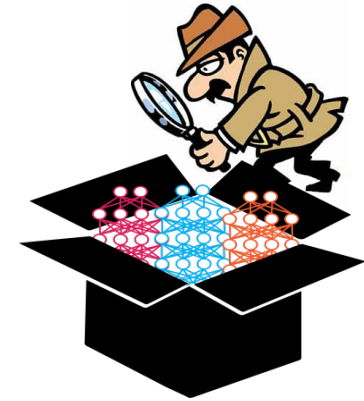
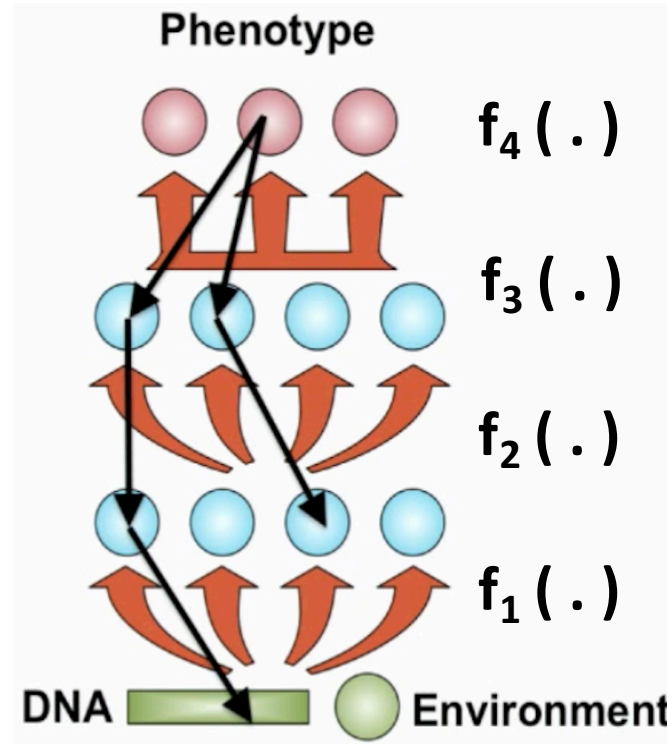
**1. Deep Learning module to reflect biological modules**

**2. Compose modules to reflect biology**

**3. Borrow ideas from human's attention strategy to open DNN black-box modeling**

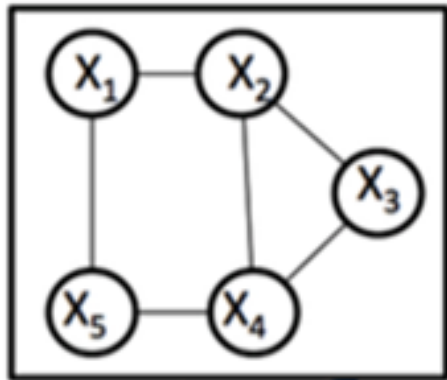


X	Y
DNA	RNA / Func
Epigenetic	RNA
DNA	Interaction to Protein (TF)
Protein	Funcs
Protein	Interaction to DNA/RNA
10/10/18 ...	...



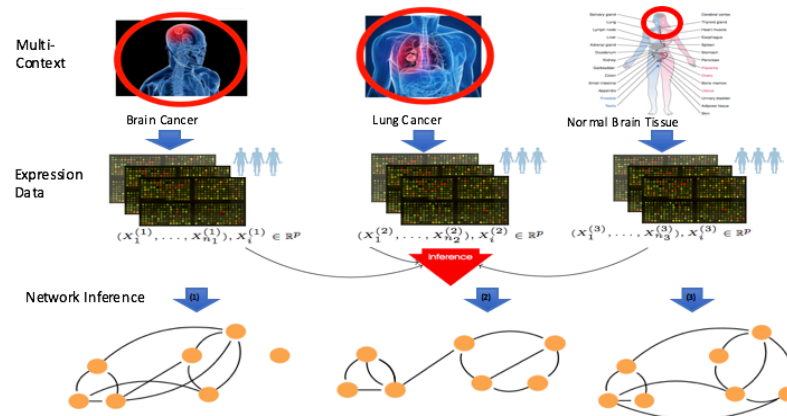
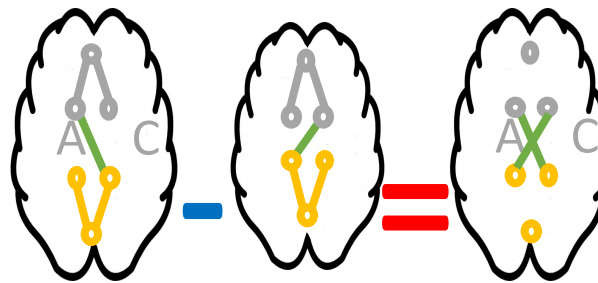
# Our Solution (more): from Data to Connectome

**1. Graphical Models to reflect interactions among important**



$X_i$	$X_j$
Protein	Protein
Gene	Gene
Protein	DNA/RNA
Neuron Region	Neuron Region
...	....

**2. Consider Sample Heterogeneity to reflect network biology**

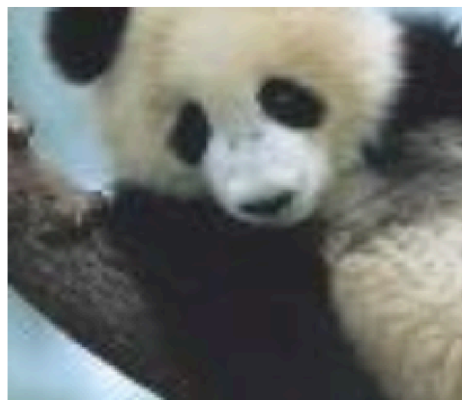


jointnets.org

- Joint graph discovery
- From heterogeneous samples
- Fast and scalable graph estimators
- Parallelizable method (GPU, multi-threading)
- Sharp convergence rate (sharp error bounds)

# Our Solution (more): Making Deep Learning Robust

<http://trustworthymachinelearning.org>



“panda”



+

$0.007 \times [\textit{noise}]$

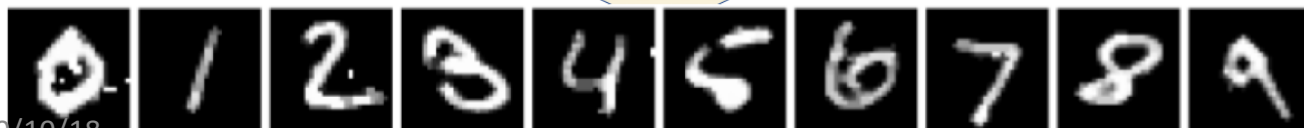
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“gibbon”



Squeeze Features



Weilin Xu, David Evans, Yanjun Qi. *Feature Squeezing: Detecting Adversarial Examples in Deep Neural Networks*. *2018 Network and Distributed System Security Symposium*. NDSS2018