

# N2A

## A neuroinformatics framework



# The Challenge



Society for Neuroscience  
>30,000 scientists attend  
>1,000 topic areas presented

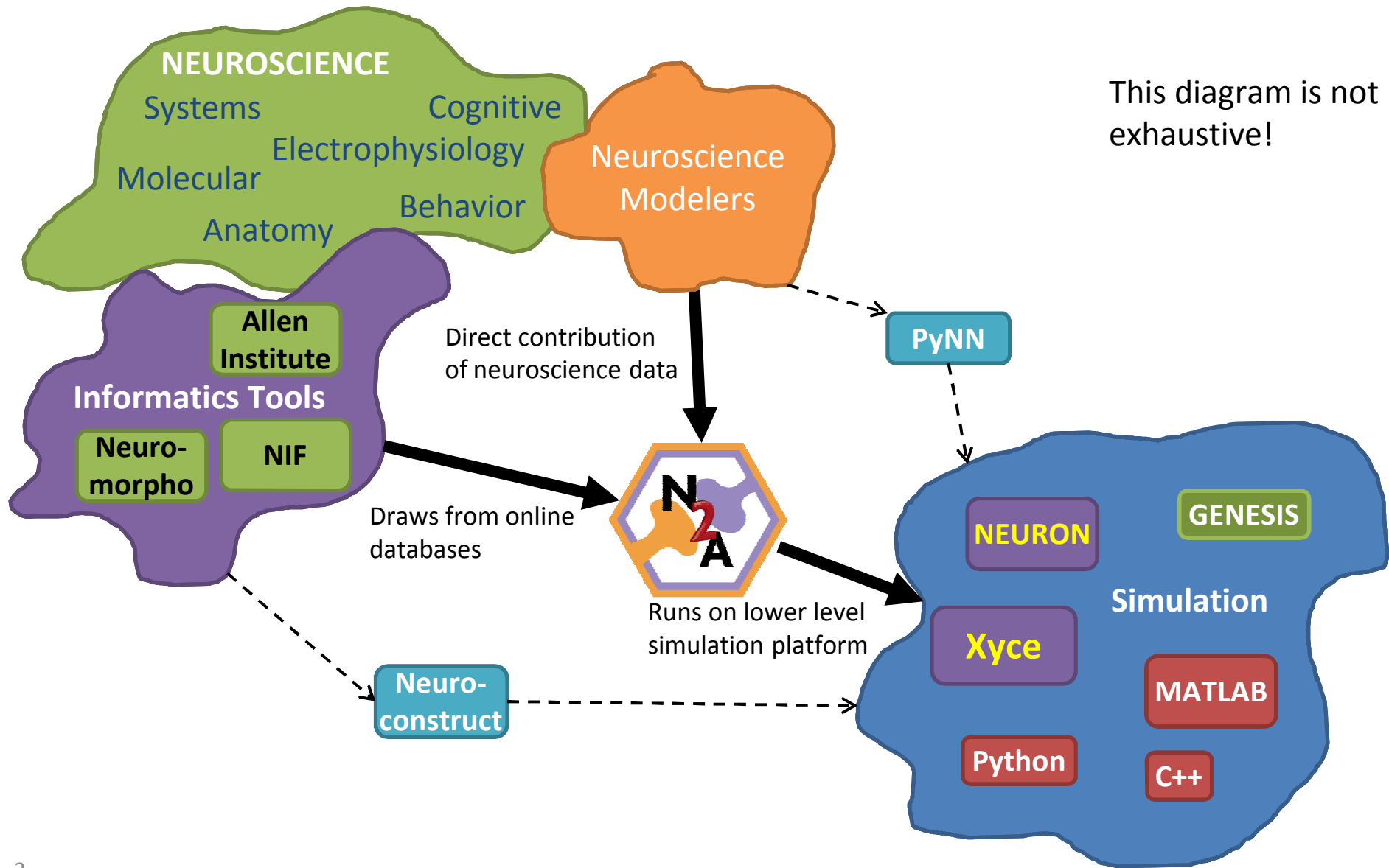
Need to integrate all this knowledge. Beyond capacity of anyone to comprehend.

Complete model of human cognition *cannot* exist as an idea in one person's mind.

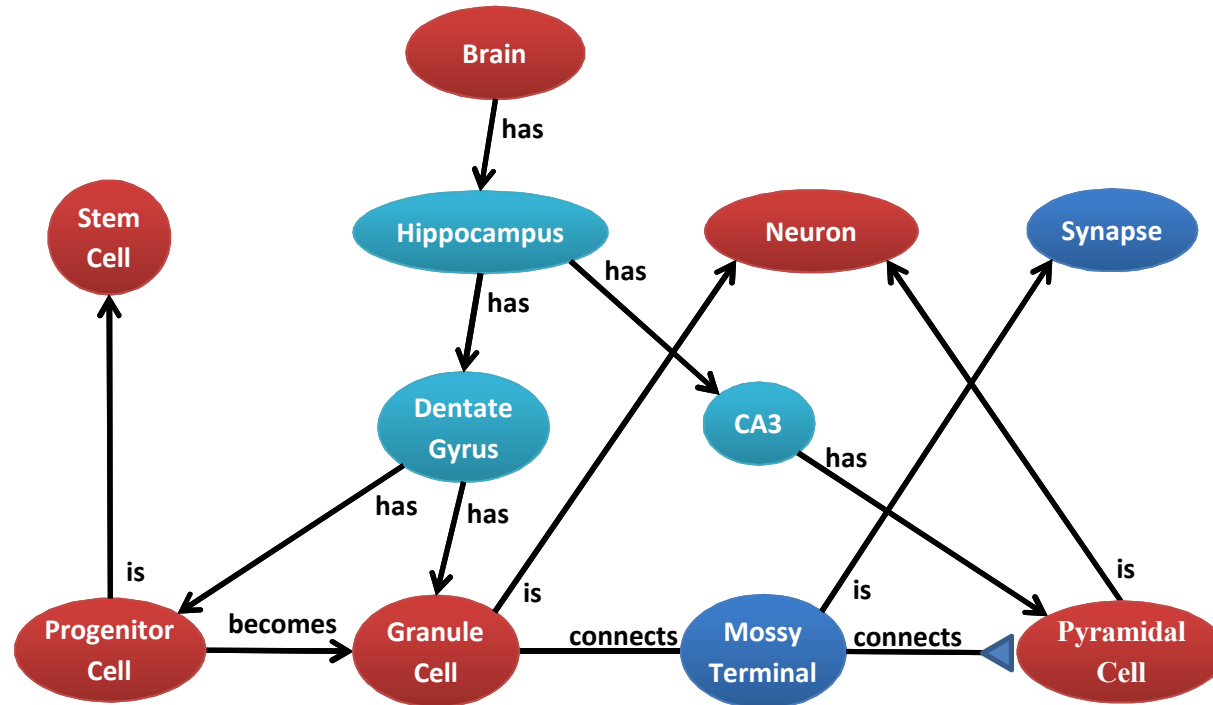
Must be an information structure held in a large computer system.

# Neuroinformatics Vision

This diagram is not exhaustive!



# A unified modeling framework



## Attributes

Name = Hippocampus CA3 pyramidal cell

Organism = Vertebrata

Neurotransmitter released = Glutamate

Dendrite Length = 12481.9 +- 2998.9 um

Equations  
(a type of attribute)

$$V' = (G * (V_{rest} - V) + I_{inj}) / C$$

$$G = 0.3$$

...

# Example: Cable Model

## Cable Model

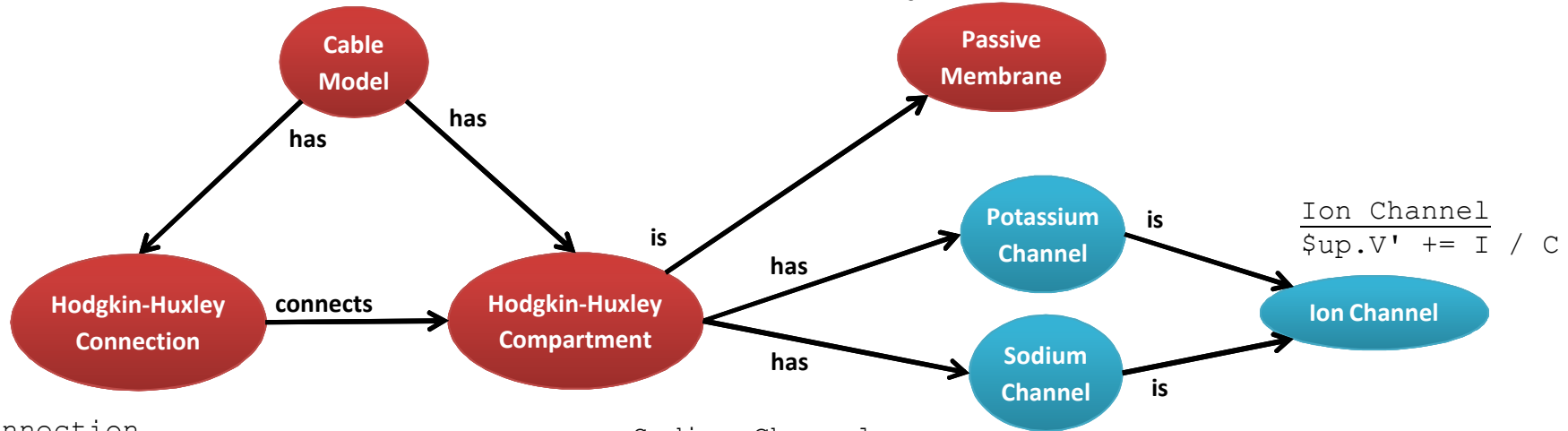
```

HH      = $include ("HH Compartment")
HH.$n   = 3
C       = $include ("HH Connection")
C.A     = HH
C.B     = HH
C.$p    = C.A.$index == C.B.$index - 1
    
```

## Passive Membrane

```

V'      = (G * (V_rest - V) + I_inj) / C
G       = 0.3
V_rest  = 10.613
C       = 1
    
```



## HH Connection

```

A      = $connect ("HH Compartment")
B      = $connect ("HH Compartment")
A.V' += (B.V - A.V) / R
B.V' += (A.V - B.V) / R
R      = 10
    
```

## HH Compartment

```

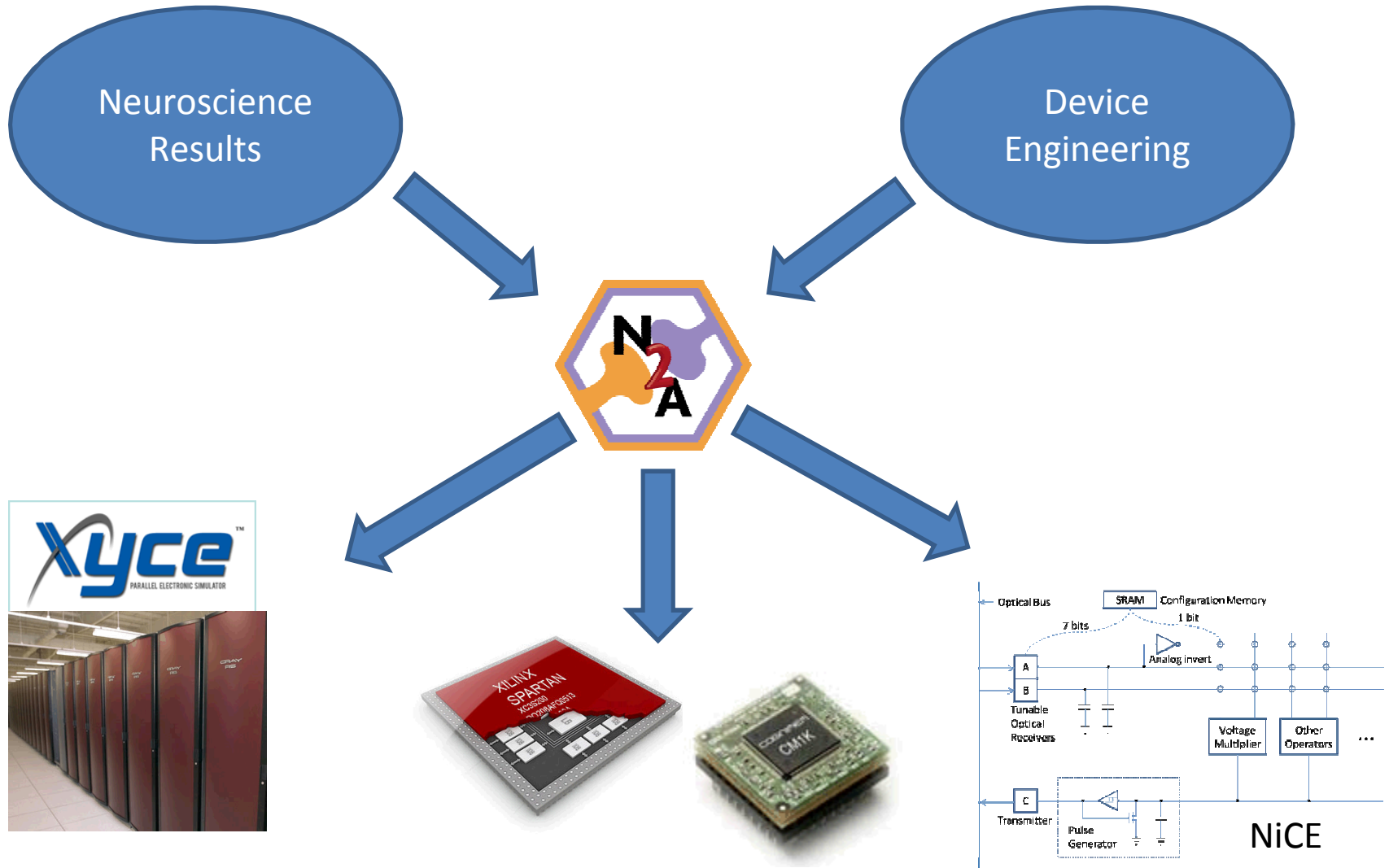
parent = $inherit ("Passive Membrane")
K      = $include ("Potassium Channel")
Na     = $include ("Sodium Channel")
    
```

## Sodium Channel

```

parent = $inherit ("Ion Channel")
I      = G * m^3 * h * (E - V)
m'     = alpha_m * (1 - m) - beta_m * m
h'     = alpha_h * (1 - h) - beta_h * h
alpha_m := (25 - V) / (10 * (exp ((25 - V) / 10) - 1))
beta_m  := 4 * exp (- V / 18)
alpha_h := 0.07 * exp (- V / 20)
beta_h  := 1 / (exp ((30 - V) / 10) + 1)
G       = 120
E       = 115
    
```

# Neural Compiler



# Neural Compiler Outputs

## Xyce

```
* seed: 1380077478872
.tran 0 0.0

* initial condition equations for HHmod

* remaining equations for HHmod
CV_1 V_1_node 0 1
BV_1_equ 0 V_1_node I={ (G_m_1 * (V_rest_1 - V(V_1_node)) + I_inj_1) / C_m_1}
.param I_inj_1 = {10.0}
.param C_m_1 = {1.0}
.param V_rest_1 = {10.613}
.param G_m_1 = {0.3}
CV_2 V_2_node 0 1
BV_2_equ 0 V_2_node I={ (G_m_1 * (V_rest_1 - V(V_2_node)) + I_inj_1) / C_m_1}
CV_3 V_3_node 0 1
BV_3_equ 0 V_3_node I={ (G_m_1 * (V_rest_1 - V(V_3_node)) + I_inj_1) / C_m_1}

* initial condition equations for HHmodHHmod

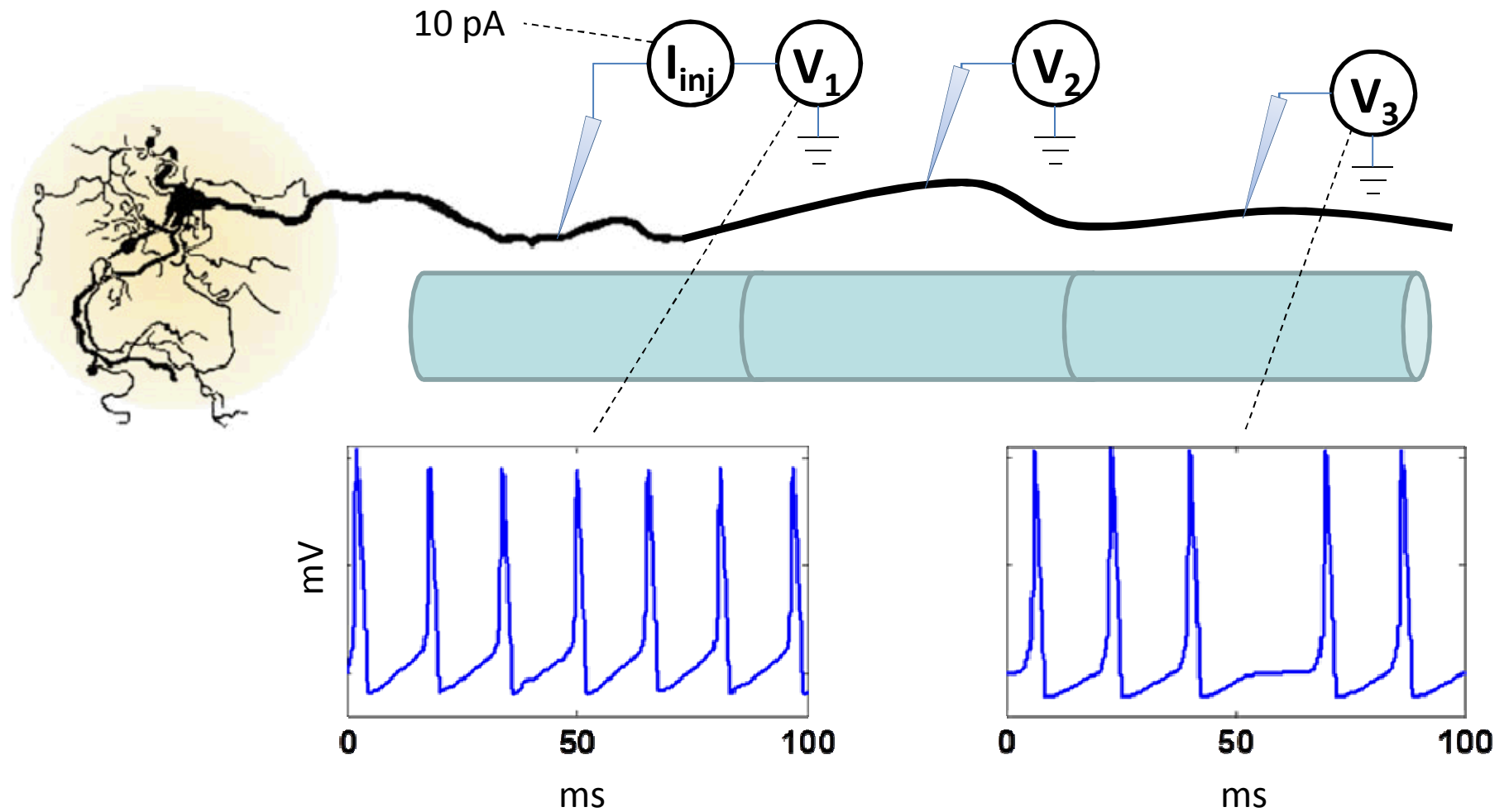
* remaining equations for HHmodHHmod
BB.V_4_equ 0 V_2_node I={ (V(V_1_node) - V(V_2_node)) / (C_m_1 * R_4)}
.param R_4 = {10.0}
BA.V_4_equ 0 V_1_node I={ (V(V_2_node) - V(V_1_node)) / (C_m_1 * R_4)}
BB.V_5_equ 0 V_3_node I={ (V(V_2_node) - V(V_3_node)) / (C_m_1 * R_4)}
BA.V_5_equ 0 V_2_node I={ (V(V_3_node) - V(V_2_node)) / (C_m_1 * R_4)}

* outputs
.print tran
```

## C++

```
class Model : public _Compartment
{
public:
    class HHmod : public _Compartment
    {
    public:
        ...
        virtual void update (float _24t, float & _24dt)
        {
            float Na_2ealpha_5fh;
            Na_2ealpha_5fh = 0.07f * exp(-V / 20.0f);
            float Na_2ealpha_5fm;
            Na_2ealpha_5fm = (25.0f - V) / (10.0f * (exp((25.0f - V) / 10.0f) - 1.0f));
            float K_2ealpha_5fn;
            K_2ealpha_5fn = (10.0f - V) / (100.0f * (exp((10.0f - V) / 10.0f) - 1.0f));
            float Na_2ebeta_5fh;
            Na_2ebeta_5fh = 1.0f / (exp((30.0f - V) / 10.0f) + 1.0f);
            float Na_2ebeta_5fm;
            Na_2ebeta_5fm = 4.0f * exp(-V / 18.0f);
            float K_2ebeta_5fn;
            K_2ebeta_5fn = 0.125f * exp(-V / 80.0f);
            _nextV_27 += (0.3f * (10.613f - V) + I_5finj) / 1.0f + K_2el / 1.0f + Na_2el / 1.0f;
            Na_2eh_27 = Na_2ealpha_5fh * (1.0f - Na_2eh) - Na_2ebeta_5fh * Na_2eh;
            Na_2el = 120.0f * pow (Na_2em, 3.0f) * Na_2eh * (115.0f - V);
            K_2el = 36.0f * pow (K_2en, 4.0f) * (-12.0f - V);
            Na_2em_27 = Na_2ealpha_5fm * (1.0f - Na_2em) - Na_2ebeta_5fm * Na_2em;
            K_2en_27 = K_2ealpha_5fn * (1.0f - K_2en) - K_2ebeta_5fn * K_2en;
            if (_24index == 0.0f)
                I_5finj = 10.0f;
        }
        ...
    };
};
```

# Typical behavior



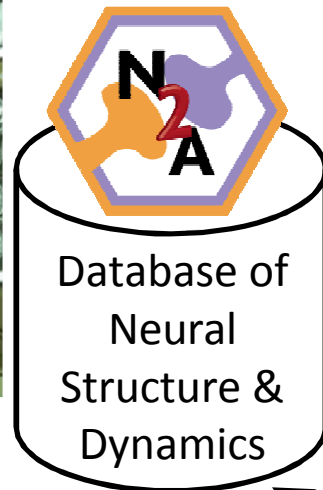
# Backup Slides

# Workflow



- Contributed models
- Neurophysiology literature
- Online databases

- Visualization
- Automatic analysis



Simulate



Fit parameters

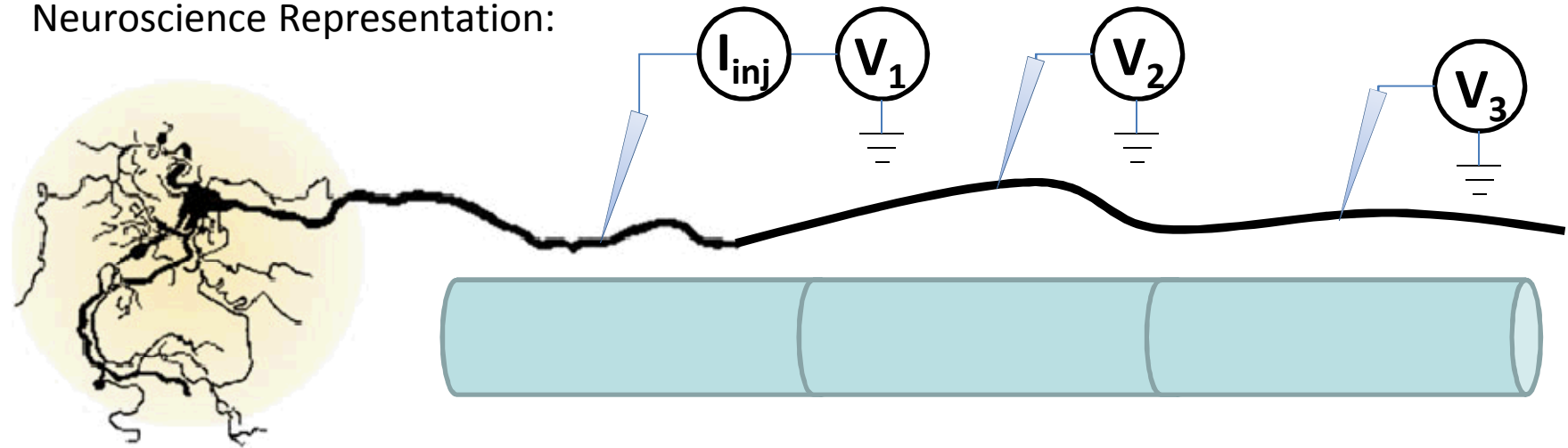


Characterize model behavior

Algorithmic motifs

# Simulate spike propagation through a Hodgkin-Huxley cable

Neuroscience Representation:



N2A Representation:

