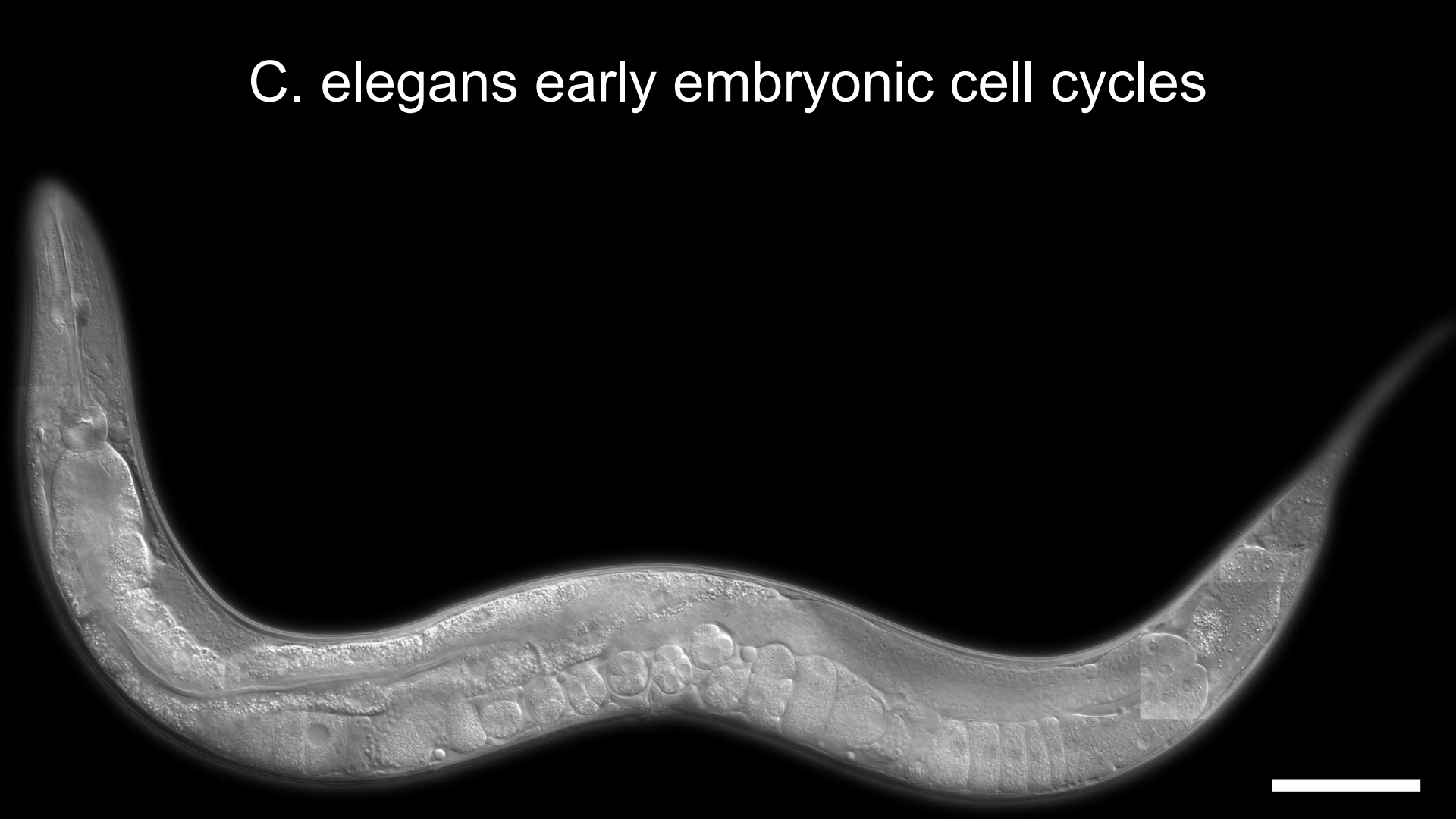
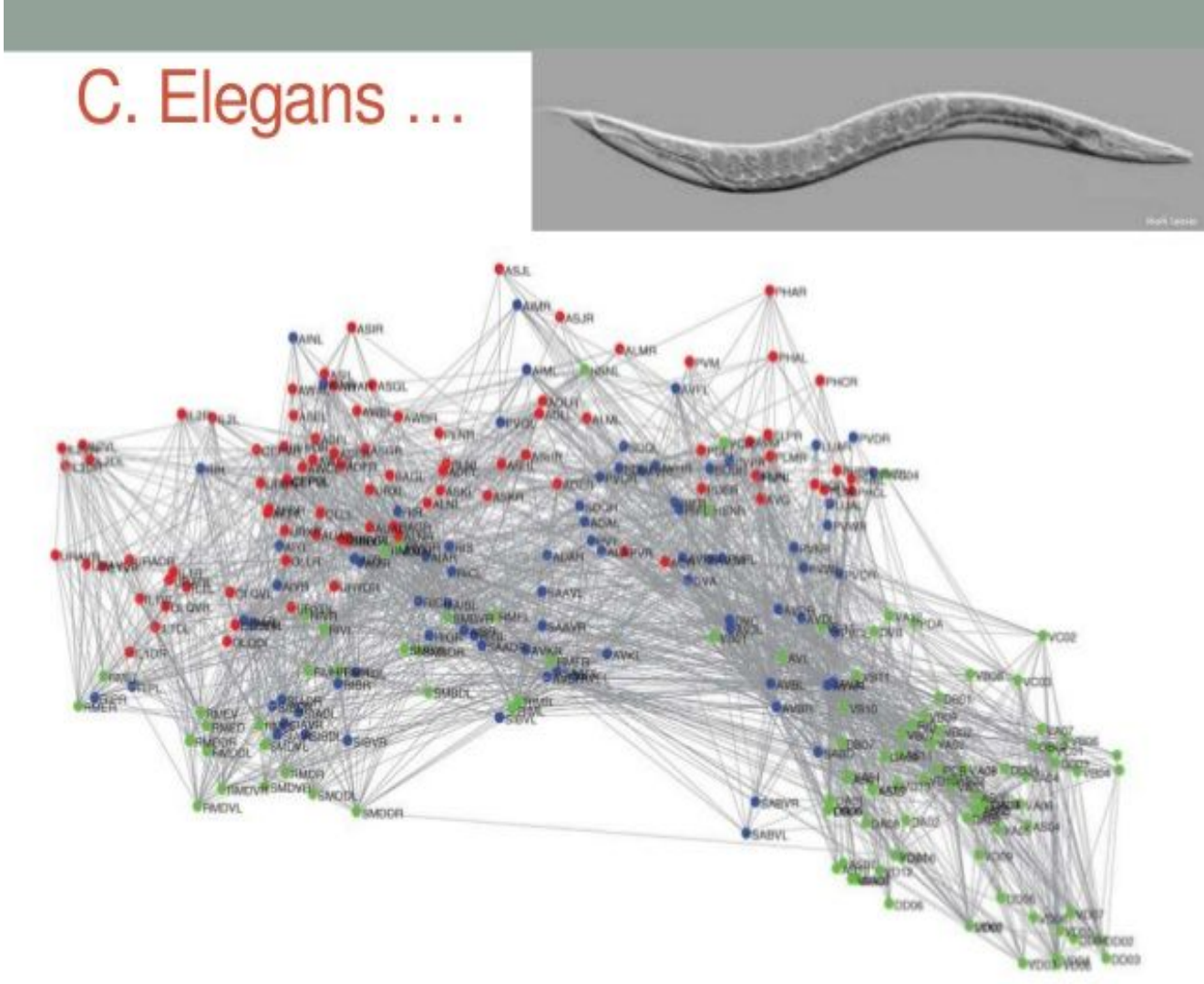
C. elegans early embryonic cell cycles



Background: A Popular Model Organism

- First multicellular organism to have its genome completely sequenced
- Has had its “connectome”, the wiring of its 302 neurons, mapped. The resulting network has small world properties.



C. elegans cell cycle, late embryo/ larval stages

Phase 1: Gap 1

Phase 2: Synthesis (genome duplicates)

Phase 3: Gap 2

Phase 4: Mitosis (cell divides into daughter cells)

C. elegans cell cycle, ~~late embryo/ larval stages~~ early embryo development

~~Phase 1: Gap 1~~

Phase 2: Synthesis (genome duplicates)

~~Phase 3: Gap 2~~

Phase 4: Mitosis (cell divides into daughter cells)

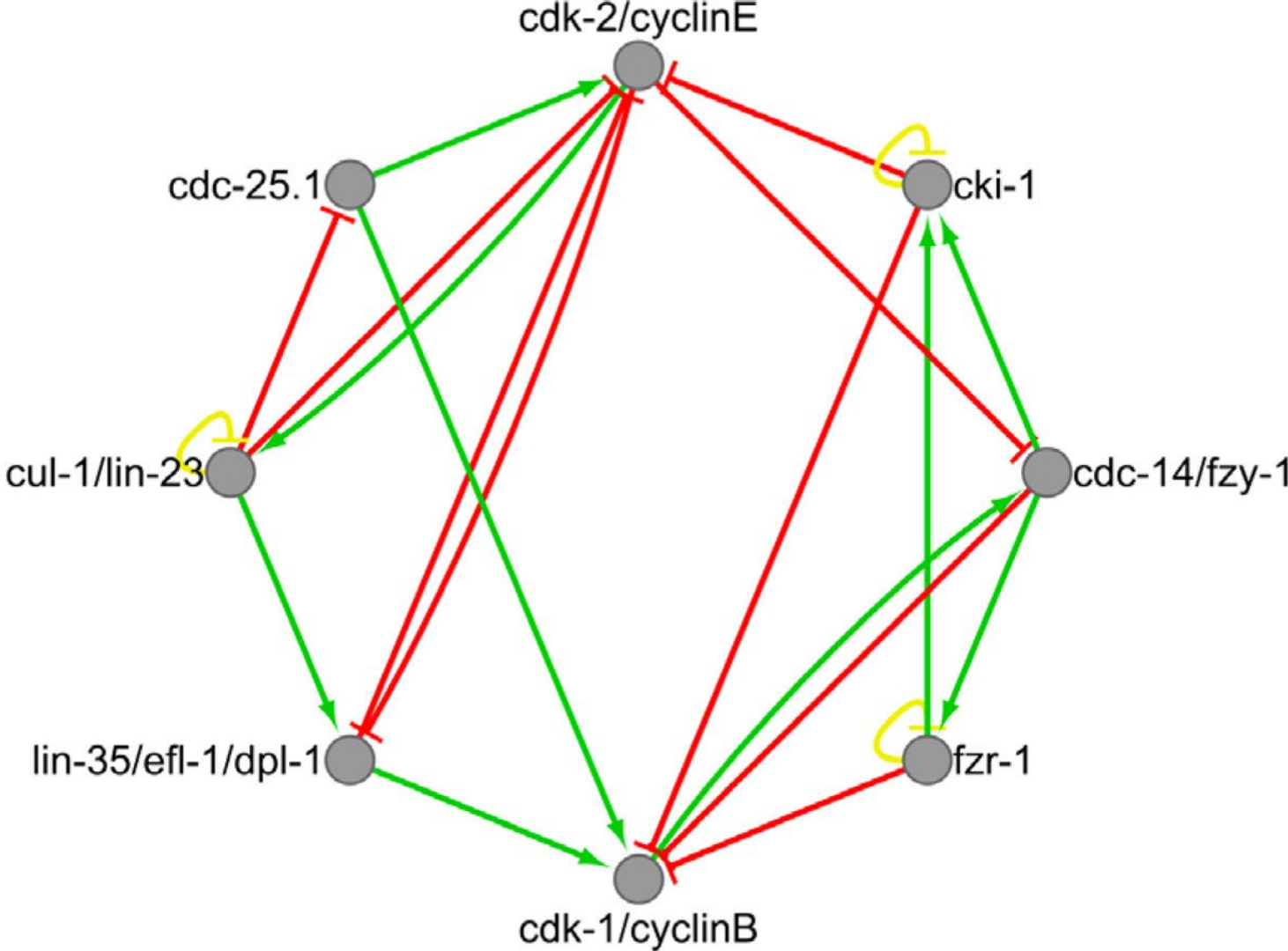
Nodes = 8

Red Edge = Deactivation (-1)

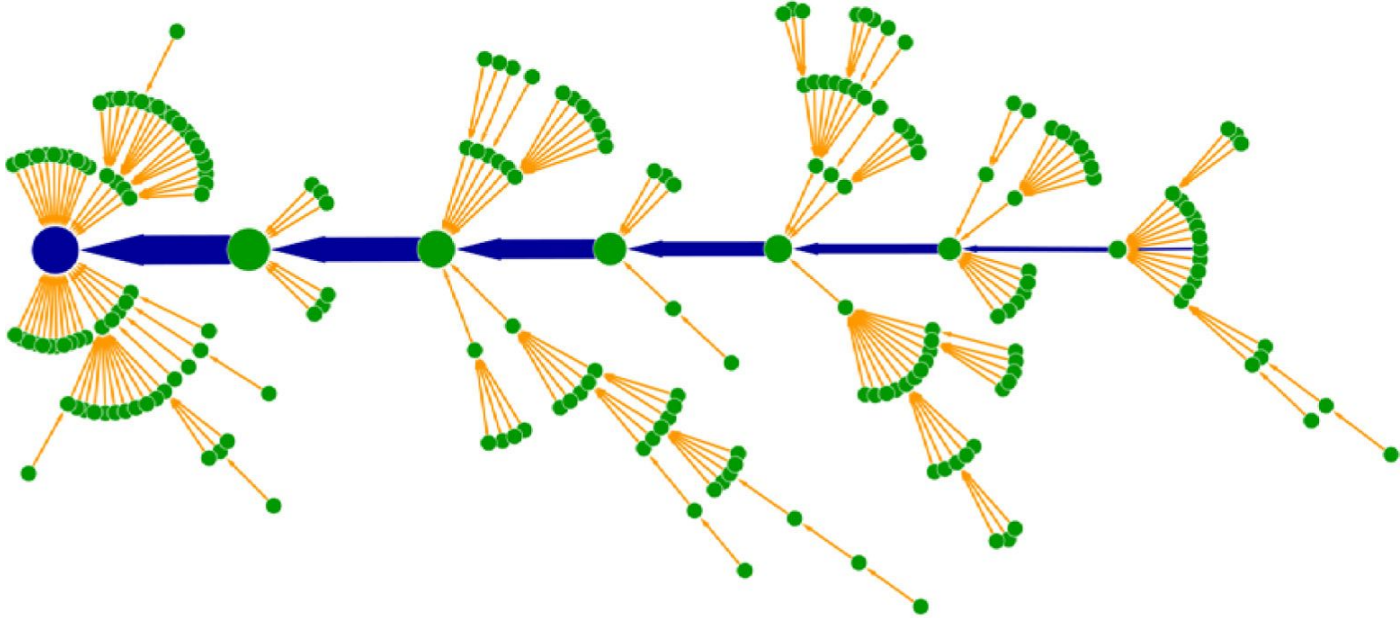
Green Edge = Activation (1)

Yellow Edge = Self Degradation (-1)

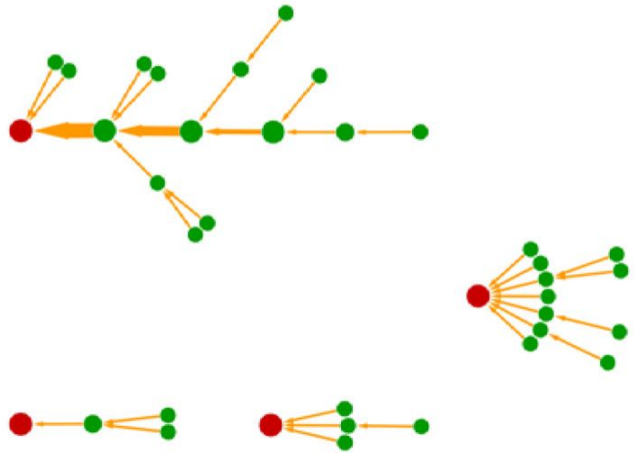
Node Threshold = 0



$2^8 = 256$ possible initial states

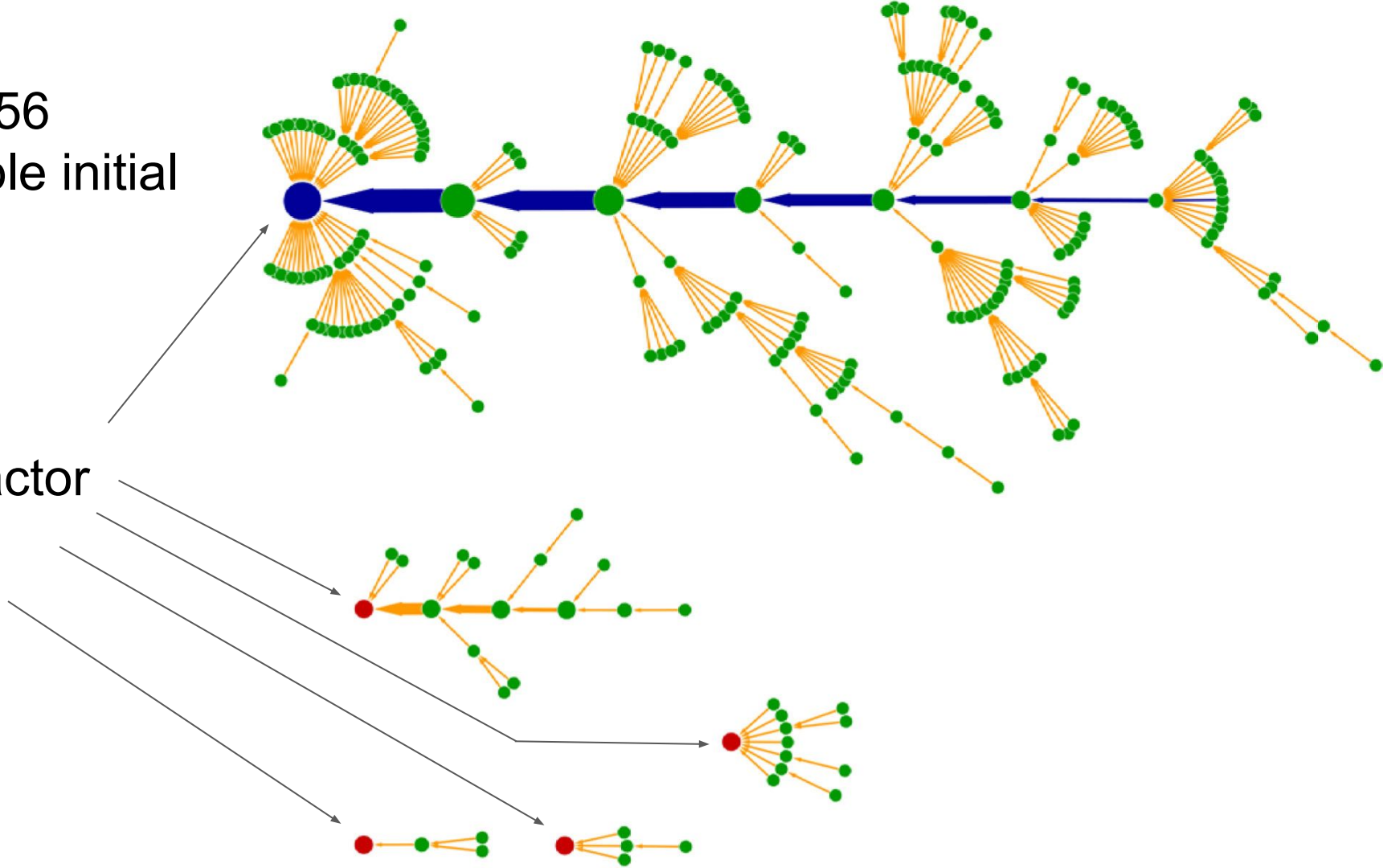


Largest Attractor Basin Size = 219 (85.5% of possible states)



$2^8 = 256$ possible initial states

5 attractor states



1) 01110001

2) 01110000

3) 01110101

4) 01110100

5) 00000000

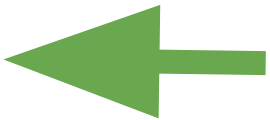
1) 01110001

2) 01110000

3) 01110101

4) 01110100

5) 00000000



Biologically
Functional Attractor

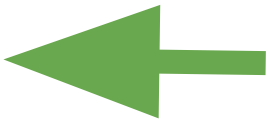
1) 01110001

2) 01110000

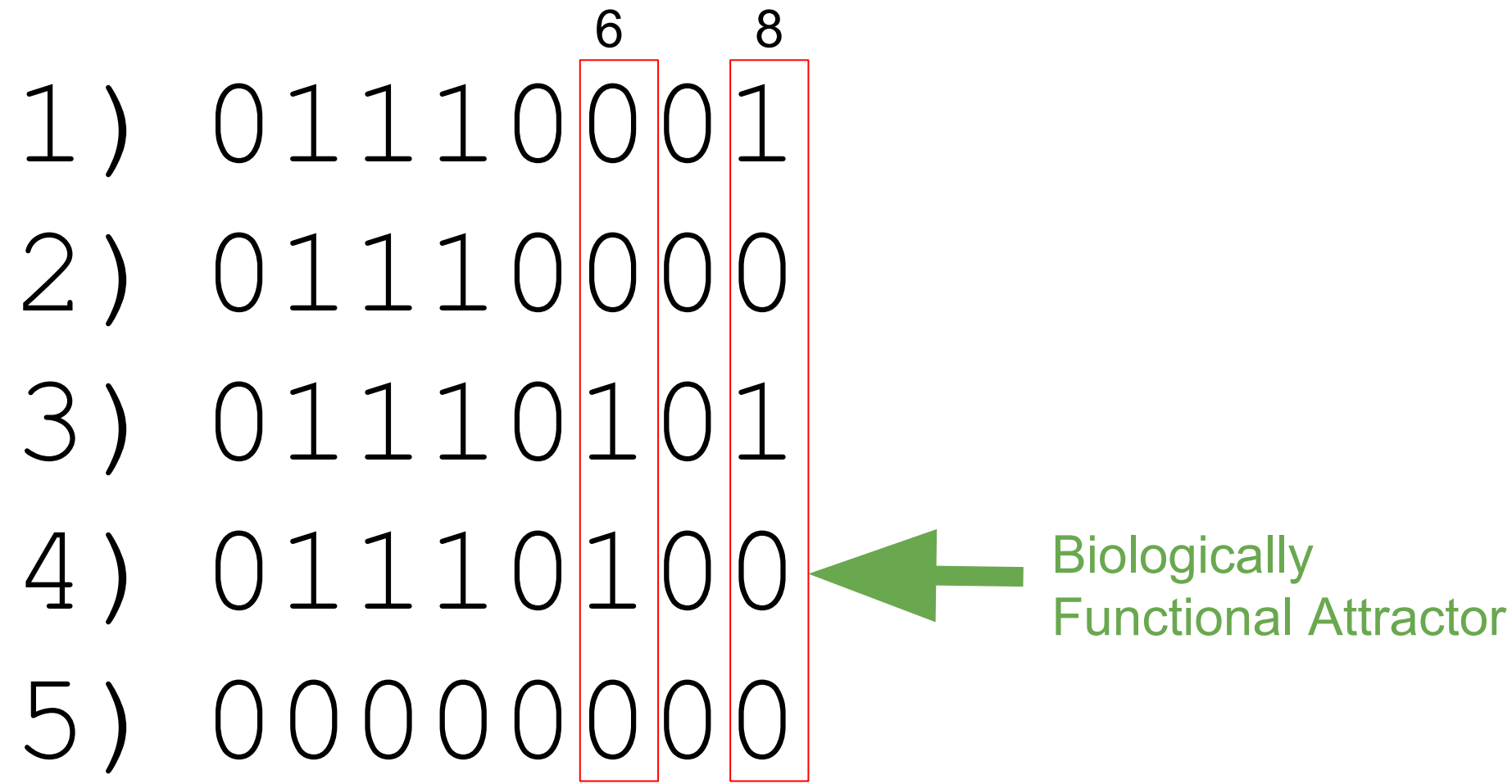
3) 01110101

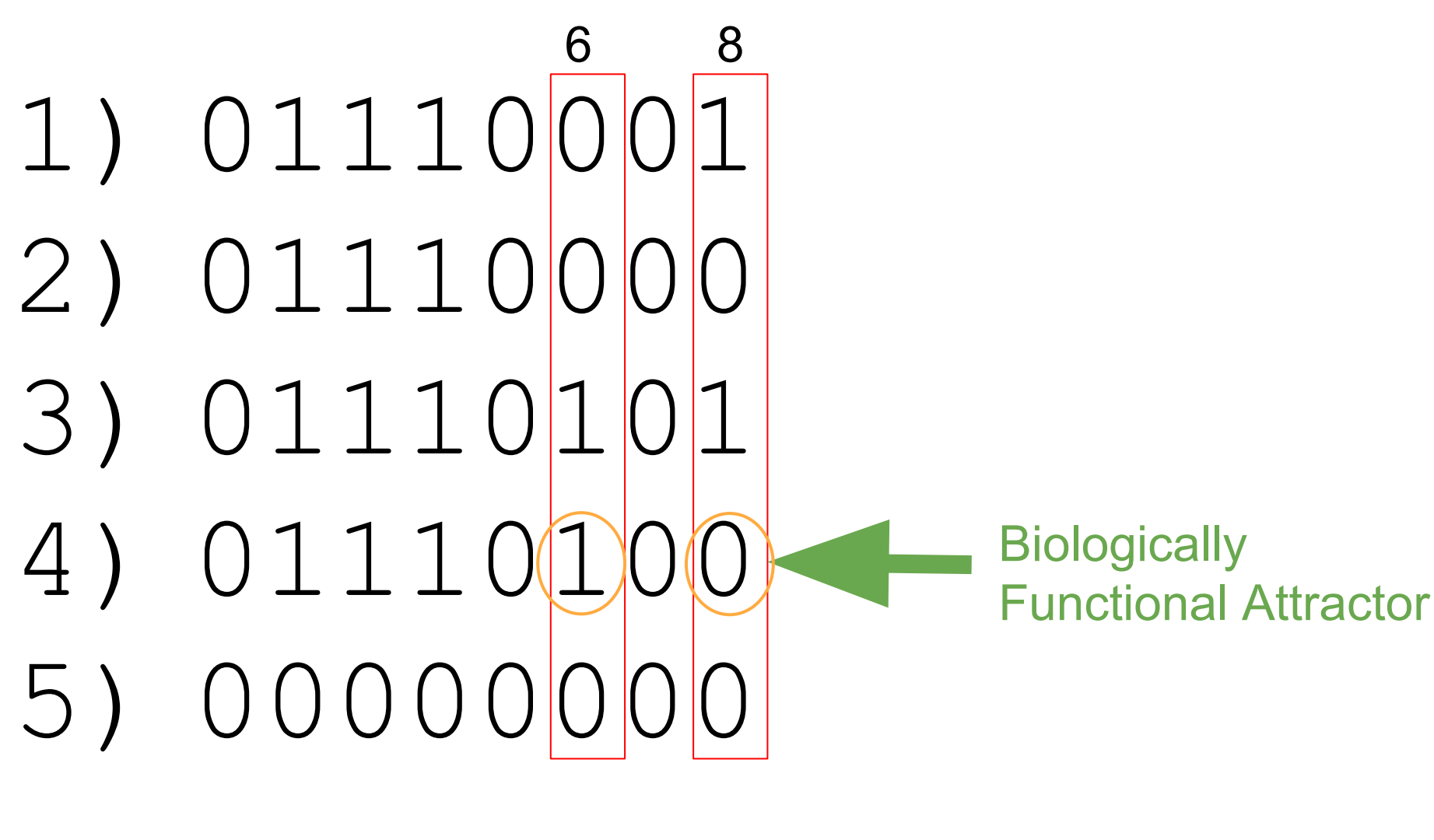
4) 01110100

5) 00000000



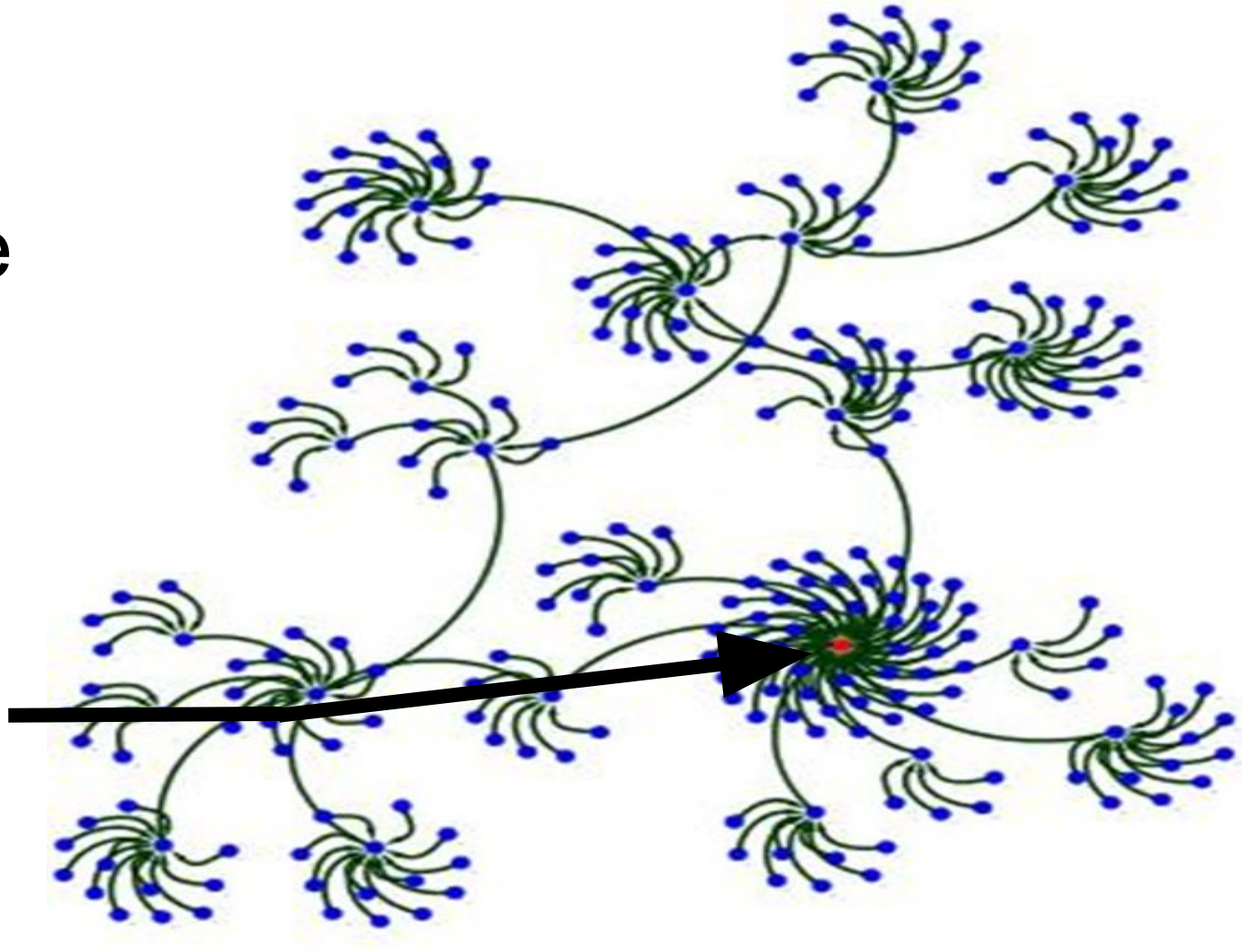
Biologically
Functional Attractor

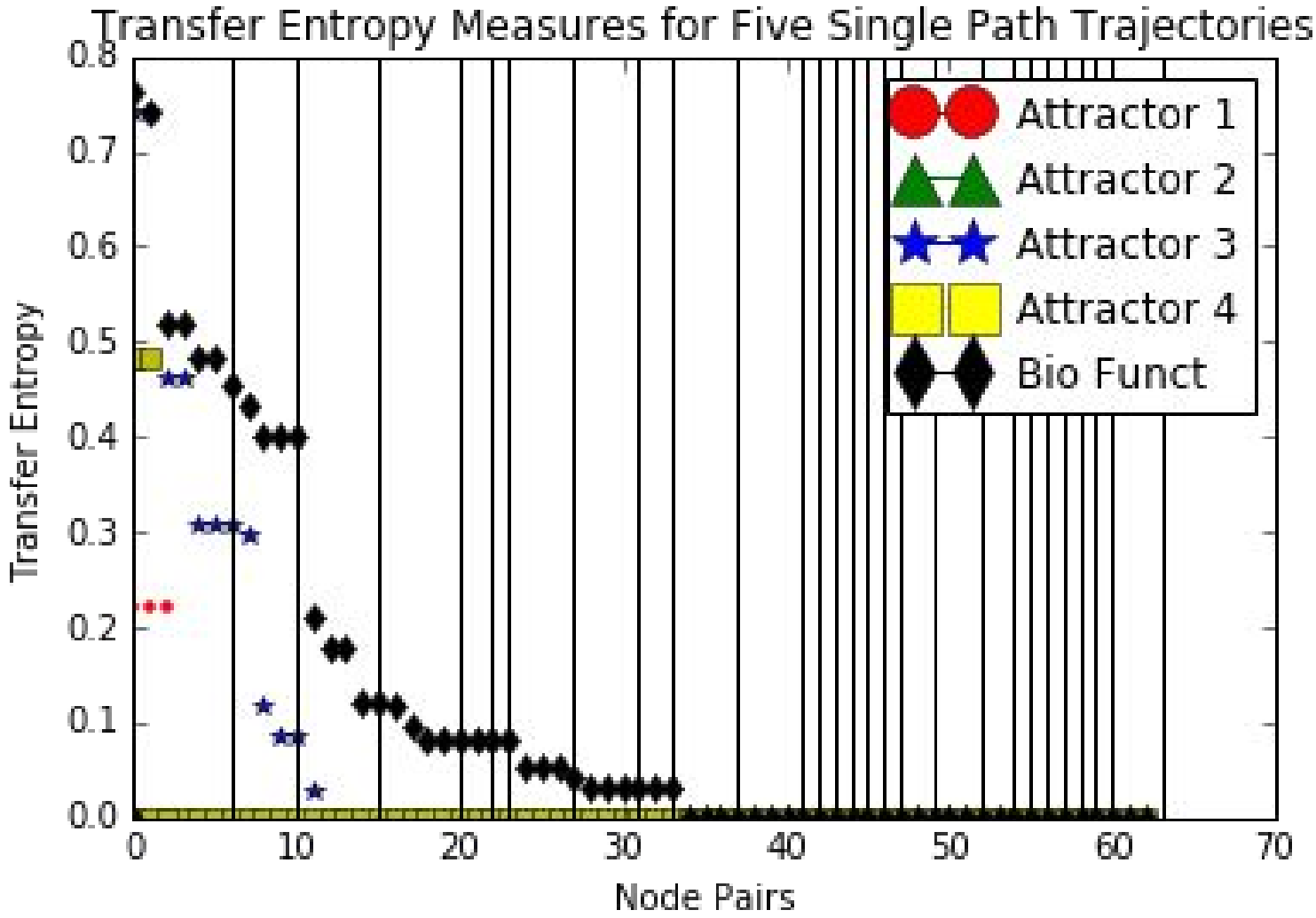

6
8
1) 01110001
2) 01110000
3) 01110101
4) 01110100
5) 00000000
Biologically
Functional Attractor

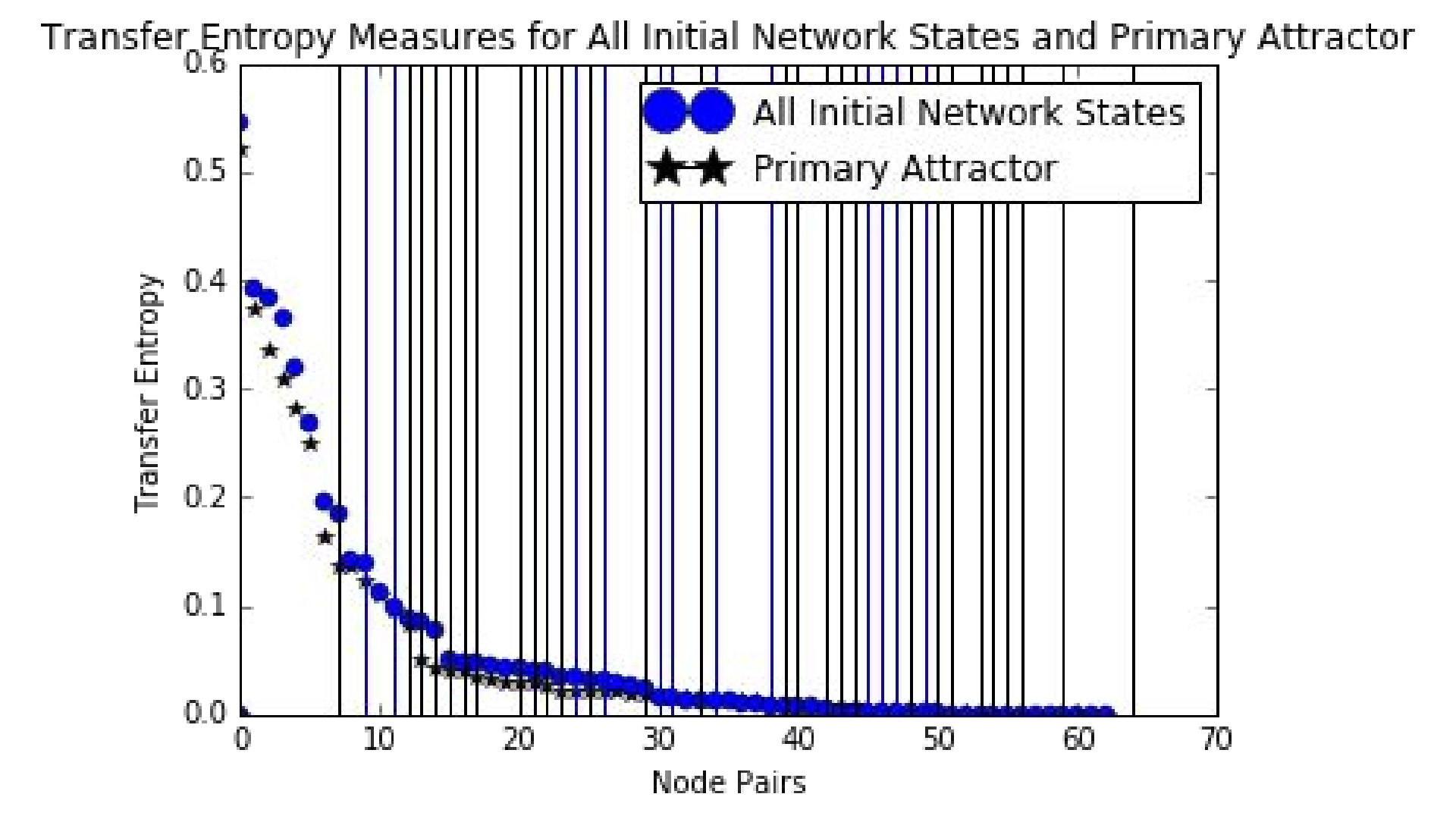

6
8
1) 01110001
2) 01110000
3) 01110101
4) 01110100
5) 00000000
Biologically
Functional Attractor

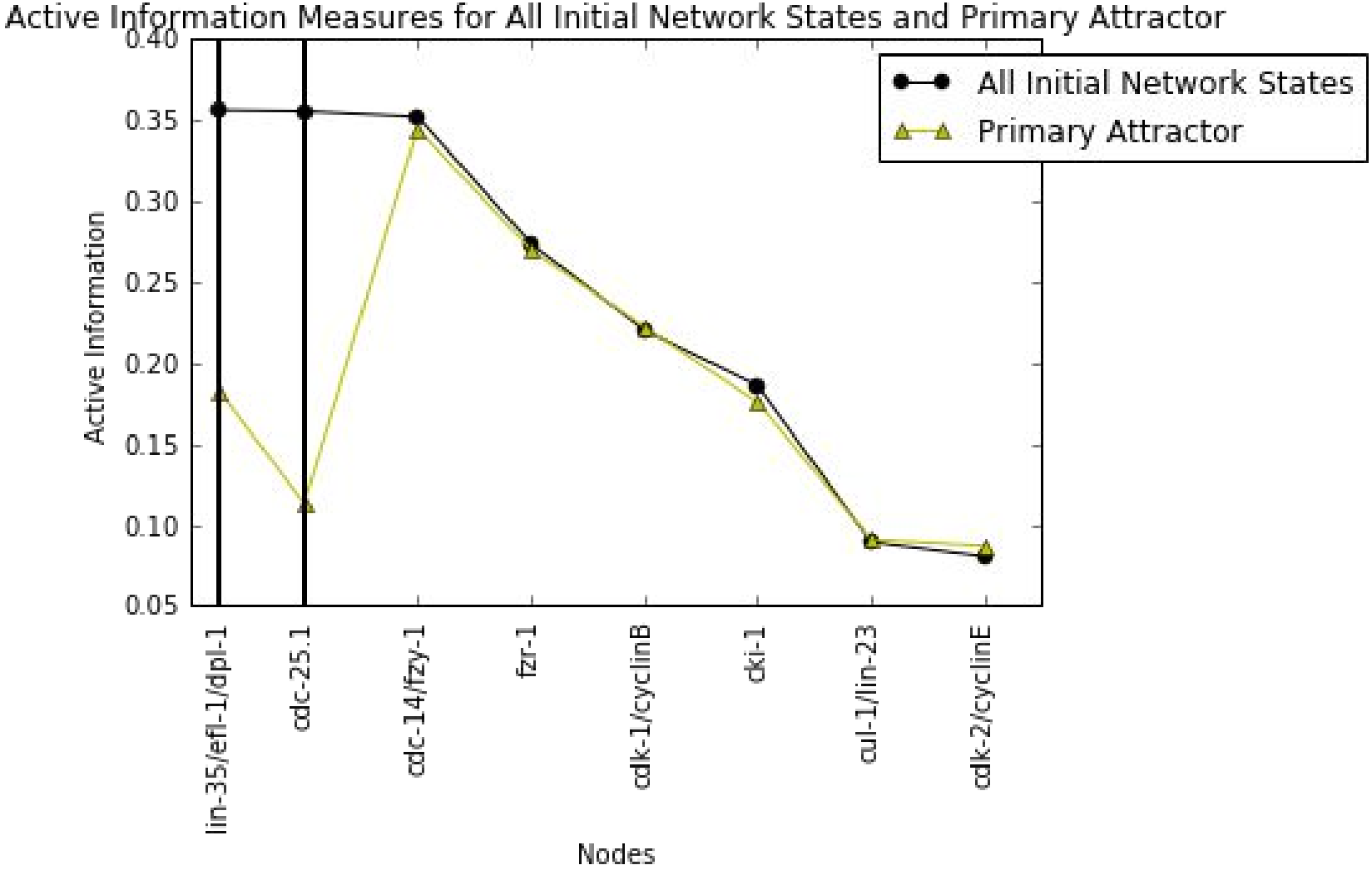
Attractor Landscape Influenced by Control Kernel

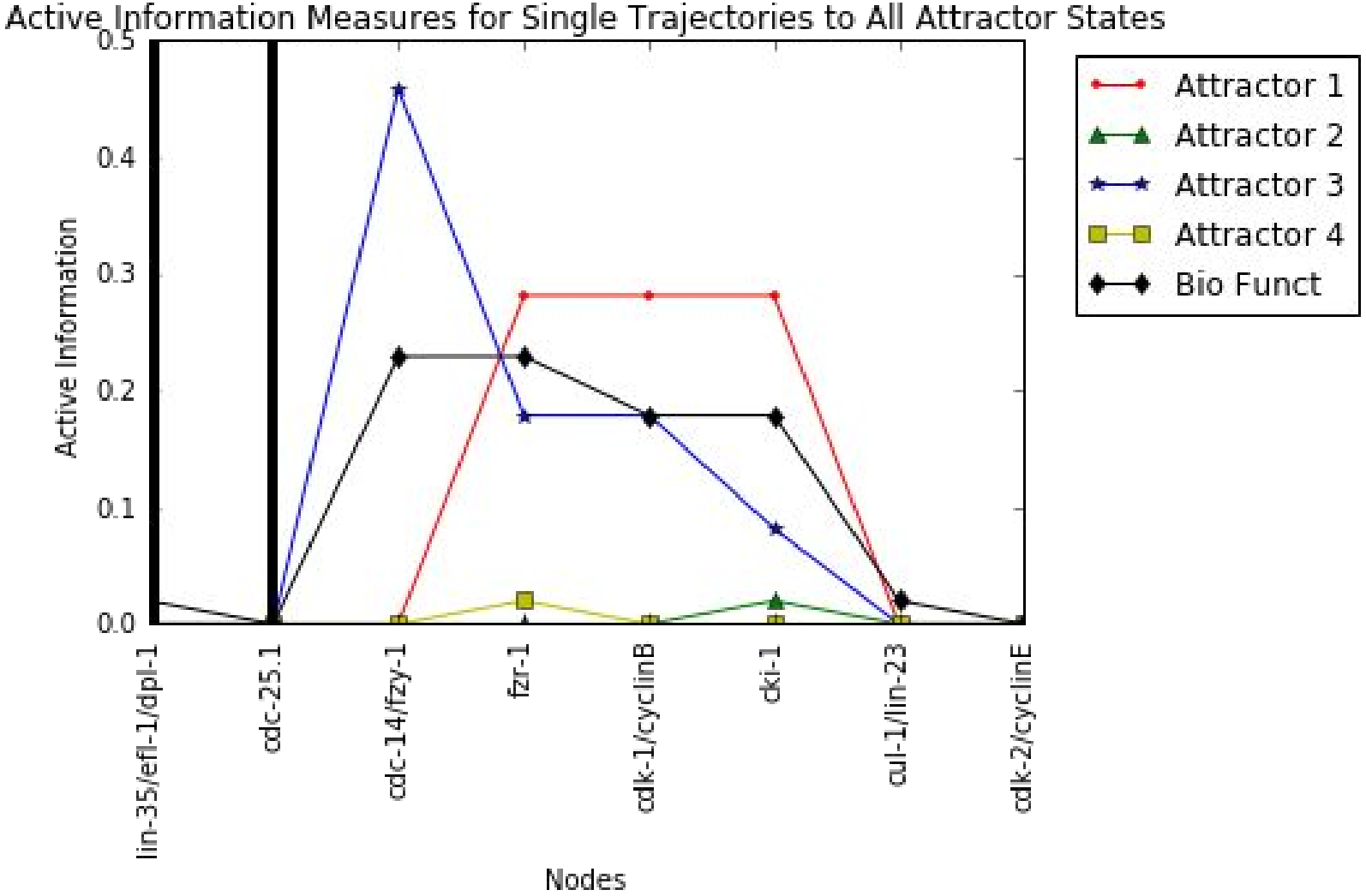
Only 1 attractor (the biologically functional one)




Transfer Entropy Measures for Five Single Path Trajectories
Transfer Entropy
Node Pairs
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
10
20
30
40
50
60
70
Attractor 1
Attractor 2
Attractor 3
Attractor 4
Bio Funct


Transfer Entropy Measures for All Initial Network States and Primary Attractor
All Initial Network States
Primary Attractor
Transfer Entropy
Node Pairs
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0
10
20
30
40
50
60
70


Active Information Measures for All Initial Network States and Primary Attractor
All Initial Network States
Primary Attractor
Active Information
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
lin-35/efl-1/dpl-1
cdc-25.1
cdc-14/fzy-1
fzr-1
cdk-1/cyclinB
cki-1
cul-1/lin-23
cdk-2/cyclinE
Nodes


Active Information Measures for Single Trajectories to All Attractor States
Active Information
0.0
0.1
0.2
0.3
0.4
0.5
lin-35/efl-1/dpl-1
cdc-25.1
cdc-14/fzy-1
fzr-1
cdk-1/cyclinB
cki-1
cul-1/lin-23
cdk-2/cyclinE
Nodes
Attractor 1
Attractor 2
Attractor 3
Attractor 4
Bio Funct