Dendrite growth increased by visual activity requires NMDA receptor and Rho GTPases

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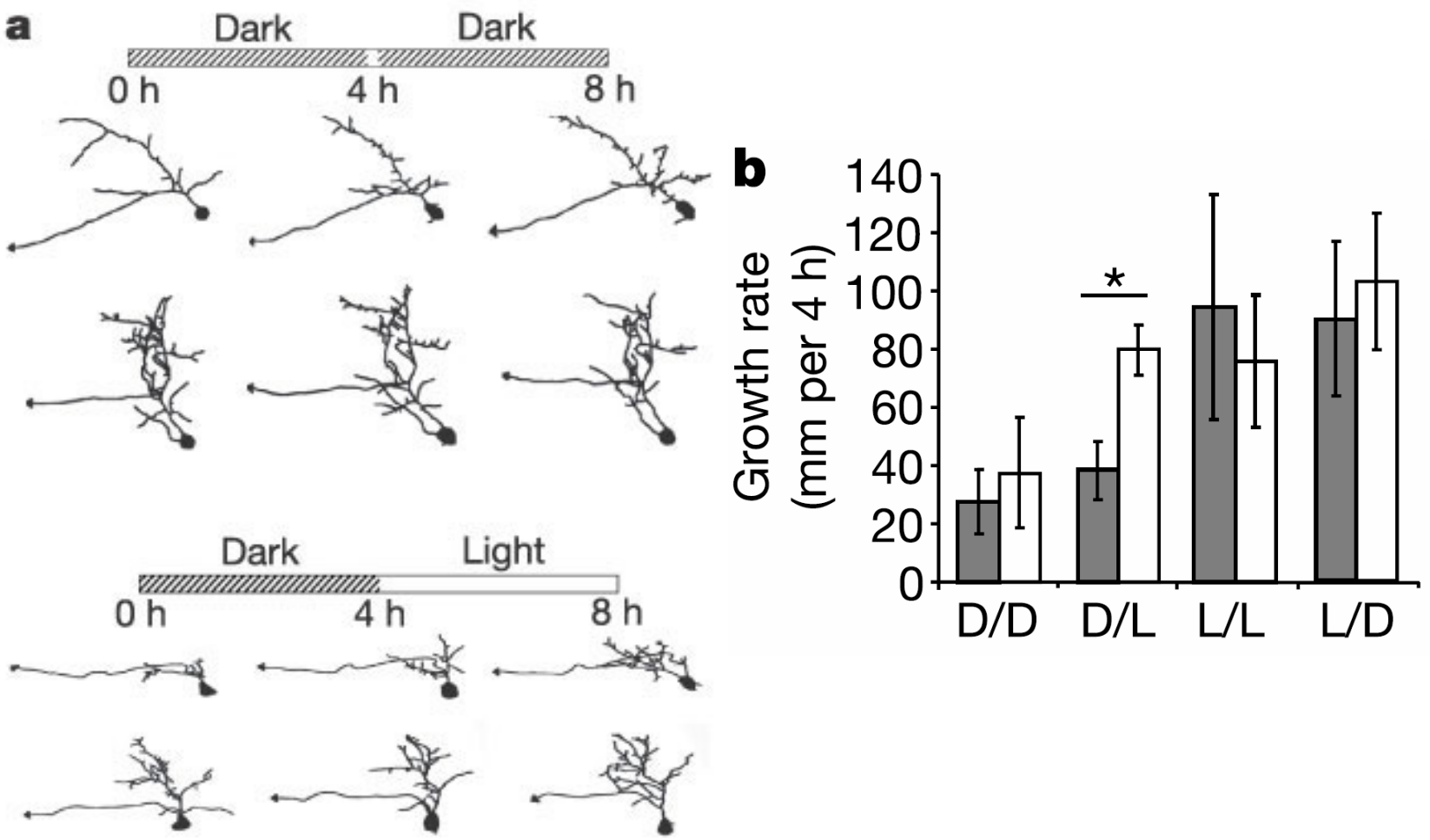
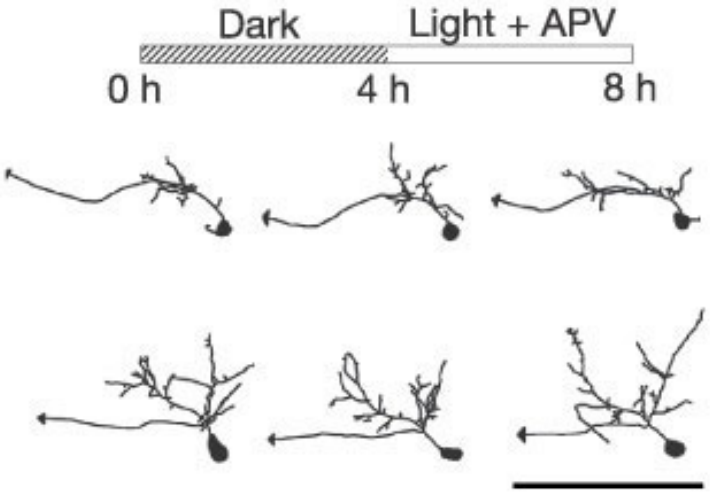
Background
Experience-dependent plasticity:

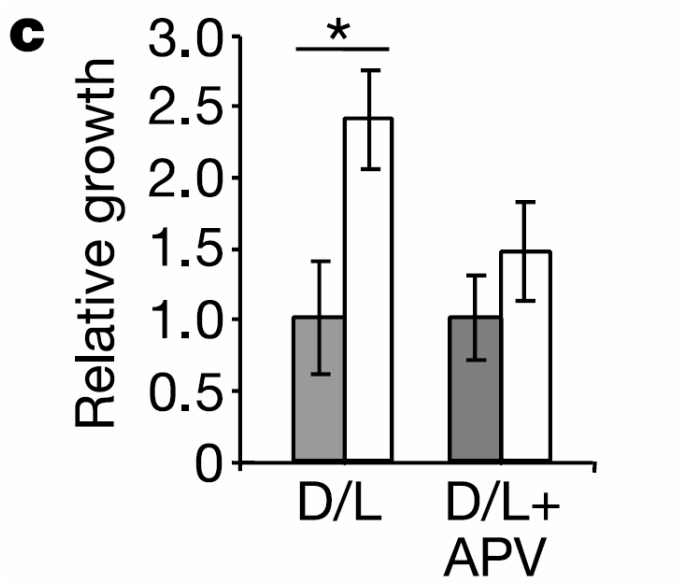
- Functional plasticity
  - Adult animals
    - Hippocampus
    - Visual cortex
  - Juvenile animals
    - Visual system (Poo, background reading)
- Structural plasticity
  - Adults (cortex - Svoboda, 2002)
  - Juvenile animals?

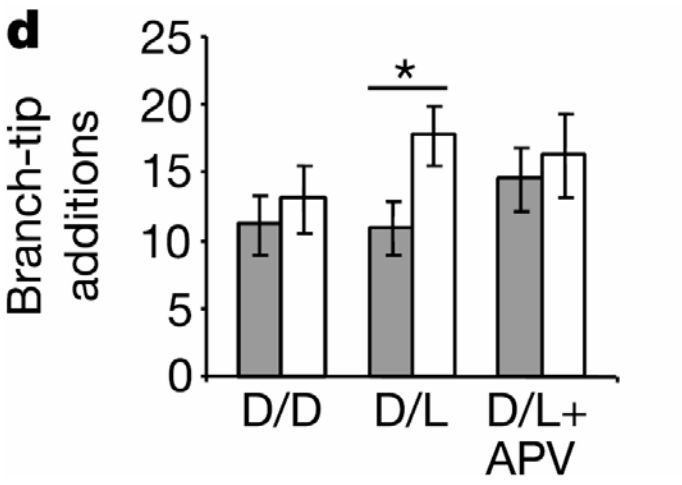
Figure 1

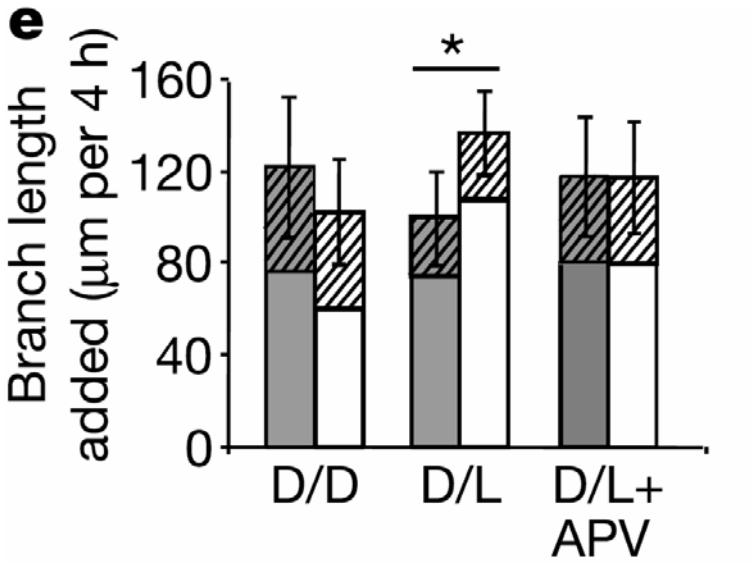
- *In vivo* time-lapse imaging
  - Raised tadpoles until stage 46-47 in ambient light
    - (funtional visual system by stage 39/40)
  - Ionophoresis of DiI
  - Confocal image of tectal dendritic arbors
  - Placed tadpoles in dark tank for 4 hours
  - Re-image
  - Light stimulation for 4 hours
  - Re-image

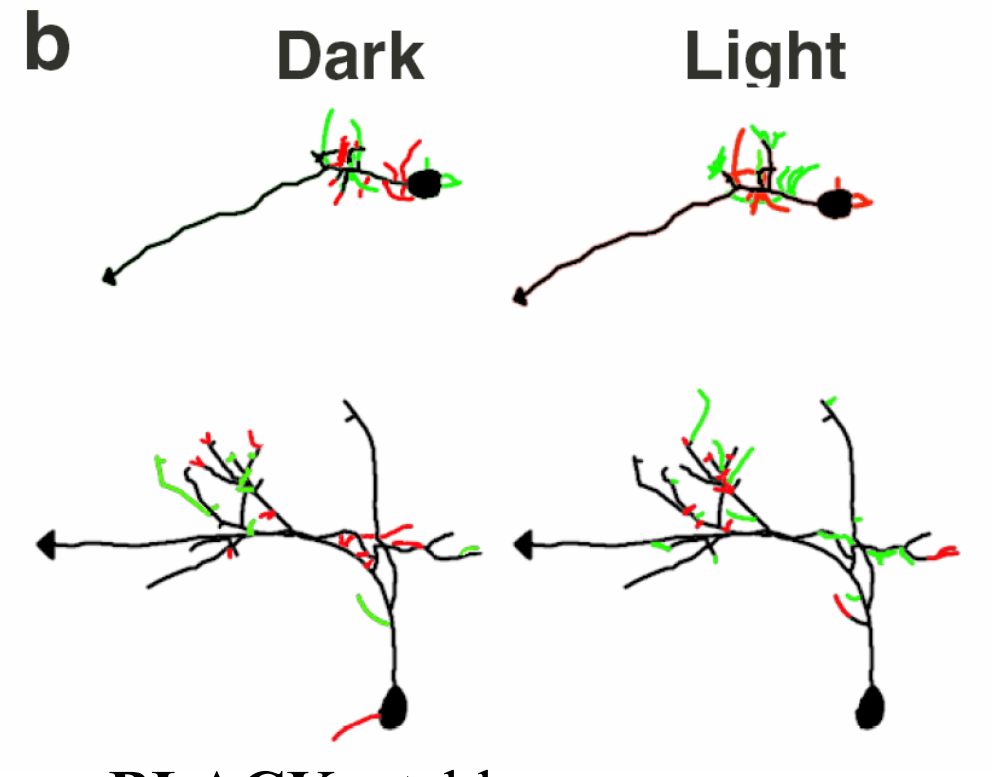

a
Dark
Dark
0 h
4 h
8 h
Dark
Light
0 h
4 h
8 h
b
Growth rate
(mm per 4 h)
140
120
100
80
60
40
20
0
*
D/D
D/L
L/L
L/D


Dark
Light + APV
0 h
4 h
8 h


c
Relative growth
3.0
2.5
2.0
1.5
1.0
0.5
0
*
D/L
D/L+
APV


d
Branch-tip
additions
25
20
15
10
5
0
*
D/D
D/L
D/L+
APV

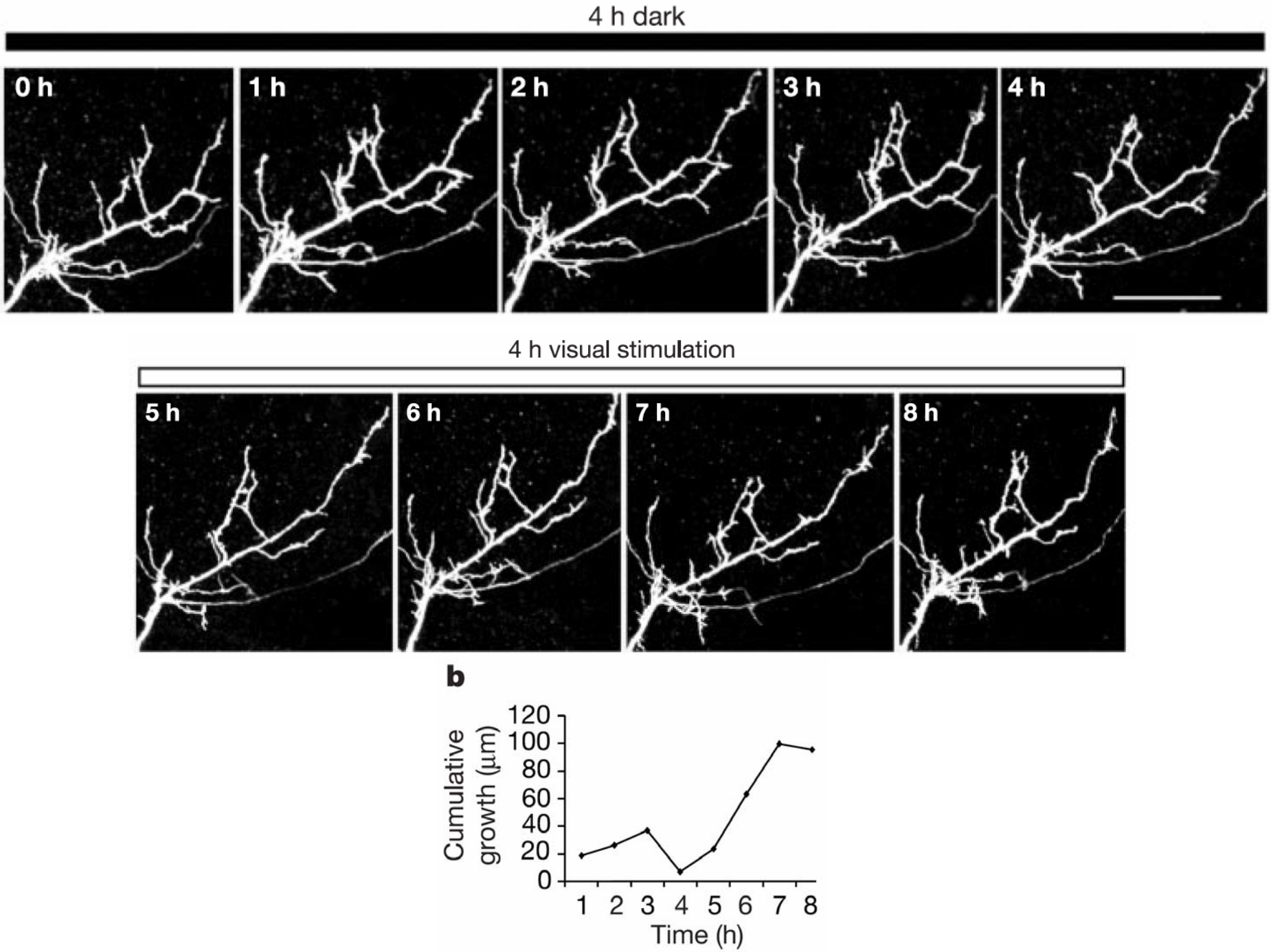


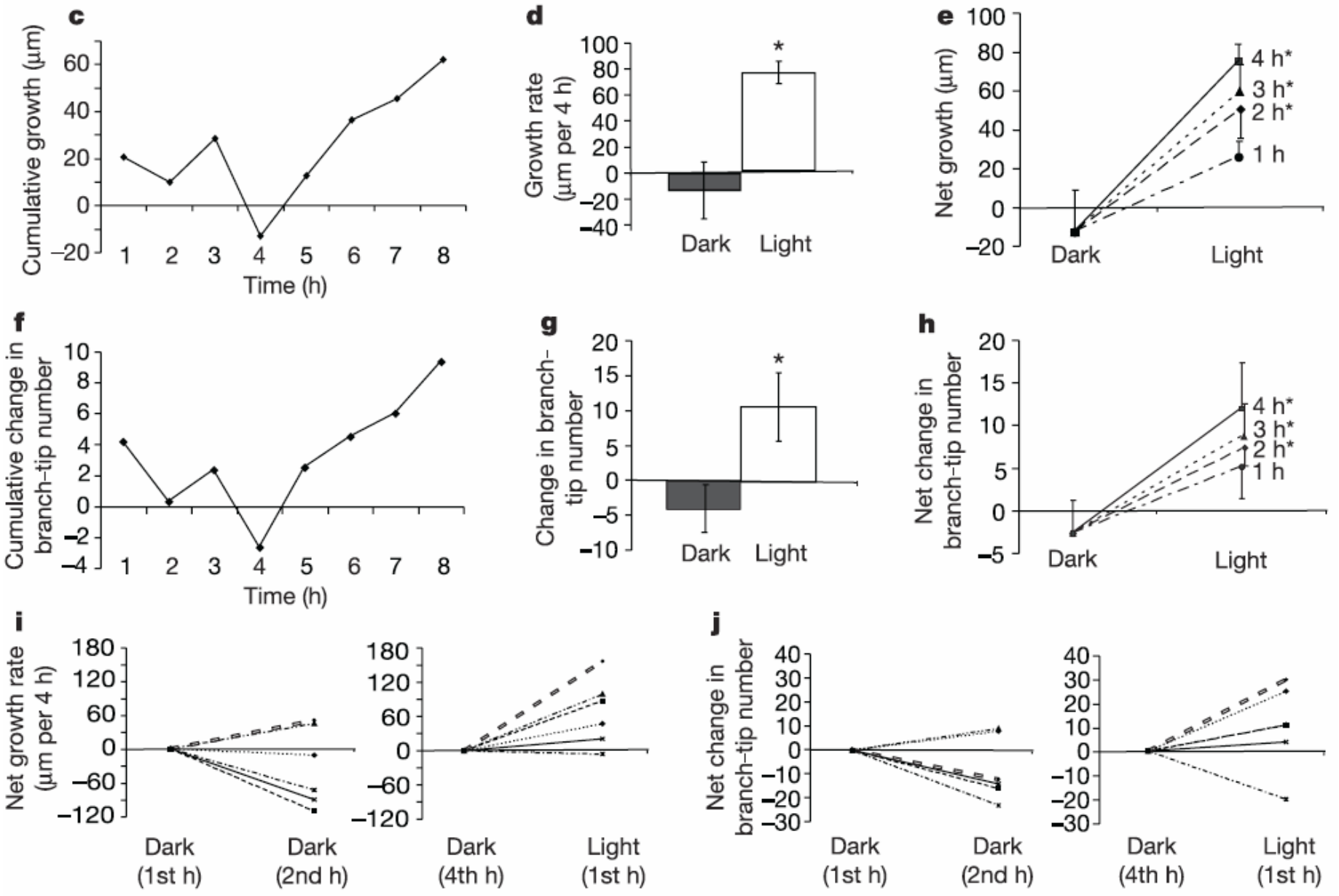


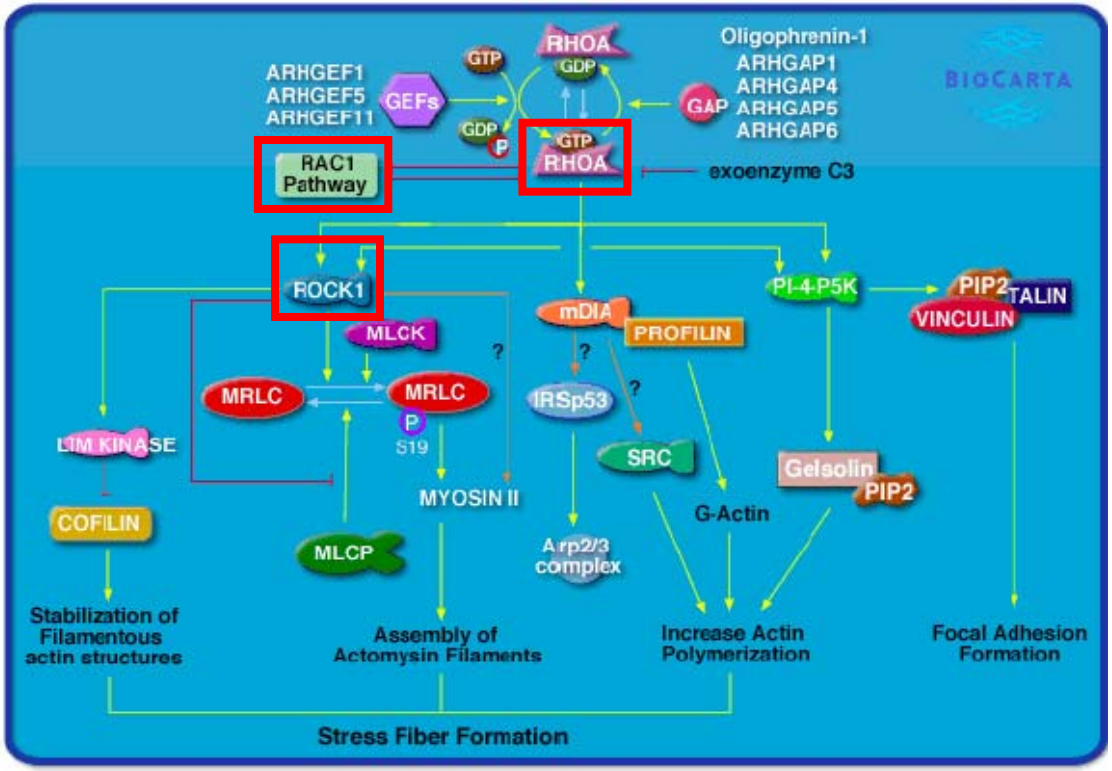
BLACK -stable

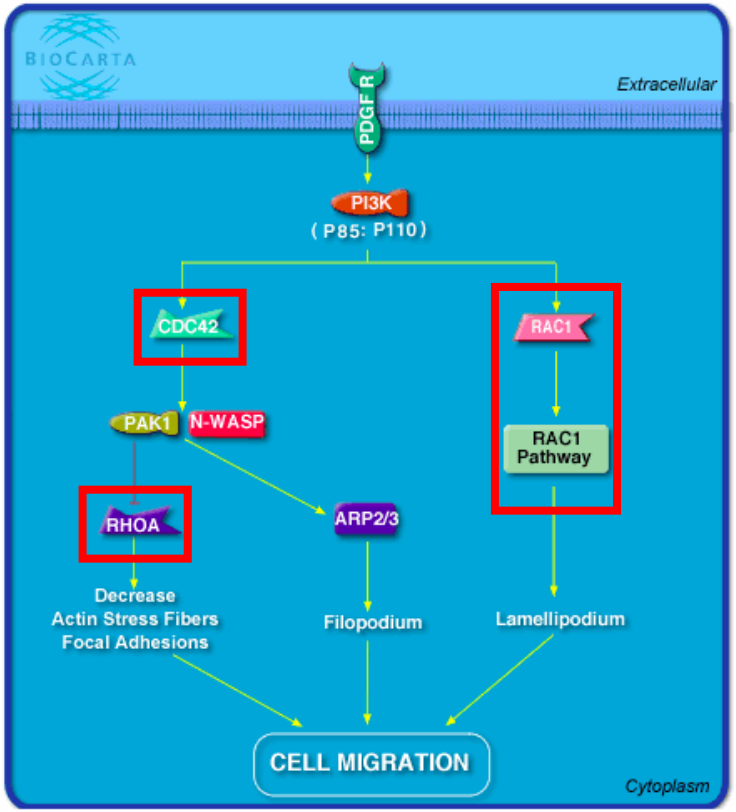
GREEN -newly added or extending

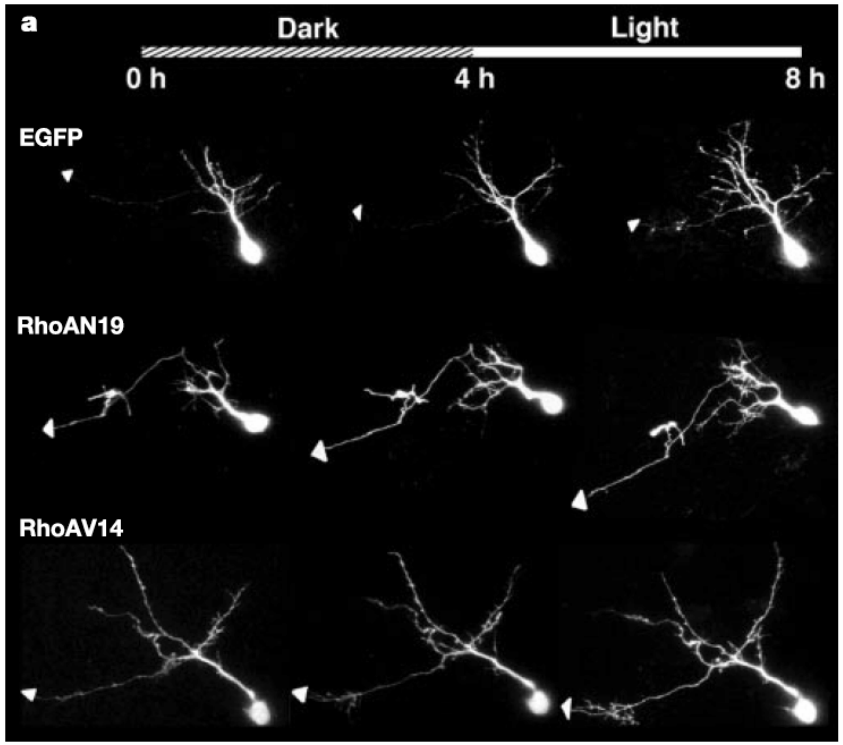
RED -lost or retracting

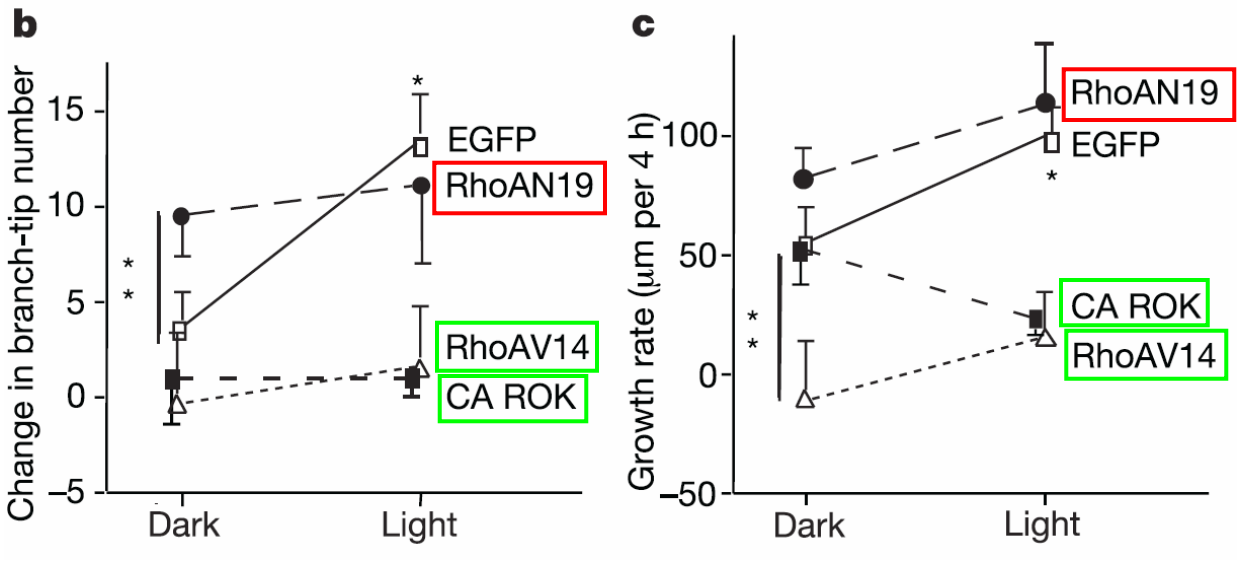

4 h dark
0 h
1 h
2 h
3 h
4 h
4 h visual stimulation
5 h
6 h
7 h
8 h
b
Cumulative growth (µm)
120
100
80
60
40
20
0
1 2 3 4 5 6 7 8
Time (h)

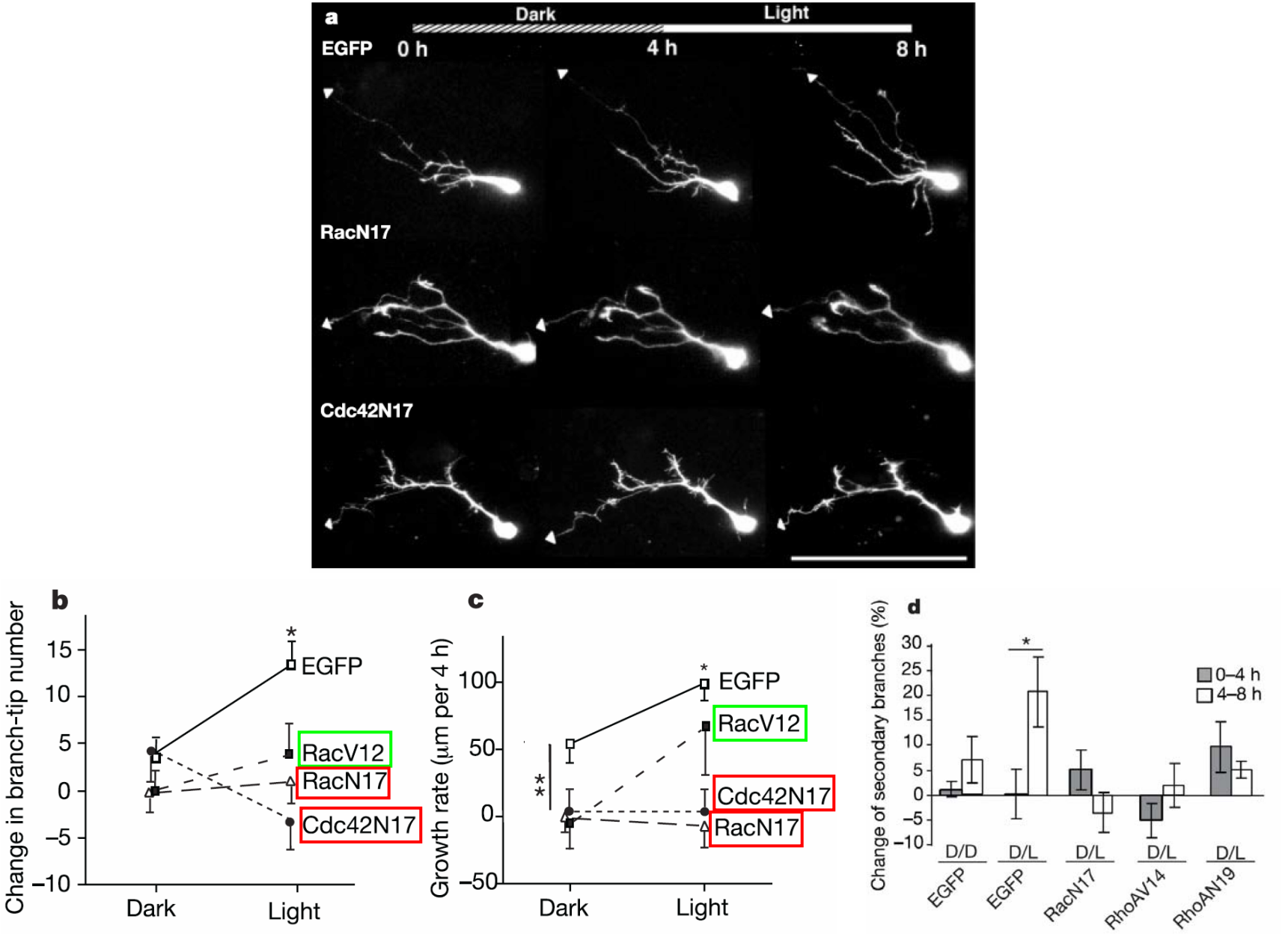

c
Cumulative growth (µm)
60
40
20
0
–20
1 2 3 4 5 6 7 8
Time (h)
d
Growth rate (µm per 4 h)
100
80
60
40
20
0
–20
–40
*
Dark
Light
e
Net growth (µm)
100
80
60
40
20
0
–20
4 h*
3 h*
2 h*
1 h
Dark
Light
f
Cumulative change in branch-tip number
10
8
6
4
2
0
–2
–4
1 2 3 4 5 6 7 8
Time (h)
g
Change in branch-tip number
20
15
10
5
0
–5
–10
*
Dark
Light
h
Net change in branch-tip number
20
15
10
5
0
–5
4 h*
3 h*
2 h*
1 h
Dark
Light
i
Net growth rate (µm per 4 h)
180
120
60
0
–60
–120
Dark (1st h)
Dark (2nd h)
Dark (4th h)
Light (1st h)
j
Net change in branch-tip number
40
30
20
10
0
–10
–20
–30
Dark (1st h)
Dark (2nd h)
Dark (4th h)
Light (1st h)

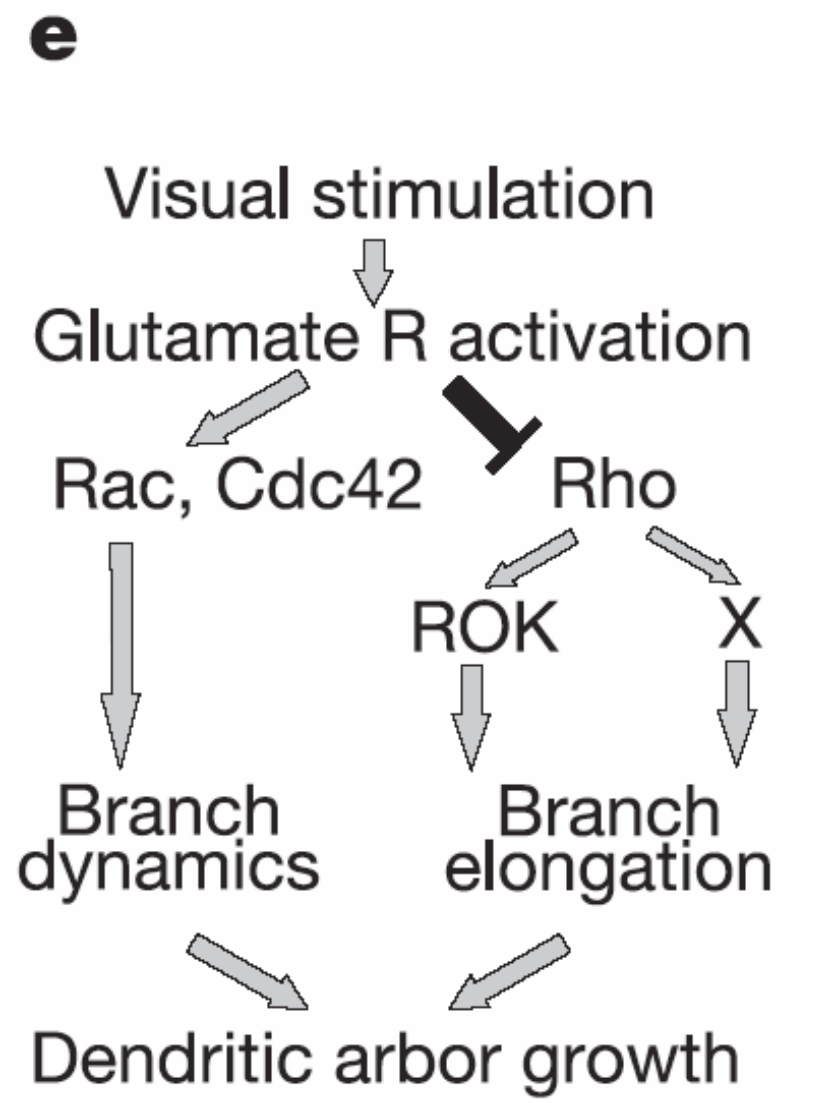

BIOCARTA
ARHGEF1
ARHGEF5
ARHGEF11
GEFs
GTP
GDP
RHOA
GDP
GTP
RHOA
GAP
Oligophrenin-1
ARHGAP1
ARHGAP4
ARHGAP5
ARHGAP6
exoenzyme C3
RAC1 Pathway
ROCK1
mDIA
PROFILIN
PI-4-P5K
PIP2
TALIN
VINCULIN
MLCK
MRLC
MRLC
P
S19
IRSp53
SRC
LIM KINASE
COFILIN
MYOSIN II
MLCP
Arp2/3 complex
G-Actin
Gelsolin
PIP2
Stabilization of Filamentous actin structures
Assembly of Actomysin Filaments
Increase Actin Polymerization
Focal Adhesion Formation
Stress Fiber Formation


BIOCARTA
Extracellular
PDGF R
PI3K
(P85: P110)
CDC42
RAC1
PAK1
N-WASP
RAC1 Pathway
RHOA
ARP2/3
Decrease Actin Stress Fibers Focal Adhesions
Filopodium
Lamellipodium
CELL MIGRATION
Cytoplasm


a
Dark
Light
0 h
4 h
8 h
EGFP
RhoAN19
RhoAV14


b
Change in branch-tip number
15
10
5
0
−5
Dark
Light
EGFP
RhoAN19
RhoAV14
CA ROK
c
Growth rate (μm per 4 h)
100
50
0
−50
Dark
Light
RhoAN19
EGFP
CA ROK
RhoAV14


a
Dark
Light
EGFP
0 h
4 h
8 h
RacN17
Cdc42N17
b
Change in branch-tip number
15
10
5
0
−5
−10
Dark
Light
*
EGFP
RacV12
RacN17
Cdc42N17
c
Growth rate (μm per 4 h)
100
50
0
−50
Dark
Light
**
*
EGFP
RacV12
Cdc42N17
RacN17
d
Change of secondary branches (%)
30
25
20
15
10
5
0
−5
−10
*
0–4 h
4–8 h
D/D
D/L
D/L
D/L
D/L
EGFP
EGFP
RacN17
RhoAV14
RhoAN19


e
Visual stimulation
Glutamate R activation
Rac, Cdc42
Rho
ROK
X
Branch dynamics
Branch elongation
Dendritic arbor growth