# Signal Transduction

## MDA course on NGS Data Analysis
## Valencia, 30 Sep 2015




Cankut CUBUK
ccubuk@cipf.es

# Signal Transduction

**Signal transduction** is the transmission of molecular signals from a cell's exterior to its interior.

Signals received by cells must be transmitted effectively into the cell to ensure an appropriate response.

This step is initiated by cell-surface receptors and terminated by target protein.

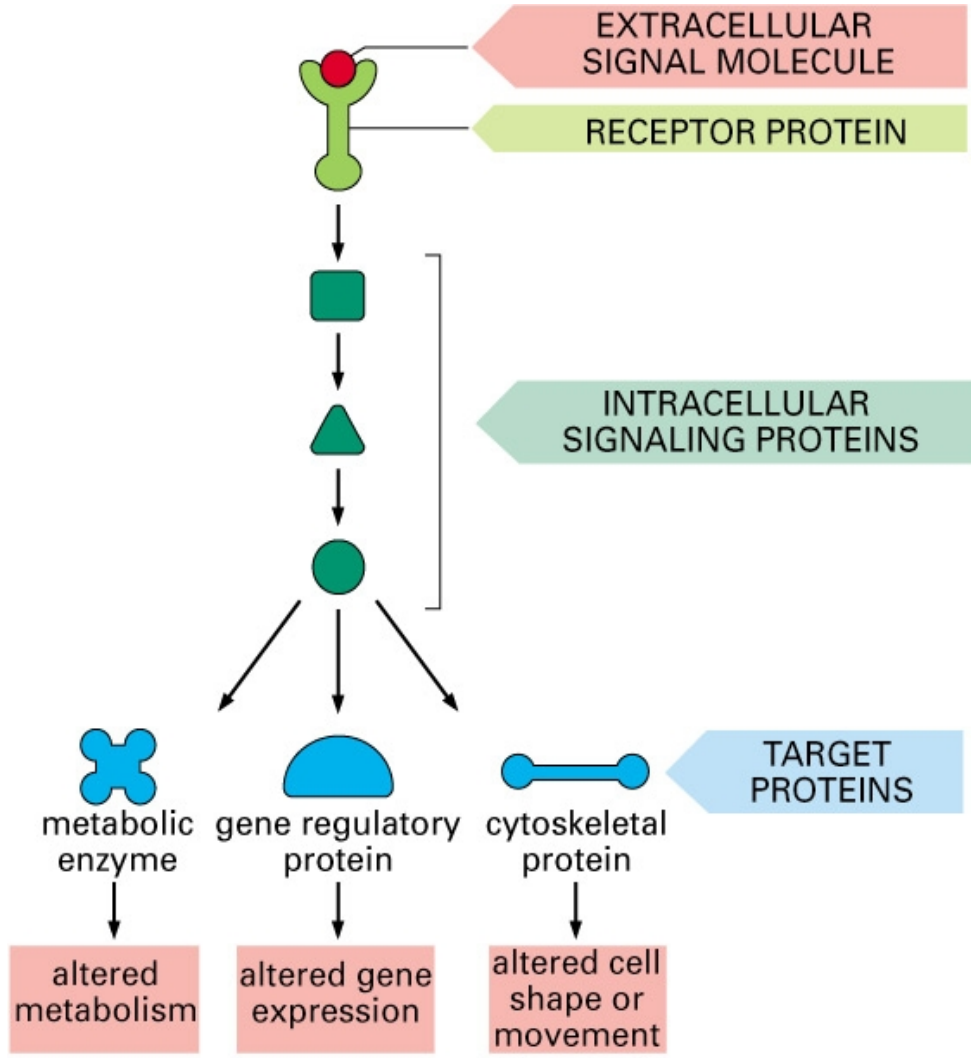


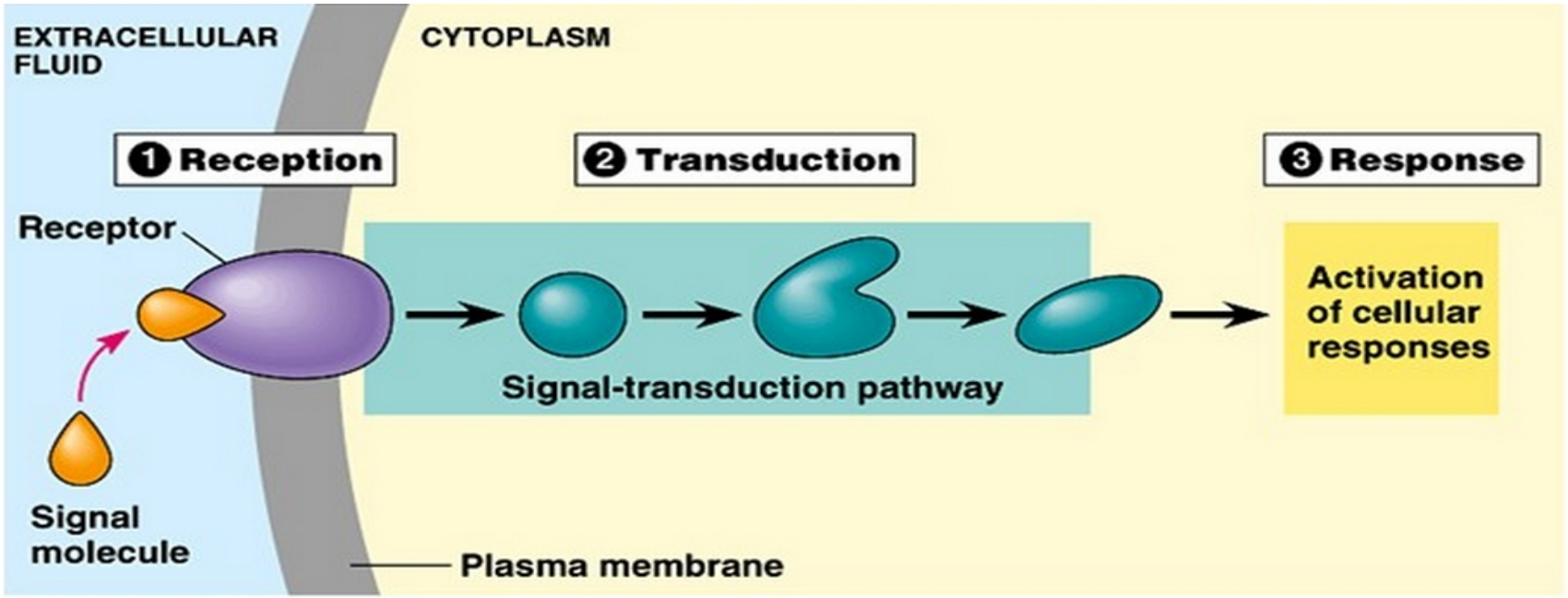

Figure 15–1. Molecular Biology of the Cell, 4th Edition.

# Signal Transduction

https://youtu.be/llY1or7gKW0

# Signal Transduction in 3 Steps

1) Reception
2) Transduction
3) Response



# Reception-Transduction-Response

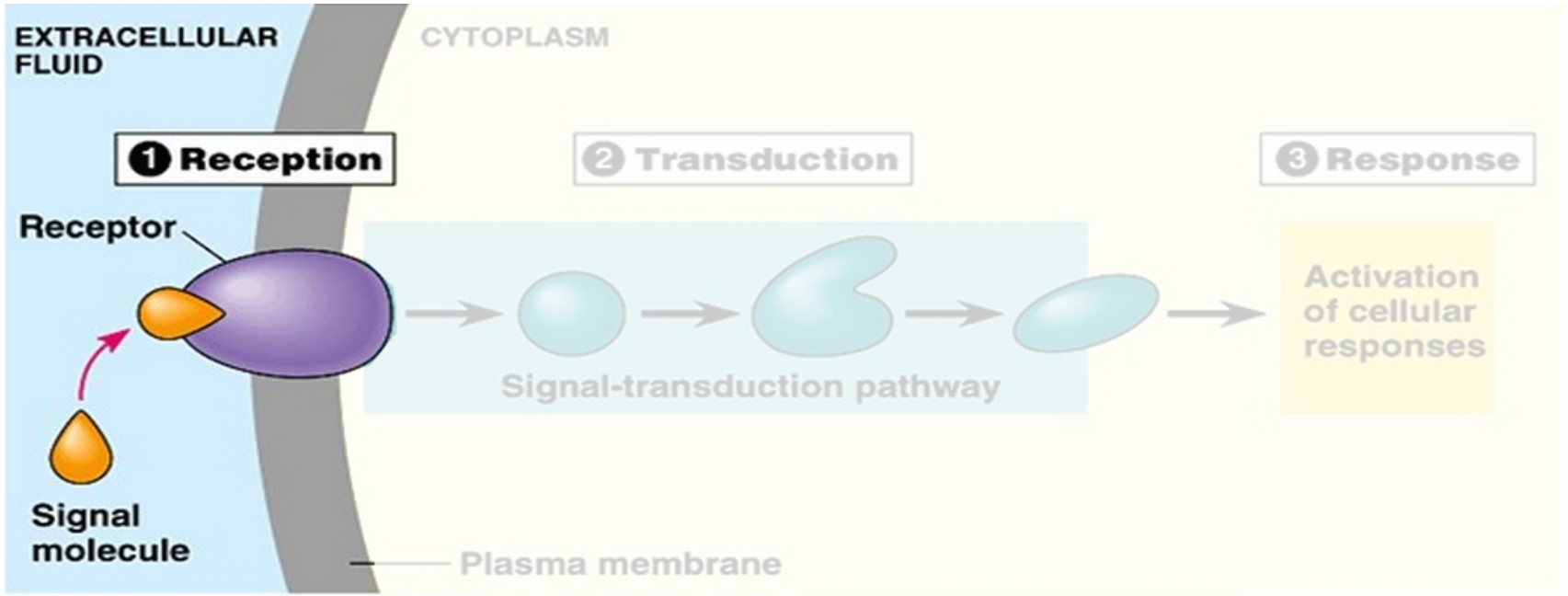
**Signal Molecules**

Physical signals

Light, electronic, mechanic, UV, heat, volume, osmotic, etc.

Chemical signals

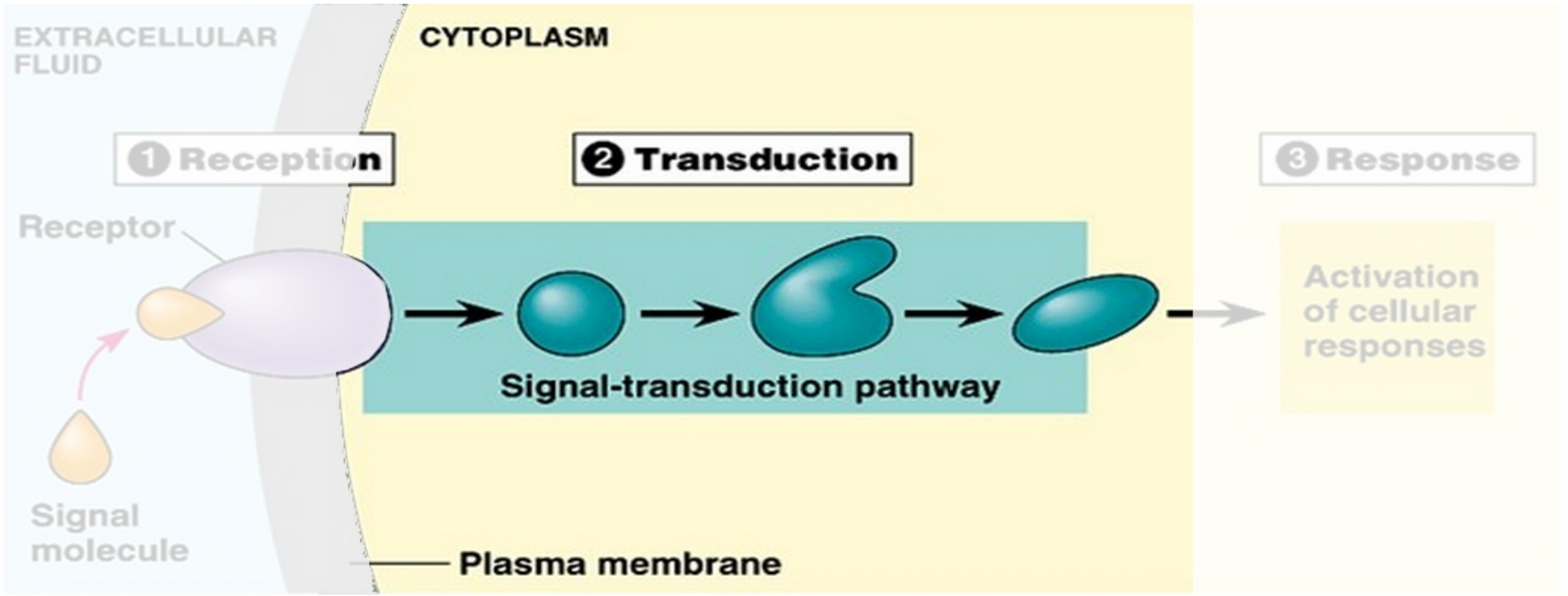
Hormones, neurotransmitters, growth factors, cytokines, odor molecules, ATP, active oxygen, drugs, toxins, etc.



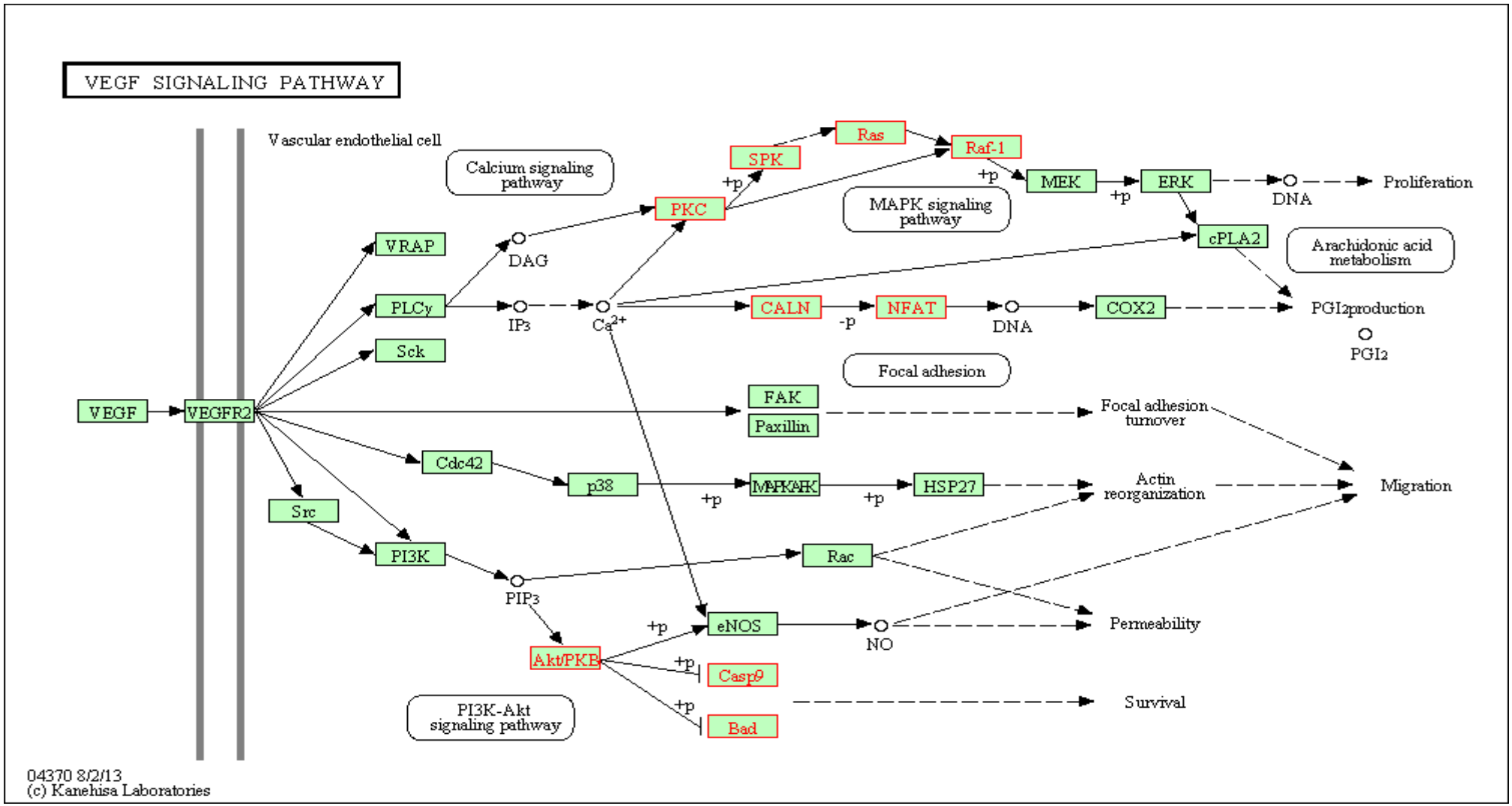
**Relation between proteins:**

Activation

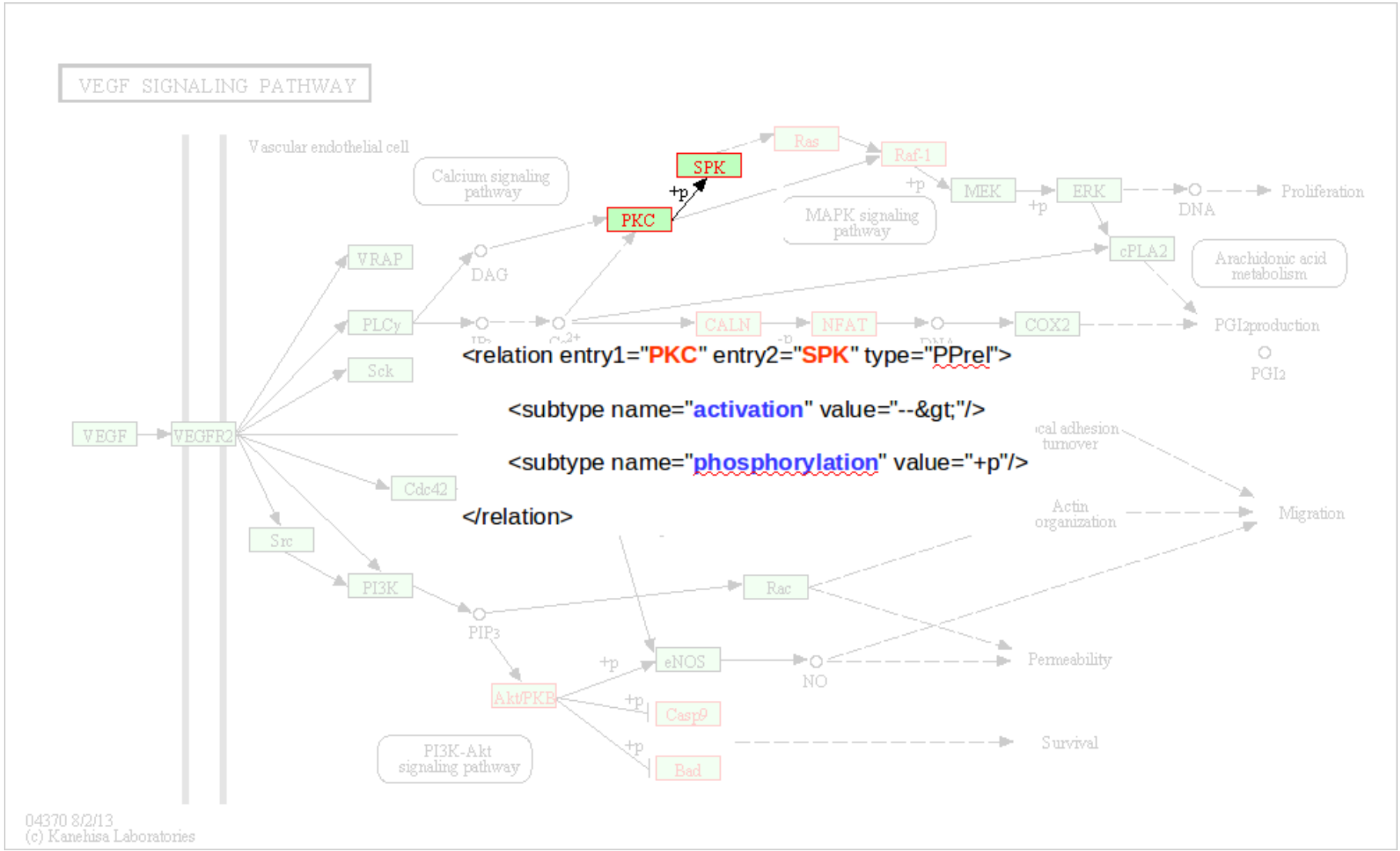
Inhibition



# An Example

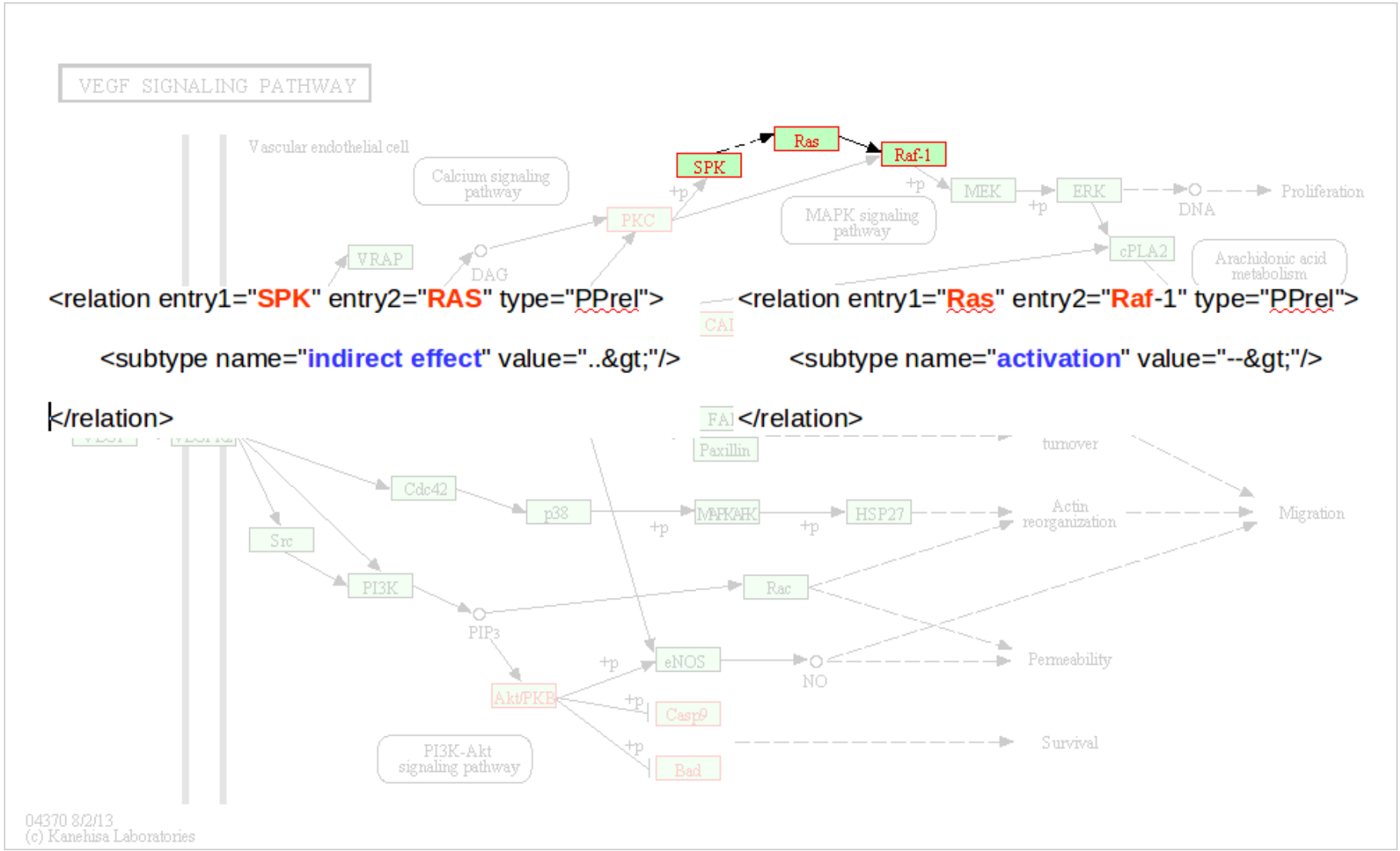

VEGF SIGNALING PATHWAY
Vascular endothelial cell
Calcium signaling pathway
MAPK signaling pathway
Focal adhesion
PI3K-Akt signaling pathway
Arachidonic acid metabolism
VEGF
VEGFR2
VRAP
PLCγ
Sck
Src
PI3K
Cdc42
p38
FAK
Paxillin
SPK
PKC
Ras
Raf-1
MEK
ERK
cPLA2
DAG
IP3
Ca2+
CALN
NFAT
COX2
PGI2production
PGI2
DNA
Proliferation
HSP27
Actin reorganization
Focal adhesion turnover
Migration
Rac
PIP3
eNOS
NO
Permeability
Akt/PKB
Casp9
Bad
Survival
+p
-p
04370 8/2/13
(c) Kanehisa Laboratories

# Phosphorylation

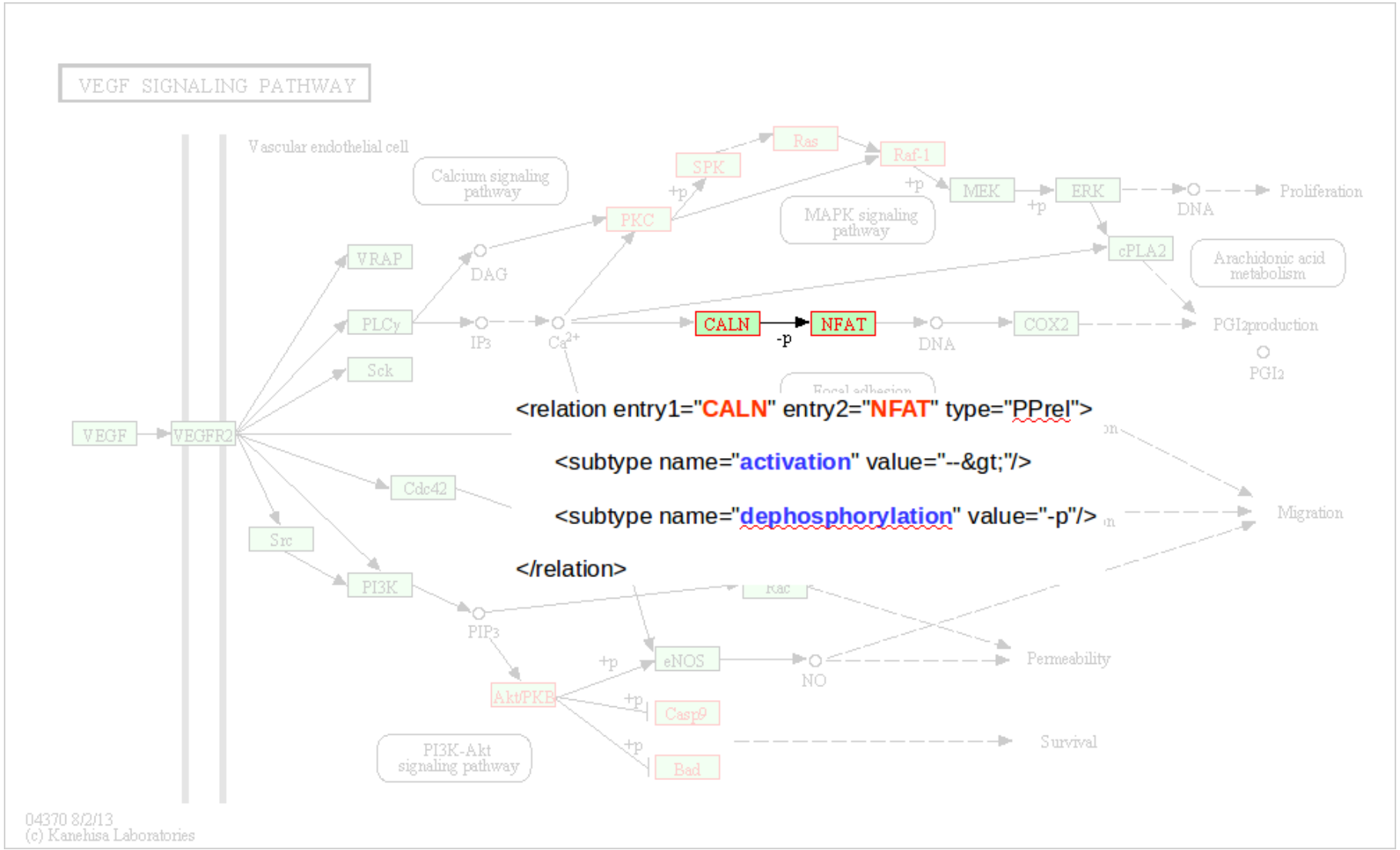



```
<relation entry1="PKC" entry2="SPK" type="PPrel">
    <subtype name="activation" value="--&gt;"/>
    <subtype name="phosphorylation" value="+p"/>
</relation>
```

# Indirect Effect & Activation

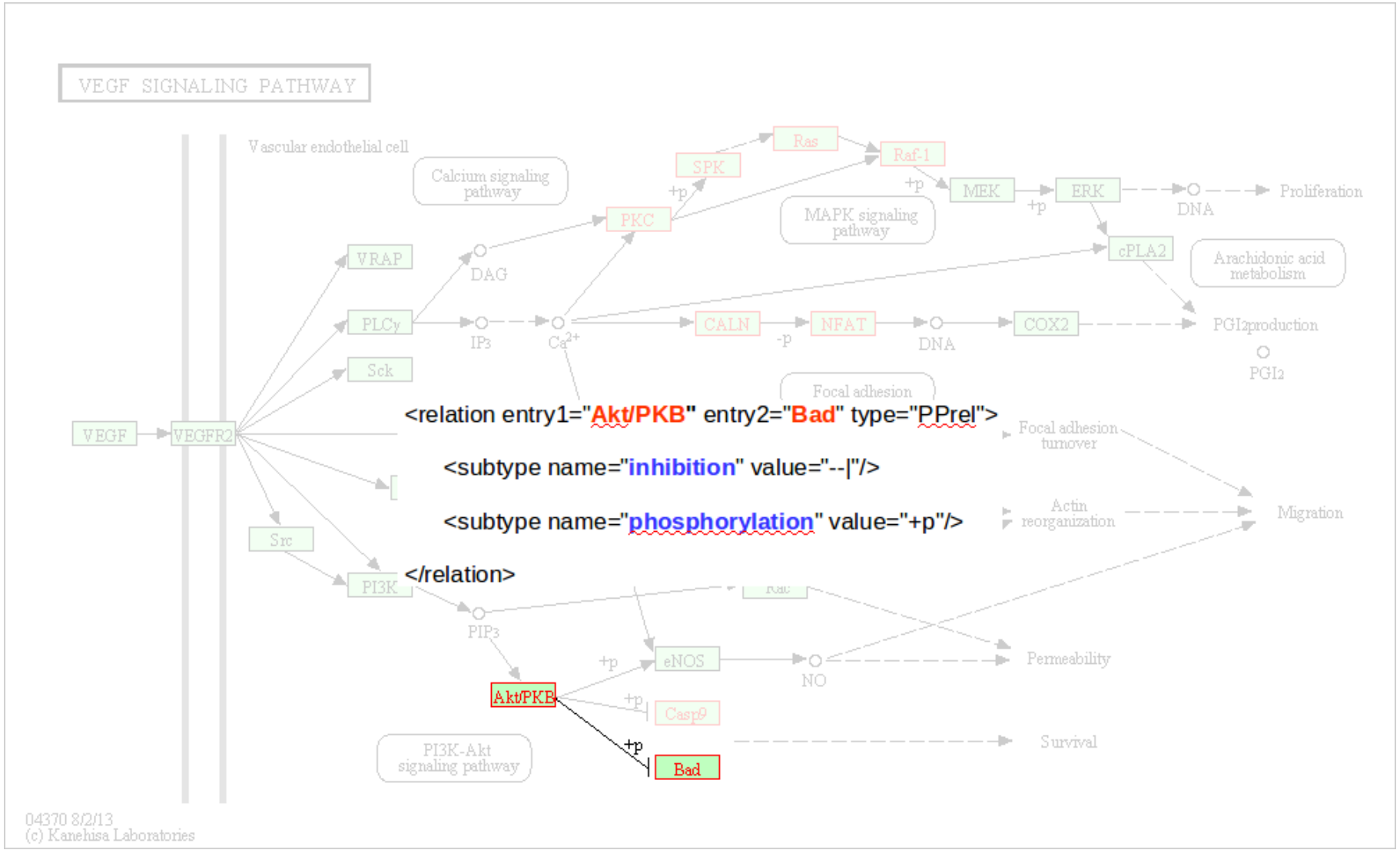


# Dephosphorylation




```
<relation entry1="CALN" entry2="NFAT" type="PPrel">
    <subtype name="activation" value="--&gt;"/>
    <subtype name="dephosphorylation" value="-p"/>
</relation>
```

# Phosphorylation

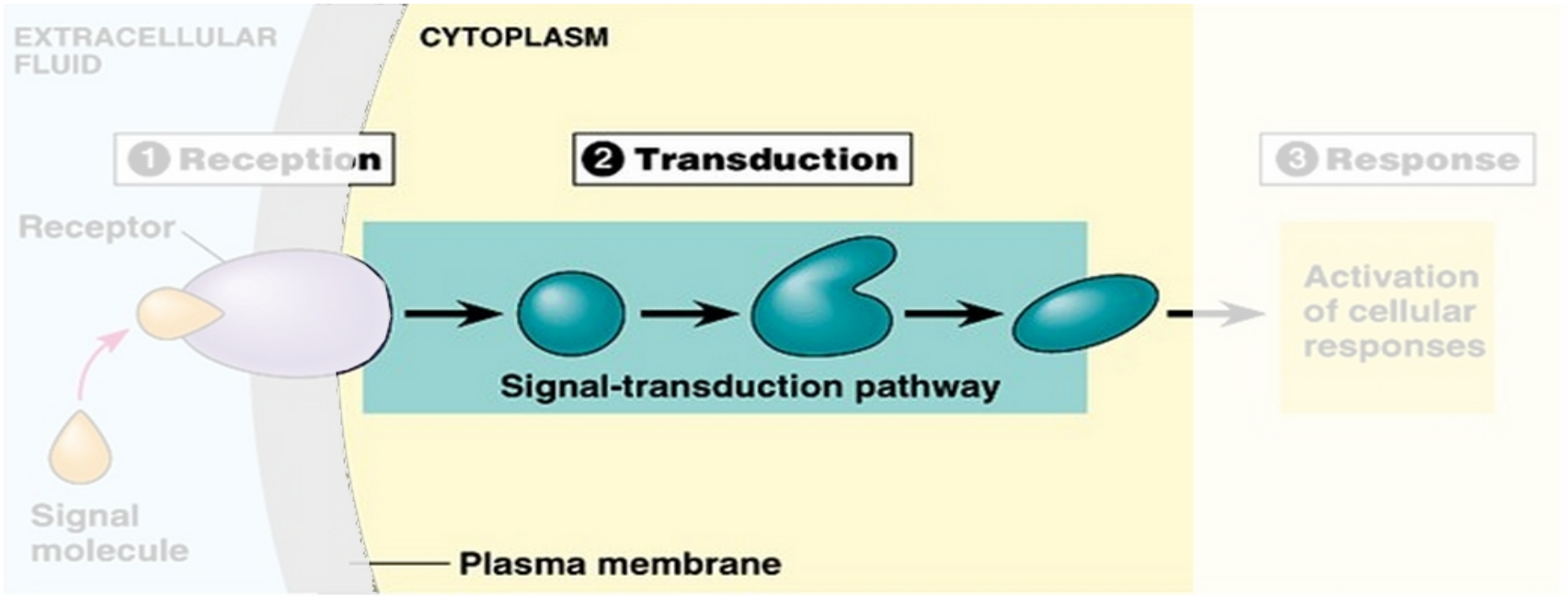



```
<relation entry1="Akt/PKB" entry2="Bad" type="PPrel">
    <subtype name="inhibition" value="--|"/>
    <subtype name="phosphorylation" value="+p"/>
</relation>
```

# Reception-Transduction-Response

**ACTIVATION:** Activation, phosphorilation, indirect expression, dephosphorilation, glycosylation.

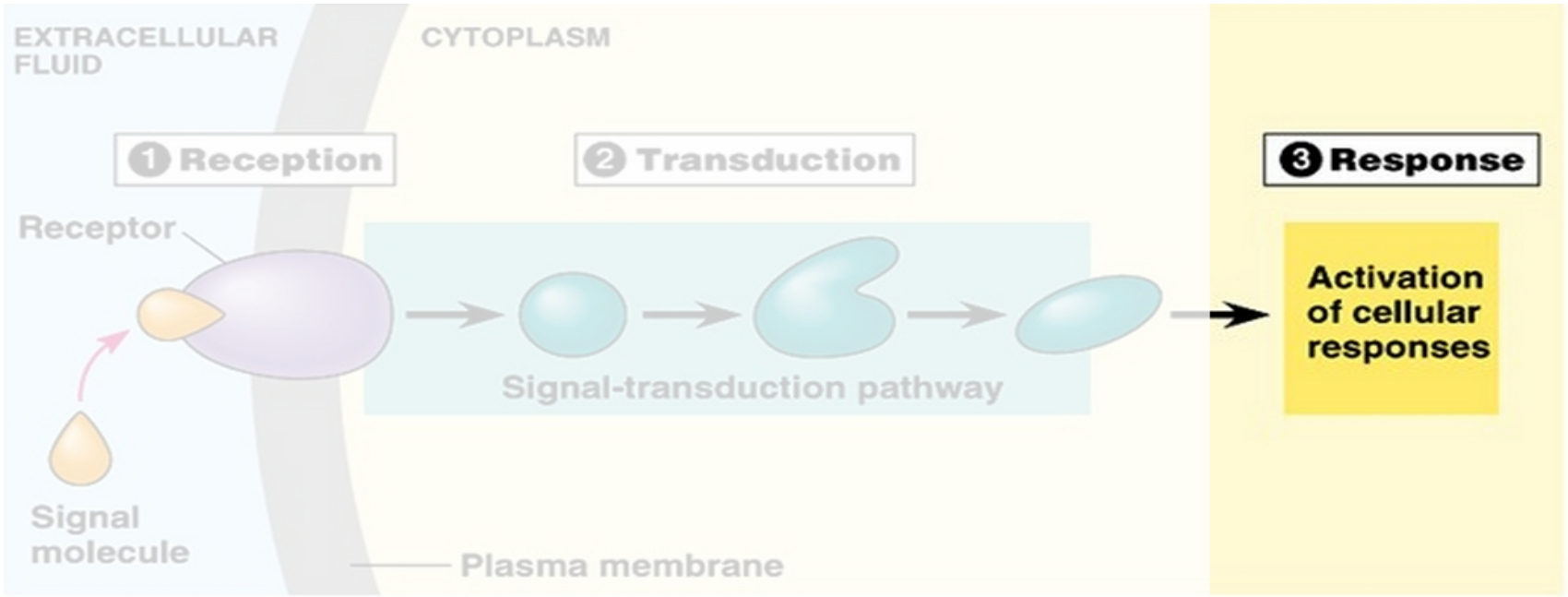
**INHIBITION:** Inhibition, ubiquitination, methylation.



# Reception-Transduction-Response

**Cellular Function:**

Apoptosis, Survival, Growth, Migration, Proliferation, Differentiation, Cell Cycle, Metabolism(Catabolism and Anabolism), etc



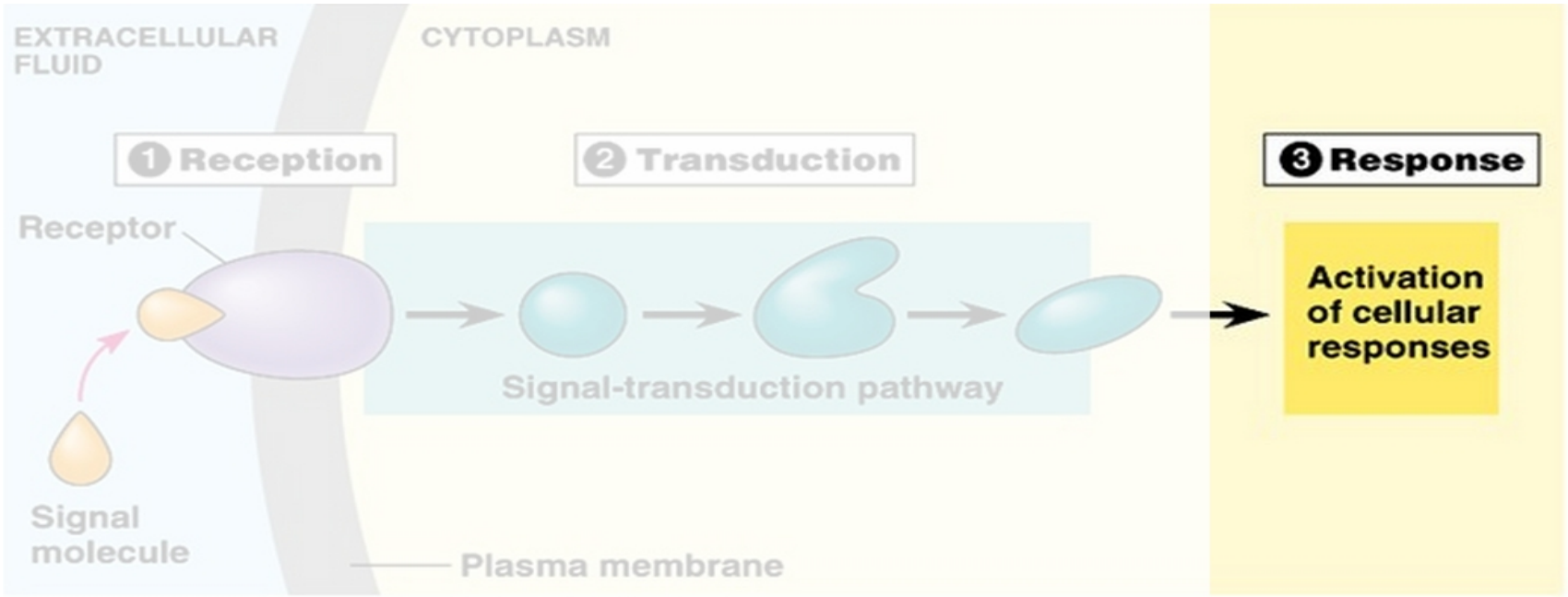
# Reception-Transduction-Response

**Cellular Functions**

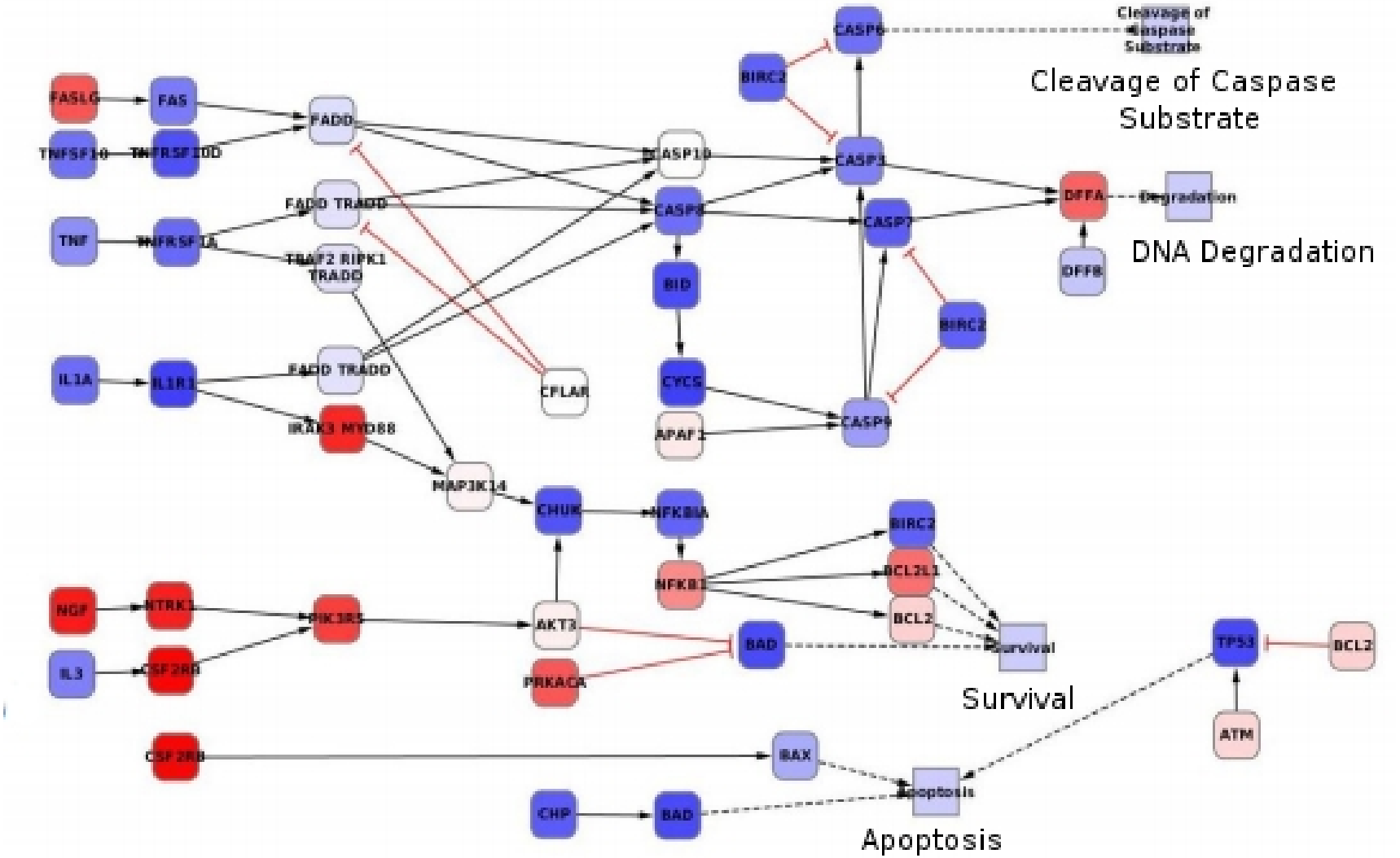
Apoptosis, Survival, Growth, Migration, Proliferation, Differentiation, Cell Cycle, Metabolism(Catabolism and Anabolism), etc.

**Diseases**

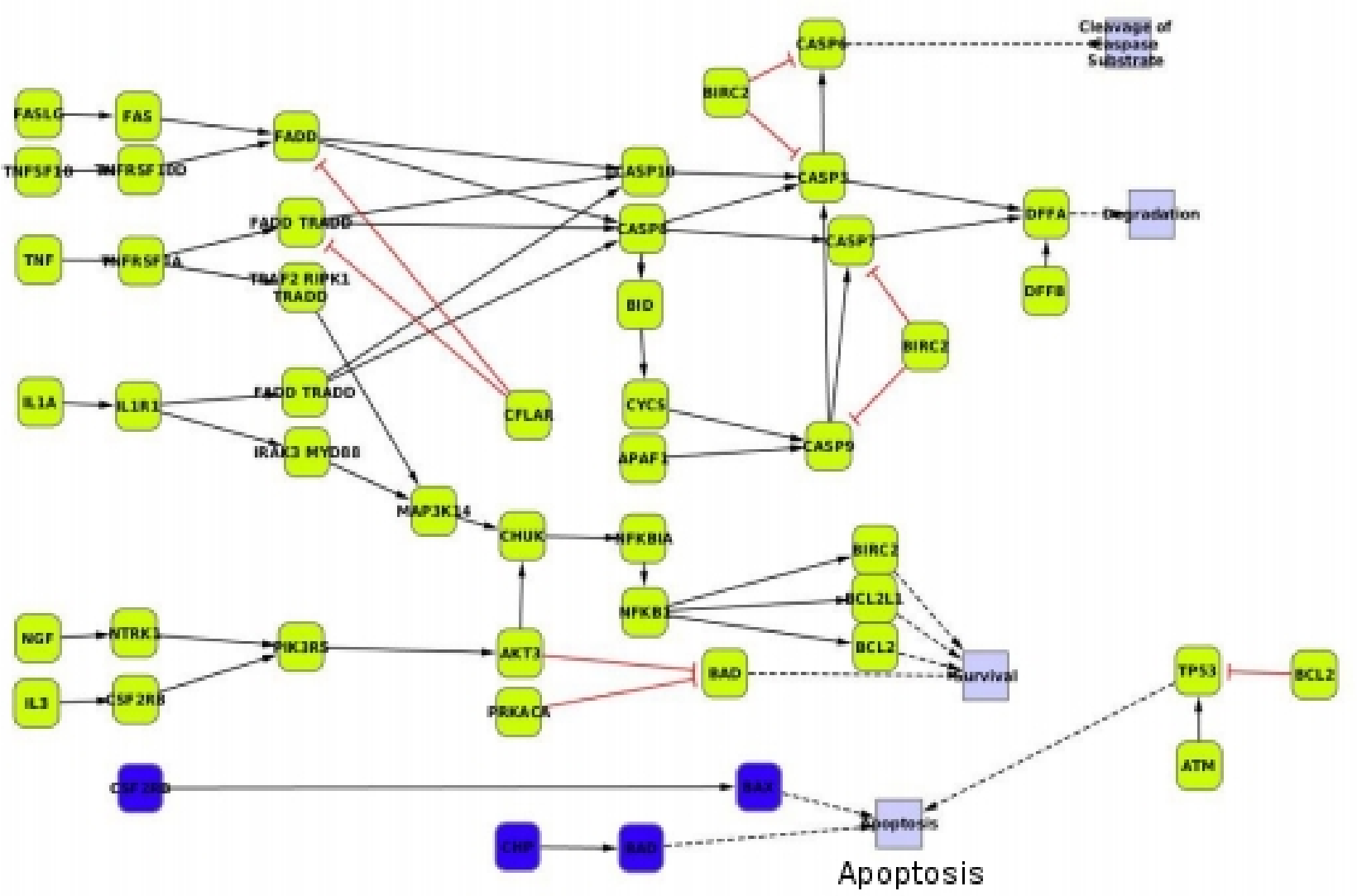
Cancer, Diabetes, Cystic fibrosis, etc.



# Apoptosis Signaling Pathway



# Subpathway with Apoptosis Function



# Signaling Pathway Databases



KEGG

Reactome

Wikipathways

Biocarta

NCI-PID

Signalink