Plasticity on two different scales: on what scale is information processed?

David Biron
C. elegans neurons

Nerve ring – interneurons

(Amphid) Sensory neurons

Motoneurons
Thermotactic behavior depends on the previous cultivation temperature ($T_s$) and on the ambient temperature ($T$) (Hedgecock and Russell, 1975) (Mori and Ohshima, 1995).

- $T = T_s$: Isothermal Tracking
Different levels of description of Thermotactic memory

- Behavior of the entire organism (1000 µm)
- Information processing in neural circuits (10 µm)
- Underlying molecular machinery – protein interactions (<0.01 µm)
C. elegans nomenclature

- **AFD**: Sensory neuron
- **AIY**: Inter-neuron

**WT dgk-3**: Enzyme (reduces DAG levels)

**dgk-3 (lof)**: A non-active dgk-3

**dgk-3 gof**: A hyper-active dgk-3
DAG is found in the plasma membrane
DAG is found in the plasma membrane
A closer look at the plasma membrane
A closer look at the plasma membrane
DAG and IP$_3$ are *messengers* in the process of converting an extra-cellular signal to an electrical response *(sensory signal transduction)*
dgk-3 down-regulates DAG levels
Entire organism level:
Measuring the position of isothermal tracks defines the thermodtactic set-point, $T_s$
The thermotactic set-point ($T_s$) of adult worms changes with continued cultivation at a new temperature.
The thermotactic set-point ($T_s$) of adult worms changes with continued cultivation at a new temperature.
A diacylglycerol kinase (*dgk-3*) is strongly expressed in the AFD neurons

(Mori and Ohshima, 1995)

**Diagram:**

- **AFD**
- **AIY**
- **RIA**
- **AIZ**

**Interneurons and motoneurons**

**Thermotactic navigational behavior**
A diacylglycerol kinase ($dgk-3$) is strongly expressed in the AFD neurons

Interneurons and motoneurons

Thermotactic navigational behavior

(Mori and Ohshima, 1995)

(Colosimo et al., 2004)
A diacylglycerol kinase (*dgk-3*) is strongly expressed in the AFD neurons

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Interneurons and motoneurons

Thermotactic navigational behavior

(Colosimo et al., 2004)

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<th>$T &gt; T_S$</th>
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<tr>
<td>Wild-Type</td>
<td>Cryophilic</td>
<td>Track</td>
</tr>
<tr>
<td><em>dgk-3</em></td>
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So *dgk-3* is in the right neuron and has known ties to sensory signal transduction.

**Diagram:**

- AFD
- AIY
- RIA
- AIZ

*Interneurons and motoneurons*

*Thermotactic navigational behavior*

**Legend:**

- Wild-Type
- *dgk-3*

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**(Mori and Ohshima, 1995)**

**(Colosimo et al., 2004)**
Knocking out \textit{dgk-3} disrupts only the worm’s ability to reset $T_S$ to new warmer temperatures.

- Reference: WT
  \[ \tau_{up} = 5.8 \pm 1.0 \text{ h}^{**} \]

- Reference: WT
  \[ \tau_{dn} = 1.1 \pm 0.2 \text{ h} \]
A gain of function mutation of the *dgk-3* gene disrupts the worm’s ability to reset $T_S$ to new colder temperatures.
AFD-specific expression of *dgk-3* rescues the upshift $T_s$ defect
In a cycling cultivation temperature \(dgk-3\) mutants reset \(T_S\) to a lower value than wild-type because \(T_S\) depends on \(\tau_{up}/\tau_{dn}\)

\[
\text{WT: } \tau_{up}/\tau_{dn} = 1.6/1.8
\]

\[
dgk-3: \tau_{up}/\tau_{dn} = 5.8/1.1
\]