# Reactive oxygen species (ROS) scavenging and transport

## Catalase (CAT)[[1]](#footnote-20)

Includes inhibition by high levels of hydrogen peroxide

| Parameter | Value | Unit | Desc. |
| --- | --- | --- | --- |
|  | 17000 | mM\*Hz | Rate constant |
|  | 1 | nM | Extra-matrix concentration of catalase |
|  | 0.05 | 1/mM | Hydrogen peroxide inhibition factor |

## Superoxide dismutase (SOD) [[2]](#footnote-23)

Based on McADAM, 1976 model, for both cytosolic and mitochondrial compartments.

$$
\begin{aligned}
J\_{SOD} &= {2k\_5E\_Tf\_{sox}(k\_1 + k\_3^\prime) \over k\_5(2 k\_1 + k\_3^\prime) + k\_3^\prime f\_{sox}} \\
k\_3^\prime &= k\_3 (1 + \frac{[H\_2O\_2]}{K\_{H\_2O\_2}}) \\
f\_{sox} &= k\_1^{SOD} [O\_2^-]
\end{aligned}
$$

| Parameter | Value | Unit | Desc. |
| --- | --- | --- | --- |
|  | 1200000 | Hz/mM | Rate constant for EA -> EB |
|  | 24000 | Hz/mM | Rate constant for EB -> EC |
|  | 0.24 | Hz | Rate constant for EC -> EA |
|  | 0.5 | mM | Inhibition constant for H2O2 |
|  | 0.0003 | mM | Concentration of Cu,ZnSOD (cytosolic) |
|  | 0.00024 | mM | Concentration of MnSOD (mitochondrial) |

## Glutathione (GSH) systems[[3]](#footnote-25)

### Glutathione peroxidase (GPX)

Dalziel type Ping-pong mechanism, for both cytosolic and mitochondrial compartments.

| Parameter | Value | Unit | Desc. |
| --- | --- | --- | --- |
|  | 50 | nM | GPX content (cytosolic) |
|  | 50 | nM | GPX content (mitochondrial) |
|  | 5E-6 | mM\*s | Dalziel coefficient |
|  | 7.5-E4 | mM\*s | Dalziel coefficient |

### Glutathione reductase (GR)

Michaelis-Menten kinetics, for both cytosolic and mitochondrial compartments.

| Parameter | Value | Unit | Desc. |
| --- | --- | --- | --- |
|  | 9E-4 | mM | GR content (cytosolic) |
|  | 9E-4 | mM | GR content (mitochondrial) |
|  | 2.5 | Hz | Catalytic constant of GR |
|  | 0.06 | mM | Michaelis constant for GSSG |
|  | 0.015 | mM | Michaelis constant for NADPH |

### Glutaredoxin system[[4]](#footnote-28)

Disabled in the cellular model.

| Parameter | Value | Unit | Desc. |
| --- | --- | --- | --- |
|  | 3.6E-4 | mM\*Hz | Extra-matrix glutaredoxin reaction rate |
|  | 3.6E-4 | mM\*Hz | Mitochondrial glutaredoxin reaction rate |
|  | 1.37E-3 | 1/mM | Equilibrium constant of glutaredoxin |
|  | 0.01 | mM | Michaelis constant for GSH of GRX |
|  | 0.0005 | mM | Michaelis constant for glutathionylated protein of glutaredoxin |
|  | 0.002 | mM | Glutaredoxin concentration |
|  | 0 |  | Cellular model |
|  | 0 |  | Cellular model |

### Glutathionylated protein[[5]](#footnote-31)

Disabled in the cellular model.

| Parameter | Value | Unit | Desc. |
| --- | --- | --- | --- |
|  | 640 | Hz | Rate constant of protein glutathionylation |
|  | 8E-4 |  | Concentration of proteins that can become glutathionylated |
|  | 1E-3 | mM | Total PSSG |
|  | 0.75 | mM | Michaelis constant of GSH |
|  | 1E-3 | mM | Activation constant of H2O2 |
|  | 0 |  | Cellular model |

### Glutathione transport[[6]](#footnote-33)

Disabled in the cellular model.

| Parameter | Value | Unit | Desc. |
| --- | --- | --- | --- |
|  | 1.5E-5 | mM \* Hz | Rate constant of glutathione transporter |
|  | 2.6 | mM | Transport association constant of GSH |
|  | 0 |  | Cellular model |

### Conservation relationship of glutathione

for both cytosolic and mitochondrial compartments.

| Parameter | Value | Unit | Desc. |
| --- | --- | --- | --- |
|  |  | mM | Cytosolic GSH pool |
|  |  | mM | Mitochondrial GSH pool |

## Thioredoxin system[[7]](#footnote-37)

### Peroxiredoxin (TPX)

Dalziel type Ping-pong mechanism, for both cytosolic and mitochondrial compartments.

| Parameter | Value | Unit | Desc. |
| --- | --- | --- | --- |
|  | 100 | μM | GPX content (cytosolic) |
|  | 3 | μM | GPX content (mitochondrial) |
|  | 3.83 | mM \* s | Dalziel coefficient |
|  | 1.85 | mM \* s | Dalziel coefficient |

### Thioredoxin reductase (TR)

Michaelis-Menten kinetics, for both cytosolic and mitochondrial compartments.

| Parameter | Value | Unit | Desc. |
| --- | --- | --- | --- |
|  | 0.35 | μM | TR content (cytosolic) |
|  | 0.35 | μM | TR content (mitochondrial) |
|  | 22.75 | Hz | Catalytic constant of GR |
|  | 35 | μM | Michaelis constant for GSSG |
|  | 65 | μM | Michaelis constant for NADPH |

### Conservation relationship of thioredoxin

For both cytosolic and mitochondrial compartments.

| Parameter | Value | Unit | Desc. |
| --- | --- | --- | --- |
|  | 25 | μM | Sum of cytosolic thioreoxin |
|  | 50 | μM | Sum of mitochondrial thioreoxin |

## Inner mitochondrial anion channel[[8]](#footnote-42)

| Parameter | Value | Unit | Desc. | | —————- | —— | ———— | ———————————- | | a | 0.001 | - | Basal IMAC conductance | | b | 10000 | - | Activation factor by | | | 10 | μM | Activation constant by | | | 0.035 | μM \* Hz / mV | Integral conductance for IMAC | | | 3.9085 | μM \* Hz / mV | Leak conductance of IMAC | | | 0.07 | 1/mV | Steepness factor | | | 4 | mV | Potential at half saturation | | j | 0.1 | - | Fraction of IMAC conductance |

## Hydrogen peroxide transfer[[9]](#footnote-44)

Simple diffusion.

| Parameter | Value | Unit | Desc. |
| --- | --- | --- | --- |
|  | 0.2 | Hz | Diffusion rate across IMM |

## Conservation of NADPH

## NADPH-producing isocitrate dehydrogenase (IDH2)[[10]](#footnote-47)

| Parameter | Value | Unit | Desc. |
| --- | --- | --- | --- |
|  | 500 | μM | Dissociation constant for H |
|  | 3.9 | μM | Michaelis constant for isocitrate |
|  | 6.7 | μM | Michaelis constant for NADP |
|  | 0.002 | μM | Inhibition constant for NADP |
|  | 12 | μM | Michaelis constant for NADPH |
|  | 510 | μM | Michaelis constant for αKG |
|  | 87 | μM\*Hz | Maximal forward rate of IDH2 |
|  | 5.45 | μM\*Hz | Maximal backward rate of IDH2 |

## Transhydrogenase (THD)[[11]](#footnote-49)

| Parameter | Value | Unit | Desc. |
| --- | --- | --- | --- |
|  | 20 | μM | Michaelis constant for NADPH |
|  | 10 | μM | Michaelis constant for NADH |
|  | 125 | μM | Michaelis constant for NAD |
|  | 17 | μM | Michaelis constant for NADP |
|  | 0.01187 | μM | Concentration of THD |
|  | 1174.74 | Hz | Forward catalytic constant |
|  | 1 | - | Apparent equilibrium constant |

## ODE system for ROS transport and scavenging

1. Cortassa S, Aon MA, Winslow RL, O’Rourke B. A mitochondrial oscillator dependent on reactive oxygen species. Biophys J. 2004;87(3):2060-73. [PMC1304608](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1304608/) [↑](#footnote-ref-20)
2. Cortassa S, Aon MA, Winslow RL, O’Rourke B. A mitochondrial oscillator dependent on reactive oxygen species. Biophys J. 2004;87(3):2060-73. [PMC1304608](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1304608/) [↑](#footnote-ref-23)
3. Cortassa S, Aon MA, Winslow RL, O’Rourke B. A mitochondrial oscillator dependent on reactive oxygen species. Biophys J. 2004;87(3):2060-73. [PMC1304608](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1304608/) [↑](#footnote-ref-25)
4. Kembro JM, Aon MA, Winslow RL, O’Rourke B, Cortassa S. Integrating mitochondrial energetics, redox and ROS metabolic networks: a two-compartment model. Biophys J. 2013;104(2):332-43. [PMC3552263](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3552263/) [↑](#footnote-ref-28)
5. Kembro JM, Aon MA, Winslow RL, O’Rourke B, Cortassa S. Integrating mitochondrial energetics, redox and ROS metabolic networks: a two-compartment model. Biophys J. 2013;104(2):332-43. [PMC3552263](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3552263/) [↑](#footnote-ref-31)
6. Kembro JM, Aon MA, Winslow RL, O’Rourke B, Cortassa S. Integrating mitochondrial energetics, redox and ROS metabolic networks: a two-compartment model. Biophys J. 2013;104(2):332-43. [PMC3552263](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3552263/) [↑](#footnote-ref-33)
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8. Cortassa S, Aon MA, Winslow RL, O’Rourke B. A mitochondrial oscillator dependent on reactive oxygen species. Biophys J. 2004;87(3):2060-73. [PMC1304608](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1304608/) [↑](#footnote-ref-42)
9. Kembro JM, Aon MA, Winslow RL, O’Rourke B, Cortassa S. Integrating mitochondrial energetics, redox and ROS metabolic networks: a two-compartment model. Biophys J. 2013;104(2):332-43. [PMC3552263](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3552263/) [↑](#footnote-ref-44)
10. Kembro JM, Aon MA, Winslow RL, O’Rourke B, Cortassa S. Integrating mitochondrial energetics, redox and ROS metabolic networks: a two-compartment model. Biophys J. 2013;104(2):332-43. [PMC3552263](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3552263/) [↑](#footnote-ref-47)
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