



## Introduction

Reactome is open-source, open access, manually curated and peer-reviewed pathway database. Pathway annotations are authored by expert biologists, in collaboration with Reactome editorial staff and cross-referenced to many bioinformatics databases. A system of evidence tracking ensures that all assertions are backed up by the primary literature. Reactome is used by clinicians, geneticists, genomics researchers, and molecular biologists to interpret the results of high-throughput experimental studies, by bioinformaticians seeking to develop novel algorithms for mining knowledge from genomic studies, and by systems biologists building predictive models of normal and disease variant pathways.

The development of Reactome is supported by grants from the US National Institutes of Health (P41 HG003751), University of Toronto (CFREF Medicine by Design), European Union (EU STRP, EMI-CD), and the European Molecular Biology Laboratory (EBI Industry program).

## Literature references

- Fabregat, A., Sidiropoulos, K., Viteri, G., Forner, O., Marin-Garcia, P., Arnau, V. et al. (2017). Reactome pathway analysis: a high-performance in-memory approach. *BMC bioinformatics*, 18, 142. [↗](#)
- Sidiropoulos, K., Viteri, G., Sevilla, C., Jupe, S., Webber, M., Orlic-Milacic, M. et al. (2017). Reactome enhanced pathway visualization. *Bioinformatics*, 33, 3461-3467. [↗](#)
- Fabregat, A., Jupe, S., Matthews, L., Sidiropoulos, K., Gillespie, M., Garapati, P. et al. (2018). The Reactome Pathway Knowledgebase. *Nucleic Acids Res*, 46, D649-D655. [↗](#)
- Fabregat, A., Korninger, F., Viteri, G., Sidiropoulos, K., Marin-Garcia, P., Ping, P. et al. (2018). Reactome graph database: Efficient access to complex pathway data. *PLoS computational biology*, 14, e1005968. [↗](#)

Reactome database release: 88

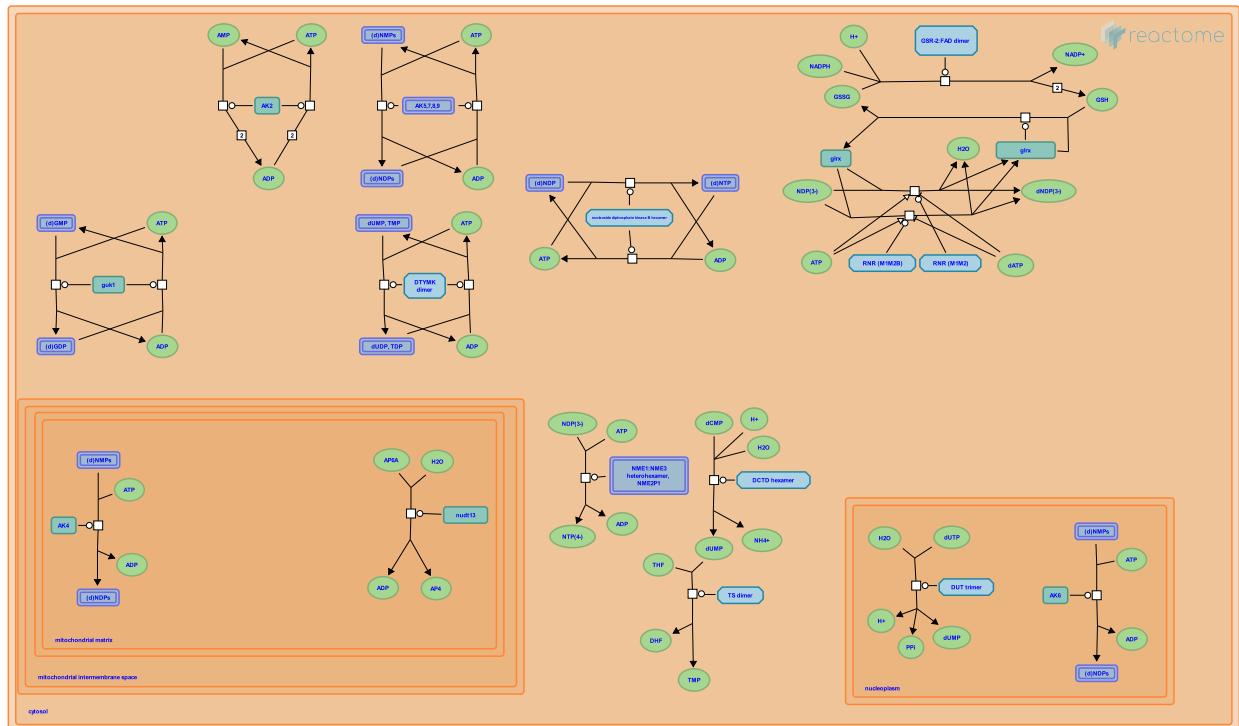
This document contains 1 pathway and 21 reactions ([see Table of Contents](#))

## Interconversion of nucleotide di- and triphosphates ↗

**Stable identifier:** R-XTR-499943

**Compartments:** cytosol, mitochondrial intermembrane space, nucleoplasm, mitochondrial inner membrane, mitochondrial matrix

**Inferred from:** [Interconversion of nucleotide di- and triphosphates \(Homo sapiens\)](#)



This event has been computationally inferred from an event that has been demonstrated in another species.

The inference is based on the homology mapping from PANTHER. Briefly, reactions for which all involved PhysicalEntities (in input, output and catalyst) have a mapped orthologue/paralogue (for complexes at least 75% of components must have a mapping) are inferred to the other species. High level events are also inferred for these events to allow for easier navigation.

[More details and caveats of the event inference in Reactome.](#) For details on PANTHER see also: <http://www.pantherdb.org/about.jsp>

**AMP + ATP <=> ADP + ADP [AK2]** ↗

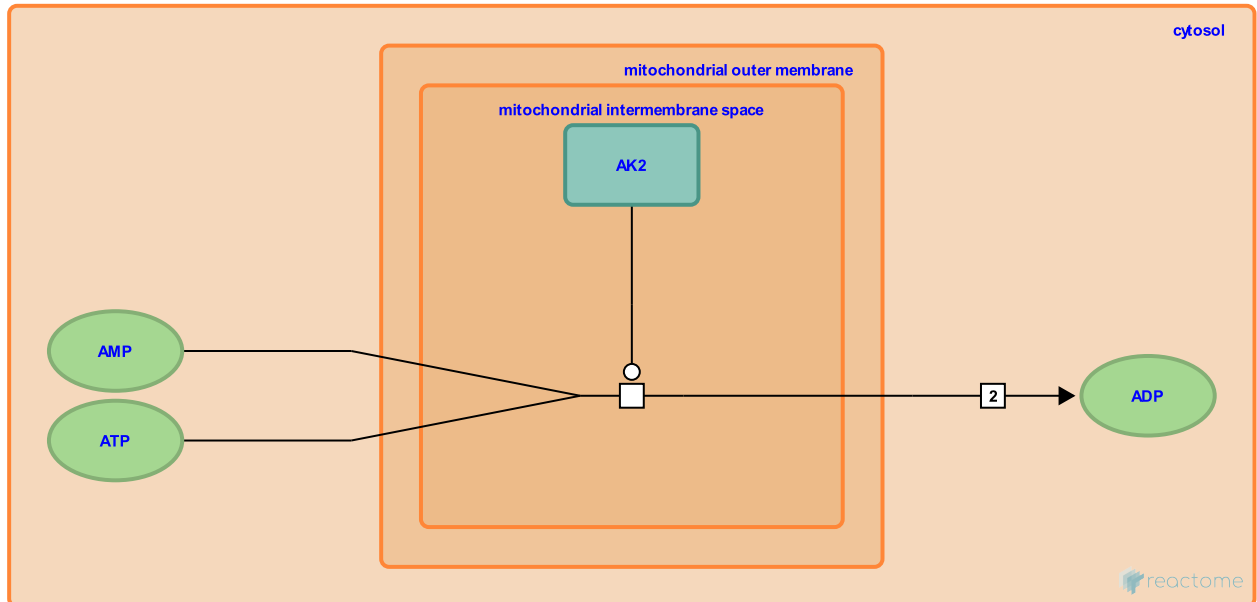
**Location:** [Interconversion of nucleotide di- and triphosphates](#)

**Stable identifier:** R-XTR-110145

**Type:** transition

**Compartments:** mitochondrial intermembrane space, cytosol

**Inferred from:** [AMP + ATP <=> ADP + ADP \[AK2\]](#) (Homo sapiens)



This event has been computationally inferred from an event that has been demonstrated in another species.

The inference is based on the homology mapping from PANTHER. Briefly, reactions for which all involved PhysicalEntities (in input, output and catalyst) have a mapped orthologue/paralogue (for complexes at least 75% of components must have a mapping) are inferred to the other species. High level events are also inferred for these events to allow for easier navigation.

[More details and caveats of the event inference in Reactome.](#) For details on PANTHER see also: <http://www.pantherdb.org/about.jsp>

## ADP + ADP <=> AMP + ATP [AK2] ↗

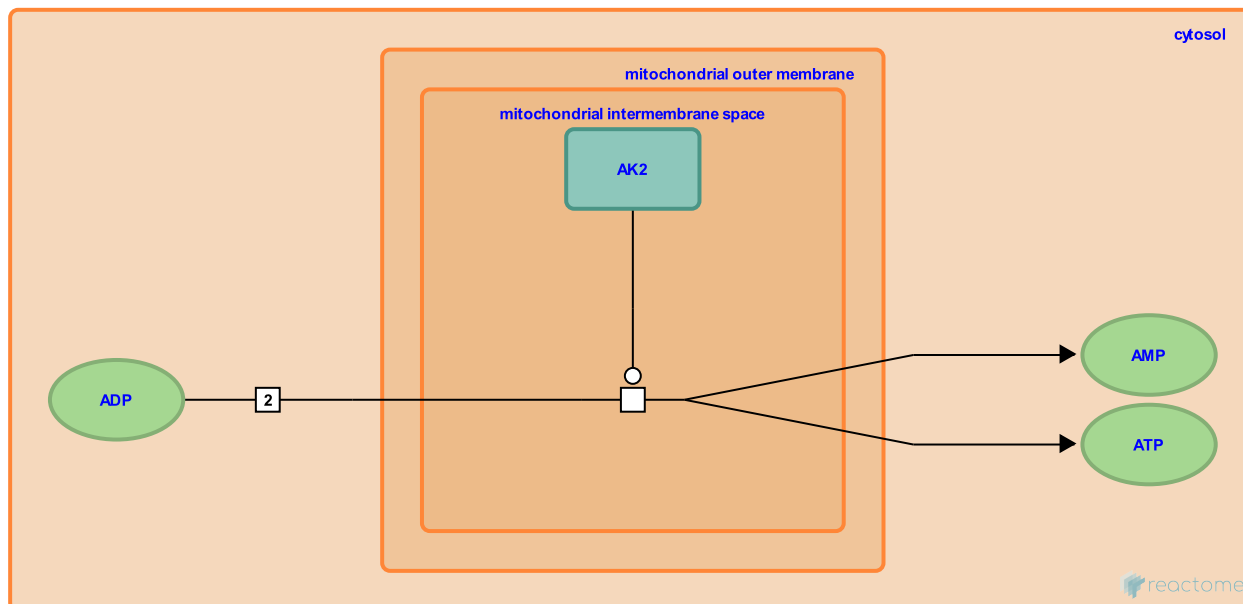
**Location:** [Interconversion of nucleotide di- and triphosphates](#)

**Stable identifier:** R-XTR-110144

**Type:** transition

**Compartments:** mitochondrial intermembrane space, cytosol

**Inferred from:** [ADP + ADP <=> AMP + ATP \[AK2\]](#) (Homo sapiens)



This event has been computationally inferred from an event that has been demonstrated in another species.

The inference is based on the homology mapping from PANTHER. Briefly, reactions for which all involved PhysicalEntities (in input, output and catalyst) have a mapped orthologue/paralogue (for complexes at least 75% of components must have a mapping) are inferred to the other species. High level events are also inferred for these events to allow for easier navigation.

[More details and caveats of the event inference in Reactome.](#) For details on PANTHER see also: <http://www.pantherdb.org/about.jsp>

## AK5,7,8,9 phosphorylates (d)NMPs to (d)NDPs ↗

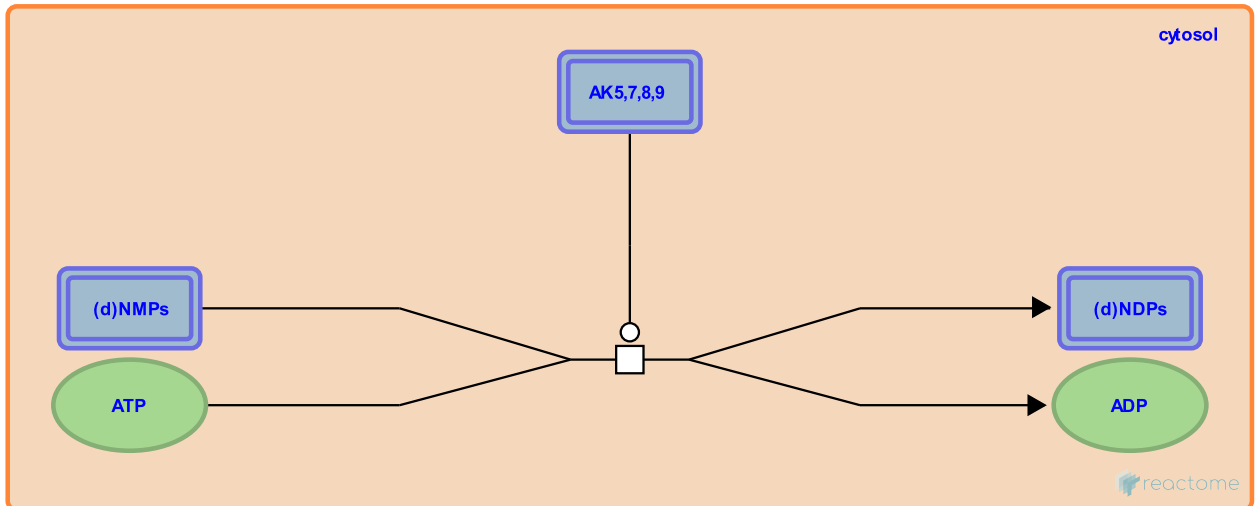
**Location:** [Interconversion of nucleotide di- and triphosphates](#)

**Stable identifier:** R-XTR-110138

**Type:** transition

**Compartments:** cytosol

**Inferred from:** [AK5,7,8,9 phosphorylates \(d\)NMPs to \(d\)NDPs \(Homo sapiens\)](#)



This event has been computationally inferred from an event that has been demonstrated in another species.

The inference is based on the homology mapping from PANTHER. Briefly, reactions for which all involved PhysicalEntities (in input, output and catalyst) have a mapped orthologue/paralogue (for complexes at least 75% of components must have a mapping) are inferred to the other species. High level events are also inferred for these events to allow for easier navigation.

[More details and caveats of the event inference in Reactome.](#) For details on PANTHER see also: <http://www.pantherdb.org/about.jsp>

**(d)ADP or (d)CDP + ADP <=> (d)AMP or (d)CMP + ATP ↗**

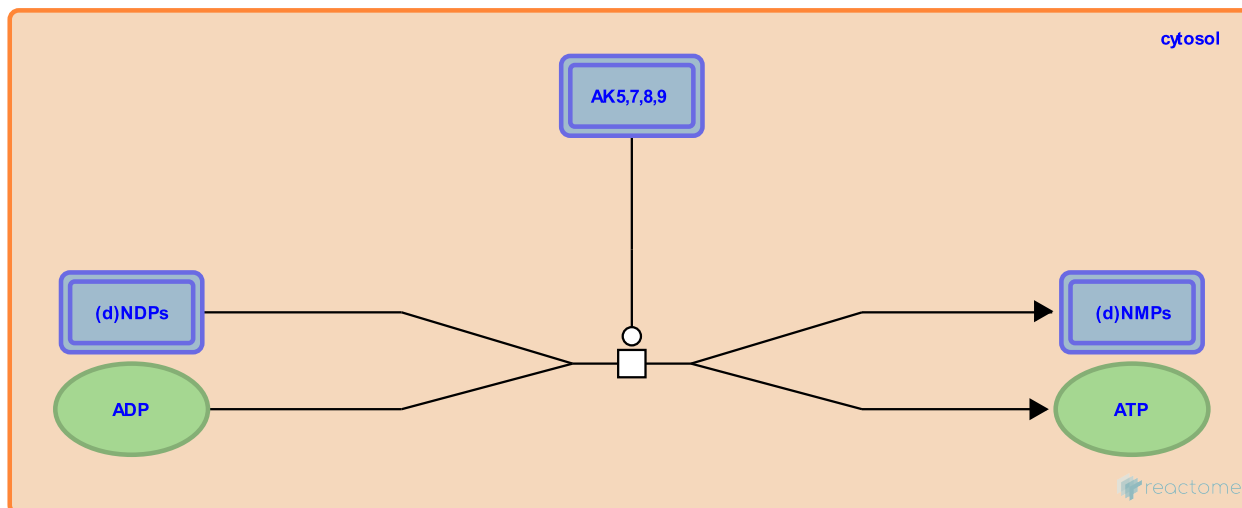
**Location:** [Interconversion of nucleotide di- and triphosphates](#)

**Stable identifier:** R-XTR-110137

**Type:** transition

**Compartments:** cytosol

**Inferred from:** [\(d\)ADP or \(d\)CDP + ADP <=> \(d\)AMP or \(d\)CMP + ATP \(Homo sapiens\)](#)



This event has been computationally inferred from an event that has been demonstrated in another species.

The inference is based on the homology mapping from PANTHER. Briefly, reactions for which all involved PhysicalEntities (in input, output and catalyst) have a mapped orthologue/paralogue (for complexes at least 75% of components must have a mapping) are inferred to the other species. High level events are also inferred for these events to allow for easier navigation.

[More details and caveats of the event inference in Reactome.](#) For details on PANTHER see also: <http://www.pantherdb.org/about.jsp>

## AK4 phosphorylates (d)NMPs to (d)NDPs ↗

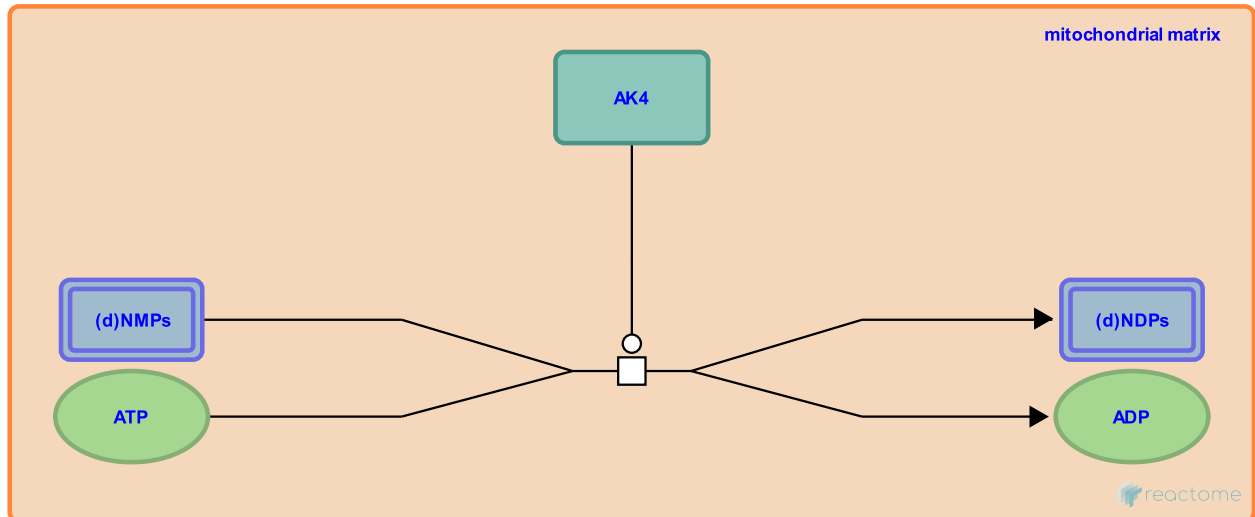
**Location:** [Interconversion of nucleotide di- and triphosphates](#)

**Stable identifier:** R-XTR-6788798

**Type:** transition

**Compartments:** mitochondrial matrix

**Inferred from:** [AK4 phosphorylates \(d\)NMPs to \(d\)NDPs \(Homo sapiens\)](#)



This event has been computationally inferred from an event that has been demonstrated in another species.

The inference is based on the homology mapping from PANTHER. Briefly, reactions for which all involved PhysicalEntities (in input, output and catalyst) have a mapped orthologue/paralogue (for complexes at least 75% of components must have a mapping) are inferred to the other species. High level events are also inferred for these events to allow for easier navigation.

[More details and caveats of the event inference in Reactome.](#) For details on PANTHER see also: <http://www.pantherdb.org/about.jsp>



## AK6 phosphorylates (d)NMPs to (d)NDPs ↗

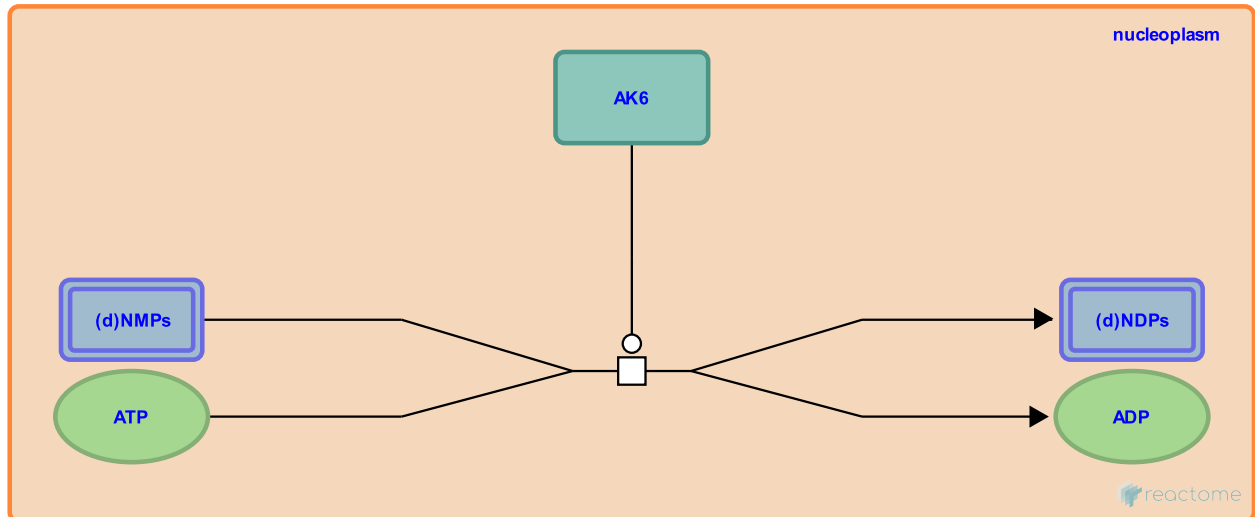
**Location:** [Interconversion of nucleotide di- and triphosphates](#)

**Stable identifier:** R-XTR-6788810

**Type:** transition

**Compartments:** nucleoplasm

**Inferred from:** [AK6 phosphorylates \(d\)NMPs to \(d\)NDPs \(Homo sapiens\)](#)



This event has been computationally inferred from an event that has been demonstrated in another species.

The inference is based on the homology mapping from PANTHER. Briefly, reactions for which all involved PhysicalEntities (in input, output and catalyst) have a mapped orthologue/paralogue (for complexes at least 75% of components must have a mapping) are inferred to the other species. High level events are also inferred for these events to allow for easier navigation.

[More details and caveats of the event inference in Reactome.](#) For details on PANTHER see also: <http://www.pantherdb.org/about.jsp>

**(d)GMP + ATP <=> (d)GDP + ADP (GUK1) ↗**

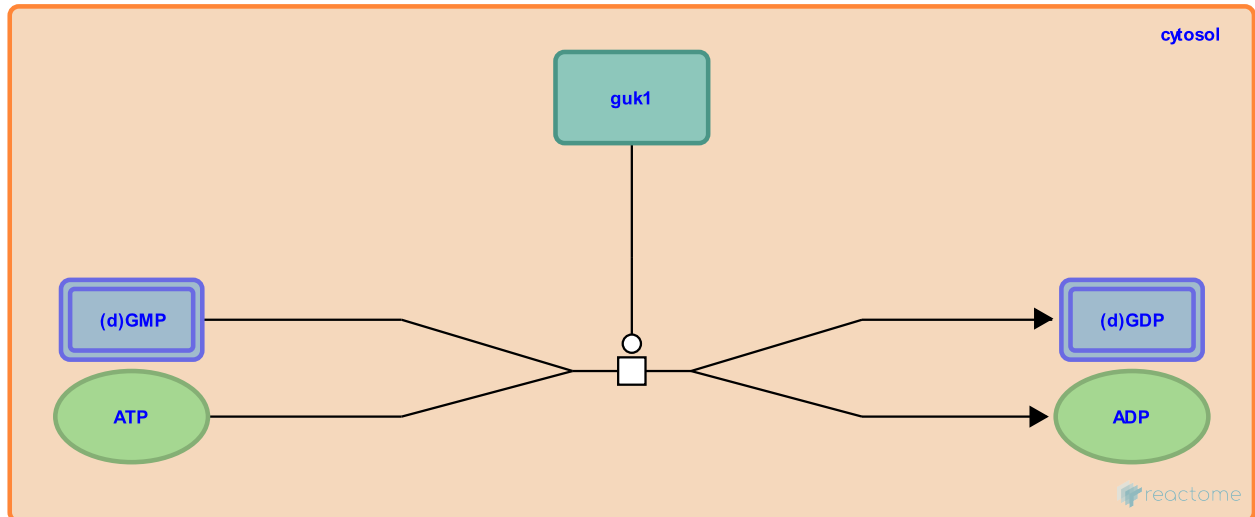
**Location:** Interconversion of nucleotide di- and triphosphates

**Stable identifier:** R-XTR-73788

**Type:** transition

**Compartments:** cytosol

**Inferred from:** (d)GMP + ATP <=> (d)GDP + ADP (GUK1) (Homo sapiens)



This event has been computationally inferred from an event that has been demonstrated in another species.

The inference is based on the homology mapping from PANTHER. Briefly, reactions for which all involved PhysicalEntities (in input, output and catalyst) have a mapped orthologue/paralogue (for complexes at least 75% of components must have a mapping) are inferred to the other species. High level events are also inferred for these events to allow for easier navigation.

[More details and caveats of the event inference in Reactome.](http://www.pantherdb.org/about.jsp) For details on PANTHER see also: <http://www.pantherdb.org/about.jsp>

**Followed by:** (d)NDP + ATP <=> (d)NTP + ADP (NME1,2,3)

**(d)GDP + ADP <=> (d)GMP + ATP (GUK1) ↗**

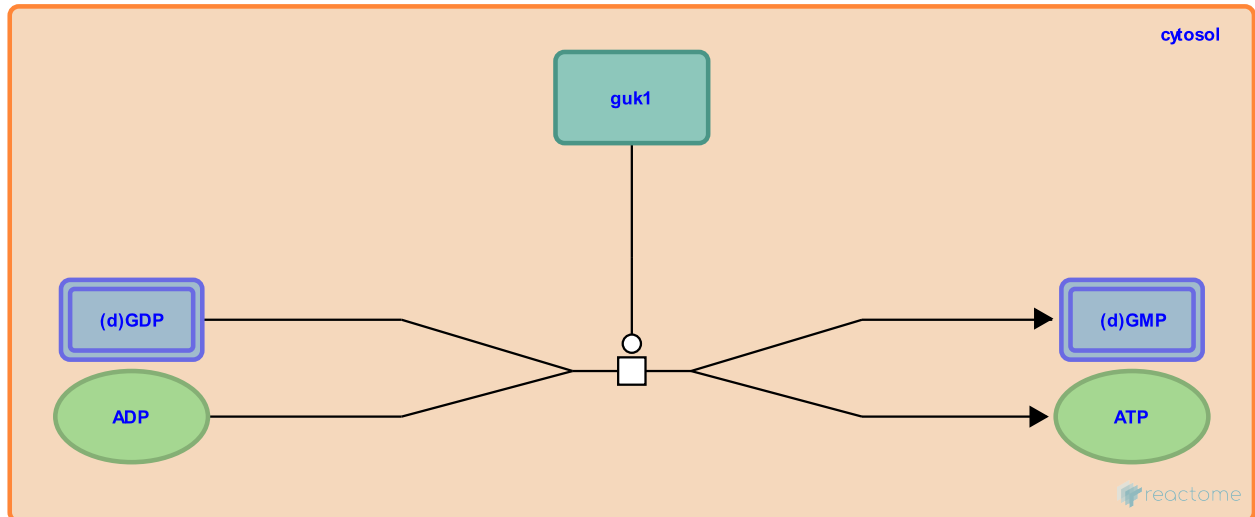
**Location:** Interconversion of nucleotide di- and triphosphates

**Stable identifier:** R-XTR-110133

**Type:** transition

**Compartments:** cytosol

**Inferred from:** (d)GDP + ADP <=> (d)GMP + ATP (GUK1) (Homo sapiens)



This event has been computationally inferred from an event that has been demonstrated in another species.

The inference is based on the homology mapping from PANTHER. Briefly, reactions for which all involved PhysicalEntities (in input, output and catalyst) have a mapped orthologue/paralogue (for complexes at least 75% of components must have a mapping) are inferred to the other species. High level events are also inferred for these events to allow for easier navigation.

[More details and caveats of the event inference in Reactome.](http://www.pantherdb.org/about.jsp) For details on PANTHER see also: <http://www.pantherdb.org/about.jsp>

**dUMP or TMP + ATP <=> dUDP or TDP + ADP [DTYMK]** ↗

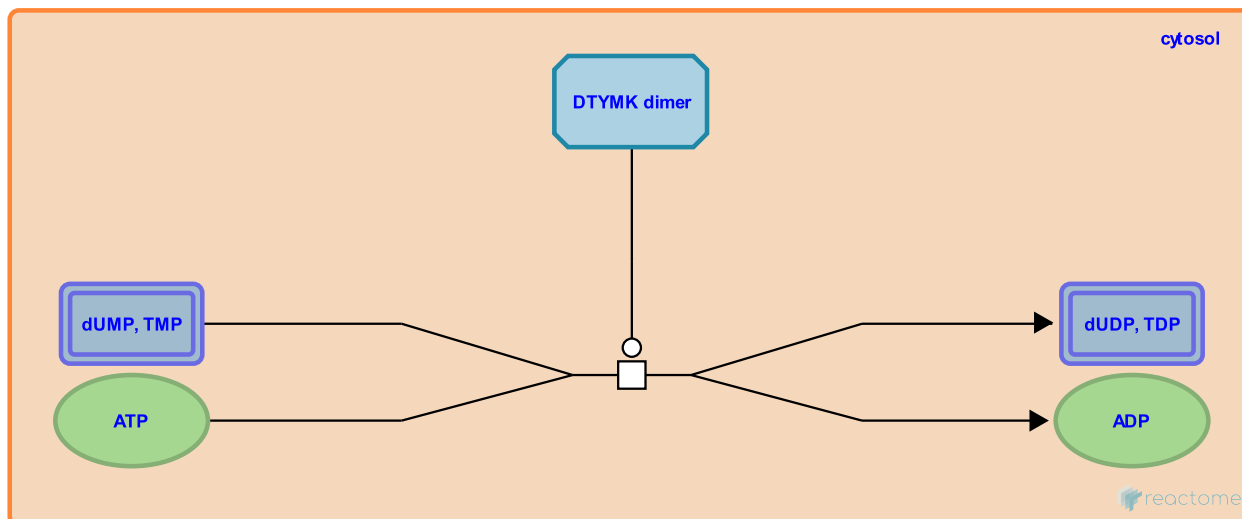
**Location:** [Interconversion of nucleotide di- and triphosphates](#)

**Stable identifier:** R-XTR-73635

**Type:** transition

**Compartments:** cytosol

**Inferred from:** [dUMP or TMP + ATP <=> dUDP or TDP + ADP \[DTYMK\]](#) (Homo sapiens)



This event has been computationally inferred from an event that has been demonstrated in another species.

The inference is based on the homology mapping from PANTHER. Briefly, reactions for which all involved PhysicalEntities (in input, output and catalyst) have a mapped orthologue/paralogue (for complexes at least 75% of components must have a mapping) are inferred to the other species. High level events are also inferred for these events to allow for easier navigation.

[More details and caveats of the event inference in Reactome.](#) For details on PANTHER see also: <http://www.pantherdb.org/about.jsp>

**Preceded by:** [dCMP + H2O => dUMP + NH4+](#), [dUMP + N5,N10-methylene tetrahydrofolate => TMP + dihydrofolate](#)

**Followed by:** [\(d\)NDP + ATP <=> \(d\)NTP + ADP \(NME1,2,3\)](#)

**dUDP or TDP + ADP <=> dUMP or TMP + ATP [DTYMK]** ↗

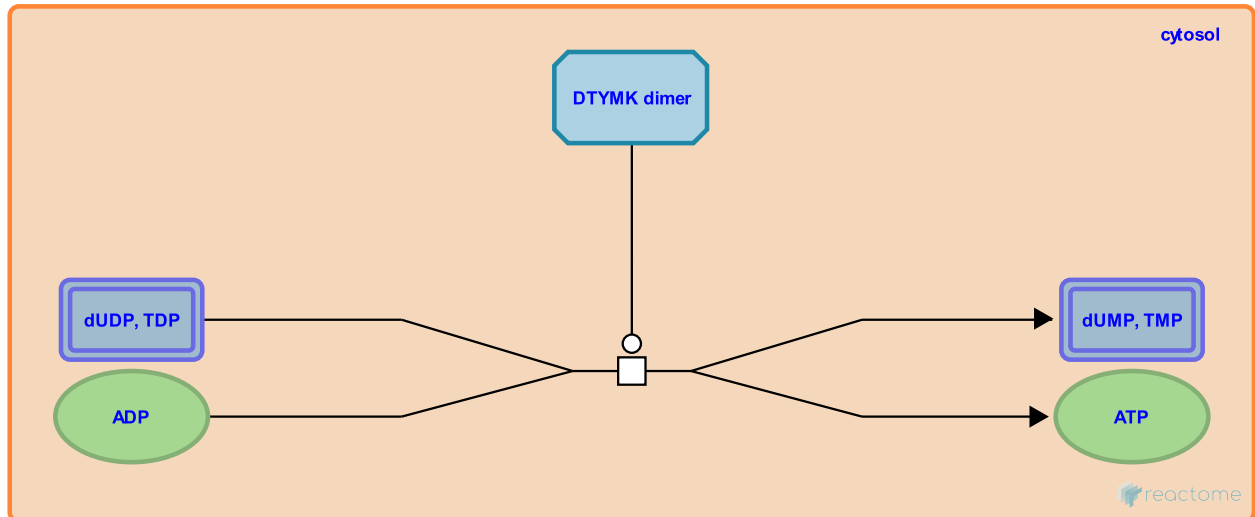
**Location:** Interconversion of nucleotide di- and triphosphates

**Stable identifier:** R-XTR-75126

**Type:** transition

**Compartments:** cytosol

**Inferred from:** dUDP or TDP + ADP <=> dUMP or TMP + ATP [DTYMK] (Homo sapiens)



This event has been computationally inferred from an event that has been demonstrated in another species.

The inference is based on the homology mapping from PANTHER. Briefly, reactions for which all involved PhysicalEntities (in input, output and catalyst) have a mapped orthologue/paralogue (for complexes at least 75% of components must have a mapping) are inferred to the other species. High level events are also inferred for these events to allow for easier navigation.

[More details and caveats of the event inference in Reactome.](http://www.pantherdb.org/about.jsp) For details on PANTHER see also: <http://www.pantherdb.org/about.jsp>

## RNR (M1M2) reduces nucleotide diphosphates to deoxynucleotide diphosphates (glutaredoxin) ↗

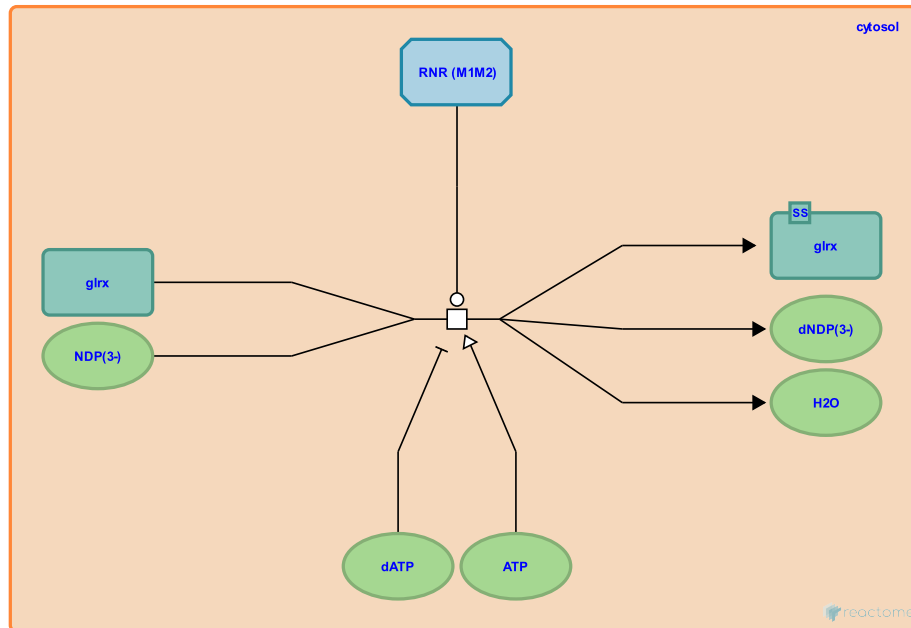
**Location:** [Interconversion of nucleotide di- and triphosphates](#)

**Stable identifier:** R-XTR-111742

**Type:** transition

**Compartments:** cytosol

**Inferred from:** [RNR \(M1M2\) reduces nucleotide diphosphates to deoxynucleotide diphosphates \(glutaredoxin\)](#) (Homo sapiens)



This event has been computationally inferred from an event that has been demonstrated in another species.

The inference is based on the homology mapping from PANTHER. Briefly, reactions for which all involved PhysicalEntities (in input, output and catalyst) have a mapped orthologue/paralogue (for complexes at least 75% of components must have a mapping) are inferred to the other species. High level events are also inferred for these events to allow for easier navigation.

[More details and caveats of the event inference in Reactome.](#) For details on PANTHER see also: <http://www.pantherdb.org/about.jsp>

**Preceded by:** glutaredoxin (oxidized) + glutathione (reduced) => glutaredoxin (reduced) + glutathione (oxidized)

## RNR (M1M2B) reduces nucleotide diphosphates to deoxynucleotide diphosphates (glutaredoxin) ↗

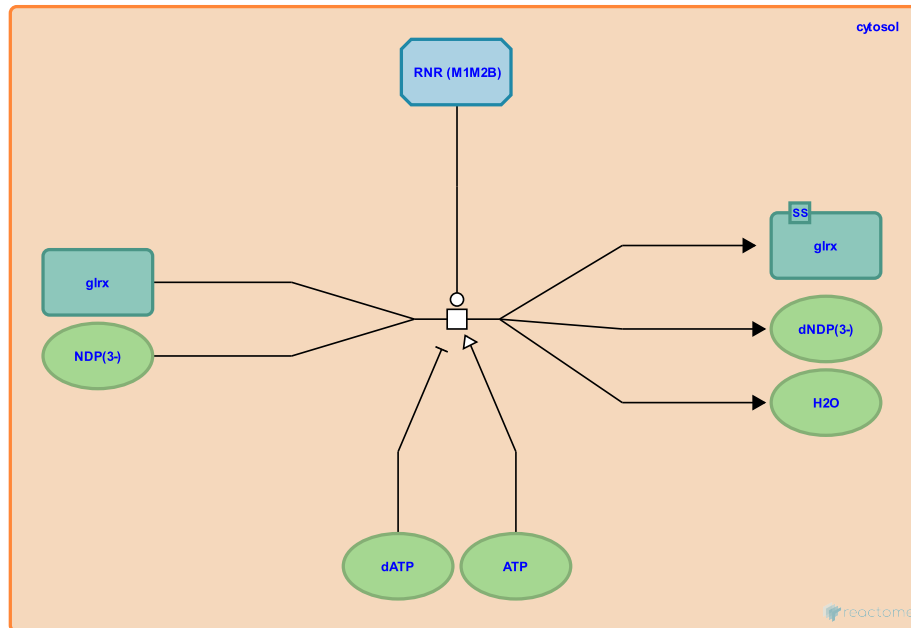
**Location:** Interconversion of nucleotide di- and triphosphates

**Stable identifier:** R-XTR-8866405

**Type:** transition

**Compartments:** cytosol

**Inferred from:** RNR (M1M2B) reduces nucleotide diphosphates to deoxynucleotide diphosphates (glutaredoxin) (Homo sapiens)



This event has been computationally inferred from an event that has been demonstrated in another species.

The inference is based on the homology mapping from PANTHER. Briefly, reactions for which all involved PhysicalEntities (in input, output and catalyst) have a mapped orthologue/paralogue (for complexes at least 75% of components must have a mapping) are inferred to the other species. High level events are also inferred for these events to allow for easier navigation.

[More details and caveats of the event inference in Reactome.](http://www.pantherdb.org/about.jsp) For details on PANTHER see also: <http://www.pantherdb.org/about.jsp>

**Preceded by:** glutaredoxin (oxidized) + glutathione (reduced) => glutaredoxin (reduced) + glutathione (oxidized)

**glutaredoxin (oxidized) + glutathione (reduced) => glutaredoxin (reduced) + glutathione (oxidized)** ↗

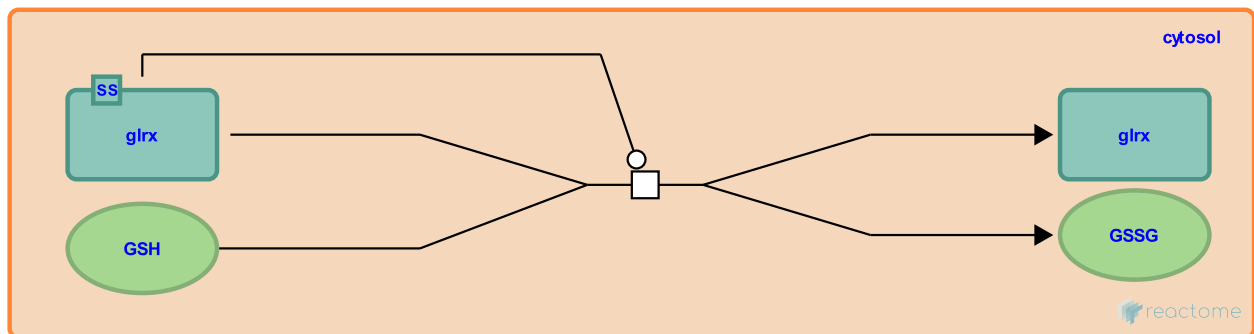
**Location:** [Interconversion of nucleotide di- and triphosphates](#)

**Stable identifier:** R-XTR-111746

**Type:** transition

**Compartments:** cytosol

**Inferred from:** [glutaredoxin \(oxidized\) + glutathione \(reduced\) => glutaredoxin \(reduced\) + glutathione \(oxidized\)](#) (Homo sapiens)



This event has been computationally inferred from an event that has been demonstrated in another species.

The inference is based on the homology mapping from PANTHER. Briefly, reactions for which all involved PhysicalEntities (in input, output and catalyst) have a mapped orthologue/paralogue (for complexes at least 75% of components must have a mapping) are inferred to the other species. High level events are also inferred for these events to allow for easier navigation.

[More details and caveats of the event inference in Reactome.](#) For details on PANTHER see also: <http://www.pantherdb.org/about.jsp>

**Followed by:** [RNR \(M1M2\) reduces nucleotide diphosphates to deoxynucleotide diphosphates \(glutaredoxin\)](#), [RNR \(M1M2B\) reduces nucleotide diphosphates to deoxynucleotide diphosphates \(glutaredoxin\)](#), [glutathione \(oxidized\) + NADPH + H+ => 2 glutathione \(reduced\) + NADP+](#)



**glutathione (oxidized) + NADPH + H+ => 2 glutathione (reduced) + NADP+ ↗**

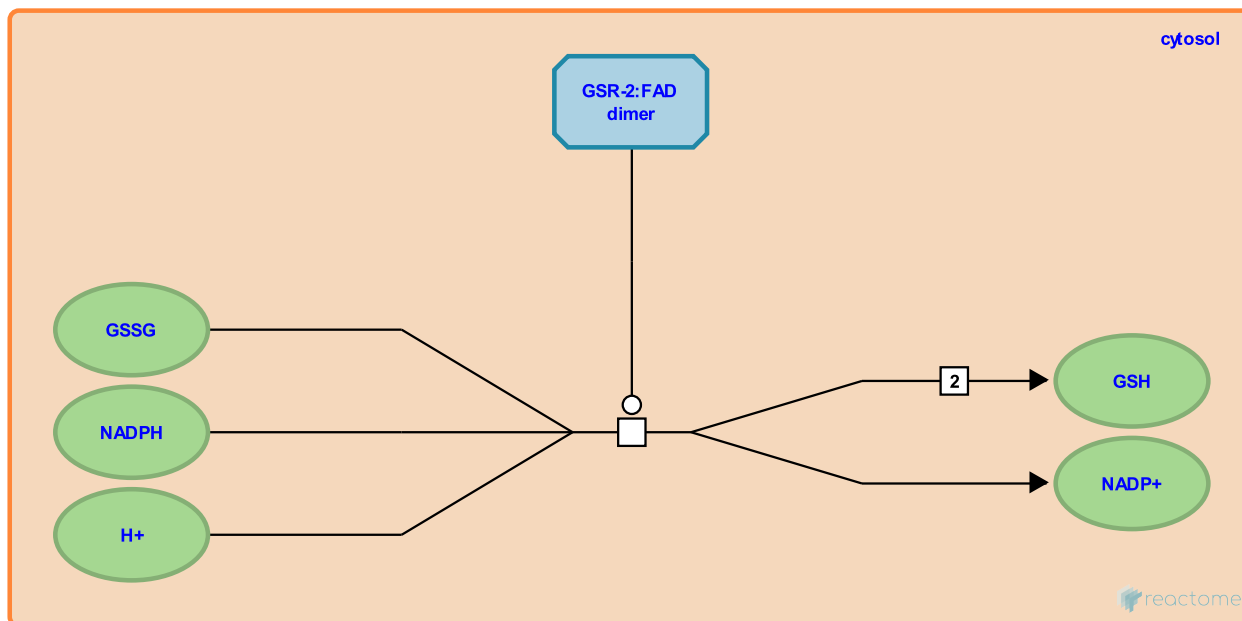
**Location:** [Interconversion of nucleotide di- and triphosphates](#)

**Stable identifier:** R-XTR-71682

**Type:** transition

**Compartments:** cytosol

**Inferred from:** [glutathione \(oxidized\) + NADPH + H+ => 2 glutathione \(reduced\) + NADP+ \(Homo sapiens\)](#)



This event has been computationally inferred from an event that has been demonstrated in another species.

The inference is based on the homology mapping from PANTHER. Briefly, reactions for which all involved PhysicalEntities (in input, output and catalyst) have a mapped orthologue/paralogue (for complexes at least 75% of components must have a mapping) are inferred to the other species. High level events are also inferred for these events to allow for easier navigation.

[More details and caveats of the event inference in Reactome.](#) For details on PANTHER see also: <http://www.pantherdb.org/about.jsp>

**Preceded by:** [glutaredoxin \(oxidized\) + glutathione \(reduced\) => glutaredoxin \(reduced\) + glutathione \(oxidized\)](#)

**(d)NDP + ATP <=> (d)NTP + ADP (NME1,2,3) ↗**

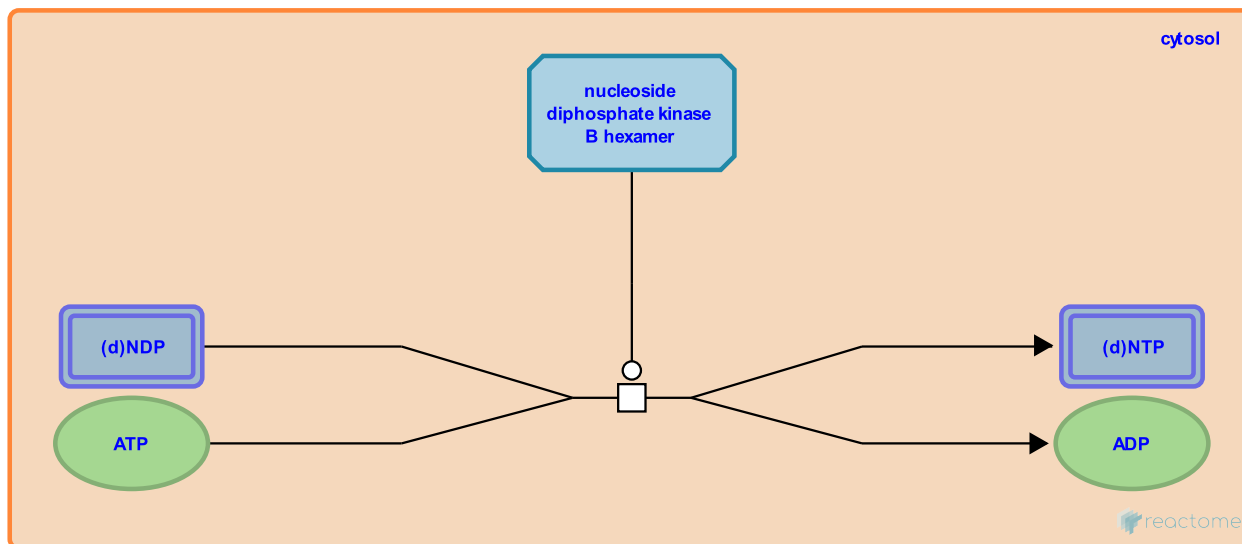
**Location:** Interconversion of nucleotide di- and triphosphates

**Stable identifier:** R-XTR-482619

**Type:** transition

**Compartments:** cytosol

**Inferred from:** (d)NDP + ATP <=> (d)NTP + ADP (NME1,2,3) (Homo sapiens)



This event has been computationally inferred from an event that has been demonstrated in another species.

The inference is based on the homology mapping from PANTHER. Briefly, reactions for which all involved PhysicalEntities (in input, output and catalyst) have a mapped orthologue/paralogue (for complexes at least 75% of components must have a mapping) are inferred to the other species. High level events are also inferred for these events to allow for easier navigation.

[More details and caveats of the event inference in Reactome.](http://www.pantherdb.org/about.jsp) For details on PANTHER see also: <http://www.pantherdb.org/about.jsp>

**Preceded by:** dUMP or TMP + ATP <=> dUDP or TDP + ADP [DTYMK], (d)GMP + ATP <=> (d)GDP + ADP (GUK1)

**(d)NTP + ADP <=> (d)NDP + ATP (NME1,2,3) ↗**

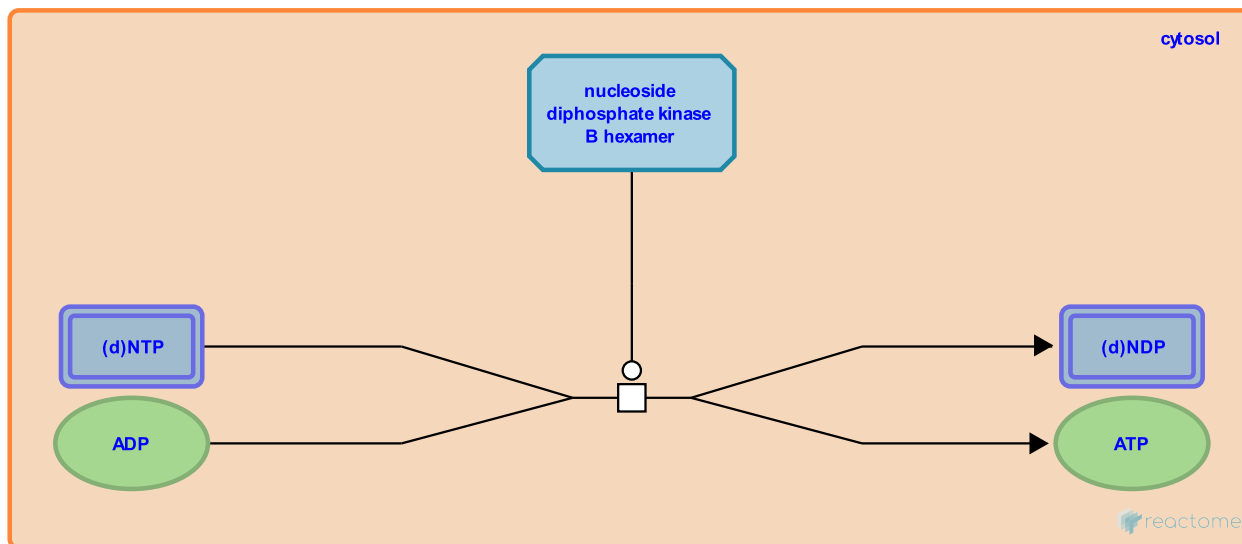
**Location:** Interconversion of nucleotide di- and triphosphates

**Stable identifier:** R-XTR-482621

**Type:** transition

**Compartments:** cytosol

**Inferred from:** (d)NTP + ADP <=> (d)NDP + ATP (NME1,2,3) (Homo sapiens)



This event has been computationally inferred from an event that has been demonstrated in another species.

The inference is based on the homology mapping from PANTHER. Briefly, reactions for which all involved PhysicalEntities (in input, output and catalyst) have a mapped orthologue/paralogue (for complexes at least 75% of components must have a mapping) are inferred to the other species. High level events are also inferred for these events to allow for easier navigation.

[More details and caveats of the event inference in Reactome.](https://www.reactome.org) For details on PANTHER see also: <http://www.pantherdb.org/about.jsp>

## NUDT13 hydrolyses AP6A to AP4 and ADP ↗

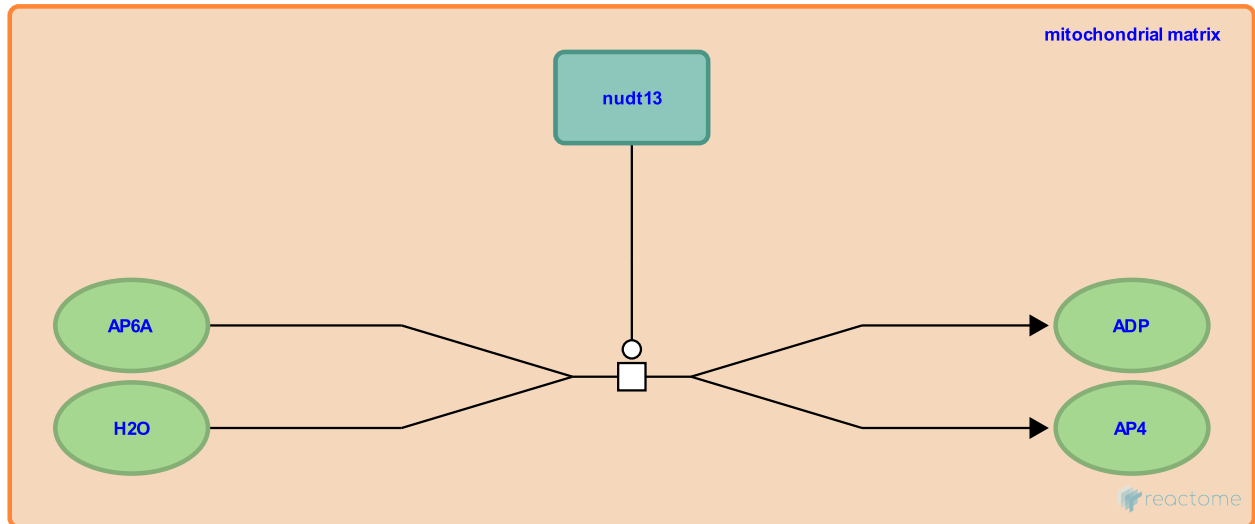
**Location:** [Interconversion of nucleotide di- and triphosphates](#)

**Stable identifier:** R-XTR-6810472

**Type:** transition

**Compartments:** mitochondrial matrix

**Inferred from:** [NUDT13 hydrolyses AP6A to AP4 and ADP \(Homo sapiens\)](#)



This event has been computationally inferred from an event that has been demonstrated in another species.

The inference is based on the homology mapping from PANTHER. Briefly, reactions for which all involved PhysicalEntities (in input, output and catalyst) have a mapped orthologue/paralogue (for complexes at least 75% of components must have a mapping) are inferred to the other species. High level events are also inferred for these events to allow for easier navigation.

[More details and caveats of the event inference in Reactome.](#) For details on PANTHER see also: <http://www.pantherdb.org/about.jsp>

## NME1:NME3 heterohexamer, NME2P1 phosphorylate NDPs to NTPs ↗

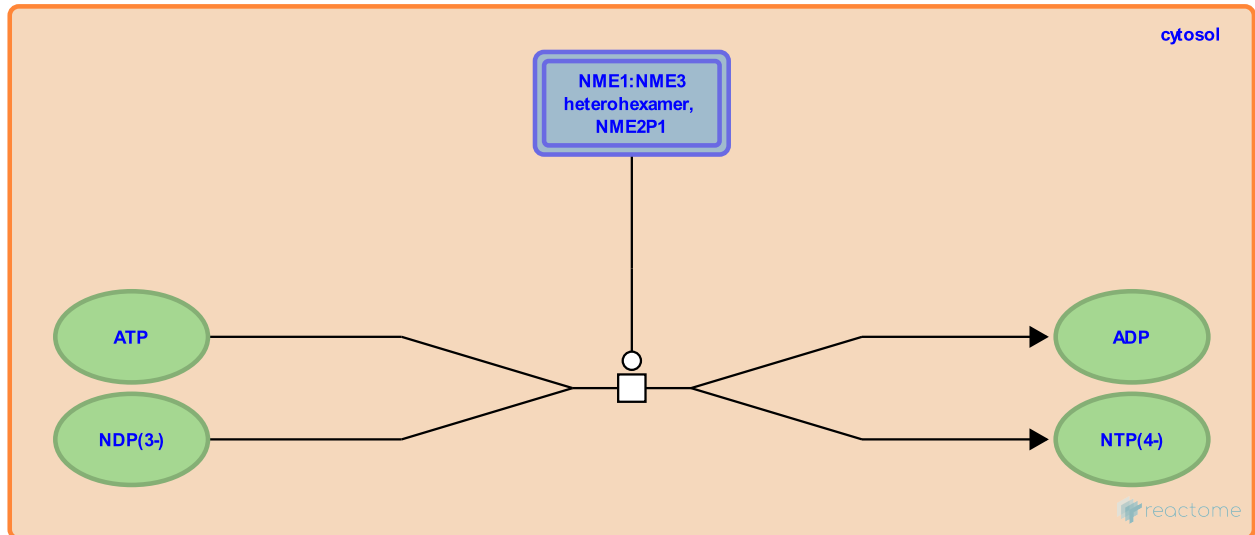
**Location:** [Interconversion of nucleotide di- and triphosphates](#)

**Stable identifier:** R-XTR-6806877

**Type:** transition

**Compartments:** cytosol

**Inferred from:** [NME1:NME3 heterohexamer, NME2P1 phosphorylate NDPs to NTPs \(Homo sapiens\)](#)



This event has been computationally inferred from an event that has been demonstrated in another species.

The inference is based on the homology mapping from PANTHER. Briefly, reactions for which all involved PhysicalEntities (in input, output and catalyst) have a mapped orthologue/paralogue (for complexes at least 75% of components must have a mapping) are inferred to the other species. High level events are also inferred for these events to allow for easier navigation.

[More details and caveats of the event inference in Reactome.](#) For details on PANTHER see also: <http://www.pantherdb.org/about.jsp>



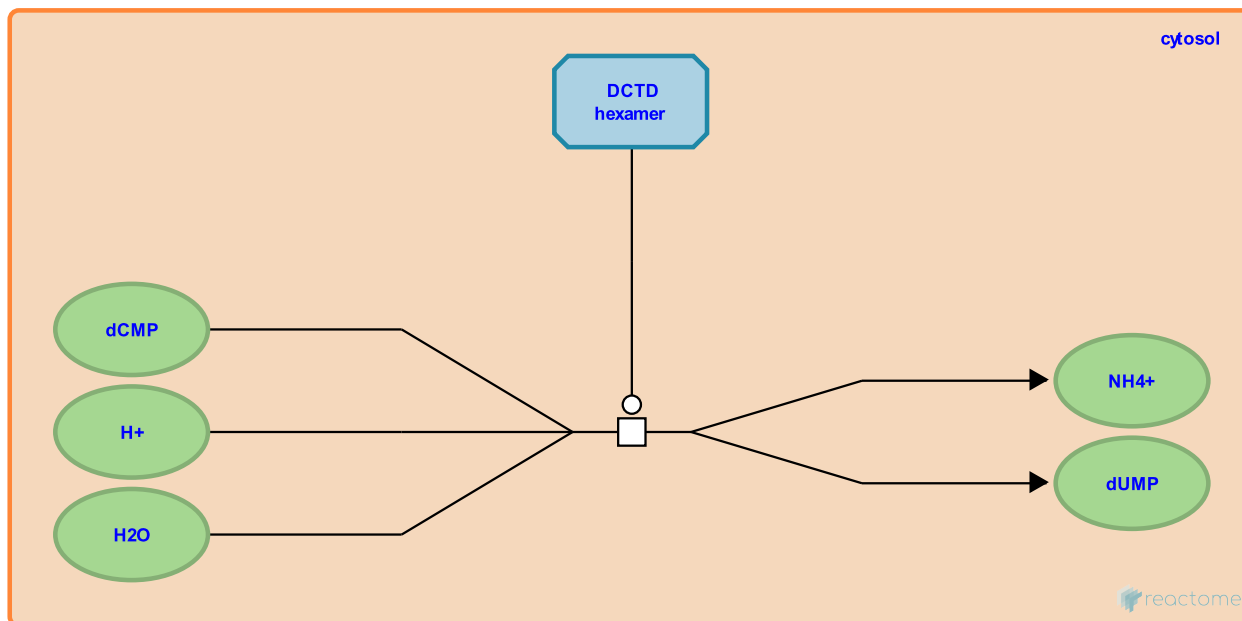
**Location:** [Interconversion of nucleotide di- and triphosphates](#)

**Stable identifier:** R-XTR-73596

**Type:** transition

**Compartments:** cytosol

**Inferred from:** [dCMP + H<sub>2</sub>O => dUMP + NH<sub>4</sub><sup>+</sup> \(Homo sapiens\)](#)



This event has been computationally inferred from an event that has been demonstrated in another species.

The inference is based on the homology mapping from PANTHER. Briefly, reactions for which all involved PhysicalEntities (in input, output and catalyst) have a mapped orthologue/paralogue (for complexes at least 75% of components must have a mapping) are inferred to the other species. High level events are also inferred for these events to allow for easier navigation.

[More details and caveats of the event inference in Reactome.](#) For details on PANTHER see also: <http://www.pantherdb.org/about.jsp>

**Followed by:** [dUMP or TMP + ATP <=> dUDP or TDP + ADP \[DTYMK\]](#), [dUMP + N<sup>5</sup>,N<sup>10</sup>-methylene tetrahydrofolate => TMP + dihydrofolate](#)

## **dUTP + H<sub>2</sub>O => dUMP + pyrophosphate** ↗

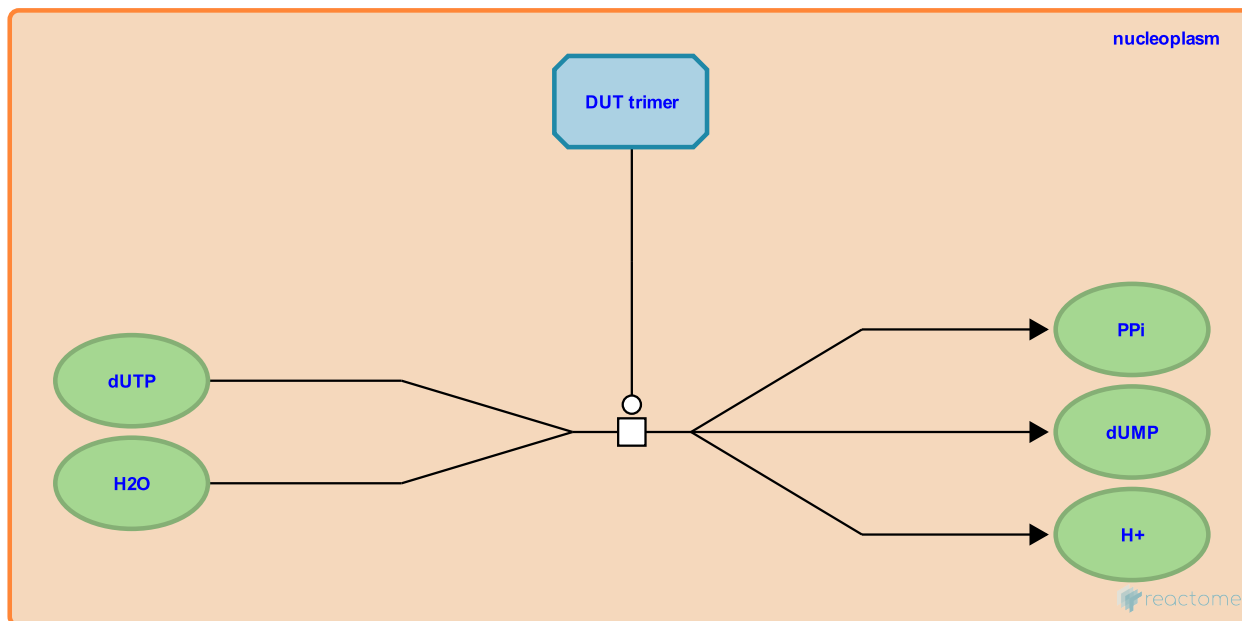
**Location:** Interconversion of nucleotide di- and triphosphates

**Stable identifier:** R-XTR-73666

**Type:** transition

**Compartments:** nucleoplasm

**Inferred from:** dUTP + H<sub>2</sub>O => dUMP + pyrophosphate (Homo sapiens)



This event has been computationally inferred from an event that has been demonstrated in another species.

The inference is based on the homology mapping from PANTHER. Briefly, reactions for which all involved PhysicalEntities (in input, output and catalyst) have a mapped orthologue/paralogue (for complexes at least 75% of components must have a mapping) are inferred to the other species. High level events are also inferred for these events to allow for easier navigation.

[More details and caveats of the event inference in Reactome.](http://www.pantherdb.org/about.jsp) For details on PANTHER see also: <http://www.pantherdb.org/about.jsp>

**Followed by:** dUMP + N<sub>5</sub>,N<sub>10</sub>-methylene tetrahydrofolate => TMP + dihydrofolate

**dUMP + N5,N10-methylene tetrahydrofolate => TMP + dihydrofolate** ↗

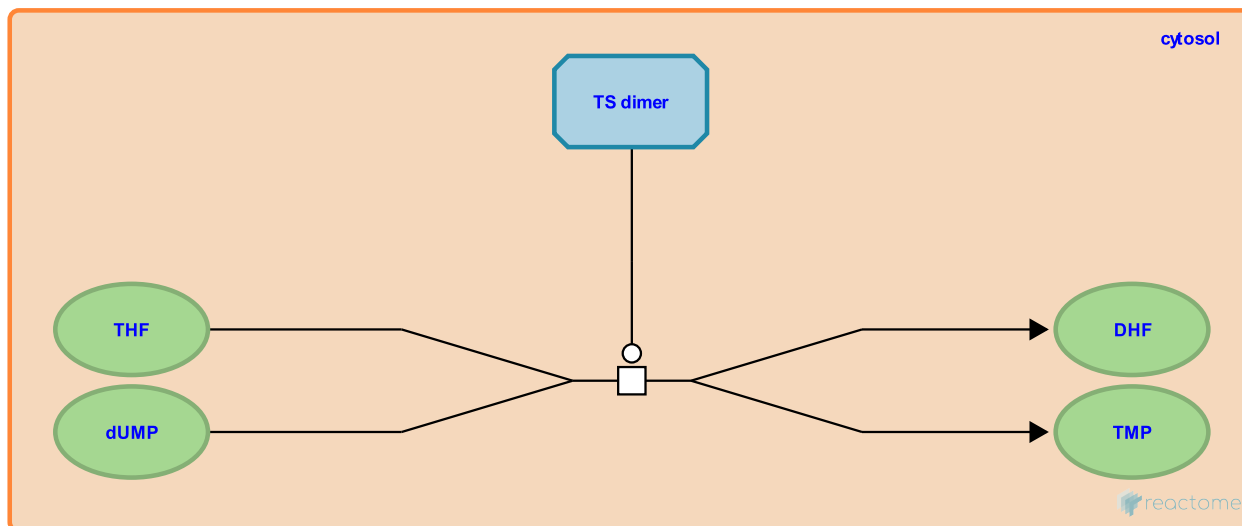
**Location:** [Interconversion of nucleotide di- and triphosphates](#)

**Stable identifier:** R-XTR-73605

**Type:** transition

**Compartments:** cytosol

**Inferred from:** [dUMP + N5,N10-methylene tetrahydrofolate => TMP + dihydrofolate \(Homo sapiens\)](#)



This event has been computationally inferred from an event that has been demonstrated in another species.

The inference is based on the homology mapping from PANTHER. Briefly, reactions for which all involved PhysicalEntities (in input, output and catalyst) have a mapped orthologue/paralogue (for complexes at least 75% of components must have a mapping) are inferred to the other species. High level events are also inferred for these events to allow for easier navigation.

[More details and caveats of the event inference in Reactome.](#) For details on PANTHER see also: <http://www.pantherdb.org/about.jsp>

**Preceded by:** [dCMP + H2O => dUMP + NH4+](#), [dUTP + H2O => dUMP + pyrophosphate](#)

**Followed by:** [dUMP or TMP + ATP <=> dUDP or TDP + ADP \[DTYMK\]](#)



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