

```
<?xml version="1.0"?>
```

```
<!-- FILE : purine_nucleotide_synthesis_model.xml
```

```
CREATED : 5th June 2002
```

```
LAST MODIFIED : 5th April 2003
```

```
AUTHOR : Catherine Lloyd  
The Bioengineering Institute  
The University of Auckland
```

```
MODEL STATUS : This model conforms to the CellML 1.0 Specification released on  
10th August 2001, and the 16/01/2002 CellML Metadata 1.0  
Specification.
```

```
DESCRIPTION : This file contains a CellML description of a generic model of  
purine nucleotide synthesis.
```

```
CHANGES:
```

```
22/07/2002 - CML - Added more metadata.
```

```
05/04/2003 - AAC - Changed the model name so the model loads in the database  
easier.
```

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-->
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```
<model name="purine_nucleotide_synthesis_model" pathway_editor:rendering_config_file="purine_  
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#" xmlns:bgs="http://www.cel
```

```
<!--
```

```
The following RDF block contains metadata that applies to this document  
as a whole, as indicated by the empty about attribute on the  
<rdf:Description> element.
```

```
-->
```

```
<rdf:Description rdf:about="">
```

```
<!--
```

```
The Model Builder Metadata. The Dublin Core "creator" element is used  
to indicate the person who translated the model into CellML.
```

```
-->
```

```
<dc:creator rdf:parseType="Resource">
```

```
<vCard:N rdf:parseType="Resource">
```

```
<vCard:Family>Lloyd</vCard:Family>
```

```
<vCard:Given>Catherine</vCard:Given>
```

```
<vCard:Other>May</vCard:Other>
```

```
</vCard:N>
```

```
<vCard:EMAIL rdf:parseType="Resource">
```

```
<rdf:value>c.lloyd@auckland.ac.nz</rdf:value>
```

```
<rdf:type rdf:resource="http://imc.org/vCard/3.0#internet" />
```

```
</vCard:EMAIL>
```

```
<vCard:ORG rdf:parseType="Resource">
```

```
<vCard:Orgname>The University of Auckland</vCard:Orgname>
```

```
<vCard:Orgunit>The Bioengineering Institute</vCard:Orgunit>
```

```
</vCard:ORG>
```

```
</dc:creator>
```

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<!--
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```
The Creation Date metadata. This is the date on which the model  
was translated into CellML.
```

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```
<dcterms:created rdf:parseType="Resource">
```

```
<dcterms:W3CDTF>2002-06-05</dcterms:W3CDTF>
```

```

</dcterms:created>

<!--
  The Last Modified Date metadata. This is the date on which
  the model was last changed.
-->
<cmeta:modification rdf:parseType="Resource">
  <rdf:value>
    Including the species N-Formylglycinamide ribonucleotide which is
    the intermediate species from Rxn 4 to Rxn 5.
  </rdf:value>
  <cmeta:modifier rdf:parseType="Resource">
    <vCard:N rdf:parseType="Resource">
      <vCard:Family>Cuellar</vCard:Family>
      <vCard:Given>Autumn</vCard:Given>
      <vCard:Other>A</vCard:Other>
    </vCard:N>
  </cmeta:modifier>
  <dcterms:modified rdf:parseType="Resource">
    <dcterms:W3CDTF>2003-09-11</dcterms:W3CDTF>
  </dcterms:modified>
</cmeta:modification>
<cmeta:modification rdf:parseType="Resource">
  <rdf:value>
    Changed the model name so the model loads in the database easier.
  </rdf:value>
  <cmeta:modifier rdf:parseType="Resource">
    <vCard:N rdf:parseType="Resource">
      <vCard:Family>Cuellar</vCard:Family>
      <vCard:Given>Autumn</vCard:Given>
      <vCard:Other>A</vCard:Other>
    </vCard:N>
  </cmeta:modifier>
  <dcterms:modified rdf:parseType="Resource">
    <dcterms:W3CDTF>2003-04-05</dcterms:W3CDTF>
  </dcterms:modified>
</cmeta:modification>

<!-- The Publisher metadata. -->
<dc:publisher>
  The University of Auckland, Bioengineering Institute
</dc:publisher>
</rdf:Description>

<!--
  The following metadata refers to the model itself, as indicated by the
  reference to the ID "purine_nucleotide_synthesis_model", which is
  declared on the <model> element.
-->
<rdf:Description rdf:about="#purine_nucleotide_synthesis_model">
  <!-- A human readable name for the model. -->
  <dc:title>A Generic Model Of Purine Nucleotide Synthesis</dc:title>

  <!-- A comment regarding the model. -->
  <cmeta:comment rdf:parseType="Resource">
    <rdf:value>
      Below is a CellML description of a general model of purine
      nucleotide synthesis. It is not based on a specific published
      mathematical model, but instead it is based on a textbook defined

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pathway. The general sequential structure and all the reactant, product and enzyme components are included. Michaelis-Menten enzyme kinetics are assumed.

The purpose of this description is to illustrate how CellML can be used to model a general metabolic pathway.

```
</rdf:value>
<!-- The creator of the comment. -->
<dc:creator>
  <vCard:FN>Catherine Lloyd</vCard:FN>
</dc:creator>
</cmeta:comment>

<cmeta:species>Homo sapiens</cmeta:species>

<!-- Keyword(s) -->
<bqs:reference rdf:parseType="Resource">
  <dc:subject rdf:parseType="Resource">
    <bqs:subject_type>keyword</bqs:subject_type>
    <rdf:value>metabolism</rdf:value>
  </dc:subject>
</bqs:reference>

<bqs:Book rdf:parseType="Resource">
  <dc:creator rdf:parseType="Resource">
    <bqs:Person rdf:parseType="Resource">
      <vCard:N rdf:parseType="Resource">
        <vCard:Family>Bronk</vCard:Family>
        <vCard:Given>J</vCard:Given>
        <vCard:Other>Ramsey</vCard:Other>
      </vCard:N>
    </bqs:Person>
  </dc:creator>
  <dc:title>Human Metabolism</dc:title>
  <dcterms:issued rdf:parseType="Resource">
    <dcterms:W3CDTF>1999</dcterms:W3CDTF>
  </dcterms:issued>
  <dc:publisher rdf:parseType="Resource">
    <bqs:Organisation>Addison Wesley Longman Limited</bqs:Organisation>
    <bqs:Property rdf:parseType="Resource">
      <bqs:property_type>location</bqs:property_type>
      <rdf:value>England</rdf:value>
    </bqs:Property>
  </dc:publisher>
</bqs:Book>
</rdf:Description>
</rdf:RDF>

<!--
  We start the model definition with a definition of some named
  sets of units for use throughout the model.
-->

<units name="micromolar">
  <unit prefix="micro" units="mole" />
  <unit units="litre" exponent="-1" />
</units>

<units name="flux">
```

```

    <unit units="micromolar" />
    <unit units="second" exponent="-1" />
</units>

<units name="first_order_rate_constant">
    <unit units="second" exponent="-1" />
</units>

<units name="second_order_rate_constant">
    <unit units="micromolar" exponent="-1" />
    <unit units="second" exponent="-1" />
</units>

<units name="third_order_rate_constant">
    <unit units="micromolar" exponent="-2" />
    <unit units="second" exponent="-1" />
</units>

<units name="forth_order_rate_constant">
    <unit units="micromolar" exponent="-3" />
    <unit units="second" exponent="-1" />
</units>

<!--
The following component is defined for modelling convenience. It contains
all the universal variables, in this case, only time.
-->
<component name="global_variables">
    <variable name="time" public_interface="out" units="second" />
</component>

<!--
The following components describe all the metabolites - both reactants and
products - involved in purine nucleotide synthesis.
-->

<component name="PRPP" cmeta:id="PRPP">
    <variable name="PRPP" public_interface="out" initial_value="1.0" units="micromolar" />
    <variable name="delta_PRPP_rxn0" public_interface="in" units="flux" />
    <variable name="time" public_interface="in" units="second" />
    <math xmlns="http://www.w3.org/1998/Math/MathML">
        <apply><eq />
        <apply><diff />
        <bvar>
            <ci>time</ci>
        </bvar>
        <ci>PRPP</ci>
    </apply>
    <ci>delta_PRPP_rxn0</ci>
    </math>
</component>

<component name="Glutamine" cmeta:id="Glutamine">
    <variable name="Glutamine" public_interface="out" initial_value="1.0" units="micromolar" />
    <variable name="delta_Glutamine_rxn1" public_interface="in" units="flux" />
    <variable name="delta_Glutamine_rxn0" public_interface="in" units="flux" />
    <variable name="delta_Glutamine_rxn4" public_interface="in" units="flux" />
    <variable name="delta_Glutamine_rxn13" public_interface="in" units="flux" />

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<variable name="time" public_interface="in" units="second" />
<math xmlns="http://www.w3.org/1998/Math/MathML">
  <apply><eq />
    <apply><diff />
      <bvar>
        <ci>time</ci>
      </bvar>
      <ci>Glutamine</ci>
    </apply>
    <apply><plus />
      <ci>delta_Glutamine_rxn1</ci>
      <ci>delta_Glutamine_rxn0</ci>
      <ci>delta_Glutamine_rxn4</ci>
      <ci>delta_Glutamine_rxn13</ci>
    </apply>
  </apply>
</math>
</component>

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<component name="Glutamate" cmeta:id="Glutamate">
  <variable name="Glutamate" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_Glutamate_rxn0" public_interface="in" units="flux" />
  <variable name="delta_Glutamate_rxn4" public_interface="in" units="flux" />
  <variable name="delta_Glutamate_rxn13" public_interface="in" units="flux" />
  <variable name="delta_Glutamate_rxn1" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>Glutamate</ci>
      </apply>
      <apply><plus />
        <ci>delta_Glutamate_rxn0</ci>
        <ci>delta_Glutamate_rxn4</ci>
        <ci>delta_Glutamate_rxn13</ci>
        <ci>delta_Glutamate_rxn1</ci>
      </apply>
    </math>
  </component>

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```

<component name="Phosphoribosylamine" cmeta:id="Phosphoribosylamine">
  <variable name="Phosphoribosylamine" public_interface="out" initial_value="1.0" units="m" />
  <variable name="delta_Phosphoribosylamine_rxn0" public_interface="in" units="flux" />
  <variable name="delta_Phosphoribosylamine_rxn2" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>Phosphoribosylamine</ci>
      </apply>
      <apply><plus />
        <ci>delta_Phosphoribosylamine_rxn0</ci>

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        <ci>delta_Phosphoribosylamine_rxn2</ci>
    </apply>
</apply>
</math>
</component>

<component name="Glycinamide_ribonucleotide" cmeta:id="Glycinamide_ribonucleotide">
  <variable name="Glycinamide_ribonucleotide" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_Glycinamide_ribonucleotide_rxn2" public_interface="in" units="flux" />
  <variable name="delta_Glycinamide_ribonucleotide_rxn3" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>Glycinamide_ribonucleotide</ci>
      </apply>
      <apply><plus />
        <ci>delta_Glycinamide_ribonucleotide_rxn2</ci>
        <ci>delta_Glycinamide_ribonucleotide_rxn3</ci>
      </apply>
    </math>
  </component>

<component name="Glycine" cmeta:id="Glycine">
  <variable name="Glycine" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_Glycine_rxn2" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>Glycine</ci>
      </apply>
      <ci>delta_Glycine_rxn2</ci>
    </math>
  </component>

<component name="ATP" cmeta:id="ATP">
  <variable name="ATP" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_ATP_rxn1" public_interface="in" units="flux" />
  <variable name="delta_ATP_rxn2" public_interface="in" units="flux" />
  <variable name="delta_ATP_rxn4" public_interface="in" units="flux" />
  <variable name="delta_ATP_rxn5" public_interface="in" units="flux" />
  <variable name="delta_ATP_rxn7" public_interface="in" units="flux" />
  <variable name="delta_ATP_rxn13" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>
        </bvar>

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    <ci>ATP</ci>
  </apply>
</apply><plus />
  <ci>delta_ATP_rxn1</ci>
  <ci>delta_ATP_rxn2</ci>
  <ci>delta_ATP_rxn4</ci>
  <ci>delta_ATP_rxn5</ci>
  <ci>delta_ATP_rxn7</ci>
  <ci>delta_ATP_rxn13</ci>
</apply>
</apply>
</math>
</component>

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```

<component name="ADP" cmeta:id="ADP">
  <variable name="ADP" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_ADP_rxn1" public_interface="in" units="flux" />
  <variable name="delta_ADP_rxn2" public_interface="in" units="flux" />
  <variable name="delta_ADP_rxn4" public_interface="in" units="flux" />
  <variable name="delta_ADP_rxn5" public_interface="in" units="flux" />
  <variable name="delta_ADP_rxn7" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>ADP</ci>
      </apply>
      <apply><plus />
        <ci>delta_ADP_rxn1</ci>
        <ci>delta_ADP_rxn2</ci>
        <ci>delta_ADP_rxn4</ci>
        <ci>delta_ADP_rxn5</ci>
        <ci>delta_ADP_rxn7</ci>
      </apply>
    </math>
  </component>

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```

<component name="Pi" cmeta:id="Pi">
  <variable name="Pi" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_Pi_rxn1" public_interface="in" units="flux" />
  <variable name="delta_Pi_rxn2" public_interface="in" units="flux" />
  <variable name="delta_Pi_rxn4" public_interface="in" units="flux" />
  <variable name="delta_Pi_rxn5" public_interface="in" units="flux" />
  <variable name="delta_Pi_rxn7" public_interface="in" units="flux" />
  <variable name="delta_Pi_rxn10" public_interface="in" units="flux" />
  <variable name="delta_Pi_rxn13" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>Pi</ci>
      </apply>
    </math>
  </component>

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```

    <apply><plus />
      <ci>delta_Pi_rxn1</ci>
      <ci>delta_Pi_rxn2</ci>
      <ci>delta_Pi_rxn4</ci>
      <ci>delta_Pi_rxn5</ci>
      <ci>delta_Pi_rxn7</ci>
      <ci>delta_Pi_rxn10</ci>
      <ci>delta_Pi_rxn13</ci>
    </apply>
  </apply>
</math>
</component>

<component name="NH4" cmeta:id="NH4">
  <variable name="NH4" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_NH4_rxn1" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>NH4</ci>
      </apply>
      <ci>delta_NH4_rxn1</ci>
    </apply>
  </math>
</component>

<component name="H" cmeta:id="H">
  <variable name="H" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_H_rxn1" public_interface="in" units="flux" />
  <variable name="delta_H_rxn12" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>H</ci>
      </apply>
      <apply><plus />
        <ci>delta_H_rxn1</ci>
        <ci>delta_H_rxn12</ci>
      </apply>
    </apply>
  </math>
</component>

<component name="H2O" cmeta:id="H2O">
  <variable name="H2O" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_H2O_rxn6" public_interface="in" units="flux" />
  <variable name="delta_H2O_rxn9" public_interface="in" units="flux" />
  <variable name="delta_H2O_rxn4" public_interface="in" units="flux" />
  <variable name="delta_H2O_rxn12" public_interface="in" units="flux" />
  <variable name="delta_H2O_rxn13" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />

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<math xmlns="http://www.w3.org/1998/Math/MathML">
  <apply><eq />
    <apply><diff />
      <bvar>
        <ci>time</ci>
      </bvar>
      <ci>H2O</ci>
    </apply>
    <apply><plus />
      <ci>delta_H2O_rxn6</ci>
      <ci>delta_H2O_rxn9</ci>
      <ci>delta_H2O_rxn4</ci>
      <ci>delta_H2O_rxn12</ci>
      <ci>delta_H2O_rxn13</ci>
    </apply>
  </apply>
</math>
</component>

<component name="HCO3" cmeta:id="HCO3">
  <variable name="HCO3" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_HCO3_rxn6" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>HCO3</ci>
      </apply>
      <ci>delta_HCO3_rxn6</ci>
    </apply>
  </math>
</component>

<component name="THF" cmeta:id="THF">
  <variable name="THF" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_THF_rxn3" public_interface="in" units="flux" />
  <variable name="delta_THF_rxn8" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>THF</ci>
      </apply>
      <apply><plus />
        <ci>delta_THF_rxn3</ci>
        <ci>delta_THF_rxn8</ci>
      </apply>
    </apply>
  </math>
</component>

<component name="N_Formyl_THF" cmeta:id="N_Formyl_THF">
  <variable name="N_Formyl_THF" public_interface="out" initial_value="1.0" units="micromola

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<variable name="delta_N_Formyl_THF_rxn3" public_interface="in" units="flux" />
<variable name="delta_N_Formyl_THF_rxn8" public_interface="in" units="flux" />
<variable name="time" public_interface="in" units="second" />
<math xmlns="http://www.w3.org/1998/Math/MathML">
  <apply><eq />
    <apply><diff />
      <bvar>
        <ci>time</ci>
      </bvar>
      <ci>N_Formyl_THF</ci>
    </apply>
    <apply><plus />
      <ci>delta_N_Formyl_THF_rxn3</ci>
      <ci>delta_N_Formyl_THF_rxn8</ci>
    </apply>
  </apply>
</math>
</component>

<component name="N_Formylglycinamide_ribonucleotide" cmeta:id="N_Formylglycinamide_ribonucleotide"
  <variable name="N_Formylglycinamide_ribonucleotide" public_interface="out" initial_value="1" />
  <variable name="delta_N_Formylglycinamide_ribonucleotide_rxn3" public_interface="in" units="flux" />
  <variable name="delta_N_Formylglycinamide_ribonucleotide_rxn4" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>N_Formylglycinamide_ribonucleotide</ci>
      </apply>
      <apply><plus />
        <ci>delta_N_Formylglycinamide_ribonucleotide_rxn3</ci>
        <ci>delta_N_Formylglycinamide_ribonucleotide_rxn4</ci>
      </apply>
    </apply>
  </math>
</component>

<component name="N_Formylglycinamidine_ribonucleotide" cmeta:id="N_Formylglycinamidine_ribonucleotide"
  <variable name="N_Formylglycinamidine_ribonucleotide" public_interface="out" initial_value="1" />
  <variable name="delta_N_Formylglycinamidine_ribonucleotide_rxn4" public_interface="in" units="flux" />
  <variable name="delta_N_Formylglycinamidine_ribonucleotide_rxn5" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>N_Formylglycinamidine_ribonucleotide</ci>
      </apply>
      <apply><plus />
        <ci>delta_N_Formylglycinamidine_ribonucleotide_rxn4</ci>
        <ci>delta_N_Formylglycinamidine_ribonucleotide_rxn5</ci>
      </apply>
    </apply>
  </math>
</component>

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</component>

```
<component name="Aminoimidazole_ribonucleotide" cmeta:id="Aminoimidazole_ribonucleotide">
  <variable name="Aminoimidazole_ribonucleotide" public_interface="out" initial_value="1.0">
  <variable name="delta_Aminoimidazole_ribonucleotide_rxn5" public_interface="in" units="f">
  <variable name="delta_Aminoimidazole_ribonucleotide_rxn6" public_interface="in" units="f">
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>Aminoimidazole_ribonucleotide</ci>
      </apply>
      <apply><plus />
        <ci>delta_Aminoimidazole_ribonucleotide_rxn5</ci>
        <ci>delta_Aminoimidazole_ribonucleotide_rxn6</ci>
      </apply>
    </apply>
  </math>
</component>
```

```
<component name="Carboxyaminoimidazole_ribonucleotide" cmeta:id="Carboxyaminoimidazole_ribonucleotide">
  <variable name="Carboxyaminoimidazole_ribonucleotide" public_interface="out" initial_value="1.0">
  <variable name="delta_Carboxyaminoimidazole_ribonucleotide_rxn6" public_interface="in" units="f">
  <variable name="delta_Carboxyaminoimidazole_ribonucleotide_rxn7" public_interface="in" units="f">
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>Carboxyaminoimidazole_ribonucleotide</ci>
      </apply>
      <apply><plus />
        <ci>delta_Carboxyaminoimidazole_ribonucleotide_rxn6</ci>
        <ci>delta_Carboxyaminoimidazole_ribonucleotide_rxn7</ci>
      </apply>
    </apply>
  </math>
</component>
```

```
<component name="Aminoimidazole_carboxamide_ribonucleotide" cmeta:id="Aminoimidazole_carboxamide_ribonucleotide">
  <variable name="Aminoimidazole_carboxamide_ribonucleotide" public_interface="out" initial_value="1.0">
  <variable name="delta_Aminoimidazole_carboxamide_ribonucleotide_rxn7" public_interface="in" units="f">
  <variable name="delta_Aminoimidazole_carboxamide_ribonucleotide_rxn8" public_interface="in" units="f">
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>Aminoimidazole_carboxamide_ribonucleotide</ci>
      </apply>
      <apply><plus />
        <ci>delta_Aminoimidazole_carboxamide_ribonucleotide_rxn7</ci>
        <ci>delta_Aminoimidazole_carboxamide_ribonucleotide_rxn8</ci>
      </apply>
    </apply>
  </math>
</component>
```

```

    <ci>delta_Aminoimidazole_carboxamide_ribonucleotide_rxn8</ci>
  </apply>
</apply>
</math>
</component>

```

```

<component name="Formamidoimidazole_carboxamide_ribonucleotide" cmeta:id="Formamidoimidazo
  <variable name="Formamidoimidazole_carboxamide_ribonucleotide" public_interface="out" in
  <variable name="delta_Formamidoimidazole_carboxamide_ribonucleotide_rxn8" public_interfa
  <variable name="delta_Formamidoimidazole_carboxamide_ribonucleotide_rxn9" public_interfa
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>Formamidoimidazole_carboxamide_ribonucleotide</ci>
      </apply>
      <apply><plus />
        <ci>delta_Formamidoimidazole_carboxamide_ribonucleotide_rxn8</ci>
        <ci>delta_Formamidoimidazole_carboxamide_ribonucleotide_rxn9</ci>
      </apply>
    </math>
  </component>

```

```

<component name="IMP" cmeta:id="IMP">
  <variable name="IMP" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_IMP_rxn9" public_interface="in" units="flux" />
  <variable name="delta_IMP_rxn10" public_interface="in" units="flux" />
  <variable name="delta_IMP_rxn12" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>IMP</ci>
      </apply>
      <apply><plus />
        <ci>delta_IMP_rxn9</ci>
        <ci>delta_IMP_rxn10</ci>
        <ci>delta_IMP_rxn12</ci>
      </apply>
    </math>
  </component>

```

```

<component name="Pyrophosphate" cmeta:id="Pyrophosphate">
  <variable name="Pyrophosphate" public_interface="out" initial_value="1.0" units="micromo
  <variable name="delta_Pyrophosphate_rxn1" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>

```

```

        </bvar>
        <ci>Pyrophosphate</ci>
    </apply>
    <ci>delta_Pyrophosphate_rxn1</ci>
</apply>
</math>
</component>

```

```

<component name="Aspartate" cmeta:id="Aspartate">
  <variable name="Aspartate" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_Aspartate_rxn7" public_interface="in" units="flux" />
  <variable name="delta_Aspartate_rxn10" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
    <apply><diff />
    <bvar>
      <ci>time</ci>
    </bvar>
    <ci>Aspartate</ci>
  </apply>
  <apply><plus />
    <ci>delta_Aspartate_rxn7</ci>
    <ci>delta_Aspartate_rxn10</ci>
  </apply>
</math>
</component>

```

```

<component name="Fumarate" cmeta:id="Fumarate">
  <variable name="Fumarate" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_Fumarate_rxn7" public_interface="in" units="flux" />
  <variable name="delta_Fumarate_rxn11" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
    <apply><diff />
    <bvar>
      <ci>time</ci>
    </bvar>
    <ci>Fumarate</ci>
  </apply>
  <apply><plus />
    <ci>delta_Fumarate_rxn7</ci>
    <ci>delta_Fumarate_rxn11</ci>
  </apply>
</math>
</component>

```

```

<component name="Adenylosuccinate" cmeta:id="Adenylosuccinate">
  <variable name="Adenylosuccinate" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_Adenylosuccinate_rxn10" public_interface="in" units="flux" />
  <variable name="delta_Adenylosuccinate_rxn11" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
    <apply><diff />
    <bvar>

```

```

        <ci>time</ci>
    </bvar>
    <ci>Adenylosuccinate</ci>
</apply>
<apply><plus />
    <ci>delta_Adenylosuccinate_rxn10</ci>
    <ci>delta_Adenylosuccinate_rxn11</ci>
</apply>
</apply>
</math>
</component>

<component name="AMP" cmeta:id="AMP">
    <variable name="AMP" public_interface="out" initial_value="1.0" units="micromolar" />
    <variable name="delta_AMP_rxn11" public_interface="in" units="flux" />
    <variable name="delta_AMP_rxn13" public_interface="in" units="flux" />
    <variable name="time" public_interface="in" units="second" />
    <math xmlns="http://www.w3.org/1998/Math/MathML">
        <apply><eq />
            <apply><diff />
                <bvar>
                    <ci>time</ci>
                </bvar>
                <ci>AMP</ci>
            </apply>
            <apply><plus />
                <ci>delta_AMP_rxn11</ci>
                <ci>delta_AMP_rxn13</ci>
            </apply>
        </apply>
    </math>
</component>

<component name="GTP" cmeta:id="GTP">
    <variable name="GTP" public_interface="out" initial_value="1.0" units="micromolar" />
    <variable name="delta_GTP_rxn10" public_interface="in" units="flux" />
    <variable name="time" public_interface="in" units="second" />
    <math xmlns="http://www.w3.org/1998/Math/MathML">
        <apply><eq />
            <apply><diff />
                <bvar>
                    <ci>time</ci>
                </bvar>
                <ci>GTP</ci>
            </apply>
            <ci>delta_GTP_rxn10</ci>
        </apply>
    </math>
</component>

<component name="GDP" cmeta:id="GDP">
    <variable name="GDP" public_interface="out" initial_value="1.0" units="micromolar" />
    <variable name="delta_GDP_rxn10" public_interface="in" units="flux" />
    <variable name="time" public_interface="in" units="second" />
    <math xmlns="http://www.w3.org/1998/Math/MathML">
        <apply><eq />
            <apply><diff />
                <bvar>
                    <ci>time</ci>
                </bvar>
            </apply>
        </math>
    </component>

```

```

        </bvar>
        <ci>GDP</ci>
    </apply>
    <ci>delta_GDP_rxn10</ci>
</apply>
</math>
</component>

<component name="Xanthine_5_phosphate" cmeta:id="Xanthine_5_phosphate">
  <variable name="Xanthine_5_phosphate" public_interface="out" initial_value="1.0" units="m" />
  <variable name="delta_Xanthine_5_phosphate_rxn12" public_interface="in" units="flux" />
  <variable name="delta_Xanthine_5_phosphate_rxn13" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>Xanthine_5_phosphate</ci>
      </apply>
      <apply><plus />
        <ci>delta_Xanthine_5_phosphate_rxn12</ci>
        <ci>delta_Xanthine_5_phosphate_rxn13</ci>
      </apply>
    </apply>
  </math>
</component>

<component name="NAD" cmeta:id="NAD">
  <variable name="NAD" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_NAD_rxn12" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>NAD</ci>
      </apply>
      <ci>delta_NAD_rxn12</ci>
    </apply>
  </math>
</component>

<component name="NADH" cmeta:id="NADH">
  <variable name="NADH" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_NADH_rxn12" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>NADH</ci>
      </apply>
      <ci>delta_NADH_rxn12</ci>
    </apply>
  </math>
</component>

```

```
    </apply>
  </math>
</component>
```

```
<component name="GMP" cmeta:id="GMP">
  <variable name="GMP" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_GMP_rxn13" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">
    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>GMP</ci>
      </apply>
      <ci>delta_GMP_rxn13</ci>
    </apply>
  </math>
</component>
```

```
<!--
  The following components describe all the enzymes involved in purine
  nucleotide synthesis.
-->
```

```
<component name="IMP_cyclohydrolase" cmeta:id="IMP_cyclohydrolase">
  <variable name="IMP_cyclohydrolase" public_interface="out" initial_value="1.0" units="micromolar" />
</component>
```

```
<component name="PRPP_amidotransferase" cmeta:id="PRPP_amidotransferase">
  <variable name="PRPP_amidotransferase" public_interface="out" initial_value="1.0" units="micromolar" />
</component>
```

```
<component name="Glycinamide_ribonucleotide_synthetase" cmeta:id="Glycinamide_ribonucleotide_synthetase">
  <variable name="Glycinamide_ribonucleotide_synthetase" public_interface="out" initial_value="1.0" units="micromolar" />
</component>
```

```
<component name="Glycinamide_ribonucleotide_transformylase" cmeta:id="Glycinamide_ribonucleotide_transformylase">
  <variable name="Glycinamide_ribonucleotide_transformylase" public_interface="out" initial_value="1.0" units="micromolar" />
</component>
```

```
<component name="Formylglycinamidine_ribonucleotide_synthetase" cmeta:id="Formylglycinamidine_ribonucleotide_synthetase">
  <variable name="Formylglycinamidine_ribonucleotide_synthetase" public_interface="out" initial_value="1.0" units="micromolar" />
</component>
```

```
<component name="Aminoimidazole_ribonucleotide_synthetase" cmeta:id="Aminoimidazole_ribonucleotide_synthetase">
  <variable name="Aminoimidazole_ribonucleotide_synthetase" public_interface="out" initial_value="1.0" units="micromolar" />
</component>
```

```
<component name="Aminoimidazole_ribonucleotide_carboxylase" cmeta:id="Aminoimidazole_ribonucleotide_carboxylase">
  <variable name="Aminoimidazole_ribonucleotide_carboxylase" public_interface="out" initial_value="1.0" units="micromolar" />
</component>
```

```
<component name="Aminoimidazole_carboxamide_ribonucleotide_synthetase" cmeta:id="Aminoimidazole_carboxamide_ribonucleotide_synthetase">
  <variable name="Aminoimidazole_carboxamide_ribonucleotide_synthetase" public_interface="out" initial_value="1.0" units="micromolar" />
</component>
```

```
<component name="Aminoimidazole_carboxamide_ribonucleotide_transformylase" cmeta:id="Aminoimidazole_carboxamide_ribonucleotide_transformylase">
```

```

    <variable name="Aminoimidazole_carboxamide_ribonucleotide_transformylase" public_interface="out" initial_value="1.0" units="micromolar" />
  </component>

  <component name="Adenylosuccinate_synthetase" cmeta:id="Adenylosuccinate_synthetase">
    <variable name="Adenylosuccinate_synthetase" public_interface="out" initial_value="1.0" units="micromolar" />
  </component>

  <component name="Adenylosuccinate_lyase" cmeta:id="Adenylosuccinate_lyase">
    <variable name="Adenylosuccinate_lyase" public_interface="out" initial_value="1.0" units="micromolar" />
  </component>

  <component name="IMP_dehydrogenase" cmeta:id="IMP_dehydrogenase">
    <variable name="IMP_dehydrogenase" public_interface="out" initial_value="1.0" units="micromolar" />
  </component>

  <component name="GMP_synthetase" cmeta:id="GMP_synthetase">
    <variable name="GMP_synthetase" public_interface="out" initial_value="1.0" units="micromolar" />
  </component>

  <!--
  The following components represent the reaction steps of purine
  nucleotide synthesis.
  -->

  <component name="reaction0">
    <variable name="PRPP" public_interface="in" units="micromolar" />
    <variable name="Glutamine" public_interface="in" units="micromolar" />
    <variable name="Phosphoribosylamine" public_interface="in" units="micromolar" />
    <variable name="Glutamate" public_interface="in" units="micromolar" />
    <variable name="PRPP_amidotransferase" public_interface="in" units="micromolar" />
    <variable name="delta_PRPP_rxn0" public_interface="out" units="flux" />
    <variable name="delta_Glutamine_rxn0" public_interface="out" units="flux" />
    <variable name="delta_Phosphoribosylamine_rxn0" public_interface="out" units="flux" />
    <variable name="delta_Glutamate_rxn0" public_interface="out" units="flux" />
    <variable name="vmax0" initial_value="1.0" units="second_order_rate_constant" />
    <variable name="km0" initial_value="1.0" units="micromolar" />
    <variable name="rate" units="flux" />
    <reaction reversible="no">
      <variable_ref variable="PRPP">
        <role role="reactant" delta_variable="delta_PRPP_rxn0" stoichiometry="1" />
      </variable_ref>
      <variable_ref variable="Glutamine">
        <role role="reactant" delta_variable="delta_Glutamine_rxn0" stoichiometry="1" />
      </variable_ref>
      <variable_ref variable="Phosphoribosylamine">
        <role role="product" delta_variable="delta_Phosphoribosylamine_rxn0" stoichiometry="1" />
      </variable_ref>
      <variable_ref variable="Glutamate">
        <role role="product" delta_variable="delta_Glutamate_rxn0" stoichiometry="1" />
      </variable_ref>
      <variable_ref variable="PRPP_amidotransferase">
        <role role="catalyst" />
      </variable_ref>
      <variable_ref variable="rate">
        <role role="rate">
          <math xmlns="http://www.w3.org/1998/Math/MathML">
            <apply><eq />
            <ci>rate</ci>
            <apply><divide />
          </math>
        </role>
      </variable_ref>
    </reaction>
  </component>

```

```

        <apply><times />
        <ci>vmax0</ci>
        <ci>PRPP</ci>
        <ci>Glutamine</ci>
    </apply>
    <apply><plus />
    <ci>km0</ci>
    <ci>PRPP</ci>
    <ci>Glutamine</ci>
    </apply>
</apply>
</math>
</role>
</variable_ref>
</reaction>
</component>

<component name="reaction1">
    <variable name="Glutamate" public_interface="in" units="micromolar" />
    <variable name="NH4" public_interface="in" units="micromolar" />
    <variable name="Pyrophosphate" public_interface="in" units="micromolar" />
    <variable name="ATP" public_interface="in" units="micromolar" />
    <variable name="Glutamine" public_interface="in" units="micromolar" />
    <variable name="H" public_interface="in" units="micromolar" />
    <variable name="ADP" public_interface="in" units="micromolar" />
    <variable name="Pi" public_interface="in" units="micromolar" />
    <variable name="delta_Glutamate_rxn1" public_interface="out" units="flux" />
    <variable name="delta_NH4_rxn1" public_interface="out" units="flux" />
    <variable name="delta_Pyrophosphate_rxn1" public_interface="out" units="flux" />
    <variable name="delta_ATP_rxn1" public_interface="out" units="flux" />
    <variable name="delta_Glutamine_rxn1" public_interface="out" units="flux" />
    <variable name="delta_H_rxn1" public_interface="out" units="flux" />
    <variable name="delta_ADP_rxn1" public_interface="out" units="flux" />
    <variable name="delta_Pi_rxn1" public_interface="out" units="flux" />
    <variable name="k1" initial_value="1.0" units="forth_order_rate_constant" />
    <variable name="rate" units="flux" />
    <reaction reversible="no">
        <variable_ref variable="Glutamate">
            <role role="reactant" delta_variable="delta_Glutamate_rxn1" stoichiometry="1" />
        </variable_ref>
        <variable_ref variable="NH4">
            <role role="reactant" delta_variable="delta_NH4_rxn1" stoichiometry="1" />
        </variable_ref>
        <variable_ref variable="Pyrophosphate">
            <role role="reactant" delta_variable="delta_Pyrophosphate_rxn1" stoichiometry="1" />
        </variable_ref>
        <variable_ref variable="ATP">
            <role role="reactant" delta_variable="delta_ATP_rxn1" stoichiometry="1" />
        </variable_ref>
        <variable_ref variable="Glutamine">
            <role role="product" delta_variable="delta_Glutamine_rxn1" stoichiometry="1" />
        </variable_ref>
        <variable_ref variable="H">
            <role role="product" delta_variable="delta_H_rxn1" stoichiometry="1" />
        </variable_ref>
        <variable_ref variable="ADP">
            <role role="product" delta_variable="delta_ADP_rxn1" stoichiometry="1" />
        </variable_ref>
    </reaction>
</component>

```

```

<variable_ref variable="Pi">
  <role role="product" delta_variable="delta_Pi_rxn1" stoichiometry="1" />
</variable_ref>
<variable_ref variable="rate">
  <role role="rate">
    <math xmlns="http://www.w3.org/1998/Math/MathML">
      <apply><eq />
        <ci>rate</ci>
        <apply><times />
          <ci>k1</ci>
          <ci>Glutamate</ci>
          <ci>NH4</ci>
          <ci>Pyrophosphate</ci>
          <ci>ATP</ci>
        </apply>
      </math>
    </role>
  </variable_ref>
</reaction>
</component>

<component name="reaction2">
  <variable name="Glycine" public_interface="in" units="micromolar" />
  <variable name="Phosphoribosylamine" public_interface="in" units="micromolar" />
  <variable name="ATP" public_interface="in" units="micromolar" />
  <variable name="Pi" public_interface="in" units="micromolar" />
  <variable name="ADP" public_interface="in" units="micromolar" />
  <variable name="Glycinamide_ribonucleotide" public_interface="in" units="micromolar" />
  <variable name="Glycinamide_ribonucleotide_synthetase" public_interface="in" units="micro
  <variable name="delta_Glycine_rxn2" public_interface="out" units="flux" />
  <variable name="delta_Phosphoribosylamine_rxn2" public_interface="out" units="flux" />
  <variable name="delta_ATP_rxn2" public_interface="out" units="flux" />
  <variable name="delta_Pi_rxn2" public_interface="out" units="flux" />
  <variable name="delta_ADP_rxn2" public_interface="out" units="flux" />
  <variable name="delta_Glycinamide_ribonucleotide_rxn2" public_interface="out" units="flux" />
  <variable name="km2" initial_value="1.0" units="micromolar" />
  <variable name="vmax2" initial_value="1.0" units="third_order_rate_constant" />
  <variable name="rate" units="flux" />
  <reaction reversible="no">
    <variable_ref variable="Glycine">
      <role role="reactant" delta_variable="delta_Glycine_rxn2" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Phosphoribosylamine">
      <role role="reactant" delta_variable="delta_Phosphoribosylamine_rxn2" stoichiometry=
    </variable_ref>
    <variable_ref variable="ATP">
      <role role="reactant" delta_variable="delta_ATP_rxn2" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Pi">
      <role role="product" delta_variable="delta_Pi_rxn2" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="ADP">
      <role role="product" delta_variable="delta_ADP_rxn2" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Glycinamide_ribonucleotide">
      <role role="product" delta_variable="delta_Glycinamide_ribonucleotide_rxn2" stoichion
    </variable_ref>
    <variable_ref variable="Glycinamide_ribonucleotide_synthetase">

```

```

    <role role="catalyst" />
  </variable_ref>
  <variable_ref variable="rate">
    <role role="rate">
      <math xmlns="http://www.w3.org/1998/Math/MathML">
        <apply><eq />
          <ci>rate</ci>
          <apply><divide />
            <apply><times />
              <ci>Glycine</ci>
              <ci>Phosphoribosylamine</ci>
              <ci>ATP</ci>
              <ci>vmax2</ci>
            </apply>
          <apply><plus />
            <ci>km2</ci>
            <ci>Glycine</ci>
            <ci>Phosphoribosylamine</ci>
            <ci>ATP</ci>
          </apply>
        </apply>
      </math>
    </role>
  </variable_ref>
</reaction>
</component>

```

```

<component name="reaction3">
  <variable name="Glycinamide_ribonucleotide" public_interface="in" units="micromolar" />
  <variable name="N_Formyl_THF" public_interface="in" units="micromolar" />
  <variable name="N_Formylglycinamide_ribonucleotide" public_interface="in" units="micromolar" />
  <variable name="THF" public_interface="in" units="micromolar" />
  <variable name="Glycinamide_ribonucleotide_transformylase" public_interface="in" units="micromolar" />
  <variable name="delta_Glycinamide_ribonucleotide_rxn3" public_interface="out" units="flux" />
  <variable name="delta_N_Formyl_THF_rxn3" public_interface="out" units="flux" />
  <variable name="delta_N_Formylglycinamide_ribonucleotide_rxn3" public_interface="out" units="flux" />
  <variable name="delta_THF_rxn3" public_interface="out" units="flux" />
  <variable name="km3" initial_value="1.0" units="micromolar" />
  <variable name="vmax3" initial_value="1.0" units="second_order_rate_constant" />
  <variable name="rate" units="flux" />
  <reaction reversible="no">
    <variable_ref variable="Glycinamide_ribonucleotide">
      <role role="reactant" delta_variable="delta_Glycinamide_ribonucleotide_rxn3" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="N_Formyl_THF">
      <role role="reactant" delta_variable="delta_N_Formyl_THF_rxn3" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="N_Formylglycinamide_ribonucleotide">
      <role role="product" delta_variable="delta_N_Formylglycinamide_ribonucleotide_rxn3" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="THF">
      <role role="product" delta_variable="delta_THF_rxn3" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Glycinamide_ribonucleotide_transformylase">
      <role role="catalyst" />
    </variable_ref>
    <variable_ref variable="rate">
      <role role="rate">

```

```

<math xmlns="http://www.w3.org/1998/Math/MathML">
  <apply><eq />
    <ci>rate</ci>
    <apply><divide />
      <apply><times />
        <ci>Glycinamide_ribonucleotide</ci>
        <ci>N_Formyl_THF</ci>
        <ci>vmax3</ci>
      </apply>
    <apply><plus />
      <ci>km3</ci>
      <ci>Glycinamide_ribonucleotide</ci>
      <ci>N_Formyl_THF</ci>
    </apply>
  </apply>
</math>
</role>
</variable_ref>
</reaction>
</component>

<component name="reaction4">
  <variable name="N_Formylglycinamide_ribonucleotide" public_interface="in" units="micromolar" />
  <variable name="N_Formylglycinamide_ribonucleotide" public_interface="in" units="micromolar" />
  <variable name="H2O" public_interface="in" units="micromolar" />
  <variable name="Glutamine" public_interface="in" units="micromolar" />
  <variable name="ATP" public_interface="in" units="micromolar" />
  <variable name="Pi" public_interface="in" units="micromolar" />
  <variable name="ADP" public_interface="in" units="micromolar" />
  <variable name="Glutamate" public_interface="in" units="micromolar" />
  <variable name="Formylglycinamide_ribonucleotide_synthetase" public_interface="in" units="micromolar" />
  <variable name="delta_N_Formylglycinamide_ribonucleotide_rxn4" public_interface="out" units="flux" />
  <variable name="delta_N_Formylglycinamide_ribonucleotide_rxn4" public_interface="out" units="flux" />
  <variable name="delta_H2O_rxn4" public_interface="out" units="flux" />
  <variable name="delta_Glutamine_rxn4" public_interface="out" units="flux" />
  <variable name="delta_ATP_rxn4" public_interface="out" units="flux" />
  <variable name="delta_Pi_rxn4" public_interface="out" units="flux" />
  <variable name="delta_ADP_rxn4" public_interface="out" units="flux" />
  <variable name="delta_Glutamate_rxn4" public_interface="out" units="flux" />
  <variable name="km4" initial_value="1.0" units="micromolar" />
  <variable name="vmax4" initial_value="1.0" units="forth_order_rate_constant" />
  <variable name="rate" units="flux" />
  <reaction reversible="no">
    <variable_ref variable="N_Formylglycinamide_ribonucleotide">
      <role role="reactant" delta_variable="delta_N_Formylglycinamide_ribonucleotide_rxn4" />
    </variable_ref>
    <variable_ref variable="H2O">
      <role role="reactant" delta_variable="delta_H2O_rxn4" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Glutamine">
      <role role="reactant" delta_variable="delta_Glutamine_rxn4" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="ATP">
      <role role="reactant" delta_variable="delta_ATP_rxn4" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="N_Formylglycinamide_ribonucleotide">
      <role role="product" delta_variable="delta_N_Formylglycinamide_ribonucleotide_rxn4" />
    </variable_ref>
  </reaction>
</component>

```

```

<variable_ref variable="Pi">
  <role role="product" delta_variable="delta_Pi_rxn4" stoichiometry="1" />
</variable_ref>
<variable_ref variable="ADP">
  <role role="product" delta_variable="delta_ADP_rxn4" stoichiometry="1" />
</variable_ref>
<variable_ref variable="Glutamate">
  <role role="product" delta_variable="delta_Glutamate_rxn4" stoichiometry="1" />
</variable_ref>
<variable_ref variable="Formylglycinamidine_ribonucleotide_synthetase">
  <role role="catalyst" />
</variable_ref>
<variable_ref variable="rate">
  <role role="rate">
    <math xmlns="http://www.w3.org/1998/Math/MathML">
      <apply><eq />
      <ci>rate</ci>
      <apply><divide />
      <apply><times />
      <ci>N_Formylglycinamide_ribonucleotide</ci>
      <ci>H2O</ci>
      <ci>Glutamine</ci>
      <ci>ATP</ci>
      <ci>vmax4</ci>
    </apply>
    <apply><plus />
    <ci>km4</ci>
    <ci>N_Formylglycinamide_ribonucleotide</ci>
    <ci>H2O</ci>
    <ci>Glutamine</ci>
    <ci>ATP</ci>
  </apply>
</math>
  </role>
</variable_ref>
</reaction>
</component>

<component name="reaction5">
  <variable name="N_Formylglycinamidine_ribonucleotide" public_interface="in" units="micromolar" />
  <variable name="ATP" public_interface="in" units="micromolar" />
  <variable name="Aminoimidazole_ribonucleotide" public_interface="in" units="micromolar" />
  <variable name="Aminoimidazole_ribonucleotide_synthetase" public_interface="in" units="micromolar" />
  <variable name="ADP" public_interface="in" units="micromolar" />
  <variable name="Pi" public_interface="in" units="micromolar" />
  <variable name="delta_N_Formylglycinamidine_ribonucleotide_rxn5" public_interface="out" units="flux" />
  <variable name="delta_ATP_rxn5" public_interface="out" units="flux" />
  <variable name="delta_Aminoimidazole_ribonucleotide_rxn5" public_interface="out" units="flux" />
  <variable name="delta_ADP_rxn5" public_interface="out" units="flux" />
  <variable name="delta_Pi_rxn5" public_interface="out" units="flux" />
  <variable name="km5" initial_value="1.0" units="micromolar" />
  <variable name="vmax5" initial_value="1.0" units="second_order_rate_constant" />
  <variable name="rate" units="flux" />
  <reaction reversible="no">
    <variable_ref variable="N_Formylglycinamidine_ribonucleotide">
      <role role="reactant" delta_variable="delta_N_Formylglycinamidine_ribonucleotide_rxn5" />
    </variable_ref>
  </reaction>
</component>

```

```

<variable_ref variable="ATP">
  <role role="reactant" delta_variable="delta_ATP_rxn5" stoichiometry="1" />
</variable_ref>
<variable_ref variable="Aminoimidazole_ribonucleotide">
  <role role="product" delta_variable="delta_Aminoimidazole_ribonucleotide_rxn5" stoichiometry="1" />
</variable_ref>
<variable_ref variable="ADP">
  <role role="product" delta_variable="delta_ADP_rxn5" stoichiometry="1" />
</variable_ref>
<variable_ref variable="Pi">
  <role role="product" delta_variable="delta_Pi_rxn5" stoichiometry="1" />
</variable_ref>
<variable_ref variable="Aminoimidazole_ribonucleotide_synthetase">
  <role role="catalyst" direction="forward" />
</variable_ref>
<variable_ref variable="rate">
  <role role="rate">
    <math xmlns="http://www.w3.org/1998/Math/MathML">
      <apply><eq />
      <ci>rate</ci>
      <apply><divide />
      <apply><times />
      <ci>N_Formylglycinamidine_ribonucleotide</ci>
      <ci>ATP</ci>
      <ci>vmax5</ci>
    </apply>
      <apply><plus />
      <ci>km5</ci>
      <ci>N_Formylglycinamidine_ribonucleotide</ci>
      <ci>ATP</ci>
    </apply>
  </apply>
</math>
  </role>
</variable_ref>
</reaction>
</component>

<component name="reaction6">
  <variable name="Aminoimidazole_ribonucleotide" public_interface="in" units="micromolar" />
  <variable name="Aminoimidazole_ribonucleotide_carboxylase" public_interface="in" units="micromolar" />
  <variable name="HCO3" public_interface="in" units="micromolar" />
  <variable name="H2O" public_interface="in" units="micromolar" />
  <variable name="Carboxyaminoimidazole_ribonucleotide" public_interface="in" units="micromolar" />
  <variable name="delta_Aminoimidazole_ribonucleotide_rxn6" public_interface="out" units="flux" />
  <variable name="delta_HCO3_rxn6" public_interface="out" units="flux" />
  <variable name="delta_H2O_rxn6" public_interface="out" units="flux" />
  <variable name="delta_Carboxyaminoimidazole_ribonucleotide_rxn6" public_interface="out" units="flux" />
  <variable name="km6" initial_value="1.0" units="micromolar" />
  <variable name="vmax6" initial_value="1.0" units="second_order_rate_constant" />
  <variable name="rate" units="flux" />
  <reaction reversible="no">
    <variable_ref variable="Aminoimidazole_ribonucleotide">
      <role role="reactant" delta_variable="delta_Aminoimidazole_ribonucleotide_rxn6" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="HCO3">
      <role role="reactant" delta_variable="delta_HCO3_rxn6" stoichiometry="1" />
    </variable_ref>
  </reaction>
</component>

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```

<variable_ref variable="H2O">
  <role role="product" delta_variable="delta_H2O_rxn6" stoichiometry="1" />
</variable_ref>
<variable_ref variable="Carboxyaminoimidazole_ribonucleotide">
  <role role="product" delta_variable="delta_Carboxyaminoimidazole_ribonucleotide_rxn6" />
</variable_ref>
<variable_ref variable="Aminoimidazole_ribonucleotide_carboxylase">
  <role role="catalyst" direction="forward" />
</variable_ref>
<variable_ref variable="rate">
  <role role="rate">
    <math xmlns="http://www.w3.org/1998/Math/MathML">
      <apply><eq />
      <ci>rate</ci>
      <apply><divide />
      <apply><times />
      <ci>Aminoimidazole_ribonucleotide</ci>
      <ci>HCO3</ci>
      <ci>vmax6</ci>
    </apply>
      <apply><plus />
      <ci>km6</ci>
      <ci>Aminoimidazole_ribonucleotide</ci>
      <ci>HCO3</ci>
    </apply>
      </apply>
    </math>
  </role>
</variable_ref>
</reaction>
</component>

<component name="reaction7">
  <variable name="Carboxyaminoimidazole_ribonucleotide" public_interface="in" units="micromolar" />
  <variable name="ATP" public_interface="in" units="micromolar" />
  <variable name="Aspartate" public_interface="in" units="micromolar" />
  <variable name="Aminoimidazole_carboxamide_ribonucleotide" public_interface="in" units="micromolar" />
  <variable name="Aminoimidazole_carboxamide_ribonucleotide_synthetase" public_interface="in" units="micromolar" />
  <variable name="Pi" public_interface="in" units="micromolar" />
  <variable name="ADP" public_interface="in" units="micromolar" />
  <variable name="Fumarate" public_interface="in" units="micromolar" />
  <variable name="delta_Carboxyaminoimidazole_ribonucleotide_rxn7" public_interface="out" units="flux" />
  <variable name="delta_ATP_rxn7" public_interface="out" units="flux" />
  <variable name="delta_Aspartate_rxn7" public_interface="out" units="flux" />
  <variable name="delta_Aminoimidazole_carboxamide_ribonucleotide_rxn7" public_interface="out" units="flux" />
  <variable name="delta_Pi_rxn7" public_interface="out" units="flux" />
  <variable name="delta_ADP_rxn7" public_interface="out" units="flux" />
  <variable name="delta_Fumarate_rxn7" public_interface="out" units="flux" />
  <variable name="km7" initial_value="1.0" units="micromolar" />
  <variable name="vmax7" initial_value="1.0" units="third_order_rate_constant" />
  <variable name="rate" units="flux" />
  <reaction reversible="no">
    <variable_ref variable="Carboxyaminoimidazole_ribonucleotide">
      <role role="reactant" delta_variable="delta_Carboxyaminoimidazole_ribonucleotide_rxn7" />
    </variable_ref>
    <variable_ref variable="ATP">
      <role role="reactant" delta_variable="delta_ATP_rxn7" stoichiometry="1" />
    </variable_ref>
  </reaction>
</component>

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```

<variable_ref variable="Aspartate">
  <role role="reactant" delta_variable="delta_Aspartate_rxn7" stoichiometry="1" />
</variable_ref>
<variable_ref variable="Aminoimidazole_carboxamide_ribonucleotide">
  <role role="product" delta_variable="delta_Aminoimidazole_carboxamide_ribonucleotide" />
</variable_ref>
<variable_ref variable="Pi">
  <role role="product" delta_variable="delta_Pi_rxn7" stoichiometry="1" />
</variable_ref>
<variable_ref variable="ADP">
  <role role="product" delta_variable="delta_ADP_rxn7" stoichiometry="1" />
</variable_ref>
<variable_ref variable="Fumarate">
  <role role="product" delta_variable="delta_Fumarate_rxn7" stoichiometry="1" />
</variable_ref>
<variable_ref variable="Aminoimidazole_carboxamide_ribonucleotide_synthetase">
  <role role="catalyst" direction="forward" />
</variable_ref>
<variable_ref variable="rate">
  <role role="rate">
    <math xmlns="http://www.w3.org/1998/Math/MathML">
      <apply><eq />
        <ci>rate</ci>
        <apply><divide />
          <apply><times />
            <ci>Carboxyaminoimidazole_ribonucleotide</ci>
            <ci>ATP</ci>
            <ci>Aspartate</ci>
            <ci>vmax7</ci>
          </apply>
          <apply><plus />
            <ci>km7</ci>
            <ci>Carboxyaminoimidazole_ribonucleotide</ci>
            <ci>ATP</ci>
            <ci>Aspartate</ci>
          </apply>
        </apply>
      </math>
    </role>
  </variable_ref>
</reaction>
</component>

<component name="reaction8">
  <variable name="N_Formyl_THF" public_interface="in" units="micromolar" />
  <variable name="Aminoimidazole_carboxamide_ribonucleotide" public_interface="in" units="micromolar" />
  <variable name="Aminoimidazole_carboxamide_ribonucleotide_transformylase" public_interface="in" units="micromolar" />
  <variable name="THF" public_interface="in" units="micromolar" />
  <variable name="Formamidoimidazole_carboxamide_ribonucleotide" public_interface="in" units="micromolar" />
  <variable name="delta_N_Formyl_THF_rxn8" public_interface="out" units="flux" />
  <variable name="delta_Aminoimidazole_carboxamide_ribonucleotide_rxn8" public_interface="out" units="flux" />
  <variable name="delta_THF_rxn8" public_interface="out" units="flux" />
  <variable name="delta_Formamidoimidazole_carboxamide_ribonucleotide_rxn8" public_interface="out" units="flux" />
  <variable name="km8" initial_value="1.0" units="micromolar" />
  <variable name="vmax8" initial_value="1.0" units="second_order_rate_constant" />
  <variable name="rate" units="flux" />
  <reaction reversible="no">
    <variable_ref variable="N_Formyl_THF">

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```

    <role role="reactant" delta_variable="delta_N_Formyl_THF_rxn8" stoichiometry="1" />
  </variable_ref>
  <variable_ref variable="Aminoimidazole_carboxamide_ribonucleotide">
    <role role="reactant" delta_variable="delta_Aminoimidazole_carboxamide_ribonucleotide" />
  </variable_ref>
  <variable_ref variable="THF">
    <role role="product" delta_variable="delta_THF_rxn8" stoichiometry="1" />
  </variable_ref>
  <variable_ref variable="Formamidoimidazole_carboxamide_ribonucleotide">
    <role role="product" delta_variable="delta_Formamidoimidazole_carboxamide_ribonucleotide" />
  </variable_ref>
  <variable_ref variable="rate">
    <role role="rate">
      <math xmlns="http://www.w3.org/1998/Math/MathML">
        <apply><eq />
          <ci>rate</ci>
          <apply><divide />
            <apply><times />
              <ci>N_Formyl_THF</ci>
              <ci>Aminoimidazole_carboxamide_ribonucleotide</ci>
              <ci>vmax8</ci>
            </apply>
          <apply><plus />
            <ci>km8</ci>
            <ci>Aminoimidazole_carboxamide_ribonucleotide</ci>
            <ci>vmax8</ci>
          </apply>
        </math>
      </role>
    </variable_ref>
  </reaction>
</component>

<component name="reaction9">
  <variable name="Formamidoimidazole_carboxamide_ribonucleotide" public_interface="in" units="micromolar" />
  <variable name="H2O" public_interface="in" units="micromolar" />
  <variable name="IMP" public_interface="in" units="micromolar" />
  <variable name="IMP_cyclohydrolase" public_interface="in" units="micromolar" />
  <variable name="delta_Formamidoimidazole_carboxamide_ribonucleotide_rxn9" public_interface="out" units="flux" />
  <variable name="delta_H2O_rxn9" public_interface="out" units="flux" />
  <variable name="delta_IMP_rxn9" public_interface="out" units="flux" />
  <variable name="km9" initial_value="1.0" units="micromolar" />
  <variable name="vmax9" initial_value="1.0" units="first_order_rate_constant" />
  <variable name="rate" units="flux" />
  <reaction reversible="no">
    <variable_ref variable="Formamidoimidazole_carboxamide_ribonucleotide">
      <role role="reactant" delta_variable="delta_Formamidoimidazole_carboxamide_ribonucleotide" />
    </variable_ref>
    <variable_ref variable="H2O">
      <role role="product" delta_variable="delta_H2O_rxn9" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="IMP">
      <role role="product" delta_variable="delta_IMP_rxn9" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="IMP_cyclohydrolase">
      <role role="catalyst" />
    </variable_ref>
  </reaction>

```

```

<variable_ref variable="rate">
  <role role="rate">
    <math xmlns="http://www.w3.org/1998/Math/MathML">
      <apply><eq />
        <ci>rate</ci>
        <apply><divide />
          <apply><times />
            <ci>Formamidoimidazole_carboxamide_ribonucleotide</ci>
            <ci>vmax9</ci>
          </apply>
        <apply><plus />
          <ci>km9</ci>
          <ci>Formamidoimidazole_carboxamide_ribonucleotide</ci>
        </apply>
      </apply>
    </math>
  </role>
</variable_ref>
</reaction>
</component>

<component name="reaction10">
  <variable name="GTP" public_interface="in" units="micromolar" />
  <variable name="Aspartate" public_interface="in" units="micromolar" />
  <variable name="IMP" public_interface="in" units="micromolar" />
  <variable name="Pi" public_interface="in" units="micromolar" />
  <variable name="Adenylosuccinate" public_interface="in" units="micromolar" />
  <variable name="Adenylosuccinate_synthetase" public_interface="in" units="micromolar" />
  <variable name="GDP" public_interface="in" units="micromolar" />
  <variable name="delta_GTP_rxn10" public_interface="out" units="flux" />
  <variable name="delta_Aspartate_rxn10" public_interface="out" units="flux" />
  <variable name="delta_IMP_rxn10" public_interface="out" units="flux" />
  <variable name="delta_Pi_rxn10" public_interface="out" units="flux" />
  <variable name="delta_Adenylosuccinate_rxn10" public_interface="out" units="flux" />
  <variable name="delta_GDP_rxn10" public_interface="out" units="flux" />
  <variable name="km10" initial_value="1.0" units="micromolar" />
  <variable name="vmax10" initial_value="1.0" units="third_order_rate_constant" />
  <variable name="rate" units="flux" />
  <reaction reversible="no">
    <variable_ref variable="GTP">
      <role role="reactant" delta_variable="delta_GTP_rxn10" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Aspartate">
      <role role="reactant" delta_variable="delta_Aspartate_rxn10" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="IMP">
      <role role="reactant" delta_variable="delta_IMP_rxn10" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Pi">
      <role role="product" delta_variable="delta_Pi_rxn10" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Adenylosuccinate">
      <role role="product" delta_variable="delta_Adenylosuccinate_rxn10" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="GDP">
      <role role="product" delta_variable="delta_GDP_rxn10" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Adenylosuccinate_synthetase">

```

```

    <role role="catalyst" direction="forward" />
  </variable_ref>
  <variable_ref variable="rate">
    <role role="rate">
      <math xmlns="http://www.w3.org/1998/Math/MathML">
        <apply><eq />
          <ci>rate</ci>
          <apply><divide />
            <apply><times />
              <ci>GTP</ci>
              <ci>Aspartate</ci>
              <ci>IMP</ci>
              <ci>vmax10</ci>
            </apply>
          <apply><plus />
            <ci>km10</ci>
            <ci>GTP</ci>
            <ci>Aspartate</ci>
            <ci>IMP</ci>
          </apply>
        </math>
      </role>
    </variable_ref>
  </reaction>
</component>

```

```

<component name="reaction11">
  <variable name="Adenylosuccinate" public_interface="in" units="micromolar" />
  <variable name="Fumarate" public_interface="in" units="micromolar" />
  <variable name="AMP" public_interface="in" units="micromolar" />
  <variable name="IMP_dehydrogenase" public_interface="in" units="micromolar" />
  <variable name="delta_Adenylosuccinate_rxn11" public_interface="out" units="flux" />
  <variable name="delta_Fumarate_rxn11" public_interface="out" units="flux" />
  <variable name="delta_AMP_rxn11" public_interface="out" units="flux" />
  <variable name="km11" initial_value="1.0" units="micromolar" />
  <variable name="vmax11" initial_value="1.0" units="first_order_rate_constant" />
  <variable name="rate" units="flux" />
  <reaction reversible="no">
    <variable_ref variable="Adenylosuccinate">
      <role role="reactant" delta_variable="delta_Adenylosuccinate_rxn11" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Fumarate">
      <role role="product" delta_variable="delta_Fumarate_rxn11" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="AMP">
      <role role="product" delta_variable="delta_AMP_rxn11" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="IMP_dehydrogenase">
      <role role="catalyst" />
    </variable_ref>
    <variable_ref variable="rate">
      <role role="rate">
        <math xmlns="http://www.w3.org/1998/Math/MathML">
          <apply><eq />
            <ci>rate</ci>
            <apply><divide />
              <apply><times />

```

```

        <ci>Adenylosuccinate</ci>
        <ci>vmax11</ci>
    </apply>
    <apply><plus />
        <ci>km11</ci>
        <ci>Adenylosuccinate</ci>
    </apply>
</apply>
</math>
</role>
</variable_ref>
</reaction>
</component>

```

```

<component name="reaction12">
  <variable name="IMP" public_interface="in" units="micromolar" />
  <variable name="H2O" public_interface="in" units="micromolar" />
  <variable name="NAD" public_interface="in" units="micromolar" />
  <variable name="H" public_interface="in" units="micromolar" />
  <variable name="NADH" public_interface="in" units="micromolar" />
  <variable name="Xanthine_5_phosphate" public_interface="in" units="micromolar" />
  <variable name="IMP_dehydrogenase" public_interface="in" units="micromolar" />
  <variable name="delta_IMP_rxn12" public_interface="out" units="flux" />
  <variable name="delta_H2O_rxn12" public_interface="out" units="flux" />
  <variable name="delta_NAD_rxn12" public_interface="out" units="flux" />
  <variable name="delta_H_rxn12" public_interface="out" units="flux" />
  <variable name="delta_NADH_rxn12" public_interface="out" units="flux" />
  <variable name="delta_Xanthine_5_phosphate_rxn12" public_interface="out" units="flux" />
  <variable name="km12" initial_value="1.0" units="micromolar" />
  <variable name="vmax12" initial_value="1.0" units="third_order_rate_constant" />
  <variable name="rate" units="flux" />
  <reaction reversible="no">
    <variable_ref variable="IMP">
      <role role="reactant" delta_variable="delta_IMP_rxn12" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="H2O">
      <role role="reactant" delta_variable="delta_H2O_rxn12" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="NAD">
      <role role="reactant" delta_variable="delta_NAD_rxn12" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="H">
      <role role="product" delta_variable="delta_H_rxn12" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="NADH">
      <role role="product" delta_variable="delta_NADH_rxn12" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Xanthine_5_phosphate">
      <role role="product" delta_variable="delta_Xanthine_5_phosphate_rxn12" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="IMP_dehydrogenase">
      <role role="catalyst" direction="forward" />
    </variable_ref>
    <variable_ref variable="rate">
      <role role="rate">
        <math xmlns="http://www.w3.org/1998/Math/MathML">
          <apply><eq />
            <ci>rate</ci>

```

```

    <apply><divide />
      <apply><times />
        <ci>IMP</ci>
        <ci>H2O</ci>
        <ci>NAD</ci>
        <ci>vmax12</ci>
      </apply>
    <apply><plus />
      <ci>km12</ci>
      <ci>IMP</ci>
      <ci>H2O</ci>
      <ci>NAD</ci>
    </apply>
  </math>
</role>
</variable_ref>
</reaction>
</component>

<component name="reaction13">
  <variable name="Xanthine_5_phosphate" public_interface="in" units="micromolar" />
  <variable name="H2O" public_interface="in" units="micromolar" />
  <variable name="Glutamine" public_interface="in" units="micromolar" />
  <variable name="ATP" public_interface="in" units="micromolar" />
  <variable name="Glutamate" public_interface="in" units="micromolar" />
  <variable name="GMP" public_interface="in" units="micromolar" />
  <variable name="GMP_synthetase" public_interface="in" units="micromolar" />
  <variable name="Pi" public_interface="in" units="micromolar" />
  <variable name="AMP" public_interface="in" units="micromolar" />
  <variable name="delta_Xanthine_5_phosphate_rxn13" public_interface="out" units="flux" />
  <variable name="delta_H2O_rxn13" public_interface="out" units="flux" />
  <variable name="delta_Glutamine_rxn13" public_interface="out" units="flux" />
  <variable name="delta_ATP_rxn13" public_interface="out" units="flux" />
  <variable name="delta_Glutamate_rxn13" public_interface="out" units="flux" />
  <variable name="delta_GMP_rxn13" public_interface="out" units="flux" />
  <variable name="delta_Pi_rxn13" public_interface="out" units="flux" />
  <variable name="delta_AMP_rxn13" public_interface="out" units="flux" />
  <variable name="km13" initial_value="1.0" units="micromolar" />
  <variable name="vmax13" initial_value="1.0" units="forth_order_rate_constant" />
  <variable name="rate" units="flux" />
  <reaction reversible="no">
    <variable_ref variable="Xanthine_5_phosphate">
      <role role="reactant" delta_variable="delta_Xanthine_5_phosphate_rxn13" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="H2O">
      <role role="reactant" delta_variable="delta_H2O_rxn13" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Glutamine">
      <role role="reactant" delta_variable="delta_Glutamine_rxn13" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="ATP">
      <role role="reactant" delta_variable="delta_ATP_rxn13" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Glutamate">
      <role role="product" delta_variable="delta_Glutamate_rxn13" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="GMP">

```

```

    <role role="product" delta_variable="delta_GMP_rxn13" stoichiometry="1" />
  </variable_ref>
  <variable_ref variable="Pi">
    <role role="product" delta_variable="delta_Pi_rxn13" stoichiometry="2" />
  </variable_ref>
  <variable_ref variable="AMP">
    <role role="product" delta_variable="delta_AMP_rxn13" stoichiometry="1" />
  </variable_ref>
  <variable_ref variable="GMP_synthetase">
    <role role="catalyst" direction="forward" />
  </variable_ref>
  <variable_ref variable="rate">
    <role role="rate">
      <math xmlns="http://www.w3.org/1998/Math/MathML">
        <apply><eq />
          <ci>rate</ci>
          <apply><divide />
            <apply><times />
              <ci>Xanthine_5_phosphate</ci>
              <ci>H2O</ci>
              <ci>Glutamine</ci>
              <ci>ATP</ci>
              <ci>vmax13</ci>
            </apply>
          <apply><plus />
            <ci>km13</ci>
            <ci>Xanthine_5_phosphate</ci>
            <ci>H2O</ci>
            <ci>Glutamine</ci>
            <ci>ATP</ci>
          </apply>
        </apply>
      </math>
    </role>
  </variable_ref>
</reaction>
</component>

<connection>
  <map_components component_1="PRPP" component_2="reaction0" />
  <map_variables variable_1="PRPP" variable_2="PRPP" />
  <map_variables variable_1="delta_PRPP_rxn0" variable_2="delta_PRPP_rxn0" />
</connection>

<connection>
  <map_components component_1="Glutamine" component_2="reaction1" />
  <map_variables variable_1="Glutamine" variable_2="Glutamine" />
  <map_variables variable_1="delta_Glutamine_rxn1" variable_2="delta_Glutamine_rxn1" />
</connection>

<connection>
  <map_components component_1="Glutamine" component_2="reaction0" />
  <map_variables variable_1="Glutamine" variable_2="Glutamine" />
  <map_variables variable_1="delta_Glutamine_rxn0" variable_2="delta_Glutamine_rxn0" />
</connection>

<connection>
  <map_components component_1="Glutamine" component_2="reaction4" />

```

```
<map_variables variable_1="Glutamine" variable_2="Glutamine" />
<map_variables variable_1="delta_Glutamine_rxn4" variable_2="delta_Glutamine_rxn4" />
</connection>

<connection>
  <map_components component_1="Glutamine" component_2="reaction13" />
  <map_variables variable_1="Glutamine" variable_2="Glutamine" />
  <map_variables variable_1="delta_Glutamine_rxn13" variable_2="delta_Glutamine_rxn13" />
</connection>

<connection>
  <map_components component_1="Glutamate" component_2="reaction0" />
  <map_variables variable_1="Glutamate" variable_2="Glutamate" />
  <map_variables variable_1="delta_Glutamate_rxn0" variable_2="delta_Glutamate_rxn0" />
</connection>

<connection>
  <map_components component_1="Glutamate" component_2="reaction4" />
  <map_variables variable_1="Glutamate" variable_2="Glutamate" />
  <map_variables variable_1="delta_Glutamate_rxn4" variable_2="delta_Glutamate_rxn4" />
</connection>

<connection>
  <map_components component_1="Glutamate" component_2="reaction13" />
  <map_variables variable_1="Glutamate" variable_2="Glutamate" />
  <map_variables variable_1="delta_Glutamate_rxn13" variable_2="delta_Glutamate_rxn13" />
</connection>

<connection>
  <map_components component_1="Glutamate" component_2="reaction1" />
  <map_variables variable_1="Glutamate" variable_2="Glutamate" />
  <map_variables variable_1="delta_Glutamate_rxn1" variable_2="delta_Glutamate_rxn1" />
</connection>

<connection>
  <map_components component_1="Phosphoribosylamine" component_2="reaction0" />
  <map_variables variable_1="Phosphoribosylamine" variable_2="Phosphoribosylamine" />
  <map_variables variable_1="delta_Phosphoribosylamine_rxn0" variable_2="delta_Phosphoribosylamine_rxn0" />
</connection>

<connection>
  <map_components component_1="Phosphoribosylamine" component_2="reaction2" />
  <map_variables variable_1="Phosphoribosylamine" variable_2="Phosphoribosylamine" />
  <map_variables variable_1="delta_Phosphoribosylamine_rxn2" variable_2="delta_Phosphoribosylamine_rxn2" />
</connection>

<connection>
  <map_components component_1="Glycinamide_ribonucleotide" component_2="reaction2" />
  <map_variables variable_1="Glycinamide_ribonucleotide" variable_2="Glycinamide_ribonucleotide" />
  <map_variables variable_1="delta_Glycinamide_ribonucleotide_rxn2" variable_2="delta_Glycinamide_ribonucleotide_rxn2" />
</connection>

<connection>
  <map_components component_1="Glycinamide_ribonucleotide" component_2="reaction3" />
  <map_variables variable_1="Glycinamide_ribonucleotide" variable_2="Glycinamide_ribonucleotide" />
  <map_variables variable_1="delta_Glycinamide_ribonucleotide_rxn3" variable_2="delta_Glycinamide_ribonucleotide_rxn3" />
</connection>

<connection>
```

```
<map_components component_1="Glycine" component_2="reaction2" />
<map_variables variable_1="Glycine" variable_2="Glycine" />
<map_variables variable_1="delta_Glycine_rxn2" variable_2="delta_Glycine_rxn2" />
</connection>

<connection>
  <map_components component_1="ATP" component_2="reaction1" />
  <map_variables variable_1="ATP" variable_2="ATP" />
  <map_variables variable_1="delta_ATP_rxn1" variable_2="delta_ATP_rxn1" />
</connection>

<connection>
  <map_components component_1="ATP" component_2="reaction2" />
  <map_variables variable_1="ATP" variable_2="ATP" />
  <map_variables variable_1="delta_ATP_rxn2" variable_2="delta_ATP_rxn2" />
</connection>

<connection>
  <map_components component_1="ATP" component_2="reaction4" />
  <map_variables variable_1="ATP" variable_2="ATP" />
  <map_variables variable_1="delta_ATP_rxn4" variable_2="delta_ATP_rxn4" />
</connection>

<connection>
  <map_components component_1="ATP" component_2="reaction5" />
  <map_variables variable_1="ATP" variable_2="ATP" />
  <map_variables variable_1="delta_ATP_rxn5" variable_2="delta_ATP_rxn5" />
</connection>

<connection>
  <map_components component_1="ATP" component_2="reaction7" />
  <map_variables variable_1="ATP" variable_2="ATP" />
  <map_variables variable_1="delta_ATP_rxn7" variable_2="delta_ATP_rxn7" />
</connection>

<connection>
  <map_components component_1="ATP" component_2="reaction13" />
  <map_variables variable_1="ATP" variable_2="ATP" />
  <map_variables variable_1="delta_ATP_rxn13" variable_2="delta_ATP_rxn13" />
</connection>

<connection>
  <map_components component_1="ADP" component_2="reaction1" />
  <map_variables variable_1="ADP" variable_2="ADP" />
  <map_variables variable_1="delta_ADG_rxn1" variable_2="delta_ADG_rxn1" />
</connection>

<connection>
  <map_components component_1="ADP" component_2="reaction2" />
  <map_variables variable_1="ADP" variable_2="ADP" />
  <map_variables variable_1="delta_ADG_rxn2" variable_2="delta_ADG_rxn2" />
</connection>

<connection>
  <map_components component_1="ADP" component_2="reaction4" />
  <map_variables variable_1="ADP" variable_2="ADP" />
  <map_variables variable_1="delta_ADG_rxn4" variable_2="delta_ADG_rxn4" />
</connection>
```

```
<connection>
  <map_components component_1="ADP" component_2="reaction5" />
  <map_variables variable_1="ADP" variable_2="ADP" />
  <map_variables variable_1="delta_ADP_rxn5" variable_2="delta_ADP_rxn5" />
</connection>

<connection>
  <map_components component_1="ADP" component_2="reaction7" />
  <map_variables variable_1="ADP" variable_2="ADP" />
  <map_variables variable_1="delta_ADP_rxn7" variable_2="delta_ADP_rxn7" />
</connection>

<connection>
  <map_components component_1="Pi" component_2="reaction1" />
  <map_variables variable_1="Pi" variable_2="Pi" />
  <map_variables variable_1="delta_Pi_rxn1" variable_2="delta_Pi_rxn1" />
</connection>

<connection>
  <map_components component_1="Pi" component_2="reaction2" />
  <map_variables variable_1="Pi" variable_2="Pi" />
  <map_variables variable_1="delta_Pi_rxn2" variable_2="delta_Pi_rxn2" />
</connection>

<connection>
  <map_components component_1="Pi" component_2="reaction4" />
  <map_variables variable_1="Pi" variable_2="Pi" />
  <map_variables variable_1="delta_Pi_rxn4" variable_2="delta_Pi_rxn4" />
</connection>

<connection>
  <map_components component_1="Pi" component_2="reaction5" />
  <map_variables variable_1="Pi" variable_2="Pi" />
  <map_variables variable_1="delta_Pi_rxn5" variable_2="delta_Pi_rxn5" />
</connection>

<connection>
  <map_components component_1="Pi" component_2="reaction7" />
  <map_variables variable_1="Pi" variable_2="Pi" />
  <map_variables variable_1="delta_Pi_rxn7" variable_2="delta_Pi_rxn7" />
</connection>

<connection>
  <map_components component_1="Pi" component_2="reaction10" />
  <map_variables variable_1="Pi" variable_2="Pi" />
  <map_variables variable_1="delta_Pi_rxn10" variable_2="delta_Pi_rxn10" />
</connection>

<connection>
  <map_components component_1="Pi" component_2="reaction13" />
  <map_variables variable_1="Pi" variable_2="Pi" />
  <map_variables variable_1="delta_Pi_rxn13" variable_2="delta_Pi_rxn13" />
</connection>

<connection>
  <map_components component_1="NH4" component_2="reaction1" />
  <map_variables variable_1="NH4" variable_2="NH4" />
  <map_variables variable_1="delta_NH4_rxn1" variable_2="delta_NH4_rxn1" />
</connection>
```

```
<connection>
  <map_components component_1="H" component_2="reaction1" />
  <map_variables variable_1="H" variable_2="H" />
  <map_variables variable_1="delta_H_rxn1" variable_2="delta_H_rxn1" />
</connection>

<connection>
  <map_components component_1="H" component_2="reaction12" />
  <map_variables variable_1="H" variable_2="H" />
  <map_variables variable_1="delta_H_rxn12" variable_2="delta_H_rxn12" />
</connection>

<connection>
  <map_components component_1="H2O" component_2="reaction6" />
  <map_variables variable_1="H2O" variable_2="H2O" />
  <map_variables variable_1="delta_H2O_rxn6" variable_2="delta_H2O_rxn6" />
</connection>

<connection>
  <map_components component_1="H2O" component_2="reaction9" />
  <map_variables variable_1="H2O" variable_2="H2O" />
  <map_variables variable_1="delta_H2O_rxn9" variable_2="delta_H2O_rxn9" />
</connection>

<connection>
  <map_components component_1="H2O" component_2="reaction4" />
  <map_variables variable_1="H2O" variable_2="H2O" />
  <map_variables variable_1="delta_H2O_rxn4" variable_2="delta_H2O_rxn4" />
</connection>

<connection>
  <map_components component_1="H2O" component_2="reaction12" />
  <map_variables variable_1="H2O" variable_2="H2O" />
  <map_variables variable_1="delta_H2O_rxn12" variable_2="delta_H2O_rxn12" />
</connection>

<connection>
  <map_components component_1="H2O" component_2="reaction13" />
  <map_variables variable_1="H2O" variable_2="H2O" />
  <map_variables variable_1="delta_H2O_rxn13" variable_2="delta_H2O_rxn13" />
</connection>

<connection>
  <map_components component_1="HCO3" component_2="reaction6" />
  <map_variables variable_1="HCO3" variable_2="HCO3" />
  <map_variables variable_1="delta_HCO3_rxn6" variable_2="delta_HCO3_rxn6" />
</connection>

<connection>
  <map_components component_1="THF" component_2="reaction3" />
  <map_variables variable_1="THF" variable_2="THF" />
  <map_variables variable_1="delta_THF_rxn3" variable_2="delta_THF_rxn3" />
</connection>

<connection>
  <map_components component_1="THF" component_2="reaction8" />
  <map_variables variable_1="THF" variable_2="THF" />
  <map_variables variable_1="delta_THF_rxn8" variable_2="delta_THF_rxn8" />
</connection>
```



```
<map_variables variable_1="delta_Carboxyaminoimidazole_ribonucleotide_rxn7" variable_2="delta_Carboxyaminoimidazole_ribonucleotide_rxn7" />
</connection>

<connection>
  <map_components component_1="Aminoimidazole_carboxamide_ribonucleotide" component_2="reaction7" />
  <map_variables variable_1="Aminoimidazole_carboxamide_ribonucleotide" variable_2="Aminoimidazole_carboxamide_ribonucleotide" />
  <map_variables variable_1="delta_Aminoimidazole_carboxamide_ribonucleotide_rxn7" variable_2="delta_Aminoimidazole_carboxamide_ribonucleotide_rxn7" />
</connection>

<connection>
  <map_components component_1="Aminoimidazole_carboxamide_ribonucleotide" component_2="reaction8" />
  <map_variables variable_1="Aminoimidazole_carboxamide_ribonucleotide" variable_2="Aminoimidazole_carboxamide_ribonucleotide" />
  <map_variables variable_1="delta_Aminoimidazole_carboxamide_ribonucleotide_rxn8" variable_2="delta_Aminoimidazole_carboxamide_ribonucleotide_rxn8" />
</connection>

<connection>
  <map_components component_1="Formamidoimidazole_carboxamide_ribonucleotide" component_2="reaction9" />
  <map_variables variable_1="Formamidoimidazole_carboxamide_ribonucleotide" variable_2="Formamidoimidazole_carboxamide_ribonucleotide" />
  <map_variables variable_1="delta_Formamidoimidazole_carboxamide_ribonucleotide_rxn8" variable_2="delta_Formamidoimidazole_carboxamide_ribonucleotide_rxn8" />
</connection>

<connection>
  <map_components component_1="Formamidoimidazole_carboxamide_ribonucleotide" component_2="reaction10" />
  <map_variables variable_1="Formamidoimidazole_carboxamide_ribonucleotide" variable_2="Formamidoimidazole_carboxamide_ribonucleotide" />
  <map_variables variable_1="delta_Formamidoimidazole_carboxamide_ribonucleotide_rxn9" variable_2="delta_Formamidoimidazole_carboxamide_ribonucleotide_rxn9" />
</connection>

<connection>
  <map_components component_1="IMP" component_2="reaction9" />
  <map_variables variable_1="IMP" variable_2="IMP" />
  <map_variables variable_1="delta_IMP_rxn9" variable_2="delta_IMP_rxn9" />
</connection>

<connection>
  <map_components component_1="IMP" component_2="reaction10" />
  <map_variables variable_1="IMP" variable_2="IMP" />
  <map_variables variable_1="delta_IMP_rxn10" variable_2="delta_IMP_rxn10" />
</connection>

<connection>
  <map_components component_1="IMP" component_2="reaction12" />
  <map_variables variable_1="IMP" variable_2="IMP" />
  <map_variables variable_1="delta_IMP_rxn12" variable_2="delta_IMP_rxn12" />
</connection>

<connection>
  <map_components component_1="Pyrophosphate" component_2="reaction1" />
  <map_variables variable_1="Pyrophosphate" variable_2="Pyrophosphate" />
  <map_variables variable_1="delta_Pyrophosphate_rxn1" variable_2="delta_Pyrophosphate_rxn1" />
</connection>

<connection>
  <map_components component_1="Aspartate" component_2="reaction7" />
  <map_variables variable_1="Aspartate" variable_2="Aspartate" />
  <map_variables variable_1="delta_Aspartate_rxn7" variable_2="delta_Aspartate_rxn7" />
</connection>

<connection>
  <map_components component_1="Aspartate" component_2="reaction10" />
  <map_variables variable_1="Aspartate" variable_2="Aspartate" />
  <map_variables variable_1="delta_Aspartate_rxn10" variable_2="delta_Aspartate_rxn10" />
</connection>
```

```
<map_variables variable_1="Aspartate" variable_2="Aspartate" />
<map_variables variable_1="delta_Aspartate_rxn10" variable_2="delta_Aspartate_rxn10" />
</connection>

<connection>
  <map_components component_1="Fumarate" component_2="reaction7" />
  <map_variables variable_1="Fumarate" variable_2="Fumarate" />
  <map_variables variable_1="delta_Fumarate_rxn7" variable_2="delta_Fumarate_rxn7" />
</connection>

<connection>
  <map_components component_1="Fumarate" component_2="reaction11" />
  <map_variables variable_1="Fumarate" variable_2="Fumarate" />
  <map_variables variable_1="delta_Fumarate_rxn11" variable_2="delta_Fumarate_rxn11" />
</connection>

<connection>
  <map_components component_1="IMP_cyclohydrolase" component_2="reaction9" />
  <map_variables variable_1="IMP_cyclohydrolase" variable_2="IMP_cyclohydrolase" />
</connection>

<connection>
  <map_components component_1="IMP_dehydrogenase" component_2="reaction11" />
  <map_variables variable_1="IMP_dehydrogenase" variable_2="IMP_dehydrogenase" />
</connection>

<connection>
  <map_components component_1="Adenylosuccinate" component_2="reaction10" />
  <map_variables variable_1="Adenylosuccinate" variable_2="Adenylosuccinate" />
  <map_variables variable_1="delta_Adenylosuccinate_rxn10" variable_2="delta_Adenylosuccinate_rxn10" />
</connection>

<connection>
  <map_components component_1="Adenylosuccinate" component_2="reaction11" />
  <map_variables variable_1="Adenylosuccinate" variable_2="Adenylosuccinate" />
  <map_variables variable_1="delta_Adenylosuccinate_rxn11" variable_2="delta_Adenylosuccinate_rxn11" />
</connection>

<connection>
  <map_components component_1="AMP" component_2="reaction11" />
  <map_variables variable_1="AMP" variable_2="AMP" />
  <map_variables variable_1="delta_AMP_rxn11" variable_2="delta_AMP_rxn11" />
</connection>

<connection>
  <map_components component_1="AMP" component_2="reaction13" />
  <map_variables variable_1="AMP" variable_2="AMP" />
  <map_variables variable_1="delta_AMP_rxn13" variable_2="delta_AMP_rxn13" />
</connection>

<connection>
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<connection>
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  <map_components component_1="H2O" component_2="global_variables" />
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  <map_components component_1="THF" component_2="global_variables" />
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<connection>
  <map_components component_1="Formamidoimidazole_carboxamide_ribonucleotide" component_2="global_variables" />
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  <map_components component_1="IMP" component_2="global_variables" />
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  <map_components component_1="Aspartate" component_2="global_variables" />
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  <map_components component_1="Fumarate" component_2="global_variables" />
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<connection>
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<connection>
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<connection>
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<connection>
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  <map_variables variable_1="time" variable_2="time" />
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<connection>
  <map_components component_1="PRPP_amidotransferase" component_2="reaction0" />
  <map_variables variable_1="PRPP_amidotransferase" variable_2="PRPP_amidotransferase" />
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<connection>
  <map_components component_1="Glycinamide_ribonucleotide_synthetase" component_2="reaction0" />
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<connection>
  <map_components component_1="Glycinamide_ribonucleotide_transformylase" component_2="reaction0" />
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<connection>
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<connection>
  <map_components component_1="Aminoimidazole_ribonucleotide_carboxylase" component_2="reaction0" />
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  <map_components component_1="Aminoimidazole_carboxamide_ribonucleotide_transformylase" component_2="reaction0" />
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</connection>

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<connection>
  <map_components component_1="IMP_dehydrogenase" component_2="reaction12" />
  <map_variables variable_1="IMP_dehydrogenase" variable_2="IMP_dehydrogenase" />
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<connection>
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