

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

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

```
CREATED : 31st May 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 the  
pentose phosphate pathway.
```

```
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="the_pentose_phosphate_pathway_model" pathway_editor:rendering_config_file="pent
```

```
<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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```
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>2002-05-31</dcterms:W3CDTF>
```

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</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>
    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>
<cmeta:modification rdf:parseType="Resource">
  <rdf:value>
    Added more metadata.
  </rdf:value>
  <cmeta:modifier 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>
  </cmeta:modifier>
  <dcterms:modified rdf:parseType="Resource">
    <dcterms:W3CDTF>2002-07-22</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 "pentose_phosphate_pathway_model", which is declared
  on the <model> element.
-->
<rdf:Description rdf:about="#pentose_phosphate_pathway_model">
  <!-- A human readable name for the model. -->
  <dc:title>A Generic Model Of The Pentose Phosphate Pathway</dc:title>

  <!-- A comment regarding the model. -->
  <cmeta:comment rdf:parseType="Resource">
    <rdf:value>
      Below is a CellML description of a general model of the metabolic
      pentose phosphate pathway. It is not based on a specific published
      mathematical model, but instead it is based on a textbook defined
      pathway. The general sequential structure and all the reactant,

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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" />
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    <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>

<!--
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 glycolysis.
-->

<component name="Glucose_6_phosphate" cmeta:id="Glucose_6_phosphate">
    <variable name="Glucose_6_phosphate" public_interface="out" initial_value="1.0" units="flux" />
    <variable name="delta_Glucose_6_phosphate_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>Glucose_6_phosphate</ci>
            </apply>
            <ci>delta_Glucose_6_phosphate_rxn0</ci>
        </apply>
    </math>
</component>

<component name="Phosphoglucono_lactone_6" cmeta:id="Phosphoglucono_lactone_6">
    <variable name="Phosphoglucono_lactone_6" public_interface="out" initial_value="1.0" units="flux" />
    <variable name="delta_Phosphoglucono_lactone_6_rxn0" public_interface="in" units="flux" />
    <variable name="delta_Phosphoglucono_lactone_6_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 />

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        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>Phosphoglucono_lactone_6</ci>
      </apply>
    <apply>
      <plus />
      <ci>delta_Phosphoglucono_lactone_6_rxn0</ci>
      <ci>delta_Phosphoglucono_lactone_6_rxn1</ci>
    </apply>
  </apply>
</math>
</component>

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<component name="Phosphogluconate_6" cmeta:id="Phosphogluconate_6">
  <variable name="Phosphogluconate_6" public_interface="out" initial_value="1.0" units="mole">
  <variable name="delta_Phosphogluconate_6_rxn1" public_interface="in" units="flux" />
  <variable name="delta_Phosphogluconate_6_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>Phosphogluconate_6</ci>
      </apply>
      <apply>
        <plus />
        <ci>delta_Phosphogluconate_6_rxn1</ci>
        <ci>delta_Phosphogluconate_6_rxn2</ci>
      </apply>
    </apply>
  </math>
</component>

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<component name="Ribulose_5_phosphate" cmeta:id="Ribulose_5_phosphate">
  <variable name="Ribulose_5_phosphate" public_interface="out" initial_value="1.0" units="mole">
  <variable name="delta_Ribulose_5_phosphate_rxn2" public_interface="in" units="flux" />
  <variable name="delta_Ribulose_5_phosphate_rxn3" public_interface="in" units="flux" />
  <variable name="delta_Ribulose_5_phosphate_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>Ribulose_5_phosphate</ci>
      </apply>
      <apply>
        <plus />
        <ci>delta_Ribulose_5_phosphate_rxn2</ci>
        <ci>delta_Ribulose_5_phosphate_rxn3</ci>
        <ci>delta_Ribulose_5_phosphate_rxn4</ci>
      </apply>
    </math>
  </component>

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

<component name="Xylulose_5_phosphate" cmeta:id="Xylulose_5_phosphate">
  <variable name="Xylulose_5_phosphate" public_interface="out" initial_value="1.0" units="flux" />
  <variable name="delta_Xylulose_5_phosphate_rxn3" public_interface="in" units="flux" />
  <variable name="delta_Xylulose_5_phosphate_rxn7" public_interface="in" units="flux" />
  <variable name="delta_Xylulose_5_phosphate_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>Xylulose_5_phosphate</ci>
      </apply>
      <apply>
        <plus />
        <ci>delta_Xylulose_5_phosphate_rxn3</ci>
        <ci>delta_Xylulose_5_phosphate_rxn7</ci>
        <ci>delta_Xylulose_5_phosphate_rxn5</ci>
      </apply>
    </math>
</component>

<component name="Ribose_5_phosphate" cmeta:id="Ribose_5_phosphate">
  <variable name="Ribose_5_phosphate" public_interface="out" initial_value="1.0" units="flux" />
  <variable name="delta_Ribose_5_phosphate_rxn4" public_interface="in" units="flux" />
  <variable name="delta_Ribose_5_phosphate_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>Ribose_5_phosphate</ci>
      </apply>
      <apply>
        <plus />
        <ci>delta_Ribose_5_phosphate_rxn4</ci>
        <ci>delta_Ribose_5_phosphate_rxn5</ci>
      </apply>
    </math>
</component>

<component name="Glyceraldehyde_3_phosphate" cmeta:id="Glyceraldehyde_3_phosphate">
  <variable name="Glyceraldehyde_3_phosphate" public_interface="out" initial_value="1.0" units="flux" />
  <variable name="delta_Glyceraldehyde_3_phosphate_rxn5" public_interface="in" units="flux" />
  <variable name="delta_Glyceraldehyde_3_phosphate_rxn10" public_interface="in" units="flux" />

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<variable name="delta_Glyceraldehyde_3_phosphate_rxn6" public_interface="in" units="flux" />
<variable name="delta_Glyceraldehyde_3_phosphate_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>Glyceraldehyde_3_phosphate</ci>
    </apply>
    <apply>
      <plus />
      <ci>delta_Glyceraldehyde_3_phosphate_rxn5</ci>
      <ci>delta_Glyceraldehyde_3_phosphate_rxn10</ci>
      <ci>delta_Glyceraldehyde_3_phosphate_rxn6</ci>
      <ci>delta_Glyceraldehyde_3_phosphate_rxn7</ci>
    </apply>
  </apply>
</math>
</component>

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<component name="Sedoheptulose_7_phosphate" cmeta:id="Sedoheptulose_7_phosphate">
  <variable name="Sedoheptulose_7_phosphate" public_interface="out" initial_value="1.0" units="flux" />
  <variable name="delta_Sedoheptulose_7_phosphate_rxn5" public_interface="in" units="flux" />
  <variable name="delta_Sedoheptulose_7_phosphate_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>Sedoheptulose_7_phosphate</ci>
      </apply>
      <apply>
        <plus />
        <ci>delta_Sedoheptulose_7_phosphate_rxn5</ci>
        <ci>delta_Sedoheptulose_7_phosphate_rxn6</ci>
      </apply>
    </apply>
  </math>
</component>

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<component name="Erythrose_4_phosphate" cmeta:id="Erythrose_4_phosphate">
  <variable name="Erythrose_4_phosphate" public_interface="out" initial_value="1.0" units="flux" />
  <variable name="delta_Erythrose_4_phosphate_rxn6" public_interface="in" units="flux" />
  <variable name="delta_Erythrose_4_phosphate_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>

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        <ci>time</ci>
      </bvar>
      <ci>Erythrose_4_phosphate</ci>
    </apply>
  <apply>
    <plus />
    <ci>delta_Erythrose_4_phosphate_rxn6</ci>
    <ci>delta_Erythrose_4_phosphate_rxn7</ci>
  </apply>
</apply>
</math>
</component>

<component name="Fructose_6_phosphate" cmeta:id="Fructose_6_phosphate">
  <variable name="Fructose_6_phosphate" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_Fructose_6_phosphate_rxn6" public_interface="in" units="flux" />
  <variable name="delta_Fructose_6_phosphate_rxn9" public_interface="in" units="flux" />
  <variable name="delta_Fructose_6_phosphate_rxn7" public_interface="in" units="flux" />
  <variable name="delta_Fructose_6_phosphate_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>Fructose_6_phosphate</ci>
      </apply>
      <apply>
        <plus />
        <ci>delta_Fructose_6_phosphate_rxn6</ci>
        <ci>delta_Fructose_6_phosphate_rxn9</ci>
        <ci>delta_Fructose_6_phosphate_rxn7</ci>
        <ci>delta_Fructose_6_phosphate_rxn8</ci>
      </apply>
    </apply>
  </math>
</component>

<component name="NADP" cmeta:id="NADP">
  <variable name="NADP" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_NADP_rxn0" public_interface="in" units="flux" />
  <variable name="delta_NADP_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>NADP</ci>
      </apply>
      <apply>
        <plus />
        <ci>delta_NADP_rxn0</ci>
      </apply>
    </math>
  </component>

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        <ci>delta_NADP_rxn2</ci>
    </apply>
</apply>
</math>
</component>

<component name="NADPH" cmeta:id="NADPH">
    <variable name="NADPH" public_interface="out" initial_value="1.0" units="micromolar" />
    <variable name="delta_NADPH_rxn0" public_interface="in" units="flux" />
    <variable name="delta_NADPH_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>NADPH</ci>
            </apply>
            <apply>
                <plus />
                <ci>delta_NADPH_rxn0</ci>
                <ci>delta_NADPH_rxn2</ci>
            </apply>
        </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_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>H</ci>
            </apply>
            <ci>delta_H_rxn0</ci>
        </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_rxn1" public_interface="in" units="flux" />
    <variable name="delta_H2O_rxn9" 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 />

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        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>H2O</ci>
      </apply>
    <apply>
      <plus />
      <ci>delta_H2O_rxn1</ci>
      <ci>delta_H2O_rxn9</ci>
    </apply>
  </apply>
</math>
</component>

<component name="CO2" cmeta:id="CO2">
  <variable name="CO2" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_CO2_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>CO2</ci>
      </apply>
      <ci>delta_CO2_rxn2</ci>
    </apply>
  </math>
</component>

<component name="Fructose_1_6_bisphosphate" cmeta:id="Fructose_1_6_bisphosphate">
  <variable name="Fructose_1_6_bisphosphate" public_interface="out" initial_value="1.0" u
  <variable name="delta_Fructose_1_6_bisphosphate_rxn8" public_interface="in" units="flux
  <variable name="delta_Fructose_1_6_bisphosphate_rxn9" public_interface="in" units="flux
  <variable name="delta_Fructose_1_6_bisphosphate_rxn10" public_interface="in" units="flu
  <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>Fructose_1.6_bisphosphate</ci>
      </apply>
      <apply>
        <plus />
        <ci>delta_Fructose_1_6_bisphosphate_rxn8</ci>
        <ci>delta_Fructose_1_6_bisphosphate_rxn9</ci>
        <ci>delta_Fructose_1_6_bisphosphate_rxn10</ci>
      </apply>
    </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_rxn9" 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>
      <ci>delta_Pi_rxn9</ci>
    </apply>
  </math>
</component>

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<component name="ATP" cmeta:id="ATP">
  <variable name="ATP" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_ATP_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>ATP</ci>
      </apply>
      <ci>delta_ATP_rxn8</ci>
    </apply>
  </math>
</component>

```

```

<component name="ADP" cmeta:id="ADP">
  <variable name="ADP" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_ADP_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>ADP</ci>
      </apply>
      <ci>delta_ADP_rxn8</ci>
    </apply>
  </math>
</component>

```

<!--

The following components describe all the enzymes involved in glycolysis.

-->

```
<component name="Glucose_6_phosphate_dehydrogenase" cmeta:id="Glucose_6_phosphate_dehydrogenase">  
  <variable name="Glucose_6_phosphate_dehydrogenase" public_interface="out" initial_value="1.0" units="micromolar" />  
  <variable name="time" public_interface="in" units="second" />  
</component>
```

```
<component name="Lactonase" cmeta:id="Lactonase">  
  <variable name="Lactonase" public_interface="out" initial_value="1.0" units="micromolar" />  
  <variable name="time" public_interface="in" units="second" />  
</component>
```

```
<component name="Phosphogluconate_6_dehydrogenase" cmeta:id="Phosphogluconate_6_dehydrogenase">  
  <variable name="Phosphogluconate_6_dehydrogenase" public_interface="out" initial_value="1.0" units="micromolar" />  
  <variable name="time" public_interface="in" units="second" />  
</component>
```

```
<component name="Phosphopentose_isomerase" cmeta:id="Phosphopentose_isomerase">  
  <variable name="Phosphopentose_isomerase" public_interface="out" initial_value="1.0" units="micromolar" />  
  <variable name="time" public_interface="in" units="second" />  
</component>
```

```
<component name="Phosphopentose_epimerase" cmeta:id="Phosphopentose_epimerase">  
  <variable name="Phosphopentose_epimerase" public_interface="out" initial_value="1.0" units="micromolar" />  
  <variable name="time" public_interface="in" units="second" />  
</component>
```

```
<component name="Transketolase" cmeta:id="Transketolase">  
  <variable name="Transketolase" public_interface="out" initial_value="1.0" units="micromolar" />  
  <variable name="time" public_interface="in" units="second" />  
</component>
```

```
<component name="Transaldolase" cmeta:id="Transaldolase">  
  <variable name="Transaldolase" public_interface="out" initial_value="1.0" units="micromolar" />  
  <variable name="time" public_interface="in" units="second" />  
</component>
```

```
<component name="Fructose_1_6_bisphosphatase" cmeta:id="Fructose_1_6_bisphosphatase">  
  <variable name="Fructose_1_6_bisphosphatase" public_interface="out" initial_value="1.0" units="micromolar" />  
  <variable name="time" public_interface="in" units="second" />  
</component>
```

```
<component name="Phosphofructokinase" cmeta:id="Phosphofructokinase">  
  <variable name="Phosphofructokinase" public_interface="out" initial_value="1.0" units="micromolar" />  
  <variable name="time" public_interface="in" units="second" />  
</component>
```

```
<component name="Aldolase" cmeta:id="Aldolase">  
  <variable name="Aldolase" public_interface="out" initial_value="1.0" units="micromolar" />  
  <variable name="time" public_interface="in" units="second" />  
</component>
```

<!--

*The following components represent the reaction steps of glycolysis.*

-->

```
<component name="reaction0">  
  <variable name="Glucose_6_phosphate" public_interface="in" units="micromolar" />  
  <variable name="NADP" public_interface="in" units="micromolar" />
```

```

<variable name="H" public_interface="in" units="micromolar" />
<variable name="Phosphoglucono_lactone_6" public_interface="in" units="micromolar" />
<variable name="NADPH" public_interface="in" units="micromolar" />
<variable name="Glucose_6_phosphate_dehydrogenase" public_interface="in" units="micromolar" />
<variable name="delta_Glucose_6_phosphate_rxn0" public_interface="out" units="flux" />
<variable name="delta_NADP_rxn0" public_interface="out" units="flux" />
<variable name="delta_H_rxn0" public_interface="out" units="flux" />
<variable name="delta_Phosphoglucono_lactone_6_rxn0" public_interface="out" units="flux" />
<variable name="delta_NADPH_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="Glucose_6_phosphate">
    <role role="reactant" delta_variable="delta_Glucose_6_phosphate_rxn0" stoichiometry="1" />
  </variable_ref>
  <variable_ref variable="NADP">
    <role role="reactant" delta_variable="delta_NADP_rxn0" stoichiometry="1" />
  </variable_ref>
  <variable_ref variable="H">
    <role role="product" delta_variable="delta_H_rxn0" stoichiometry="1" />
  </variable_ref>
  <variable_ref variable="Phosphoglucono_lactone_6">
    <role role="product" delta_variable="delta_Phosphoglucono_lactone_6_rxn0" stoichiometry="1" />
  </variable_ref>
  <variable_ref variable="NADPH">
    <role role="product" delta_variable="delta_NADPH_rxn0" stoichiometry="1" />
  </variable_ref>
  <variable_ref variable="Glucose_6_phosphate_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>vmax0</ci>
              <ci>Glucose_6_phosphate</ci>
              <ci>NADP</ci>
            </apply>
          <apply><plus />
            <ci>km0</ci>
            <ci>Glucose_6_phosphate</ci>
            <ci>NADP</ci>
          </apply>
        </apply>
      </math>
    </role>
  </variable_ref>
</reaction>
</component>

<component name="reaction1">
  <variable name="Phosphoglucono_lactone_6" public_interface="in" units="micromolar" />
  <variable name="H2O" public_interface="in" units="micromolar" />

```

```

<variable name="Phosphogluconate_6" public_interface="in" units="micromolar" />
<variable name="Lactonase" public_interface="in" units="micromolar" />
<variable name="delta_Phosphoglucono_lactone_6_rxn1" public_interface="out" units="flux" />
<variable name="delta_H2O_rxn1" public_interface="out" units="flux" />
<variable name="delta_Phosphogluconate_6_rxn1" public_interface="out" units="flux" />
<variable name="kml" initial_value="1.0" units="micromolar" />
<variable name="vmax1" initial_value="1.0" units="second_order_rate_constant" />
<variable name="rate" units="flux" />
<reaction reversible="no">
  <variable_ref variable="Phosphoglucono_lactone_6">
    <role role="reactant" delta_variable="delta_Phosphoglucono_lactone_6_rxn1" stoichiometry="1" />
  </variable_ref>
  <variable_ref variable="H2O">
    <role role="reactant" delta_variable="delta_H2O_rxn1" stoichiometry="1" />
  </variable_ref>
  <variable_ref variable="Phosphogluconate_6">
    <role role="product" delta_variable="delta_Phosphogluconate_6_rxn1" stoichiometry="1" />
  </variable_ref>
  <variable_ref variable="Lactonase">
    <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>Phosphoglucono_lactone_6</ci>
              <ci>H2O</ci>
              <ci>vmax1</ci>
            </apply>
            <apply>
              <plus />
              <ci>kml</ci>
              <ci>H2O</ci>
              <ci>Phosphoglucono_lactone_6</ci>
            </apply>
          </apply>
        </math>
      </role>
    </variable_ref>
  </reaction>
</component>

<component name="reaction2">
  <variable name="Phosphogluconate_6" public_interface="in" units="micromolar" />
  <variable name="NADP" public_interface="in" units="micromolar" />
  <variable name="CO2" public_interface="in" units="micromolar" />
  <variable name="Ribulose_5_phosphate" public_interface="in" units="micromolar" />
  <variable name="NADPH" public_interface="in" units="micromolar" />
  <variable name="delta_Phosphogluconate_6_rxn2" public_interface="out" units="flux" />
  <variable name="delta_NADP_rxn2" public_interface="out" units="flux" />
  <variable name="delta_CO2_rxn2" public_interface="out" units="flux" />
  <variable name="delta_Ribulose_5_phosphate_rxn2" public_interface="out" units="flux" />

```

```

<variable name="delta_NADPH_rxn2" public_interface="out" units="flux" />
<variable name="km2" initial_value="1.0" units="micromolar" />
<variable name="vmax2" initial_value="1.0" units="second_order_rate_constant" />
<variable name="rate" units="flux" />
<reaction reversible="no">
  <variable_ref variable="Phosphogluconate_6">
    <role role="reactant" delta_variable="delta_Phosphogluconate_6_rxn2" stoichiometry="1" />
  </variable_ref>
  <variable_ref variable="NADP">
    <role role="reactant" delta_variable="delta_NADP_rxn2" stoichiometry="1" />
  </variable_ref>
  <variable_ref variable="CO2">
    <role role="product" delta_variable="delta_CO2_rxn2" stoichiometry="1" />
  </variable_ref>
  <variable_ref variable="Ribulose_5_phosphate">
    <role role="product" delta_variable="delta_Ribulose_5_phosphate_rxn2" stoichiometry="1" />
  </variable_ref>
  <variable_ref variable="NADPH">
    <role role="product" delta_variable="delta_NADPH_rxn2" 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>
            <divide />
            <apply>
              <times />
              <ci>Phosphogluconate_6</ci>
              <ci>NADP</ci>
              <ci>vmax2</ci>
            </apply>
            <apply>
              <plus />
              <ci>km2</ci>
              <ci>NADP</ci>
              <ci>Phosphogluconate_6</ci>
            </apply>
          </apply>
        </math>
      </role>
    </variable_ref>
  </reaction>
</component>

<component name="reaction3">
  <variable name="Ribulose_5_phosphate" public_interface="in" units="micromolar" />
  <variable name="Xylulose_5_phosphate" public_interface="in" units="micromolar" />
  <variable name="Phosphopentose_epimerase" public_interface="in" units="micromolar" />
  <variable name="delta_Ribulose_5_phosphate_rxn3" public_interface="out" units="flux" />
  <variable name="delta_Xylulose_5_phosphate_rxn3" public_interface="out" units="flux" />
  <variable name="km3" initial_value="1.0" units="micromolar" />
  <variable name="vmax3" initial_value="1.0" units="first_order_rate_constant" />
  <variable name="km3_" initial_value="1.0" units="micromolar" />
  <variable name="vmax3_" initial_value="1.0" units="first_order_rate_constant" />
  <variable name="rate" units="flux" />

```

```

<reaction reversible="yes">
  <variable_ref variable="Ribulose_5_phosphate">
    <role role="reactant" direction="forward" delta_variable="delta_Ribulose_5_phosph
  </variable_ref>
  <variable_ref variable="Xylulose_5_phosphate">
    <role role="product" direction="forward" delta_variable="delta_Xylulose_5_phosph
  </variable_ref>
  <variable_ref variable="Phosphopentose_epimerase">
    <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>
              <minus />
              <apply>
                <times />
                <ci>vmax3</ci>
                <apply>
                  <divide />
                  <ci>Ribulose_5_phosphate</ci>
                  <ci>km3</ci>
                </apply>
              </apply>
            </apply>
            <times />
            <ci>vmax3_</ci>
            <apply>
              <divide />
              <ci>Xylulose_5_phosphate</ci>
              <ci>km3_</ci>
            </apply>
          </apply>
        </apply>
        <plus />
        <cn cellml:units="dimensionless">1.0</cn>
        <apply>
          <divide />
          <ci>Ribulose_5_phosphate</ci>
          <ci>km3</ci>
        </apply>
        <apply>
          <divide />
          <ci>Xylulose_5_phosphate</ci>
          <ci>km3_</ci>
        </apply>
      </math>
    </role>
  </variable_ref>
</reaction>

```

</component>

<component name="reaction4">

<variable name="Ribulose\_5\_phosphate" public\_interface="in" units="micromolar" />  
<variable name="Ribose\_5\_phosphate" public\_interface="in" units="micromolar" />  
<variable name="Phosphopentose\_isomerase" public\_interface="in" units="micromolar" />  
<variable name="delta\_Ribulose\_5\_phosphate\_rxn4" public\_interface="out" units="flux" />  
<variable name="delta\_Ribose\_5\_phosphate\_rxn4" public\_interface="out" units="flux" />  
<variable name="km4" initial\_value="1.0" units="micromolar" />  
<variable name="vmax4" initial\_value="1.0" units="first\_order\_rate\_constant" />  
<variable name="km4\_" initial\_value="1.0" units="micromolar" />  
<variable name="vmax4\_" initial\_value="1.0" units="first\_order\_rate\_constant" />  
<variable name="rate" units="flux" />  
<reaction reversible="yes">

<variable\_ref variable="Ribulose\_5\_phosphate">

<role role="reactant" direction="forward" delta\_variable="delta\_Ribulose\_5\_phosphate" />

</variable\_ref>

<variable\_ref variable="Ribose\_5\_phosphate">

<role role="product" direction="forward" delta\_variable="delta\_Ribose\_5\_phosphate" />

</variable\_ref>

<variable\_ref variable="Phosphopentose\_isomerase">

<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>

<minus />

<apply>

<times />

<ci>vmax4</ci>

<apply>

<divide />

<ci>Ribulose\_5\_phosphate</ci>

<ci>km4</ci>

</apply>

</apply>

<apply>

<times />

<ci>vmax4\_</ci>

<apply>

<divide />

<ci>Ribose\_5\_phosphate</ci>

<ci>km4\_</ci>

</apply>

</apply>

</apply>

<apply>

<plus />

<cn cellml:units="dimensionless">1.0</cn>

<apply>

<divide />

<ci>Ribulose\_5\_phosphate</ci>

<ci>km4</ci>

```

        </apply>
        <apply>
            <divide />
            <ci>Ribose_5_phosphate</ci>
            <ci>km4.</ci>
        </apply>
    </apply>
</apply>
</math>
</role>
</variable_ref>
</reaction>
</component>

<component name="reaction5">
    <variable name="Ribose_5_phosphate" public_interface="in" units="micromolar" />
    <variable name="Xylulose_5_phosphate" public_interface="in" units="micromolar" />
    <variable name="Sedoheptulose_7_phosphate" public_interface="in" units="micromolar" />
    <variable name="Glyceraldehyde_3_phosphate" public_interface="in" units="micromolar" />
    <variable name="Transketolase" public_interface="in" units="micromolar" />
    <variable name="delta_Ribose_5_phosphate_rxn5" public_interface="out" units="flux" />
    <variable name="delta_Xylulose_5_phosphate_rxn5" public_interface="out" units="flux" />
    <variable name="delta_Sedoheptulose_7_phosphate_rxn5" public_interface="out" units="flux" />
    <variable name="delta_Glyceraldehyde_3_phosphate_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="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="yes">
        <variable_ref variable="Ribose_5_phosphate">
            <role role="reactant" direction="forward" delta_variable="delta_Ribose_5_phosphate" />
        </variable_ref>
        <variable_ref variable="Xylulose_5_phosphate">
            <role role="reactant" direction="forward" delta_variable="delta_Xylulose_5_phosphate" />
        </variable_ref>
        <variable_ref variable="Sedoheptulose_7_phosphate">
            <role role="product" direction="forward" delta_variable="delta_Sedoheptulose_7_phosphate" />
        </variable_ref>
        <variable_ref variable="Glyceraldehyde_3_phosphate">
            <role role="product" direction="forward" delta_variable="delta_Glyceraldehyde_3_phosphate" />
        </variable_ref>
        <variable_ref variable="Transketolase">
            <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>
                                <minus />
                                <apply>
                                    <times />
                                    <ci>vmax5</ci>
                                </apply>
                            </apply>
                        </apply>
                    </math>
                </role>
            </variable_ref>
        </reaction>
    </component>

```

```

        <apply>
          <divide />
          <apply>
            <times />
            <ci>Ribose_5_phosphate</ci>
            <ci>Xylulose_5_phosphate</ci>
          </apply>
          <ci>km5</ci>
        </apply>
      </apply>
    <apply>
      <times />
      <ci>vmax5_</ci>
      <apply>
        <divide />
        <apply>
          <times />
          <ci>Sedoheptulose_7_phosphate</ci>
          <ci>Glyceraldehyde_3_phosphate</ci>
        </apply>
        <ci>km5_</ci>
      </apply>
    </apply>
  </apply>
</apply>
<apply>
  <plus />
  <cn cellml:units="dimensionless">1.0</cn>
  <apply>
    <divide />
    <apply>
      <times />
      <ci>Ribose_5_phosphate</ci>
      <ci>Xylulose_5_phosphate</ci>
    </apply>
    <ci>km5</ci>
  </apply>
  <apply>
    <divide />
    <apply>
      <times />
      <ci>Sedoheptulose_7_phosphate</ci>
      <ci>Glyceraldehyde_3_phosphate</ci>
    </apply>
    <ci>km5_</ci>
  </apply>
</apply>
</apply>
</math>
</role>
</variable_ref>
</reaction>
</component>

```

```

<component name="reaction6">
  <variable name="Sedoheptulose_7_phosphate" public_interface="in" units="micromolar" />
  <variable name="Glyceraldehyde_3_phosphate" public_interface="in" units="micromolar" />
  <variable name="Fructose_6_phosphate" public_interface="in" units="micromolar" />
  <variable name="Erythrose_4_phosphate" public_interface="in" units="micromolar" />

```

```

<variable name="Transaldolase" public_interface="in" units="micromolar" />
<variable name="delta_Sedoheptulose_7_phosphate_rxn6" public_interface="out" units="flux" />
<variable name="delta_Glyceraldehyde_3_phosphate_rxn6" public_interface="out" units="flux" />
<variable name="delta_Fructose_6_phosphate_rxn6" public_interface="out" units="flux" />
<variable name="delta_Erythrose_4_phosphate_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="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="yes">
  <variable_ref variable="Sedoheptulose_7_phosphate">
    <role role="reactant" direction="forward" delta_variable="delta_Sedoheptulose_7_p
  </variable_ref>
  <variable_ref variable="Glyceraldehyde_3_phosphate">
    <role role="reactant" direction="forward" delta_variable="delta_Glyceraldehyde_3
  </variable_ref>
  <variable_ref variable="Fructose_6_phosphate">
    <role role="product" direction="forward" delta_variable="delta_Fructose_6_phosph
  </variable_ref>
  <variable_ref variable="Erythrose_4_phosphate">
    <role role="product" direction="forward" delta_variable="delta_Erythrose_4_phosph
  </variable_ref>
  <variable_ref variable="Transaldolase">
    <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>
              <minus />
              <apply>
                <times />
                <ci>vmax6</ci>
                <apply>
                  <divide />
                  <apply>
                    <times />
                    <ci>Sedoheptulose_7_phosphate</ci>
                    <ci>Glyceraldehyde_3_phosphate</ci>
                  </apply>
                  <ci>km6</ci>
                </apply>
              </apply>
            </apply>
          <apply>
            <times />
            <ci>vmax6_</ci>
            <apply>
              <divide />
              <apply>
                <times />
                <ci>Fructose_6_phosphate</ci>
                <ci>Erythrose_4_phosphate</ci>
              </apply>
            </apply>
          </math>
        </role>
      </variable_ref>
    </reaction>

```

```

        <ci>km6_</ci>
      </apply>
    </apply>
  </apply>
</math>
</role>
</variable_ref>
</reaction>
</component>

```

```

<component name="reaction7">
  <variable name="Glyceraldehyde_3_phosphate" public_interface="in" units="micromolar" />
  <variable name="Fructose_6_phosphate" public_interface="in" units="micromolar" />
  <variable name="Erythrose_4_phosphate" public_interface="in" units="micromolar" />
  <variable name="Xylulose_5_phosphate" public_interface="in" units="micromolar" />
  <variable name="Transketolase" public_interface="in" units="micromolar" />
  <variable name="delta_Glyceraldehyde_3_phosphate_rxn7" public_interface="out" units="flux" />
  <variable name="delta_Fructose_6_phosphate_rxn7" public_interface="out" units="flux" />
  <variable name="delta_Erythrose_4_phosphate_rxn7" public_interface="out" units="flux" />
  <variable name="delta_Xylulose_5_phosphate_rxn7" public_interface="out" units="flux" />
  <variable name="km7" initial_value="1.0" units="micromolar" />
  <variable name="vmax7" initial_value="1.0" units="second_order_rate_constant" />
  <variable name="km7_" initial_value="1.0" units="micromolar" />
  <variable name="vmax7_" initial_value="1.0" units="second_order_rate_constant" />
  <variable name="rate" units="flux" />
  <reaction reversible="yes">
    <variable_ref variable="Glyceraldehyde_3_phosphate">
      <role role="reactant" direction="forward" delta_variable="delta_Glyceraldehyde_3_
    </variable_ref>
    <variable_ref variable="Fructose_6_phosphate">
      <role role="reactant" direction="forward" delta_variable="delta_Fructose_6_phosph
    </variable_ref>
    <variable_ref variable="Erythrose_4_phosphate">
      <role role="product" direction="forward" delta_variable="delta_Erythrose_4_phosph
    </variable_ref>
  </reaction>

```

```

<variable_ref variable="Xylulose_5_phosphate">
  <role role="product" direction="forward" delta_variable="delta_Xylulose_5_phosphat
</variable_ref>
<variable_ref variable="Transketolase">
  <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>
            <minus />
            <apply>
              <times />
              <ci>vmax7</ci>
              <apply>
                <divide />
                <apply>
                  <times />
                  <ci>Fructose_6_phosphate</ci>
                  <ci>Glyceraldehyde_3_phosphate</ci>
                </apply>
                <ci>km7</ci>
              </apply>
            </apply>
          </apply>
          <times />
          <ci>vmax7</ci>
          <apply>
            <divide />
            <apply>
              <times />
              <ci>Xylulose_5_phosphate</ci>
              <ci>Erythrose_4_phosphate</ci>
            </apply>
            <ci>km7</ci>
          </apply>
        </apply>
      </apply>
      <plus />
      <cn cellml:units="dimensionless">1.0</cn>
      <apply>
        <divide />
        <apply>
          <times />
          <ci>Fructose_6_phosphate</ci>
          <ci>Glyceraldehyde_3_phosphate</ci>
        </apply>
        <ci>km7</ci>
      </apply>
      <apply>
        <divide />
        <apply>
          <times />

```

```

        <ci>Xylulose_5_phosphate</ci>
        <ci>Erythrose_4_phosphate</ci>
    </apply>
    <ci>km7</ci>
</apply>
</apply>
</apply>
</apply>
</math>
</role>
</variable_ref>
</reaction>
</component>

<component name="reaction8">
  <variable name="Fructose_6_phosphate" public_interface="in" units="micromolar" />
  <variable name="ATP" public_interface="in" units="micromolar" />
  <variable name="Fructose_1_6_bisphosphate" public_interface="in" units="micromolar" />
  <variable name="ADP" public_interface="in" units="micromolar" />
  <variable name="Phosphofructokinase" public_interface="in" units="micromolar" />
  <variable name="delta_Fructose_6_phosphate_rxn8" public_interface="out" units="flux" />
  <variable name="delta_ATP_rxn8" public_interface="out" units="flux" />
  <variable name="delta_Fructose_1_6_bisphosphate_rxn8" public_interface="out" units="flux" />
  <variable name="delta_ADP_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="Fructose_6_phosphate">
      <role role="reactant" delta_variable="delta_Fructose_6_phosphate_rxn8" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="ATP">
      <role role="reactant" delta_variable="delta_ATP_rxn8" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Fructose_1_6_bisphosphate">
      <role role="product" delta_variable="delta_Fructose_1_6_bisphosphate_rxn8" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="ADP">
      <role role="product" delta_variable="delta_ADP_rxn8" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Phosphofructokinase">
      <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>ATP</ci>
                <ci>Fructose_6_phosphate</ci>
                <ci>vmax8</ci>
              </apply>
            </apply>
            <plus />
          </math>
        </role>
      </variable_ref>
    </reaction>
  </component>

```

```

        <ci>km8</ci>
        <ci>ATP</ci>
        <ci>Fructose_6_phosphate</ci>
    </apply>
</apply>
</apply>
</math>
</role>
</variable_ref>
</reaction>
</component>

<component name="reaction9">
  <variable name="H2O" public_interface="in" units="micromolar" />
  <variable name="Fructose_1_6_bisphosphate" public_interface="in" units="micromolar" />
  <variable name="Pi" public_interface="in" units="micromolar" />
  <variable name="Fructose_6_phosphate" public_interface="in" units="micromolar" />
  <variable name="Fructose_1_6_bisphosphatase" public_interface="in" units="micromolar" />
  <variable name="delta_H2O_rxn9" public_interface="out" units="flux" />
  <variable name="delta_Fructose_1_6_bisphosphate_rxn9" public_interface="out" units="flux" />
  <variable name="delta_Pi_rxn9" public_interface="out" units="flux" />
  <variable name="delta_Fructose_6_phosphate_rxn9" public_interface="out" units="flux" />
  <variable name="km9" initial_value="1.0" units="micromolar" />
  <variable name="vmax9" initial_value="1.0" units="second_order_rate_constant" />
  <variable name="rate" units="flux" />
  <reaction reversible="no">
    <variable_ref variable="H2O">
      <role role="reactant" delta_variable="delta_H2O_rxn9" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Fructose_1_6_bisphosphate">
      <role role="reactant" delta_variable="delta_Fructose_1_6_bisphosphate_rxn9" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Pi">
      <role role="product" delta_variable="delta_Pi_rxn9" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Fructose_6_phosphate">
      <role role="product" delta_variable="delta_Fructose_6_phosphate_rxn9" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Fructose_1_6_bisphosphatase">
      <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>H2O</ci>
                <ci>Fructose_1_6_bisphosphate</ci>
                <ci>vmax9</ci>
              </apply>
            </apply>
            <plus />
            <ci>km9</ci>
            <ci>H2O</ci>
          </math>
        </role>
      </variable_ref>
    </reaction>
  </component>

```

```

        <ci>Fructose_1_6_bisphosphate</ci>
      </apply>
    </apply>
  </apply>
</math>
</role>
</variable_ref>
</reaction>
</component>

<component name="reaction10">
  <variable name="Fructose_1_6_bisphosphate" public_interface="in" units="micromolar" />
  <variable name="Glyceraldehyde_3_phosphate" public_interface="in" units="micromolar" />
  <variable name="Aldolase" public_interface="in" units="micromolar" />
  <variable name="delta_Fructose_1_6_bisphosphate_rxn10" public_interface="out" units="flux" />
  <variable name="delta_Glyceraldehyde_3_phosphate_rxn10" public_interface="out" units="flux" />
  <variable name="km10" initial_value="1.0" units="dimensionless" />
  <variable name="vmax10" initial_value="1.0" units="dimensionless" />
  <variable name="km10_" initial_value="1.0" units="dimensionless" />
  <variable name="vmax10_" initial_value="1.0" units="dimensionless" />
  <variable name="rate" units="flux" />
  <reaction reversible="yes">
    <variable_ref variable="Fructose_1_6_bisphosphate">
      <role role="reactant" direction="forward" delta_variable="delta_Fructose_1_6_bisphosphate_rxn10" />
    </variable_ref>
    <variable_ref variable="Glyceraldehyde_3_phosphate">
      <role role="product" direction="forward" delta_variable="delta_Glyceraldehyde_3_phosphate_rxn10" />
    </variable_ref>
    <variable_ref variable="Aldolase">
      <role role="catalyst" direction="forward" />
    </variable_ref>
    <variable_ref variable="rate">
      <role role="rate">
        <math xmlns="http://www.w3.org/1998/Math/MathML">
          <math display="block">\text{rate} = \frac{v_{\text{max}10} \cdot [\text{Fructose\_1\_6\_bisphosphate}]}{K_{\text{m}10} + [\text{Fructose\_1\_6\_bisphosphate}] + \frac{v_{\text{max}10} \cdot [\text{Glyceraldehyde\_3\_phosphate}]}{K_{\text{m}10_}}}
        </math>
      </role>
    </variable_ref>
  </reaction>
</component>

```

```

    </apply>
    <apply>
      <plus />
      <cn cellml:units="dimensionless">1.0</cn>
      <apply>
        <divide />
        <ci>Fructose_1_6_bisphosphate</ci>
        <ci>km10</ci>
      </apply>
      <apply>
        <divide />
        <ci>Glyceraldehyde_3_phosphate</ci>
        <ci>km10</ci>
      </apply>
    </apply>
  </apply>
</math>
</role>
</variable_ref>
</reaction>
</component>

<connection>
  <map_components component_1="Glucose_6_phosphate" component_2="reaction0" />
  <map_variables variable_1="Glucose_6_phosphate" variable_2="Glucose_6_phosphate" />
  <map_variables variable_1="delta_Glucose_6_phosphate_rxn0" variable_2="delta_Glucose_6_
</connection>

<connection>
  <map_components component_1="Phosphoglucono_lactone_6" component_2="reaction0" />
  <map_variables variable_1="Phosphoglucono_lactone_6" variable_2="Phosphoglucono_lactone
  <map_variables variable_1="delta_Phosphoglucono_lactone_6_rxn0" variable_2="delta_Phosp
</connection>

<connection>
  <map_components component_1="Phosphoglucono_lactone_6" component_2="reaction1" />
  <map_variables variable_1="Phosphoglucono_lactone_6" variable_2="Phosphoglucono_lactone
  <map_variables variable_1="delta_Phosphoglucono_lactone_6_rxn1" variable_2="delta_Phosp
</connection>

<connection>
  <map_components component_1="Phosphogluconate_6" component_2="reaction1" />
  <map_variables variable_1="Phosphogluconate_6" variable_2="Phosphogluconate_6" />
  <map_variables variable_1="delta_Phosphogluconate_6_rxn1" variable_2="delta_Phosphoglu
</connection>

<connection>
  <map_components component_1="Phosphogluconate_6" component_2="reaction2" />
  <map_variables variable_1="Phosphogluconate_6" variable_2="Phosphogluconate_6" />
  <map_variables variable_1="delta_Phosphogluconate_6_rxn2" variable_2="delta_Phosphoglu
</connection>

<connection>
  <map_components component_1="Ribulose_5_phosphate" component_2="reaction2" />
  <map_variables variable_1="Ribulose_5_phosphate" variable_2="Ribulose_5_phosphate" />
  <map_variables variable_1="delta_Ribulose_5_phosphate_rxn2" variable_2="delta_Ribulose_
</connection>

```



```
<connection>
  <map_components component_1="Glyceraldehyde_3_phosphate" component_2="reaction7" />
  <map_variables variable_1="Glyceraldehyde_3_phosphate" variable_2="Glyceraldehyde_3_phosphate" />
  <map_variables variable_1="delta_Glyceraldehyde_3_phosphate_rxn7" variable_2="delta_Glyceraldehyde_3_phosphate_rxn7" />
</connection>

<connection>
  <map_components component_1="Sedoheptulose_7_phosphate" component_2="reaction5" />
  <map_variables variable_1="Sedoheptulose_7_phosphate" variable_2="Sedoheptulose_7_phosphate" />
  <map_variables variable_1="delta_Sedoheptulose_7_phosphate_rxn5" variable_2="delta_Sedoheptulose_7_phosphate_rxn5" />
</connection>

<connection>
  <map_components component_1="Sedoheptulose_7_phosphate" component_2="reaction6" />
  <map_variables variable_1="Sedoheptulose_7_phosphate" variable_2="Sedoheptulose_7_phosphate" />
  <map_variables variable_1="delta_Sedoheptulose_7_phosphate_rxn6" variable_2="delta_Sedoheptulose_7_phosphate_rxn6" />
</connection>

<connection>
  <map_components component_1="Erythrose_4_phosphate" component_2="reaction6" />
  <map_variables variable_1="Erythrose_4_phosphate" variable_2="Erythrose_4_phosphate" />
  <map_variables variable_1="delta_Erythrose_4_phosphate_rxn6" variable_2="delta_Erythrose_4_phosphate_rxn6" />
</connection>

<connection>
  <map_components component_1="Erythrose_4_phosphate" component_2="reaction7" />
  <map_variables variable_1="Erythrose_4_phosphate" variable_2="Erythrose_4_phosphate" />
  <map_variables variable_1="delta_Erythrose_4_phosphate_rxn7" variable_2="delta_Erythrose_4_phosphate_rxn7" />
</connection>

<connection>
  <map_components component_1="Fructose_6_phosphate" component_2="reaction6" />
  <map_variables variable_1="Fructose_6_phosphate" variable_2="Fructose_6_phosphate" />
  <map_variables variable_1="delta_Fructose_6_phosphate_rxn6" variable_2="delta_Fructose_6_phosphate_rxn6" />
</connection>

<connection>
  <map_components component_1="Fructose_6_phosphate" component_2="reaction9" />
  <map_variables variable_1="Fructose_6_phosphate" variable_2="Fructose_6_phosphate" />
  <map_variables variable_1="delta_Fructose_6_phosphate_rxn9" variable_2="delta_Fructose_6_phosphate_rxn9" />
</connection>

<connection>
  <map_components component_1="Fructose_6_phosphate" component_2="reaction7" />
  <map_variables variable_1="Fructose_6_phosphate" variable_2="Fructose_6_phosphate" />
  <map_variables variable_1="delta_Fructose_6_phosphate_rxn7" variable_2="delta_Fructose_6_phosphate_rxn7" />
</connection>

<connection>
  <map_components component_1="Fructose_6_phosphate" component_2="reaction8" />
  <map_variables variable_1="Fructose_6_phosphate" variable_2="Fructose_6_phosphate" />
  <map_variables variable_1="delta_Fructose_6_phosphate_rxn8" variable_2="delta_Fructose_6_phosphate_rxn8" />
</connection>

<connection>
  <map_components component_1="NADP" component_2="reaction0" />
  <map_variables variable_1="NADP" variable_2="NADP" />
  <map_variables variable_1="delta_NADP_rxn0" variable_2="delta_NADP_rxn0" />
</connection>
```

```

</connection>

<connection>
  <map_components component_1="NADP" component_2="reaction2" />
  <map_variables variable_1="NADP" variable_2="NADP" />
  <map_variables variable_1="delta_NADP_rxn2" variable_2="delta_NADP_rxn2" />
</connection>

<connection>
  <map_components component_1="NADPH" component_2="reaction0" />
  <map_variables variable_1="NADPH" variable_2="NADPH" />
  <map_variables variable_1="delta_NADPH_rxn0" variable_2="delta_NADPH_rxn0" />
</connection>

<connection>
  <map_components component_1="NADPH" component_2="reaction2" />
  <map_variables variable_1="NADPH" variable_2="NADPH" />
  <map_variables variable_1="delta_NADPH_rxn2" variable_2="delta_NADPH_rxn2" />
</connection>

<connection>
  <map_components component_1="H" component_2="reaction0" />
  <map_variables variable_1="H" variable_2="H" />
  <map_variables variable_1="delta_H_rxn0" variable_2="delta_H_rxn0" />
</connection>

<connection>
  <map_components component_1="H2O" component_2="reaction1" />
  <map_variables variable_1="H2O" variable_2="H2O" />
  <map_variables variable_1="delta_H2O_rxn1" variable_2="delta_H2O_rxn1" />
</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="Phosphopentose_isomerase" component_2="reaction4" />
  <map_variables variable_1="Phosphopentose_isomerase" variable_2="Phosphopentose_isomerase" />
</connection>

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

<connection>
  <map_components component_1="CO2" component_2="reaction2" />
  <map_variables variable_1="CO2" variable_2="CO2" />
  <map_variables variable_1="delta_CO2_rxn2" variable_2="delta_CO2_rxn2" />
</connection>

<connection>
  <map_components component_1="Fructose_1_6_bisphosphate" component_2="reaction8" />
  <map_variables variable_1="Fructose_1_6_bisphosphate" variable_2="Fructose_1_6_bisphosphate" />
  <map_variables variable_1="delta_Fructose_1_6_bisphosphate_rxn8" variable_2="delta_Fructose_1_6_bisphosphate_rxn8" />
</connection>

```

```

<connection>
  <map_components component_1="Fructose_1_6_bisphosphate" component_2="reaction9" />
  <map_variables variable_1="Fructose_1_6_bisphosphate" variable_2="Fructose_1_6_bisphosphate" />
  <map_variables variable_1="delta_Fructose_1_6_bisphosphate_rxn9" variable_2="delta_Fructose_1_6_bisphosphate_rxn9" />
</connection>

<connection>
  <map_components component_1="Fructose_1_6_bisphosphate" component_2="reaction10" />
  <map_variables variable_1="Fructose_1_6_bisphosphate" variable_2="Fructose_1_6_bisphosphate" />
  <map_variables variable_1="delta_Fructose_1_6_bisphosphate_rxn10" variable_2="delta_Fructose_1_6_bisphosphate_rxn10" />
</connection>

<connection>
  <map_components component_1="Pi" component_2="reaction9" />
  <map_variables variable_1="Pi" variable_2="Pi" />
  <map_variables variable_1="delta_Pi_rxn9" variable_2="delta_Pi_rxn9" />
</connection>

<connection>
  <map_components component_1="ATP" component_2="reaction8" />
  <map_variables variable_1="ATP" variable_2="ATP" />
  <map_variables variable_1="delta_ATP_rxn8" variable_2="delta_ATP_rxn8" />
</connection>

<connection>
  <map_components component_1="ADP" component_2="reaction8" />
  <map_variables variable_1="ADP" variable_2="ADP" />
  <map_variables variable_1="delta_ADP_rxn8" variable_2="delta_ADP_rxn8" />
</connection>

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

<connection>
  <map_components component_1="Glucose_6_phosphate" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="Phosphoglucono_lactone_6" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="Phosphogluconate_6" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="Ribulose_5_phosphate" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="Xylulose_5_phosphate" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

```

```
</connection>

<connection>
  <map_components component_1="Ribose_5_phosphate" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="Glyceraldehyde_3_phosphate" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="Sedoheptulose_7_phosphate" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="Erythrose_4_phosphate" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="Fructose_6_phosphate" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="NADP" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="NADPH" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="H" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="H2O" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="Glucose_6_phosphate_dehydrogenase" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="Lactonase" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="Phosphogluconate_6_dehydrogenase" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>
```

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

<connection>
  <map_components component_1="Phosphopentose_isomerase" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="Phosphopentose_epimerase" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="Transketolase" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="Transaldolase" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="CO2" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="Fructose_1_6_bisphosphate" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="Pi" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="ATP" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="ADP" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="Fructose_1_6_bisphosphatase" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="Phosphofructokinase" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
```

```
<map_components component_1="Aldolase" component_2="global_variables" />
<map_variables variable_1="time" variable_2="time" />
</connection>

<connection>
  <map_components component_1="Glucose_6_phosphate_dehydrogenase" component_2="reaction0" />
  <map_variables variable_1="Glucose_6_phosphate_dehydrogenase" variable_2="Glucose_6_phosphate_dehydrogenase" />
</connection>

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

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

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

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

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

<connection>
  <map_components component_1="Fructose_1_6_bisphosphatase" component_2="reaction9" />
  <map_variables variable_1="Fructose_1_6_bisphosphatase" variable_2="Fructose_1_6_bisphosphatase" />
</connection>

</model>
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