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<?xml version="1.0"?>

<!-- FILE : glycolipid_synthesis_model.xml

CREATED : 14th June 2002

LAST MODIFIED : 22nd July 2002

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
              glycolipid synthesis.

CHANGES:
  22/07/2002 - CML - Added more metadata.
-->

<model name="glycolipid_synthesis_model" pathway_editor:rendering_config_file="glycolipid_sy
  <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>

    <!--
      The Creation Date metadata. This is the date on which the model
      was translated into CellML.
    -->
    <dcterms:created rdf:parseType="Resource">
      <dcterms:W3CDTF>2002-06-14</dcterms:W3CDTF>
    </dcterms:created>

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<!--
  The Last Modified Date metadata. This is the date on which
  the model was last changed.
-->

<!-- 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 "glycolipid_synthesis_model", which is declared on
  the <model> element.
-->
<rdf:Description rdf:about="#glycolipid_synthesis_model">
  <!-- A human readable name for the model. -->
  <dc:title>A Generic Model Of Glycolipid 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 glycolipid
      synthesis. 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, 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>
  </bqs:Book>

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<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>

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

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```

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

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```

<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>

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```

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

```

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<!--
  The following component is defined for modelling convenience. It contains
  all the universal variables, in this case, only time.
-->

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```

<component name="global_variables">
  <variable name="time" public_interface="out" units="second" />
</component>

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<!--
  The following components describe all the metabolites - both reactants and
  products - involved in glycolipid synthesis.
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<component name="Palmitoyl_CoA" cmeta:id="Palmitoyl_CoA">
  <variable name="Palmitoyl_CoA" public_interface="out" initial_value="1.0" units="micromo

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<variable name="delta_Palmitoyl_CoA_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>Palmitoyl_CoA</ci>
    </apply>
    <ci>delta_Palmitoyl_CoA_rxn0</ci>
  </apply>
</math>
</component>

<component name="Serine" cmeta:id="Serine">
  <variable name="Serine" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_Serine_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>Serine</ci>
      </apply>
      <ci>delta_Serine_rxn0</ci>
    </apply>
  </math>
</component>

<component name="Dehydrosphinganine" cmeta:id="Dehydrosphinganine">
  <variable name="Dehydrosphinganine" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_Dehydrosphinganine_rxn0" public_interface="in" units="flux" />
  <variable name="delta_Dehydrosphinganine_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>Dehydrosphinganine</ci>
      </apply>
      <apply><plus />
        <ci>delta_Dehydrosphinganine_rxn0</ci>
        <ci>delta_Dehydrosphinganine_rxn1</ci>
      </apply>
    </apply>
  </math>
</component>

<component name="CoA_SH" cmeta:id="CoA_SH">
  <variable name="CoA_SH" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_CoA_SH_rxn0" public_interface="in" units="flux" />
  <variable name="delta_CoA_SH_rxn2" public_interface="in" units="flux" />
  <variable name="time" public_interface="in" units="second" />
  <math xmlns="http://www.w3.org/1998/Math/MathML">

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```

    <apply><eq />
      <apply><diff />
        <bvar>
          <ci>time</ci>
        </bvar>
        <ci>CoA_SH</ci>
      </apply>
    <apply><plus />
      <ci>delta_CoA_SH_rxn0</ci>
      <ci>delta_CoA_SH_rxn2</ci>
    </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_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>CO2</ci>
      </apply>
      <ci>delta_CO2_rxn0</ci>
    </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_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>NADPH</ci>
      </apply>
      <ci>delta_NADPH_rxn1</ci>
    </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_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>

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    <ci>NADP</ci>
  </apply>
  <ci>delta_NADP_rxn1</ci>
</apply>
</math>
</component>

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<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="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_rxn1</ci>
    </apply>
  </math>
</component>

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<component name="Dehydrosphingasine" cmeta:id="Dehydrosphingasine">
  <variable name="Dehydrosphingasine" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_Dehydrosphingasine_rxn1" public_interface="in" units="flux" />
  <variable name="delta_Dehydrosphingasine_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>Dehydrosphingasine</ci>
      </apply>
      <apply><plus />
        <ci>delta_Dehydrosphingasine_rxn1</ci>
        <ci>delta_Dehydrosphingasine_rxn2</ci>
      </apply>
    </apply>
  </math>
</component>

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<component name="Dihydroceramide" cmeta:id="Dihydroceramide">
  <variable name="Dihydroceramide" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_Dihydroceramide_rxn2" public_interface="in" units="flux" />
  <variable name="delta_Dihydroceramide_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>Dihydroceramide</ci>
      </apply>
      <apply><plus />

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        <ci>delta_Dihydroceramide_rxn2</ci>
        <ci>delta_Dihydroceramide_rxn3</ci>
    </apply>
</apply>
</math>
</component>

<component name="FAD" cmeta:id="FAD">
    <variable name="FAD" public_interface="out" initial_value="1.0" units="micromolar" />
    <variable name="delta_FAD_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>FAD</ci>
            </apply>
            <ci>delta_FAD_rxn3</ci>
        </apply>
    </math>
</component>

<component name="FADH2" cmeta:id="FADH2">
    <variable name="FADH2" public_interface="out" initial_value="1.0" units="micromolar" />
    <variable name="delta_FADH2_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>FADH2</ci>
            </apply>
            <ci>delta_FADH2_rxn3</ci>
        </apply>
    </math>
</component>

<component name="Fatty_acyl_CoA" cmeta:id="Fatty_acyl_CoA">
    <variable name="Fatty_acyl_CoA" public_interface="out" initial_value="1.0" units="micromolar" />
    <variable name="delta_Fatty_acyl_CoA_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>Fatty_acyl_CoA</ci>
            </apply>
            <ci>delta_Fatty_acyl_CoA_rxn2</ci>
        </apply>
    </math>
</component>

<component name="Ceramide" cmeta:id="Ceramide">

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<variable name="Ceramide" public_interface="out" initial_value="1.0" units="micromolar" />
<variable name="delta_Ceramide_rxn3" public_interface="in" units="flux" />
<variable name="delta_Ceramide_rxn4" public_interface="in" units="flux" />
<variable name="delta_Ceramide_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>Ceramide</ci>
    </apply>
    <apply><plus />
      <ci>delta_Ceramide_rxn3</ci>
      <ci>delta_Ceramide_rxn4</ci>
      <ci>delta_Ceramide_rxn5</ci>
    </apply>
  </math>
</component>

<component name="Galactocerebroside" cmeta:id="Galactocerebroside">
  <variable name="Galactocerebroside" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_Galactocerebroside_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>Galactocerebroside</ci>
      </apply>
      <ci>delta_Galactocerebroside_rxn4</ci>
    </math>
  </component>

<component name="Glucocerebroside" cmeta:id="Glucocerebroside">
  <variable name="Glucocerebroside" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_Glucocerebroside_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>Glucocerebroside</ci>
      </apply>
      <ci>delta_Glucocerebroside_rxn5</ci>
    </math>
  </component>

<component name="UDP_galactose" cmeta:id="UDP_galactose">
  <variable name="UDP_galactose" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_UDP_galactose_rxn4" 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>UDP_galactose</ci>
    </apply>
    <ci>delta_UDP_galactose_rxn4</ci>
  </apply>
</math>
</component>

<component name="UDP" cmeta:id="UDP">
  <variable name="UDP" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_UDP_rxn4" public_interface="in" units="flux" />
  <variable name="delta_UDP_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>UDP</ci>
      </apply>
      <apply><plus />
        <ci>delta_UDP_rxn4</ci>
        <ci>delta_UDP_rxn5</ci>
      </apply>
    </apply>
  </math>
</component>

<component name="UDP_glucose" cmeta:id="UDP_glucose">
  <variable name="UDP_glucose" public_interface="out" initial_value="1.0" units="micromolar" />
  <variable name="delta_UDP_glucose_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>UDP_glucose</ci>
      </apply>
      <ci>delta_UDP_glucose_rxn5</ci>
    </apply>
  </math>
</component>

<!--
  The following components describe all the enzymes involved in glycolipid
  synthesis.
-->

<component name="Dehydrosphinganine_synthase" cmeta:id="Dehydrosphinganine_synthase">
  <variable name="Dehydrosphinganine_synthase" public_interface="out" initial_value="1.0" u

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</component>

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

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

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

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

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

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

<component name="reaction0">
  <variable name="Serine" public_interface="in" units="micromolar" />
  <variable name="Palmitoyl_CoA" public_interface="in" units="micromolar" />
  <variable name="CoA_SH" public_interface="in" units="micromolar" />
  <variable name="CO2" public_interface="in" units="micromolar" />
  <variable name="Dehydrosphinganine" public_interface="in" units="micromolar" />
  <variable name="Dehydrosphinganine_synthase" public_interface="in" units="micromolar" />
  <variable name="delta_Serine_rxn0" public_interface="out" units="flux" />
  <variable name="delta_Palmitoyl_CoA_rxn0" public_interface="out" units="flux" />
  <variable name="delta_CoA_SH_rxn0" public_interface="out" units="flux" />
  <variable name="delta_CO2_rxn0" public_interface="out" units="flux" />
  <variable name="delta_Dehydrosphinganine_rxn0" public_interface="out" units="flux" />
  <variable name="km0" initial_value="1.0" units="micromolar" />
  <variable name="vmax0" initial_value="1.0" units="second_order_rate_constant" />
  <variable name="rate" units="flux" />
  <reaction reversible="no">
    <variable_ref variable="Serine">
      <role role="reactant" delta_variable="delta_Serine_rxn0" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Palmitoyl_CoA">
      <role role="reactant" delta_variable="delta_Palmitoyl_CoA_rxn0" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="CoA_SH">
      <role role="product" delta_variable="delta_CoA_SH_rxn0" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="CO2">
      <role role="product" delta_variable="delta_CO2_rxn0" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Dehydrosphinganine">
      <role role="product" delta_variable="delta_Dehydrosphinganine_rxn0" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Dehydrosphinganine_synthase">

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    <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>Serine</ci>
              <ci>Palmitoyl.CoA</ci>
              <ci>vmax0</ci>
            </apply>
          <apply><plus />
            <ci>km0</ci>
            <ci>Serine</ci>
            <ci>Palmitoyl.CoA</ci>
          </apply>
        </math>
      </role>
    </variable_ref>
  </reaction>
</component>

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```

<component name="reaction1">
  <variable name="Dehydroshinganine" public_interface="in" units="micromolar" />
  <variable name="NADPH" public_interface="in" units="micromolar" />
  <variable name="H" public_interface="in" units="micromolar" />
  <variable name="Dehydroshingasine" public_interface="in" units="micromolar" />
  <variable name="Dehydroshinganine_reductase" public_interface="in" units="micromolar" />
  <variable name="NADP" public_interface="in" units="micromolar" />
  <variable name="delta_Dehydroshinganine_rxn1" public_interface="out" units="flux" />
  <variable name="delta_NADPH_rxn1" public_interface="out" units="flux" />
  <variable name="delta_H_rxn1" public_interface="out" units="flux" />
  <variable name="delta_Dehydroshingasine_rxn1" public_interface="out" units="flux" />
  <variable name="delta_NADP_rxn1" public_interface="out" units="flux" />
  <variable name="km1" initial_value="1.0" units="micromolar" />
  <variable name="vmax1" initial_value="1.0" units="third_order_rate_constant" />
  <variable name="rate" units="flux" />
  <reaction reversible="no">
    <variable_ref variable="Dehydroshinganine">
      <role role="reactant" delta_variable="delta_Dehydroshinganine_rxn1" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="NADPH">
      <role role="reactant" delta_variable="delta_NADPH_rxn1" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="H">
      <role role="reactant" delta_variable="delta_H_rxn1" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Dehydroshingasine">
      <role role="product" delta_variable="delta_Dehydroshingasine_rxn1" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="NADP">
      <role role="product" delta_variable="delta_NADP_rxn1" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Dehydroshinganine_reductase">
      <role role="catalyst" />
    </variable_ref>
  </reaction>

```

```

</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>Dehydrosphinganine</ci>
            <ci>NADPH</ci>
            <ci>H</ci>
            <ci>vmax1</ci>
          </apply>
        <apply><plus />
          <ci>km1</ci>
          <ci>Dehydrosphinganine</ci>
          <ci>NADPH</ci>
          <ci>H</ci>
        </apply>
      </apply>
    </math>
  </role>
</variable_ref>
</reaction>
</component>

```

```

<component name="reaction2">
  <variable name="Fatty_acyl_CoA" public_interface="in" units="micromolar" />
  <variable name="Dehydrosphingasine" public_interface="in" units="micromolar" />
  <variable name="CoA_SH" public_interface="in" units="micromolar" />
  <variable name="Acyl_CoA_transferase" public_interface="in" units="micromolar" />
  <variable name="Dihydroceramide" public_interface="in" units="micromolar" />
  <variable name="delta_Fatty_acyl_CoA_rxn2" public_interface="out" units="flux" />
  <variable name="delta_Dehydrosphingasine_rxn2" public_interface="out" units="flux" />
  <variable name="delta_CoA_SH_rxn2" public_interface="out" units="flux" />
  <variable name="delta_Dihydroceramide_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="Fatty_acyl_CoA">
      <role role="reactant" delta_variable="delta_Fatty_acyl_CoA_rxn2" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Dehydrosphingasine">
      <role role="reactant" delta_variable="delta_Dehydrosphingasine_rxn2" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="CoA_SH">
      <role role="product" delta_variable="delta_CoA_SH_rxn2" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Dihydroceramide">
      <role role="product" delta_variable="delta_Dihydroceramide_rxn2" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Acyl_CoA_transferase">
      <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>Fatty_acyl_CoA</ci>
          <ci>Dehydrosphingasine</ci>
          <ci>vmax2</ci>
        </apply>
      <apply><plus />
        <ci>km2</ci>
        <ci>Fatty_acyl_CoA</ci>
        <ci>Dehydrosphingasine</ci>
      </apply>
    </apply>
  </math>
</role>
</variable_ref>
</reaction>
</component>

<component name="reaction3">
  <variable name="FAD" public_interface="in" units="micromolar" />
  <variable name="Dihydroceramide" public_interface="in" units="micromolar" />
  <variable name="Dihydroceramide_reductase" public_interface="in" units="micromolar" />
  <variable name="Ceramide" public_interface="in" units="micromolar" />
  <variable name="FADH2" public_interface="in" units="micromolar" />
  <variable name="delta_FAD_rxn3" public_interface="out" units="flux" />
  <variable name="delta_Dihydroceramide_rxn3" public_interface="out" units="flux" />
  <variable name="delta_Ceramide_rxn3" public_interface="out" units="flux" />
  <variable name="delta_FADH2_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="FAD">
      <role role="reactant" delta_variable="delta_FAD_rxn3" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Dihydroceramide">
      <role role="reactant" delta_variable="delta_Dihydroceramide_rxn3" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Ceramide">
      <role role="product" delta_variable="delta_Ceramide_rxn3" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="FADH2">
      <role role="product" delta_variable="delta_FADH2_rxn3" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Dihydroceramide_reductase">
      <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>FAD</ci>
                <ci>Dihydroceramide</ci>

```

```

        <ci>vmax3</ci>
      </apply>
    </math>
  </role>
</variable_ref>
</reaction>
</component>

```

```

<component name="reaction4">
  <variable name="Ceramide" public_interface="in" units="micromolar" />
  <variable name="UDP_galactose" public_interface="in" units="micromolar" />
  <variable name="UDP" public_interface="in" units="micromolar" />
  <variable name="Galactocerebroside" public_interface="in" units="micromolar" />
  <variable name="Galactocerebroside_synthase" public_interface="in" units="micromolar" />
  <variable name="delta_Ceramide_rxn4" public_interface="out" units="flux" />
  <variable name="delta_UDP_galactose_rxn4" public_interface="out" units="flux" />
  <variable name="delta_UDP_rxn4" public_interface="out" units="flux" />
  <variable name="delta_Galactocerebroside_rxn4" public_interface="out" units="flux" />
  <variable name="km4" initial_value="1.0" units="micromolar" />
  <variable name="vmax4" initial_value="1.0" units="second_order_rate_constant" />
  <variable name="rate" units="flux" />
  <reaction reversible="no">
    <variable_ref variable="Ceramide">
      <role role="reactant" delta_variable="delta_Ceramide_rxn4" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="UDP_galactose">
      <role role="reactant" delta_variable="delta_UDP_galactose_rxn4" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="UDP">
      <role role="product" delta_variable="delta_UDP_rxn4" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Galactocerebroside">
      <role role="product" delta_variable="delta_Galactocerebroside_rxn4" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Galactocerebroside_synthase">
      <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>Ceramide</ci>
                <ci>UDP_galactose</ci>
                <ci>vmax4</ci>
              </apply>
            <apply><plus />
              <ci>km4</ci>
              <ci>Ceramide</ci>
              <ci>UDP_galactose</ci>
          </math>
        </role>
      </variable_ref>
    </reaction>
  </component>

```

```

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

```

```

<component name="reaction5">
  <variable name="Ceramide" public_interface="in" units="micromolar" />
  <variable name="UDP_glucose" public_interface="in" units="micromolar" />
  <variable name="UDP" public_interface="in" units="micromolar" />
  <variable name="Glucocerebroside" public_interface="in" units="micromolar" />
  <variable name="Glucocerebroside_synthase" public_interface="in" units="micromolar" />
  <variable name="delta_Ceramide_rxn5" public_interface="out" units="flux" />
  <variable name="delta_UDP_glucose_rxn5" public_interface="out" units="flux" />
  <variable name="delta_UDP_rxn5" public_interface="out" units="flux" />
  <variable name="delta_Glucocerebroside_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="Ceramide">
      <role role="reactant" delta_variable="delta_Ceramide_rxn5" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="UDP_glucose">
      <role role="reactant" delta_variable="delta_UDP_glucose_rxn5" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="UDP">
      <role role="product" delta_variable="delta_UDP_rxn5" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Glucocerebroside">
      <role role="product" delta_variable="delta_Glucocerebroside_rxn5" stoichiometry="1" />
    </variable_ref>
    <variable_ref variable="Glucocerebroside_synthase">
      <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>Ceramide</ci>
                <ci>UDP_glucose</ci>
                <ci>vmax5</ci>
              </apply>
            <apply><plus />
              <ci>km5</ci>
              <ci>Ceramide</ci>
              <ci>UDP_glucose</ci>
            </apply>
          </math>
        </role>
      </variable_ref>
    </reaction>
  </component>

```

```

    </reaction>
</component>

<connection>
  <map_components component_1="Palmitoyl_CoA" component_2="reaction0" />
  <map_variables variable_1="Palmitoyl_CoA" variable_2="Palmitoyl_CoA" />
  <map_variables variable_1="delta_Palmitoyl_CoA_rxn0" variable_2="delta_Palmitoyl_CoA_rxn0" />
</connection>

<connection>
  <map_components component_1="Serine" component_2="reaction0" />
  <map_variables variable_1="Serine" variable_2="Serine" />
  <map_variables variable_1="delta_Serine_rxn0" variable_2="delta_Serine_rxn0" />
</connection>

<connection>
  <map_components component_1="Dehydrosphinganine" component_2="reaction0" />
  <map_variables variable_1="Dehydrosphinganine" variable_2="Dehydrosphinganine" />
  <map_variables variable_1="delta_Dehydrosphinganine_rxn0" variable_2="delta_Dehydrosphinganine_rxn0" />
</connection>

<connection>
  <map_components component_1="Dehydrosphinganine" component_2="reaction1" />
  <map_variables variable_1="Dehydrosphinganine" variable_2="Dehydrosphinganine" />
  <map_variables variable_1="delta_Dehydrosphinganine_rxn1" variable_2="delta_Dehydrosphinganine_rxn1" />
</connection>

<connection>
  <map_components component_1="CoA_SH" component_2="reaction0" />
  <map_variables variable_1="CoA_SH" variable_2="CoA_SH" />
  <map_variables variable_1="delta_CoA_SH_rxn0" variable_2="delta_CoA_SH_rxn0" />
</connection>

<connection>
  <map_components component_1="CoA_SH" component_2="reaction2" />
  <map_variables variable_1="CoA_SH" variable_2="CoA_SH" />
  <map_variables variable_1="delta_CoA_SH_rxn2" variable_2="delta_CoA_SH_rxn2" />
</connection>

<connection>
  <map_components component_1="CO2" component_2="reaction0" />
  <map_variables variable_1="CO2" variable_2="CO2" />
  <map_variables variable_1="delta_CO2_rxn0" variable_2="delta_CO2_rxn0" />
</connection>

<connection>
  <map_components component_1="NADPH" component_2="reaction1" />
  <map_variables variable_1="NADPH" variable_2="NADPH" />
  <map_variables variable_1="delta_NADPH_rxn1" variable_2="delta_NADPH_rxn1" />
</connection>

<connection>
  <map_components component_1="NADP" component_2="reaction1" />
  <map_variables variable_1="NADP" variable_2="NADP" />
  <map_variables variable_1="delta_NADP_rxn1" variable_2="delta_NADP_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="Dehydrosphingasine" component_2="reaction1" />
    <map_variables variable_1="Dehydrosphingasine" variable_2="Dehydrosphingasine" />
    <map_variables variable_1="delta_Dehydrosphingasine_rxn1" variable_2="delta_Dehydrosphing
</connection>

<connection>
    <map_components component_1="Dehydrosphingasine" component_2="reaction2" />
    <map_variables variable_1="Dehydrosphingasine" variable_2="Dehydrosphingasine" />
    <map_variables variable_1="delta_Dehydrosphingasine_rxn2" variable_2="delta_Dehydrosphing
</connection>

<connection>
    <map_components component_1="Dihydroceramide" component_2="reaction2" />
    <map_variables variable_1="Dihydroceramide" variable_2="Dihydroceramide" />
    <map_variables variable_1="delta_Dihydroceramide_rxn2" variable_2="delta_Dihydroceramide
</connection>

<connection>
    <map_components component_1="Dihydroceramide" component_2="reaction3" />
    <map_variables variable_1="Dihydroceramide" variable_2="Dihydroceramide" />
    <map_variables variable_1="delta_Dihydroceramide_rxn3" variable_2="delta_Dihydroceramide
</connection>

<connection>
    <map_components component_1="FAD" component_2="reaction3" />
    <map_variables variable_1="FAD" variable_2="FAD" />
    <map_variables variable_1="delta_FAD_rxn3" variable_2="delta_FAD_rxn3" />
</connection>

<connection>
    <map_components component_1="FADH2" component_2="reaction3" />
    <map_variables variable_1="FADH2" variable_2="FADH2" />
    <map_variables variable_1="delta_FADH2_rxn3" variable_2="delta_FADH2_rxn3" />
</connection>

<connection>
    <map_components component_1="Fatty_acyl_CoA" component_2="reaction2" />
    <map_variables variable_1="Fatty_acyl_CoA" variable_2="Fatty_acyl_CoA" />
    <map_variables variable_1="delta_Fatty_acyl_CoA_rxn2" variable_2="delta_Fatty_acyl_CoA_r
</connection>

<connection>
    <map_components component_1="Ceramide" component_2="reaction3" />
    <map_variables variable_1="Ceramide" variable_2="Ceramide" />
    <map_variables variable_1="delta_Ceramide_rxn3" variable_2="delta_Ceramide_rxn3" />
</connection>

<connection>
    <map_components component_1="Ceramide" component_2="reaction4" />
    <map_variables variable_1="Ceramide" variable_2="Ceramide" />
    <map_variables variable_1="delta_Ceramide_rxn4" variable_2="delta_Ceramide_rxn4" />
</connection>

<connection>

```

```
<map_components component_1="Ceramide" component_2="reaction5" />
<map_variables variable_1="Ceramide" variable_2="Ceramide" />
<map_variables variable_1="delta_Ceramide_rxn5" variable_2="delta_Ceramide_rxn5" />
</connection>

<connection>
  <map_components component_1="Galactocerebroside" component_2="reaction4" />
  <map_variables variable_1="Galactocerebroside" variable_2="Galactocerebroside" />
  <map_variables variable_1="delta_Galactocerebroside_rxn4" variable_2="delta_Galactocerebroside_rxn4" />
</connection>

<connection>
  <map_components component_1="Glucocerebroside" component_2="reaction5" />
  <map_variables variable_1="Glucocerebroside" variable_2="Glucocerebroside" />
  <map_variables variable_1="delta_Glucocerebroside_rxn5" variable_2="delta_Glucocerebroside_rxn5" />
</connection>

<connection>
  <map_components component_1="UDP_galactose" component_2="reaction4" />
  <map_variables variable_1="UDP_galactose" variable_2="UDP_galactose" />
  <map_variables variable_1="delta_UDP_galactose_rxn4" variable_2="delta_UDP_galactose_rxn4" />
</connection>

<connection>
  <map_components component_1="UDP" component_2="reaction4" />
  <map_variables variable_1="UDP" variable_2="UDP" />
  <map_variables variable_1="delta_UDP_rxn4" variable_2="delta_UDP_rxn4" />
</connection>

<connection>
  <map_components component_1="UDP" component_2="reaction5" />
  <map_variables variable_1="UDP" variable_2="UDP" />
  <map_variables variable_1="delta_UDP_rxn5" variable_2="delta_UDP_rxn5" />
</connection>

<connection>
  <map_components component_1="UDP_glucose" component_2="reaction5" />
  <map_variables variable_1="UDP_glucose" variable_2="UDP_glucose" />
  <map_variables variable_1="delta_UDP_glucose_rxn5" variable_2="delta_UDP_glucose_rxn5" />
</connection>

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

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

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

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

```
</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="NADPH" 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="H" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

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

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

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

<connection>
  <map_components component_1="FADH2" component_2="global_variables" />
  <map_variables variable_1="time" variable_2="time" />
</connection>

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

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

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

<connection>
  <map_components component_1="Glucocerebroside" component_2="global_variables" />
```

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

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

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

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

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

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

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

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

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

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

</model>
```