CLAIMS

1. A method for producing a product of an enzymatic or chemical pathway from a starting substrate, the pathway comprising one or more conversion steps selected from the group consisting of:

contacting guluronic acid with a uronate dehydrogenase to perform an enzymatic conversion of guluronic acid into D-glucarate (Step 7);

contacting 5-ketogluconate (5-KGA) with an isomerase to perform an enzymatic conversion of 5-ketogluconate (5-KGA) into L-Iduronic acid (Step 15);

contacting L-Iduronic acid with a uronate dehydrogenase to perform an enzymatic conversion of L-Iduronic acid into Idaric acid (Step 7b); and

contacting 5-ketogluconate with a gluconate dehydratase to perform an enzymatic conversion of 5-ketogluconate into 4,6-dihydroxy 2,5-diketo hexanoate (2,5-DDH) (Step 16); and

contacting 1,5-gluconolactone with an alditol oxidase to perform an enzymatic conversion of 1,5-gluconolactone to gulurono-lactone (Step 19).

2. The method of claim 1 wherein the one or more conversion steps comprises contacting guluronic acid with a uronate dehydrogenase to perform the enzymatic conversion of guluronic acid into D-glucarate (Step 7).

3. The method of claim 1 wherein the one or more conversion steps comprises contacting 5-ketogluconate (5-KGA) with an isomerase to perform the enzymatic conversion of 5-ketogluconate (5-KGA) into L-Iduronic acid (Step 15).

4. The method of claim 1 wherein the one or more conversion steps comprises contacting L-Iduronic acid with a uronate dehydrogenase to perform the enzymatic conversion of L-Iduronic acid into Idaric acid Step 7b).

5. The method of claim 1 wherein the one or more conversion steps comprises contacting 5-ketogluconate with a gluconate dehydratase to perform the enzymatic conversion of 5-ketogluconate into 4,6-dihydroxy 2,5-diketo hexanoate (2,5-DDH) (Step 16).

6. The method of claim 1 wherein the one or more conversion steps comprises contacting 1,5-gluconolactone with an alditol oxidase to perform the enzymatic conversion of 1,5-gluconolactone to gulurono-lactone (Step 19).

7. The method of claim 1 wherein the pathway is an enzymatic pathway and the product is 5-dehydro-4-deoxy-glucarate (DDG).

8. The method of claim 1 wherein the substrate is glucose and the product is 5-dehydro- 4-deoxy-glucarate (DDG), comprising the steps of:

contacting D-glucose with an oxygen dependent glucose oxidase or an NAD(P)-dependent glucose dehydrogenase to perform an enzymatic conversion of D-glucose to 1,5-gluconolactone (Step 1);

contacting 1,5-gluconolactone with an alditol oxidase to perform the enzymatic conversion of 1,5-gluconolactone to gulurono-lactone (Step 19);

contacting gulurono-lactone with a lactonase to perform an enzymatic conversion of gulurono-lactone to guluronic acid (Step 1B), or converting gulurono-lactone to guluronic acid by spontaneous reaction in an aqueous solution;

contacting guluronic acid with a uronate dehydrogenase to perform the enzymatic conversion of guluronic acid to D-glucarate (Step 7);

contacting D-glucarate with a glucarate dehydratase to perform an enzymatic conversion of D-glucarate to 5-dehydro-4-deoxy-glucarate (DDG) (Step 8).

9. A method of claim 1 wherein the substrate is glucose and the product is DDG, comprising the steps of:

contacting D-glucose with an oxygen dependent glucose oxidase to produce 1,5-gluconolactone (Step 1);

hydrolyzing 1,5-gluconolactone to gluconic acid (Step 1a);

contacting gluconic acid with an NAD(P)-dependent dehydrogenase to produce 5-ketogluconate (5-KGA) (Step 14);

contacting 5-ketogluconate (5-KGA) with an isomerase to produce L-Iduronic acid (Step 15);

contacting L-Iduronic acid with a uronate dehydrogenase to produce Idaric acid (Step 7b); and

contacting Idaric acid with a glucarate dehydratase to produce DDG (Step 8a).

10. A method of claim 1 wherein the substrate is glucose and the product is DDG, comprising the steps of:

contacting D-glucose with an oxygen dependent glucose oxidase and an NAD(P)-dependent glucose dehydrogenase to produce 1,5-gluconolactone (Step 1);

hydrolyzing 1,5-gluconolactone to gluconic acid (Step 1a);

contacting gluconic acid with an NAD(P)-dependent dehydrogenase to produce 5-ketogluconate (5-KGA) (Step 14);

contacting 5- ketogluconate (5-KGA) with a gluconate dehydratase to produce 4,6-dihydroxy 2,5-diketo hexanoate (2,5-DDH) (Step 16);

contacting 4,6-dihydroxy 2,5-diketo hexanoate (2,5-DDH) with a glucoronate isomerase to produce 4-deoxy-5-threo-hexosulose uronate (DTHU) (Step 4); and

oxidizing 4-deoxy-5-threo-hexosulose uronate (DTHU) to DDG (Step 5).

11. A method of claim 1 wherein the substrate is glucose and the product is DDG, comprising the steps of:

contacting D-glucose with an oxygen dependent glucose oxidase to produce 1,5-gluconolactone (Step 1);

hydrolyzing 1,5-gluconolactone to gluconic acid (Step 1a);

contacting gluconic acid with an NAD(P)-dependent dehydrogenase to produce 5-ketogluconate (5-KGA) (Step 14);

contacting 5-ketogluconate (5-KGA) with an isomerase to produce L-Iduronic acid (Step 15);

contacting L-Iduronic acid with a uronate dehydrogenase to produce 4-deoxy-5-threo-hexosulose uronate (DTHU) (Step 7b); and

oxidizing 4-deoxy-5-threo-hexosulose uronate (DTHU) to produce DDG (Step 5).

12. The method of claim 8 further comprising the step of converting the DDG to 2,5-furan-dicarboxylic acid (FDCA) by contacting the DDG with an inorganic acid.

13. The method of claim 9 further comprising the step of converting the DDG to 2,5-furan-dicarboxylic acid (FDCA) by contacting the DDG with an inorganic acid.

14. The method of claim 10 further comprising the step of converting the DDG to 2,5-furan-dicarboxylic acid (FDCA) by contacting the DDG with an inorganic acid..

15. The method of claim 11 further comprising the step of converting the DDG to 2,5-furan-dicarboxylic acid (FDCA) by contacting the DDG with an inorganic acid.

16. The method of claim 2 wherein the uronate dehydrogenase comprises SEQ ID NO: 1-3 or a homolog having at least 70% sequence identity to SEQ ID NOs: 1-3; or is encoded by a nucleic acid of SEQ ID NOs: 4-6 or a homolog having at least 70% sequence identity to a nucleic acid of SEQ ID NOs: 4-6.

17. The method of claim 3 wherein the isomerase comprises SEQ ID NOs: 7-19 or a homolog having at least 70% sequence identity to an isomerase of SEQ ID NOs: 7 -19; or is encoded by a nucleic acid of SEQ ID NOs: 20-32 or a homolog having at least 70% sequence identity to a nucleic acid of SEQ ID NOs: 20-32.

18. The method of claim 5 wherein the gluconate dehydratase comprises SEQ ID NOs: 33-35 or a homolog having at least 70% sequence identity to a gluconate dehydratase of SEQ ID NOs: 33-35; or is encoded by a nucleic acid of SEQ ID NOs: 36-38 or a homolog having at least 70% sequence identity to a nucleic acid of SEQ ID NOs: 36-38.

19. The method of claim 6 wherein the alditol oxidase comprises SEQ ID NOs: 39-46 or a homolog having at least 70% sequence identity to an alditol oxidase of SEQ ID NOs: 39-46; or is encoded by a nucleic acid of SEQ ID NOs: 47-54 or a homolog having at least 70% sequence identity to a nucleic acid of SEQ ID NOs: 47-54.

20. The method of claim 4 wherein the uronate dehydrogenase comprises SEQ ID NO: 1-3 or a homolog having at least 70% sequence identity to SEQ ID NOs: 1-3; or is encoded by a nucleic acid of SEQ ID NOs: 4-6 or a homolog having at least 70% sequence identity to a nucleic acid of SEQ ID NOs: 4-6.