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<110> SYNTHETIC GENOMICS, INC.
Griffin , Benjamin M.
Kambourakis, Spiros

<120> METHODS FOR PRODUCING DICARBOXYLIC ACIDS

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<150> US 61/906,819
<151> 2013-11-20

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Asp Phe Ala Gly Asp Gly Leu Phe Thr Ser Trp Thr His Glu Lys Asn
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Trp Lys Lys Ala His Asn Ile Leu Leu Pro Ser Phe Ser Gln Gln Ala
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Met Lys Gly Tyr His Ala Met Met Val Asp Ile Ala Val Gln Leu Val
        115                 120                 125

Gln Lys Trp Glu Arg Leu Asn Ala Asp Glu His Ile Glu Val Pro Glu
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Asp Met Thr Arg Leu Thr Leu Asp Thr Ile Gly Leu Cys Gly Phe Asn
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Tyr Arg Phe Asn Ser Phe Tyr Arg Asp Gln Pro His Pro Phe Ile Thr
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Ser Met Val Arg Ala Leu Asp Glu Ala Met Asn Lys Leu Gln Arg Ala
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Asp Ile Lys Val Met Asn Asp Leu Val Asp Lys Ile Ile Ala Asp Arg
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Gln Lys Ala Ala Glu Glu Ala Ala Arg Val Leu Val Asp Pro Val Pro
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Ser Tyr Lys Gln Val Lys Gln Leu Lys Tyr Val Gly Met Val Leu Asn
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Lys Glu Asp Thr Val Leu Gly Gly Glu Tyr Pro Leu Glu Lys Gly Asp
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Gly Asp Asp Val Glu Glu Phe Arg Pro Glu Arg Phe Glu Asn Pro Ser
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Ala Ile Pro Gln His Ala Phe Lys Pro Phe Gly Asn Gly Gln Arg Ala
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Cys Ile Gly Gln Gln Phe Ala Leu His Glu Ala Thr Leu Val Leu Gly
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Gln Val Ala Thr Leu Asp Ser His Ala Gly Asn Leu Pro Arg Glu Gly
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Ala Lys Met His Gly Ala Phe Ser Thr Asn Val Val Ala Ser Lys Glu
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Leu Pro Lys Glu Ala Ser Tyr Gln Glu Gly Asp His Leu Gly Val Ile
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Pro Arg Asn Tyr Glu Gly Ile Val Asn Arg Val Thr Ala Arg Phe Gly
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Gly Glu Ala His Leu Tyr Phe Gly Cys Arg Ser Pro His Glu Asp Tyr
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Leu His Thr Ala Phe Ser Arg Met Pro Asn Gln Pro Lys Thr Tyr Val
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Asn Leu Pro Leu Ile Asp Lys Asp Lys Pro Thr Leu Ser Phe Ile Lys
        35                  40                  45

Ile Ala Glu Glu Tyr Gly Pro Ile Phe Gln Ile Gln Thr Leu Ser Asp
    50                  55                  60

Thr Ile Ile Val Val Ser Gly His Glu Leu Val Ala Glu Val Cys Asp
65                  70                  75                  80

Glu Thr Arg Phe Asp Lys Ser Ile Glu Gly Ala Leu Ala Lys Val Arg
                85                  90                  95

Ala Phe Ala Gly Asp Gly Leu Phe Thr Ser Glu Thr Gln Glu Pro Asn
            100                 105                 110

Trp Lys Lys Ala His Asn Ile Leu Met Pro Thr Phe Ser Gln Arg Ala
        115                 120                 125

Met Lys Asp Tyr His Ala Met Met Val Asp Ile Ala Val Gln Leu Val
    130                 135                 140

Gln Lys Trp Ala Arg Leu Asn Pro Asn Glu Asn Val Asp Val Pro Glu
145                 150                 155                 160

Asp Met Thr Arg Leu Thr Leu Asp Thr Ile Gly Leu Cys Gly Phe Asn
                165                 170                 175

Tyr Arg Phe Asn Ser Tyr Tyr Arg Glu Thr Pro His Pro Phe Ile Thr
            180                 185                 190
```

```
Ser Met Ser Arg Ala Leu Asp Glu Ala Met His Gln Leu Gln Arg Leu
        195                 200                 205

Asp Ile Glu Asp Lys Leu Met Trp Arg Thr Lys Arg Gln Phe Gln His
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Asp Ile Gln Ser Met Phe Ser Leu Val Asp Asn Ile Ile Ala Glu Arg
225                 230                 235                 240

Lys Ser Ser Gly Asn Gln Glu Glu Asn Asp Leu Leu Ser Arg Met Leu
                245                 250                 255

Asn Val Gln Asp Pro Glu Thr Gly Glu Lys Leu Asp Asp Glu Asn Ile
            260                 265                 270

Arg Phe Gln Ile Ile Thr Phe Leu Ile Ala Gly His Glu Thr Thr Ser
        275                 280                 285

Gly Leu Leu Ser Phe Ala Ile Tyr Phe Leu Leu Lys Asn Pro Asp Lys
    290                 295                 300

Leu Lys Lys Ala Tyr Glu Glu Val Asp Arg Val Leu Thr Asp Pro Thr
305                 310                 315                 320

Pro Thr Tyr Gln Gln Val Met Lys Leu Lys Tyr Ile Arg Met Ile Leu
                325                 330                 335

Asn Glu Ser Leu Arg Leu Trp Pro Thr Ala Pro Ala Phe Ser Leu Tyr
            340                 345                 350

Ala Lys Glu Asp Thr Val Ile Gly Gly Lys Tyr Pro Ile Lys Lys Gly
        355                 360                 365

Glu Asp Arg Ile Ser Val Leu Ile Pro Gln Leu His Arg Asp Lys Asp
    370                 375                 380
```

```
Ala Trp Gly Asp Asn Val Glu Glu Phe Gln Pro Glu Arg Phe Glu Glu
385                 390                 395                 400


Leu Asp Lys Ile Pro His His Ala Tyr Lys Pro Phe Gly Asn Gly Gln
                405                 410                 415


Arg Ala Cys Ile Gly Met Gln Phe Ala Leu His Glu Ala Thr Leu Val
            420                 425                 430


Met Gly Met Leu Leu Gln His Phe Glu Phe Ile Asp Tyr Gln Asp Tyr
        435                 440                 445


Gln Leu Asp Val Lys Gln Thr Leu Thr Leu Lys Pro Gly Asp Phe Lys
    450                 455                 460


Ile Arg Ile Leu Pro Arg Lys Gln Thr Ile Ser His Thr Thr Val Leu
465                 470                 475                 480


Ala Pro Ile Glu Glu Lys Leu Lys Asn His Glu Ile Glu Gln Gln Val
                485                 490                 495


Gln Lys Thr Pro Ser Ile Ile Gly Ala Asp Asn Leu Ser Leu Leu Val
            500                 505                 510


Leu Tyr Gly Ser Asp Thr Gly Val Ala Glu Gly Ile Ala Arg Glu Leu
        515                 520                 525


Ala Asp Thr Ala Ser Leu Glu Gly Val Gln Thr Glu Val Val Ala Leu
    530                 535                 540


Asn Asp Arg Ile Gly Ser Leu Pro Lys Glu Gly Ala Val Leu Ile Val
545                 550                 555                 560


Thr Ser Ser Tyr Asn Gly Lys Pro Pro Ser Asn Ala Gly Gln Phe Val
                565                 570                 575
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Gln Trp Leu Glu Glu Leu Lys Pro Asp Glu Leu Lys Gly Val Gln Tyr
            580                 585                 590

Ala Val Phe Gly Cys Gly Asp His Asn Trp Ala Ser Thr Tyr Gln Arg
        595                 600                 605

Ile Pro Arg Tyr Ile Asp Glu Gln Met Ala Gln Lys Gly Ala Thr Arg
    610                 615                 620

Phe Ser Thr Arg Gly Glu Ala Asp Ala Ser Gly Asp Phe Glu Glu Gln
625                 630                 635                 640

Leu Glu Gln Trp Lys Gln Ser Met Trp Ser Asp Ala Met Lys Ala Phe
                645                 650                 655

Gly Leu Glu Leu Asn Lys Asn Ile Glu Lys Glu Arg Ser Thr Leu Ser
            660                 665                 670

Leu Gln Phe Val Ser Arg Leu Gly Gly Ser Pro Leu Ala Arg Thr Tyr
        675                 680                 685

Glu Ala Val Tyr Ala Ser Ile Leu Glu Asn Arg Glu Leu Gln Ser Ser
    690                 695                 700

Ser Ser Glu Arg Ser Thr Arg His Ile Glu Ile Ser Leu Pro Val Gly
705                 710                 715                 720

Ala Thr Tyr Gln Glu Gly Asp His Leu Gly Val Leu Pro Ile Asn Ser
                725                 730                 735

Glu Lys Asn Val Asn Arg Ile Leu Lys Arg Phe Gly Leu Asn Gly Lys
            740                 745                 750

Asp Gln Val Ile Leu Ser Ala Ser Gly Arg Ser Val Asn His Ile Pro
        755                 760                 765
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```
Leu Asp Ser Pro Val Ser Leu Phe Asp Leu Leu Ser Tyr Ser Val Glu
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Ile Gln Glu Ala Ala Thr Arg Ala Gln Ile Arg Glu Met Val Thr Phe
785                 790                 795                 800

Thr Ala Cys Pro Pro His Lys Lys Glu Leu Glu Ser Leu Leu Glu Glu
                805                 810                 815

Gly Val Tyr His Glu Gln Ile Leu Lys Lys Arg Met Ser Met Leu Asp
            820                 825                 830

Leu Leu Glu Lys Tyr Glu Ala Cys Glu Ile Arg Phe Glu Arg Phe Leu
        835                 840                 845

Glu Leu Leu Pro Ala Leu Lys Pro Arg Tyr Tyr Ser Ile Ser Ser Ser
    850                 855                 860

Pro Leu Val Ala Gln Asp Arg Leu Ser Ile Thr Val Gly Val Val Asn
865                 870                 875                 880

Ala Pro Ala Trp Ser Gly Val Gly Thr Tyr Glu Gly Val Ala Ser Asn
                885                 890                 895

Tyr Leu Ala Gln Arg His Asn Lys Asp Glu Ile Ile Cys Phe Ile Arg
            900                 905                 910

Thr Pro Gln Ser Asn Phe Gln Leu Pro Glu Asn Pro Glu Thr Pro Ile
        915                 920                 925

Ile Met Val Gly Pro Gly Thr Gly Ile Ala Pro Phe Arg Gly Phe Leu
    930                 935                 940

Gln Ala Arg Arg Val Gln Lys Gln Lys Gly Ile Asn Leu Gly Gln Ala
945                 950                 955                 960
```

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His Leu Tyr Phe Gly Cys Arg His Pro Glu Lys Asp Tyr Leu Tyr Arg
                965                 970                 975


Thr Glu Leu Glu Asn Asp Glu Arg Asp Gly Leu Ile Ser Leu His Thr
            980                 985                 990


Ala Phe Ser Arg Leu Glu Gly Tyr  Pro Lys Thr Tyr Val  Gln His Leu
        995                 1000                1005


Ile Lys  Gln Asp Arg Ile Asn  Leu Ile Ser Leu Leu  Asp Asn Gly
    1010                1015                1020


Ala His  Leu Tyr Ile Cys Gly  Asp Gly Ser Lys Met  Ala Pro Asp
    1025                1030                1035


Val Glu  Asp Thr Leu Cys Gln  Ala Tyr Gln Glu Ile  His Glu Val
    1040                1045                1050


Ser Glu  Gln Glu Ala Arg Asn  Trp Leu Asp Arg Val  Gln Glu Glu
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Gly Arg  Tyr Gly Lys Asp Val  Trp Ala Gly Ile
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Leu Trp Arg Leu Ala Asp Glu Leu Gly Pro Ile Phe Arg Phe Asp Phe
        35                  40                  45


Pro Gly Val Ser Ser Val Phe Val Ser Gly His Asn Leu Val Ala Glu
    50                  55                  60


Val Cys Asp Glu Ser Arg Phe Asp Lys Asn Leu Gly Lys Gly Leu Leu
65                  70                  75                  80


Lys Val Arg Glu Phe Gly Gly Asp Gly Leu Phe Thr Ser Trp Thr His
                85                  90                  95


Glu Pro Asn Trp Gln Lys Ala His Arg Ile Leu Leu Pro Ser Phe Ser
            100                 105                 110


Gln Lys Ala Met Lys Gly Tyr His Ser Met Met Leu Asp Ile Ala Thr
        115                 120                 125


Gln Leu Ile Gln Lys Trp Ser Arg Leu Asn Pro Asn Glu Glu Ile Asp
    130                 135                 140


Val Ala Asp Asp Met Thr Arg Leu Thr Leu Asp Thr Ile Gly Leu Cys
145                 150                 155                 160
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Gly Phe Asn Tyr Arg Phe Asn Ser Phe Tyr Arg Asp Ser Gln His Pro
                165                 170                 175

Phe Ile Thr Ser Met Leu Ser Ala Leu Lys Glu Ala Met Asn Gln Ser
            180                 185                 190

Lys Arg Leu Gly Leu Gln Asp Lys Met Met Val Lys Thr Lys Leu Gln
        195                 200                 205

Phe Gln Lys Asp Ile Glu Val Met Asn Ser Leu Val Asp Arg Met Ile
    210                 215                 220

Ala Glu Arg Lys Glu Asn Pro Asp Glu Asn Ile Lys Asp Leu Leu Ser
225                 230                 235                 240

Leu Met Leu Tyr Ala Lys Asp Pro Val Thr Gly Glu Thr Leu Asp Asp
                245                 250                 255

Glu Asn Ile Arg Tyr Gln Ile Ile Thr Phe Leu Ile Ala Gly His Glu
            260                 265                 270

Thr Thr Ser Gly Leu Leu Ser Phe Ala Ile Tyr Cys Leu Leu Thr His
        275                 280                 285

Pro Glu Lys Leu Lys Lys Ala Gln Glu Glu Ala Asp Arg Val Leu Thr
    290                 295                 300

Asp Thr Pro Glu Tyr Lys Gln Ile Gln Gln Leu Lys Tyr Ile Arg Met
305                 310                 315                 320

Val Leu Asn Glu Thr Leu Arg Leu Tyr Pro Thr Ala Pro Ala Phe Ser
                325                 330                 335

Leu Tyr Ala Lys Glu Asp Thr Val Leu Gly Gly Glu Tyr Pro Ile Ser
            340                 345                 350
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Lys Gly Gln Pro Val Thr Val Leu Ile Pro Lys Leu His Arg Asp Gln
        355                 360                 365

Asn Ala Trp Gly Glu Asp Ala Glu Asp Phe Arg Pro Glu Arg Phe Glu
    370                 375                 380

Asp Pro Ser Ser Ile Pro His His Ala Tyr Lys Pro Phe Gly Asn Gly
385                 390                 395                 400

Gln Arg Ala Cys Ile Gly Met Gln Phe Ala Leu Gln Glu Ala Thr Met
                405                 410                 415

Val Leu Gly Leu Val Leu Lys His Phe Asp Leu Met Asn His Thr Gly
            420                 425                 430

Tyr Glu Leu Lys Ile Lys Glu Ala Leu Thr Ile Lys Pro Asp Glu Phe
        435                 440                 445

Lys Ile Thr Val Lys Pro Arg Lys Thr Ala Ala Ile Asn Val Gln Arg
    450                 455                 460

Arg Glu Gln Ala Asp Asn Lys Thr Glu Thr Lys Pro Lys Glu Thr Lys
465                 470                 475                 480

Pro Lys His Gly Thr Pro Leu Leu Val Leu Tyr Gly Ser Asn Leu Gly
                485                 490                 495

Thr Ala Glu Gly Ile Ala Gly Glu Leu Ala Ala Tyr Gly Arg Gln Leu
            500                 505                 510

Gly Phe Thr Ala Glu Thr Ala Pro Leu Asp Asp Tyr Ile Gly Lys Leu
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Pro Glu Gln Gly Ala Val Val Ile Val Thr Ala Ser Tyr Asn Gly Ala
    530                 535                 540
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Pro Pro Asp Asn Ala Ala Gly Phe Val Glu Trp Leu Glu Glu Leu Glu
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Glu Gly Arg Leu Lys Gly Val Ser Tyr Ala Val Phe Gly Cys Gly Asn
                565                 570                 575

Arg Ser Trp Ala Ser Thr Tyr Gln Arg Ile Pro Arg Leu Ile Asp Asp
            580                 585                 590

Met Met Gln Ala Lys Gly Ala Ser Arg Leu Thr Pro Ile Gly Glu Gly
        595                 600                 605

Asp Ala Ala Asp Asp Phe Glu Ser His Arg Glu Ser Trp Glu Asn Arg
    610                 615                 620

Phe Trp Lys Glu Ser Ile Lys Ala Phe Asp Ile Asn Glu Ile Ser Gln
625                 630                 635                 640

Lys Glu Asp Arg Pro Ser Leu Ser Ile Thr Phe Leu Ser Glu Ala Thr
                645                 650                 655

Glu Thr Pro Leu Ala Lys Ala Tyr Gly Ala Phe Glu Gly Ile Val Leu
            660                 665                 670

Glu Asn Arg Glu Leu Gln Thr Ala Asp Ser Pro Arg Ser Thr Arg His
        675                 680                 685

Ile Glu Leu Gln Val Pro Asp Ala Lys Thr Tyr Lys Glu Gly Asp His
    690                 695                 700

Ile Gly Ile Leu Pro Lys Asn Ser Gln Glu Leu Val Gln Arg Val Leu
705                 710                 715                 720

Ser Arg Phe Gly Leu Gln Ser Asn His Val Ile Lys Met Ser Gly Ser
                725                 730                 735
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Pro His Met Ala His Leu Pro Met Asp Arg Pro Ile Lys Val Ala Asp
            740                 745                 750

Leu Leu Ser Ser Tyr Val Glu Leu Gln Glu Pro Ala Ser Arg Leu Gln
        755                 760                 765

Leu Arg Glu Leu Ala Ser Tyr Thr Val Cys Pro Pro His Lys Lys Glu
    770                 775                 780

Leu Glu Gln Leu Val Ser Ala Asp Gly Ile Tyr Lys Glu Gln Val Leu
785                 790                 795                 800

Glu Lys Arg Leu Thr Met Leu Asp Leu Leu Glu Asp Tyr Pro Ala Cys
                805                 810                 815

Glu Met Pro Phe Glu Arg Phe Leu Glu Leu Leu Pro Ser Leu Lys Pro
            820                 825                 830

Arg Tyr Tyr Ser Ile Ser Ser Ser Pro Lys Val His Ala Asn Ile Val
        835                 840                 845

Ser Met Thr Val Gly Val Val Lys Gly Ser Ala Trp Ser Gly Arg Gly
    850                 855                 860

Glu Tyr Arg Gly Val Ala Ser Asn Tyr Leu Ala Glu Leu Asn Thr Gly
865                 870                 875                 880

Asp Ala Ala Ala Cys Phe Ile Arg Thr Pro Gln Ser Gly Phe Gln Met
                885                 890                 895

Pro Asp Asp Pro Glu Thr Pro Met Ile Met Val Gly Pro Gly Thr Gly
            900                 905                 910

Ile Ala Pro Phe Arg Gly Phe Ile Gln Thr Arg Ser Val Leu Lys Lys
        915                 920                 925
```

```
Glu Gly Asn Thr Leu Gly Glu Ala Leu Phe Tyr Phe Gly Cys Arg Arg
    930                 935                 940

Pro Asp His Asp Asp Leu Tyr Arg Glu Glu Leu Asp Gln Ala Glu Gln
945                 950                 955                 960

Asp Gly Leu Val Thr Val Arg Arg Cys Tyr Ser Arg Val Glu Asn Glu
                965                 970                 975

Ser Lys Glu Tyr Val Gln His Leu Leu Lys Leu Asp Ala Gln Lys Leu
            980                 985                 990

Ile Ser Leu Ile Glu Lys Gly Ala  His Ile Tyr Val Cys  Gly Asp Gly
        995                 1000                1005

Ser Arg  Met Ala Pro Asp Val  Glu Asn Thr Leu Arg  Leu Ala Tyr
    1010                1015                1020

Glu Ala  Glu Lys Gly Ala Asn  Gln Glu Glu Ser Ala  Glu Trp Leu
    1025                1030                1035

Met Asn  Leu Gln Asn Gln Lys  Arg Tyr Val Lys Asp  Val Trp Ser
    1040                1045                1050

Gly Met
    1055
```