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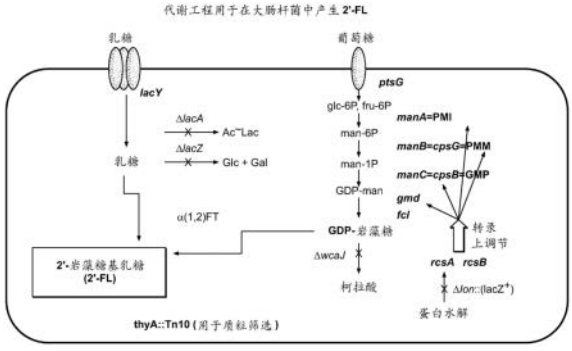
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序列表314页 附图24页

(54)发明名称

用于在产生岩藻糖基化低聚糖时使用的α(1,2)岩藻糖基转移酶变种

(57)摘要

本发明提供了用于设计大肠杆菌或者其他产生岩藻糖基化低聚糖的宿主生产细菌的组合物和方法,及其在预防或者治疗感染中的应用。



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1.一种在细菌中存在乳糖时产生岩藻糖基低聚糖的方法,包括提供包括外源乳糖-利用性α(1,2)岩藻糖转移酶的细菌,其中所述α(1,2)岩藻糖转移酶包括氨基酸序列SEQ ID NO:17。

2.权利要求1所述的方法,其中,所述α(1,2)岩藻糖转移酶包括普雷沃菌FutW。

3.根据前述任意一项权利要求所述的方法,其中,进一步包括从所述细菌中或者所述细菌的培养物上清液中收集岩藻糖基化的低聚糖。

4.根据前述任意一项权利要求所述的方法,其中,所述岩藻糖基化的低聚糖包括2'-岩藻糖基乳糖(2'FL)。

5.根据前述任意一项权利要求所述的方法,其中,所述细菌进一步包括一种外源乳糖利用性α(1,3)岩藻糖转移酶和/或一种外源乳糖利用性α(1,4)岩藻糖转移酶。

6.根据权利要求5所述的方法,其中所述外源乳糖-利用性α(1,3)岩藻糖转移酶包括幽门螺杆菌26695futA基因。

7.根据权利要求5所述的方法,其中所述外源乳糖-利用性α(1,4)岩藻糖转移酶包括幽门螺杆菌UA948 FucTa基因或者幽门螺杆菌DMS6709 FucTIII基因。

8.根据前述任意一项权利要求所述的方法,其中,所述细菌进一步包括降低水平的β-半乳糖苷酶活性,有缺陷的柯拉酸合成途径,失活的ATP-依赖型细胞内蛋白酶、失活的lacA或其组合。

9.根据权利要求8所述的方法,其中,所述方法进一步包括在色氨酸存在的情况下胸腺嘧啶不存在的情况下培养所述细菌。

10.根据权利要求8所述的方法,其中,所述降低水平的β-半乳糖苷酶活性包括所述细菌缺失内源性lacZ基因或者使内源性lacZ基因失活和/或缺失内源性lacI基因或者使内源性lacI基因失活。

11.根据权利要求10所述的方法,其中所述降低水平的β-半乳糖苷酶活性进一步包括一种外源性lacZ基因或其变体,其中,所述外源性lacZ基因或其变体包括的β-半乳糖苷酶活性水平小于野生型细菌。

12.根据权利要求8所述的方法,其中所述降低水平的β-半乳糖苷酶活性包括的活性水平小于野生型细菌。

13.根据权利要求12所述的方法,其中所述降低水平的β-半乳糖苷酶活性包括小于6,000单位的β-半乳糖苷酶活性。

14.根据权利要求12所述的方法,其中所述降低水平的β-半乳糖苷酶活性包括小于1,000单位的β-半乳糖苷酶活性。

15.根据权利要求8所述的方法,其中所述细菌包括lacIq基因启动子,直接位于lacY基因的上游。

16.根据权利要求8所述的方法,其中所述有缺陷的柯拉酸合成途径包括所述细菌wcaJ基因的失活或删除所述wcaJ基因,其中与野生型细菌相比,所述细菌中编码的wcaJ的活性降低或消除。

17.根据权利要求8所述的方法,其中所述失活的ATP-依赖型细胞内蛋白酶是内源性lon基因的无效突变、失活突变或者删除。

18.根据权利要求17所述的方法,其中,所述内源性lon基因的失活突变包括插入功能

性大肠杆菌lacZ^{+}基因。

19.根据权利要求8所述的方法,其中所述细菌进一步包括一种功能性乳糖渗透酶基因。

20.根据权利要求19所述的方法,其中所述细菌包括大肠杆菌lacY。

21.根据权利要求8所述的方法,其中所述细菌进一步包括内源性大肠杆菌rcsA基因或者大肠杆菌rcsB基因。

22.根据权利要求8所述的方法,其中所述细菌进一步包括thyA基因突变。

23.根据权利要求8所述的方法,其中所述细菌在外源性乳糖存在的情况下累积细胞内的乳糖。

24.根据权利要求8所述的方法,其中所述细菌累计内细胞内GDP-岩藻糖。

25.根据前述任意一项权利要求所述的方法,其中,所述细菌是大肠杆菌。

26.根据前述任意一项权利要求所述的方法,其中,所述细菌是杆菌、泛菌、乳酸菌、乳球菌、链球菌、Proprionibacterium、肠球菌、双歧杆菌、芽胞乳杆菌、Micromomospora、微球菌、红球菌、或者假单胞菌菌属。

27.根据前述任意一项权利要求所述的方法,其中,所述细菌选自由以下所组成的组中:地衣形芽孢杆菌,枯草芽胞杆菌、凝结芽孢杆菌、嗜热杆菌、侧孢芽胞杆菌、巨大芽孢杆菌、霉菌样杆菌、短小芽胞杆菌、迟缓芽胞杆菌、蜡样芽胞杆菌,和环状杆菌,草生欧文氏杆菌(成团泛菌)、枸橼酸杆菌、柠檬泛菌、胡萝卜软腐果胶杆菌(Pectobacterium carotovorum)、野油菜黄单胞菌、嗜酸乳杆菌、唾液乳杆菌、植物乳杆菌、瑞士乳杆菌、戴耳布吕克氏乳杆菌、鼠李糖乳杆菌、保加利亚乳杆菌、卷曲乳杆菌、加氏乳杆菌、干酪乳杆菌、罗伊氏乳杆菌、詹氏乳杆菌和乳酸乳球菌,嗜热生物链球菌和费氏丙酸杆菌屎肠球菌、嗜热生物肠道球菌、牛角椒双歧杆菌、婴儿双岐杆菌和两岐双岐杆菌、荧光假单胞菌和绿脓杆菌。

28.根据前述任意一项权利要求所述的方法,其中,所述细菌包括一种核酸构建物,所述核酸构建物包括能够编码所述α(1,2)岩藻糖转移酶的分离的核酸。

29.根据权利要求28所述的方法,其中,所述核酸与一种或者一种以上异源控制序列可操作的连接,指导细菌中产生所述酶。

30.根据权利要求29所述的方法,其中,所述异源控制序列包括一种细菌启动子或者操作子、一种细菌核糖结合位点、一种细菌转录终止子、或者一种质粒选择性标记物。

31.一种分离的细菌,其用于在乳糖存在时产生岩藻糖基低聚糖,包括能够编码外源乳糖-利用性α(1,2)岩藻糖转移酶的分离的核酸,用于在所述细菌中产生所述酶,其中,所述α(1,2)岩藻糖转移酶包括氨基酸序列SEQ ID NO:17。

32.根据权利要求31所述的分离的细菌,其中,所述α(1,2)岩藻糖转移酶包括普雷沃菌FutW。

33.根据权利要求31或32所述的分离的细菌,进一步包括α(1,3)岩藻糖转移酶和/或α(1,4)岩藻糖转移酶。

34.根据权利要求31-33中任意一项所述的分离的细菌,其中,所述细菌是大肠杆菌。

35.根据权利要求31-34中任意一项所述的分离的细菌,其中,所述细菌进一步包括降低水平的β-半乳糖苷酶活性,有缺陷的柯拉酸合成途径,失活的腺苷酸-5'-三磷酸(ATP)-

依赖型细胞内蛋白酶、失活的lacA或其组合。

36.根据权利要求34所述的分离的细菌，其中，所述细菌包括基因型ΔampC::P_{trp}^{B}cI，Δ(lacI-lacZ)::FRT，P_{lacIq}lacY^{+}，ΔwAcaJ::FRT，thyA::Tn10，Δlon:(npt3，lacZ^{+})。

用于在产生岩藻糖基化低聚糖时使用的α(1,2)岩藻糖基转移酶变种

技术领域

[0001] 本发明提供了用于产生纯化的低聚糖的组合物和方法,尤其是某些通常在人类乳汁中发现的岩藻糖基化的低聚糖。

技术背景

[0002] 人类乳汁中包含多种多样的种类丰富的中性和酸性低聚糖。已经在人体中确认超过130种不同的复合低聚糖,并且他们的结构多样性和分布量是人类独有的。虽然这些分子可能不能直接作为营养被婴儿利用,然而当建立健康的内脂生物微环境时、在预防疾病时和在建立免疫功能时,他们就能起到关键的作用。在这里所描述的发明之前,廉价地产生人类乳汁低聚糖(HMOS)的能力是存在问题的。例如,由于立体-特异性问题、前体有效性问题、产物不纯的问题和高成本问题,他们通过化学合成的生产受到了限制。因此,对廉价的生产大量人类乳汁低聚糖(HMOS)的新方法存在迫切需要。

发明内容

[0003] 本发明的特征在于一种有效的并且经济的方法,用于产生岩藻糖基化的低聚糖。使用分离的核酸完成这种岩藻糖基化的低聚糖的产生,所述分离的核酸包括编码利用乳糖的α(1,2)岩藻糖基转移酶基因产物(例如,多肽或者蛋白质)的序列,这可操作的与一种或者一种以上异源的控制序列有关,所述控制序列指导重组岩藻糖基转移酶基因产物在宿主产生细菌,例如,大肠杆菌(E.coli)中的产生。

[0004] 本发明公开的内容提供了一种新型的α(1,2)岩藻糖基转移酶(在这里也叫做α(1,2)FTs),其可以利用乳糖并催化L-岩藻糖从GDP-岩藻糖供体底物传递到接受体底物中,并以α-1,2-键合。在一种优选的实施方案中,所述接受体底物是低聚糖。这里所确定并描述的α(1,2)岩藻糖基转移酶可以有效用于在宿主细菌中表达,用于产生人类乳汁低聚糖(HMOS),例如岩藻糖基化的低聚糖。通过这里所描述的方法产生的示范性的岩藻糖基化的低聚糖包括2'-岩藻糖基乳糖(2'FL)、乳糖二岩藻四糖(LDFT)、乳-N-岩藻五糖I(LNF I)、或者乳-N-二岩藻六糖I(LDFH I)。这里所公开的"α(1,2)岩藻糖转移酶"包括α(1,2)岩藻糖基转移酶的氨基酸序列和编码所述α(1,2)岩藻糖基转移酶的核酸序列,以及显示α(1,2)岩藻糖基转移酶活性的变体及其片段。本发明还包括一种核酸构建物,所述核酸构建物包括一种分离的核酸,该分离的核酸编码接受乳糖的α(1,2)岩藻糖基转移酶,所述核酸选择性的与一种或者一种以上异源控制序列可操作的连接,指挥宿主细菌产生菌株中产生所述酶。

[0005] 这里所描述的乳糖接受性α(1,2)岩藻糖基转移酶的氨基酸序列与螺杆菌幽门26695α-(1,2)岩藻糖基转移酶(futC或者SEQ IDNO:1)的氨基酸序列相比具有至少15%、至少20%、至少25%、至少30%、至少35%、至少40%、至少45%、至少50%、至少55%、至少60%、至少65%、至少70%、至少75%、至少80%、至少85%、至少90%、至少95%的同源性。优选的,这里所描述的乳糖-接受性α(1,2)岩藻糖基转移酶与螺杆菌幽门FutC或者SEQ ID

NO:1具有至少22％的同源性。

[0006] 在另一个方面，这里所描述的的乳糖-接受性α(1,2)岩藻糖基转移酶的氨基酸序列与普通拟杆菌α(1,2)岩藻糖基转移酶(FutN或者SEQ ID NO:3)的氨基酸序列相比具有至少15％、至少20％、至少25％、至少30％、至少35％、至少40％、至少45％、至少50％、至少55％、至少60％、至少65％、至少70％、至少75％、至少80％、至少85％、至少90％、至少95％的一致性。优选的，这里所描述的乳糖-接受性α(1,2)岩藻糖基转移酶与普通拟杆菌FutN或者SEQ ID NO:3具有至少25％的同源性。

[0007] 做为选择，外源的α(1,2)岩藻糖基转移酶优选的包括与这里所公开的新型α(1,2)岩藻糖基转移酶至少具有至少15％、至少20％、至少25％、至少30％、至少35％、至少40％、至少45％、至少50％、至少55％、至少60％、至少65％、至少70％、至少75％、至少80％、至少85％、至少90％、至少95％的同源性的氨基酸序列，例如，如表1中所描述的氨基酸序列。

[0008] 示范性的α(1,2)岩藻糖基转移酶包括，但是不局限于，产黑色普雷沃菌FutO、鲍氏梭状芽孢杆菌FutP、鲍式梭状芽孢杆菌+13FutP、毛螺菌科sp.FutQ、甲烷微菌属(methanosphaerula palustris)FutR、坦纳(Tannerella)菌属FutS、粪拟杆菌FutU、丁酸弧菌属FutV、普雷沃菌FutW、乔氏拟杆菌(Parabacteroides johnsonii)FutX、肠道疣微菌(Akkermansia muciniphilia)FutY、肠道沙门氏菌FutZ、拟杆菌属菌FutZA。例如，所述α(1,2)岩藻糖基转移酶包括一种氨基酸序列，所述氨基酸序列包括以下任意一个序列:产黑色普雷沃菌FutO(SEQ ID NO:10)、鲍氏梭状芽孢杆菌FutP(SEQ ID No:11)、鲍式梭状芽孢杆菌+13FutP(SEQ ID NO:292)、毛螺科菌FutQ(SEQ ID NO:12)、甲烷微菌属(methanosphaerula palustris)FutR(SEQ ID NO:13)Tannerella菌属FutS(SEQ ID NO:14)、粪拟杆菌FutU(SEQ ID NO:15)、丁酸弧菌属FutV(SEQ ID NO:16)、普雷沃菌FutW(SEQ ID NO:17)、乔氏拟杆菌(Parabacteroides johnsonii)FutX(SEQ ID NO:18)、肠道疣微菌(Akkermansia muciniphilia)FutY(SEQ ID NO:19)、肠道沙门氏菌FutZ(SEQ ID NO:20)、和拟杆菌属菌FutZA(SEQ ID NO:21)、或者功能性变体或其片段。其他示范性的α(1,2)岩藻糖基转移酶包括表1中列出的任意一种酶、或者功能性变体或其片段。

[0009] 本发明的特征在于一种方法，所述方法通过提供表达至少一个外源的乳糖-利用性α(1,2)岩藻糖基转移酶的细菌，用于在细菌中产生岩藻糖基化的低聚糖。所述外源的乳糖利用性α(1,2)岩藻糖基转移酶的氨基酸序列优选与螺杆菌幽门FutC具有至少22％的同源性，或者与普通拟杆菌FutN具有至少25％的同源性。在一个方面，所述细菌也表达一种或者一种以上外源的乳糖-利用性α(1,3)岩藻糖基转移酶和/或一种或者一种以上外源的乳糖-利用性α(1,4)岩藻糖基转移酶。产生细菌中表达的岩藻糖基转移酶的组合取决于需要的岩藻糖基化低聚糖产物。这里所公开的方法进一步地包括从细菌或者所述细菌的培养上清液中取回岩藻糖基化的低聚糖。

[0010] 适当的(1,3)岩藻糖基转移酶的实施例包括，但是不局限于，幽门螺杆菌26695futA基因(GenBank登记号码HV532291(GI:365791177)，通过引证在此全部并入本文)、螺杆菌Hh0072、幽门螺旋杆菌11639FucT、和幽门螺旋杆菌UA948FucTa(例如，GenBank登记号码AF194963(GI:28436396)，通过引证在此全部并入本文)(Rasko,D.A.,Wang,G.,Palcic,M.M.&Taylor,D.E.J Biol Chem 275,4988-4994(2000))。适当的α(1,4)岩藻糖基转移酶包括，但是不局限于，幽门螺杆菌UA948FucTa(具有缓和的接受体特异性并且能够产

生α(1,3)-和α(1,4)-岩藻糖基键)。唯一具有(1,4)岩藻糖基转移酶活性的酶的实施例是来自幽门螺杆菌菌株DMS6709(例如,GenBank登记号码AY450598.1(GI:40646733),通过引证在此全部并入本文)的FucT III酶所产生的(S.Rabbani,V.Miksa,B.Wipf,B.Ernst,Glycobiology 15,1076-83(2005)。

[0011] 本发明的特征还在于一种核酸构建物或者一种载体,其包括编码至少一个α(1,2)岩藻糖基转移酶或者其变体或者片段的核酸,如这里所描述的。所述载体可以进一步地包括一种或者一种以上调节元素,例如,异源启动子。"异源"指的是来源于不同菌株的控制序列和蛋白质-编码序列。所述调节元素可以与一种基因可操作的连接,所述基因编码一种蛋白质、一种基因构建物,所述基因构建物编码融合蛋白质基因或者一系列与操纵子连接的基因,从而表达所述融合蛋白质。在依旧另一个方面,本发明包括一种分离的重组细胞,例如,包含上述核酸分子或者载体的细菌细胞。所述核酸选择性地整合到所述基因组的细菌寄主中。在一些实施方案中,所述核酸构建物还进一步地包括一种或者一种以上α(1,3)岩藻糖基转移酶和/或α(1,4)岩藻糖基转移酶。做为选择,所述α(1,2)岩藻糖基转移酶也显示出α(1,3)岩藻糖基转移酶活性和/或α(1,4)岩藻糖基转移酶活性。

[0012] 在这里所描述的生产方法中使用的细菌是进行了基因设计的,能够增加岩藻糖基化低聚糖产物的效力和产率。例如,宿主产生的细菌的特点在于具有降低的β-半乳糖苷酶活性水平,缺少柯拉酸合成途径、ATP-依赖型细胞内蛋白酶失活、lacA失活或其结合。在一个实施方案中,所述细菌的特点在于具有降低的β-半乳糖苷酶活性水平、缺少柯拉酸合成途径、ATP-依赖型细胞内蛋白酶失活和lacA失活。

[0013] 如这里所使用的基因、基因编码产物(例如,多肽)或者途径的"失活"或者"失活作用"指的是降低或者消除基因、基因产物或者途径的表达(例如,转录或者翻译)、蛋白质水平(即,翻译、降解速度)或者酶活性。在途径失活的情况下,优选的,在途径中的一个酶或者多肽在显示出减少的或者可以忽略的活性。例如,在途径中的酶被改变、删除或者突变,从而该途径的产物以相对于野生型细菌或者完整途径相比更低的水平产生产物。做为选择,所述途径的产物不产生。通过删除或者突变所述基因或者基因的调节元素使基因失活,从而所述基因不在被转录或者翻译。通过删除或者突变编码基因产物或者多肽突变的编码基因,破坏其活性,可以实现多肽的失活。失活突变包括一个或者一个以上的核酸的核苷酸或者氨基酸序列的氨基酸的加入、删除或者取代,从而导致所述基因或者多肽的表达或者活性降低或者消除。在其他实施方案中,通过向多肽的N-末端或者C-末端加入外源序列(即,tags)从而使多肽的活性被减少或者消除(即,通过空间位阻)实现多肽的失活。

[0014] 适用于这里所描述的生产系统的宿主细菌显示出增强的或者增加的乳糖和/或GDP-岩藻糖细胞质文库或者细胞内文库。例如,所述细菌是大肠杆菌和内源性的大肠杆菌代谢途径,并且所述基因以多种方式被操作,与野生型大肠杆菌中发现的水平相比,产生增加的乳糖和/或GDP-岩藻糖细胞质浓度。优选的,细菌积聚增加的细胞内乳糖文库和增加的细胞内GDP-岩藻糖文库。例如,所述细菌包含至少10%、20%、50%、或者2X、5X、10X或者更多水平的细胞内乳糖和/或细胞内鸟苷二磷酸-岩藻糖,与相应的不含有这里所描述的遗传修饰的野生型细菌相比。

[0015] 与野生型细菌相比,通过处理基因和涉及乳糖引入、输出和分解代谢的途径来增加宿主细菌中细胞内乳糖浓度。尤其是,这里所描述的是增加进行基因工程设计的大肠杆

菌中细胞内乳糖水平的方法，通过同时删除内源性的(半乳糖苷酶基因(lacZ)和乳糖操纵子阻遏基因(lacI)产生人乳低聚糖。在构建这些删除期间，所述lacIq启动子被放置在乳糖渗透酶基因lacY的直接上游(与乳糖渗透酶基因lacY相连)，那就是说，lacIq启动子序列直接位于编码lacY基因的序列的起始端上游或与之接近，从而所述lacY基因被lacIq启动子进行翻译调节。被修饰的菌株维持了其从培养基中(通过LacY)运输乳糖的能力，但是删除了负责乳糖分解代谢的野生型lacZ染色体拷贝(编码β-半乳糖苷酶)基因。因此，当在外源乳糖存在时，培养修饰的菌株，产生细胞内乳糖库。

[0016] 另一个增加大肠杆菌内乳糖细胞浓度的方法包括使lacA基因失活。lacA的失活突变、无效突变或者删除能够防止细胞内乙酰乳糖的形成，这不但能够从随后的提纯过程中除掉这些作为污染物的分子，还能够消除大肠杆菌从其细胞质中过度输出乳糖的能力(Danchin A.Cells need safety valves.Bioessays 2009,Jul;31(7):769-73.)，因此极大的促进了大肠杆菌细胞内乳糖池有目的的处理。

[0017] 本发明还提供了通过操作有机物内源性柯拉酸生物合成途径来增加细菌内GDP-岩藻糖细胞内水平的方法。该增加是通过对内源性大肠杆菌基因进行多种遗传修饰实现的，所述遗传修饰的基因直接包括在柯拉酸前体生物合成中，或者包括在柯拉酸合成调节子的全面控制中。尤其优选的是使在鸟苷二磷酸-岩藻糖(供体底物)产生之后和柯拉酸产生之间，对柯拉酸合成途径发挥作用的基因或者编码多肽失活。示范性的柯拉酸合成基因包括，但是不局限于：wcaJ基因，(例如，GenBank登记号码(氨基酸)BAA15900(GI:1736749)，通过引证在此全部并入本文)、wcaA基因(例如，GenBank登记号码(氨基酸)BAA15912.1(GI:1736762)，通过引证在此全部并入本文)、wcaC基因(例如，GenBank登记号码(氨基酸)BAE76574.1(GI:85675203)，通过引证在此全部并入本文)、wcaE基因(例如，GenBank登记号码(氨基酸)BAE76572.1(GI:85675201)，通过引证在此全部并入本文)、wcaI基因(例如，GenBank登记号码(氨基酸)BAA15906.1(GI:1736756)，通过引证在此全部并入本文)、wcaL基因(例如，GenBank登记号码(氨基酸)BAA15898.1(GI:1736747)，通过引证在此全部并入本文)、wcaB基因(例如，GenBank登记号码(氨基酸)BAA15911.1(GI:1736761)，通过引证在此全部并入本文)、wcaF基因(例如，GenBank登记号码(氨基酸)BAA15910.1(GI:1736760)，通过引证在此全部并入本文)、wzxE基因(例如，GenBank登记号码(氨基酸)BAE77506.1(GI:85676256)、通过引证在此全部并入本文)、wzxC基因，(例如，GenBank登记号码(氨基酸)BAA15899(GI:1736748)，通过引证在此全部并入本文)、wcaD基因，(例如，GenBank登记号码(氨基酸)BAE76573(GI:85675202)，通过引证在此全部并入本文)、wza基因(例如，GenBank登记号码(氨基酸)BAE76576(GI:85675205)，通过引证在此全部并入本文)、wzb基因(例如，GenBank登记号码(氨基酸)BAE76575(GI:85675204)，通过引证在此全部并入本文)、和wzc基因(例如，GenBank登记号码(氨基酸)BAA15913(GI:1736763)，通过引证在此全部并入本文)。

[0018] 优选的，通过使wcaJ(编码尿苷二磷酸-葡萄糖脂质载体转移酶)基因失活对宿主细菌，例如大肠杆菌，进行基因设计，产生一种人类乳汁低聚糖。可以通过删除基因、无效突变、或者使wcaJ基因发生失活突变来实现wcaJ基因的失活，从而与野生型大肠杆菌相比，编码的wcaJ的活性被减少或者消除。在wcaJ无效的背景下，鸟苷二磷酸-岩藻糖在大肠杆菌细胞质中聚集。

[0019] 在柯拉酸合成途径中，正调节蛋白质RcsA(例如，GenBank登记号码M58003(GI：1103316)，通过引证在此全部并入本文)的过表达导致细胞内鸟苷二磷酸-岩藻糖水平的增加。另一种柯拉酸生物合成的正调节蛋白(即，RcsB，例如，GenBank登记号码E04821(GI：2173017)，通过引证在此全部并入本文)的过表达也被用于，或者代替RcsA的过表达，或者作为RcsA过表达的补充，用于增加细胞内鸟苷二磷酸-岩藻糖水平。

[0020] 做为选择，对大肠杆菌lon基因(例如，GenBank登记号码L20572(GI:304907)，通过引证在此全部并入本文)引入一种突变之后，柯拉酸生物合成被增加。Lon是一种腺苷酸-5′-三磷酸盐(ATP)-依赖性的细胞内蛋白酶，负责降解RcsA，如上所述，作为大肠杆菌中柯拉酸生物合成的阳性翻译调节蛋白。在lon无效的背景下，RcsA是稳定的，RcsA水平增加，在大肠杆菌中负责鸟苷二磷酸-岩藻糖合成的基因被上调节，并且细胞内鸟苷二磷酸-岩藻糖浓度增加。适用于这里所描述的方法中的在lon中发生的突变包括无效突变或者能够破坏lon表达或功能的插入作用。

[0021] 细菌中还存在功能性的乳糖渗透酶基因。所述乳糖渗透酶基因是内源性的乳糖渗透酶基因或者外源的乳糖渗透酶基因。例如，所述乳糖渗透酶基因包括大肠杆菌lacY基因(例如，GenBank登记号码V00295(GI:41897)，通过引证在此全部并入本文)。许多细菌天生具有将乳糖从生长培养基中运输到细胞中的能力，通过使用转运蛋白，所述转运蛋白或者是大肠杆菌乳糖渗透酶的同族体(例如，如在地衣芽孢杆菌中发现的)，或者是运输蛋白，所述运输蛋白时普遍存在的PTS糖运输蛋白家族中的一员(例如，在干酪乳杆菌和鼠李糖乳杆菌中发现的)。对于天然不存在将细胞外乳糖运输到细胞质中能力的细菌，通过在重组DNA构建物中提供外源性乳糖运输蛋白基因(例如，大肠杆菌lacY)，并且或者提供在质粒表达载体上，或者当做外源基因整合到宿主染色体中来赋与其这种能力。

[0022] 如这里所描述的，在一些实施方案中，所述宿主细菌优选的具有降低水平的β-半乳糖苷酶活性。在以删除内源性β-半乳糖苷酶基因为特征的实施方案中，将外源性β-半乳糖苷酶基因引入细菌。例如，表达外源性β-半乳糖苷酶基因的质粒被引入到细菌中或者再结合或者整合到所述宿主基因组中。例如，所述外源β-半乳糖苷酶基因被引入到在宿主细菌中失活的基因中，例如Lon基因。

[0023] 这种外源的β-半乳糖苷酶基因是一种功能性的β-半乳糖苷酶基因，其特征在于与不进行任何基因操作的野生型细菌中的β-半乳糖苷酶活性相比具有减少的或者降低水平的β-半乳糖苷酶活性。示范性的β-半乳糖苷酶基因包括大肠杆菌lacZ和β-半乳糖苷酶基因，来自任何许多其他有机体(例如，乳酸克鲁维酵母的lac4基因(例如，GenBank登记号码M84410(GI:173304)，通过引证在此全部并入本文)，所述基因能够催化β-半乳糖苷水解成单糖。野生型大肠杆菌中的β-半乳糖苷酶活性水平是，例如，6,000单位。因此，本发明工程设计的宿主基因所包括的减少的β-半乳糖苷酶活性水平包括小于6,000单位，小于5,000单位，小于4,000单位，小于3,000单位，小于2,000单位，小于单位，小于900单位，小于800单位，小于700单位，小于600单位，小于500单位，小于400单位，小于300单位，小于200单位，小于100单位，或者小于50单位。降低的β-半乳糖苷酶功能水平包括β-半乳糖苷酶活性水平在0.05和1,000单位之间、在0.05和750单位之间、在0.05和500单位之间、在0.05和400单位之间、在0.05和300单位之间、在0.05和200单位之间、在0.05和100单位之间、在0.05和50单位之间、在0.05和10单位之间、在0.05和5单位之间、在0.05和4单位之间、在0.05和3单位之

间、或者在0.05和2单位之间的β-半乳糖苷酶活性。对于单位的定义和用于确定β-半乳糖苷酶活性的实验参见Miller JH,Laboratory CSH.Experiments in molecular genetics.Cold Spring Harbor Laboratory Cold Spring Harbor,NY;1972;(通过引证在此全部并入本文)。这些低水平的细胞质的β-半乳糖苷酶活性不足以显著的减少细胞内乳糖库。所述低水平的β-半乳糖苷酶活性对于容易的除去发酵末端不需要的乳糖是很有用的。

[0024] 选择性地,所述细菌具有失活的thyA基因。优选的,thyA基因在所述宿主细菌中的突变导致能够运输thyA的质粒作为一种可选择的标记基因被保留。示范性的选择性可选择的标记物包括抗菌素耐药性基因,例如BLA(β-内酰胺酶),或者proBA基因(补充proAB宿主菌株脯氨酸营养缺陷型)或者purA(补充purA宿主菌株脯氨酸营养缺陷型)。

[0025] 在一个方面,所述大肠杆菌细菌包括基因型ΔampC::P_{trp}^{B}cI,Δ(lacI-lacZ)::FRT,P_{lacIq}lacY^{+},ΔwcaJ::FRT,thyA::Tn10,Δlon:(npt3,lacZ^{+}),ΔlacA,以及包括任何一个这里所描述的外源α(1,2)岩藻糖转移酶。

[0026] 在乳糖存在的情况下培养包括这些特征的细菌。有时候,所述方法进一步地包括在色氨酸存在并且胸腺嘧啶不存在的情况下培养所述细菌。从细菌(即,细胞溶解产物)或者细菌培养上清液中回收岩藻糖基化的低聚糖。

[0027] 本发明提供了一种纯化的岩藻糖基化低聚糖,通过这里所描述的方法产生的。纯化岩藻糖基化的低聚糖用于治疗性或者营养性产物,或者细菌直接在这些产物中应用。通过工程细菌产生的岩藻糖基化的低聚糖是2'-岩藻糖基乳糖(2'-FL)或者乳糖二岩藻四糖(LDFT)。新的α-1,2-岩藻糖转移酶还可以有效用于合成大分子量的含有α1,2岩藻糖基序(例如,乳-N-岩藻五糖I(LNF I)和乳-N-二岩藻六糖I(LDFH I))的HMOS。例如,为了产生乳糖二岩藻四糖(LDFT),对宿主细菌进行工程设计使之表达外源α(1,2)岩藻糖转移酶,能够具有α(1,3)岩藻糖转移酶活性或者外源α(1,2)岩藻糖转移酶和外源α(1,3)岩藻糖转移酶。为了产生乳-N-岩藻五糖I(LNF I)和乳-N-二岩藻六糖I(LDFH I),对宿主细菌进行工程设计使之表达具有α(1,3)岩藻糖转移酶活性和/或α(1,4)岩藻糖转移酶活性的外源α-(1,2)岩藻糖转移酶、或者外源α(1,2)岩藻糖转移酶、外源α(1,3)岩藻糖转移酶和外源α(1,4)岩藻糖转移酶。

[0028] 本发明还包括通过这里所描述的方法产生的纯化的岩藻糖基化低聚糖。在工艺末端获得的纯化的低聚糖(2'-岩藻糖基乳糖(2'-FL))是一种白色的、轻微灰白色的透明甜粉末。例如,本发明的工程细菌,细菌培养上清液或者细菌细胞溶解产物包括通过这里所描述的方法产生的2'-岩藻糖基乳糖(2'-FL)、乳糖二岩藻四糖(LDFT)、乳-N-岩藻五糖I(LNF I)或者乳-N-二岩藻六糖I(LDFH I),但是在从所述细胞、培养上清液或者溶解产物中纯化岩藻糖基化低聚糖产物之前基本上不包括其他岩藻糖基化的低聚糖。作为一般物质,在含有2'-岩藻糖基乳糖(2'-FL)的细胞、细胞溶解产物或者培养物、或者上清液中,本方法产生的岩藻糖基化低聚糖包含可忽略数量的3-岩藻糖基乳糖(3-FL),例如,小于1%水平的2'-岩藻糖基乳糖(2'-FL)或者0.5%水平的2'-岩藻糖基乳糖(2'-FL)。而且,通过这里所描述的方法产生的岩藻糖基化低聚糖也具有最小量的污染乳糖,所述污染乳糖通常与岩藻糖基化低聚糖一起被纯化,比如2′-岩藻糖基乳糖(2′FL)。在工程宿主细菌中存在较低水平的β-半乳糖苷酶活性,导致污染乳糖变少。

[0029] 纯化的低聚糖，例如，2’-岩藻糖基乳糖(2’-FL)、乳糖二岩藻四糖(LDFT)、乳-N-岩藻五糖I(LNF I)或者乳-N-二岩藻六糖I(LDFH I)是按重量计算占理想低聚糖含量的至少90％，91％，92％，93％，94％，95％，98％，99％，或者100％(重量/重量)。纯度可以通过任何已知的方法来评价，例如，薄层色层分析法或者其他本领域已知的色谱技术。本发明包括一种纯化由如上所述基因工程细菌产生的岩藻糖基化低聚糖的方法，该方法包括在细菌的细菌细胞溶解产物或者细菌细胞培养上清液中将需要的岩藻糖基化低聚糖(例如，2’-岩藻糖基乳糖(2’-FL))从污染物中分离出来。

[0030] 纯化所述低聚糖并用于多种产物，得到供人及动物消费的产物，例如，作为伙伴的动物(狗，猫)以及家畜(牛、马、绵羊、公山羊或者猪科动物，及家禽)。例如：，一种药物组合物包括纯化的2’-岩藻糖基乳糖(2’-FL)和一种药学上可接受的适合于口服的赋形剂。在细菌宿主中产生大量2’-岩藻糖基乳糖(2’-FL)，例如，包括外源α(1,2)岩藻糖转移酶基因的大肠杆菌细菌。

[0031] 通过培养如上所述细菌来进行产生一种药物组合物的方法，所述药物组合物包括人类乳汁低聚糖(HMOS)，纯化通过所述细菌产生的HMOS，并将此HMOS与一种赋形剂或者载体结合，产生一种适合于口服的食物补充剂。这些组合物可以有效用于预防或者治疗幼儿和成人的肠道和/或呼吸道疾病的方法中。因此，所述组合物被施用给患有或者有风险发展成这种疾病的主体中。

[0032] 本发明还提供了识别α(1,2)岩藻糖转移酶基因的方法，所述基因能够在宿主细菌中合成岩藻糖基化的低聚糖，例如，在大肠杆菌中的2’-岩藻糖基乳糖(2’-FL)。识别新型乳糖-利用性α(1,2)岩藻糖转移酶的方法包括以下步骤：

[0033] 1)计算性检索序列数据库从而定义宽范围的任意已知的、乳糖-利用性α(1,2)岩藻糖转移酶的单一序列同族体。

[0034] 2)使用来自步骤(1)的目录，衍生已知检索曲线，该检索曲线包含公共序列和/或目录所列成员均包含的结构基序；

[0035] 3)检索序列数据库，使用来自步骤(2)的基于公共序列或者机构基序的衍生的检索曲线进行查询，确定候选序列，其中，与参考乳糖-利用性α(1,2)岩藻糖转移酶具有同源性的序列具有预先确定的百分比阈值；

[0036] 4)编辑候选有机体列表，所述有机体的特点在于表达天然存在状态的α(1,2)岩藻糖-聚糖；

[0037] 5)筛选来源于候选有机体的候选序列，产生候选乳糖-利用性酶列表；

[0038] 6)在宿主有机物中表达候选乳糖-利用性酶；和

[0039] 7)检验乳糖-利用性α(1,2)岩藻糖转移酶活性，其中，在所述有机体中检测到要求的岩藻糖基化低聚糖产物说明该候选序列包括新型的乳糖-利用性α(1,2)岩藻糖转移酶。在另一个实施方案中，从超过一个具有已知α(1,2)岩藻糖转移酶活性的酶的氨基酸序列的多个校准序列中产生检索曲线。然后，数据库检索可以被设计成改善并重复检索与多重序列校准查询具有显著序列相似性的新型的α(1,2)岩藻糖转移酶。

[0040] 本发明提供了治疗、预防或者减少主体感染风险的方法，包括对所述主体给药一种组合物，所述组合物包括纯化的重组人类乳汁低聚糖，其中所述HMOS结合病原体并且其中，所述主体感染所述病原体或者由感染此病原体的风险。在一个方面，所述感染是由诺沃

克类病毒或者空肠弯曲菌造成的。所述主体优选是需要这种治疗的哺乳动物。所述哺乳动物是，例如，任何哺乳动物，例如，人、灵长类动物、小鼠、大鼠、狗、猫、母牛，马或者猪。在一种优选的实施方案中，所述哺乳动物是人类。例如，所述组合物可以被配制成动物饲料(例如压成丸，碾碎，捣碎)或者动物饲料补充物用于陪伴类动物，例如狗或者猫，以及，通过消耗食物生长的家畜或者动物，例如，牛、羊、猪、小鸡和山羊。优选的，所述纯化的HMOS被配制成一种粉末(例如，婴儿配制食品粉末或者成人营养增补剂粉末，这些均可以在消费前与液态或者水或者果汁相混合)或者被配制成片剂、胶囊剂或者浆料形式，或者作为一种成分被整合到乳制品中，例如，奶、奶油、乳酪、酸奶酪或者山羊乳酪中，或者作为一种饮料成分，或者与包含或微生物培养物的制剂化合作为益生菌，或者在生物前制剂中用于增加有益微生物的生长，或者在体外或者在体内。

[0041] 本发明的多聚核苷酸、多肽和低聚糖是纯化的和/或分离的。纯化的用于定义一种灭菌程度，这种灭菌程度可以安全的对人类主体给药，例如，不具有传染性或者毒剂。具体地说，如这里所使用的，“分离的”或者“纯化的”核苷酸分子、多聚核苷酸、多肽、蛋白质或者低聚糖是指在通过重组技术产生时基本上不含有其他细胞物质或者培养基的物质，或者是指通过化学合成的化学前体物或者其他化学试剂。例如，纯化的HMOS组合物按重量计算(干重)占所关心化合物的至少60％。优选的，所述制剂按重量计算占所关心化合物的至少75％，更优选的占至少90％，并且最优选的，占至少99％。可以通过任何适当的标准方法来测量纯度，例如，通过柱形色谱法、薄层色层分析法、或者高效液相色谱(HPLC)分析。例如，“纯化的蛋白质”指的是已经从其天然相关的其他蛋白质、脂质和核酸中分离出来的蛋白质。优选的，所述蛋白质构成所述纯化制剂干重的至少10、20、50、70、80、90、95、99-100％。

[0042] 同样，“基本上纯的”是指从其天然伴随的成分中分离出来的低聚糖。通常，当低聚糖按重量计算不含有至少60％、至少70％、至少80％、至少90％、至少95％、或者乃至至少99％的蛋白质和其天然伴随存在的有机分子时，这种低聚糖是基本上纯的。

[0043] “分离的核酸”指的是一种核酸，这种核酸不含有其天然存在的基因组中的侧链基因，所述天然存在的基因组存在于本发明DNA所衍生的有机体中。该术语包括，例如，(a)一种DNA，这种DNA属于天然存在的基因组DNA分子的一部分，但是这部分DNA不是天然存在有机体基因组分子的侧链核苷酸序列；(b)一种核苷酸，这种核苷酸与一种载体整合或者以某种方式整合入原核生物或者真核生物基因组DNA中，从而使所得到的分子不与任意天然存在的载体或者基因组DNA相一致；(c)一种分离的分子，例如互补DNA、基因组片段、通过聚合酶链式反应(PCR)产生的片段、或者限制性片断；和(d)一种重组核苷酸序列，这种重组核苷酸序列是杂合基因的一部分，即，一种基因编码的融合蛋白。根据本发明的分离的核苷酸分子进一步包括合成产生的分子，以及任意具有改变的化学主链和/或具有修饰的主链的核苷酸。

[0044] “异源启动子”是指与基因或者核酸序列天然可操作连接的启动子所不同的启动子。

[0045] 术语“过表达”或者“过表达作用”指的是在一种位置上，通过遗传上改变细胞，从而与野生型细胞在相同的情况下相比，表达更多的因子。相似的，如果未被改变的细胞并不能表达其经过遗传改变所需要产生的因子，则术语“表达”(与“过表达”相区别)用于表示野生型细胞在进行遗传操作之前根本不表达所述因子。

[0046] 如这里所使用的术语“治疗(treating)”和“治疗(treatment)”指的是对患有不利病况、异常或者疾病并具有临床症状的个体给药一种试剂或者制剂，从而起到减少症状严重性和/或出现率，消除所述症状和/或其起因，和/或促进改善或者补救损伤的作用。术语“预防”和“防止”指的是通过向对某种不利病况、异常或者疾病敏感但是无临床症状的个体给药一种试剂或者组合物，从而防止症状出现和/或其诱因。

[0047] 术语制剂或者制剂组分的“有效量”和“治疗有效量”指的是所述制剂或其组分无毒但是足以提供理想的效果所需的数量。

[0048] 过渡术语"包括(comprising)"与"包含(including)"、"含有(containing)"或者"具有...的特征"是同义词，都属于包括性的或者开放式定义，不排除其他未列出的成分或者方法步骤。相反，术语“由...组成”不包括任何在权利要求中没有特别指出的成分、步骤或者组分。术语“基本上由...组成”将权利要求的范围限制在指定的材料或者步骤，“以及那些本质上不影响要求保护的发明的本质和新颖特性的材料或者步骤”。

[0049] 用于表达乳糖-接受性岩藻糖转移酶基因的宿主有机体通常是肠细菌大肠杆菌K12(E.coli)。大肠杆菌K-12不被认为是人或者动物的病原体也不被认为是产毒的。大肠杆菌K-12是一种细菌的标准生产菌株，并且特点在于由于其移植于结肠并产生感染的能力很差，因此是安全的(参见，例如epa.gov/oppt/biotech/pubs/fra/fra004.htm)。然而，多种细菌种类可以被用于低聚糖生物合成方法，例如，(成团泛菌)、弗氏柠檬细菌、柠檬泛菌、胡萝卜软腐病果胶杆菌或者黄单胞菌。还可以使用杆菌类的细菌，包括枯草杆菌、地衣芽孢杆菌、凝结芽孢杆菌、嗜热杆菌、侧孢芽胞杆菌、巨大芽孢杆菌、霉菌样杆菌、短小芽胞杆菌、迟缓芽胞杆菌、蜡样芽胞杆菌和环状杆菌。同样，使用本发明所述方法可以对乳杆菌属和乳球菌属进行修饰，包括但是不局限于嗜酸乳杆菌、唾液乳杆菌、植物乳杆菌、瑞士乳杆菌、戴耳布吕克氏乳杆菌、鼠李糖乳杆菌、保加利亚乳杆菌、卷曲乳杆菌、加氏乳杆菌、干酪乳杆菌、罗伊氏乳杆菌、詹氏乳杆菌和乳酸乳球菌。嗜热生物链球菌和费氏丙酸杆菌(Propinibacterium freudenreichii)也属于适合于这里所描述的发明的细菌种类。同样作为本发明一部分的是菌株，进行这里所描述的修饰，来源于肠道球菌种类(例如，屎肠球菌和嗜热生物肠道球菌)、双歧杆菌属(例如，牛角椒双歧杆菌、婴儿双岐杆菌和两岐双岐杆菌)、芽孢乳杆菌属、Micromomospora spp.、小球菌属、红球菌属和假单胞菌属(例如，荧光假单胞菌和绿脓杆菌)。在乳糖存在的情况下培养具有这里所描述的特征的细菌，并且检查来自细菌本身或者来自细菌培养上清液中的岩藻糖基化的低聚糖。纯化岩藻糖基化的低聚糖用于治疗性或者营养性产物，或者细菌直接在这些产物中应用。合适的生产宿主细菌菌株是与来源细菌菌株不同的菌株，所述来源细菌菌株中可以识别出编码岩藻糖转移酶的核酸序列。

[0050] 从下面关于本发明优选的实施方案的表述中，以及从权利要求书中，本发明的其他特点和优势将变得显而易见。除非另有定义，这里使用的所有科技用语与本发明所属领域普通技术人员通常的理解具有相同的含义。虽然与这里描述的方法和材料相似的任何方法和材料都可以被用于实施或者检测本发明，但是下面描述的是适当的方法和材料。这里应用的所有公开的外国专利和专利申请在此通过引证全部并入本文。Genbank和NCBI指明的登记号码也通过引证在此全部并入本文。这里引用的其他出版的参考文献、文件、原稿和科学文献通过引证在此全部并入本文。如果出现矛盾，以本发明说明书包括定义为准。此

外，这里所述的材料、方法和实施例只起到说明作用，并不作为限制。

[0051] 附图简要说明

[0052] 图1是示意图，显示了在人类乳汁中发现的主要中性岩藻糖-低聚糖的合成途径。

[0053] 图2是一种示意图，显示了代谢途径和将其引入到大肠杆菌(E.coli)中工程2'-岩藻糖基乳糖(2'-FL)合成法中的变化。具体地说，所述乳糖合成途径和所述鸟苷二磷酸-岩藻糖合成途径被显示了。在所述鸟苷二磷酸-岩藻糖合成途径中：manA＝磷酸甘露糖异构酶(PMI)、manB＝磷酸甘露糖变位酶(PMM)、，manC＝甘露糖-1-磷酸鸟苷酰转移酶(鸟苷酸)、gmd＝鸟苷二磷酸-甘露糖-4,6-脱水酶、fcl＝鸟苷二磷酸-岩藻糖合酶(GFS)、和ΔwcaJ＝突变的尿苷二磷酸-葡萄糖脂质载体转移酶。

[0054] 图3A和图3B显示了4种之前已知的乳糖-利用性α(1,2)-岩藻糖转移酶蛋白质序列的序列同一性和多重序列校准。图3A是一种表，显示了4种已知的乳糖-利用性α(1,2)-岩藻糖转移酶之间的序列一致性：螺杆菌幽门futC(SEQ ID NO:1)、H.mustelae FutL(SEQ ID NO:2)、普通拟杆菌futN(SEQ ID NO:3)和大肠杆菌0126wbgL SEQ ID NO:4)。图3B显示了4种已知的乳糖-利用性α(1,2)-岩藻糖转移酶之间的多重序列校准在四种酶的校准之间，卵型突出区域显示了尤其高的序列保守性。.

[0055] 图4显示了12个确定的α(1,2)-岩藻糖转移酶变种的序列校准，通过之前已知的乳糖-利用性α(1,2)-岩藻糖转移酶蛋白质序列所确定的。4种已知的乳糖-利用性α(1,2)-岩藻糖转移酶被框起来并且包括：螺杆菌幽门futC(SEQ ID NO:1)、H.mustelae FutL(SEQ ID NO:2)、普通拟杆菌futN(SEQ ID NO:3)和大肠杆菌0126wbgL SEQ ID NO:4)。12种确定的α(1,2)-岩藻糖转移酶如下：产黑素普雷沃菌Fut0(SEQ ID NO:10)、梭状芽孢杆菌(Clostridium bolteae)+13FutP(SEQ ID NO:292)、毛螺菌科FutQ(SEQ ID NO:12)、甲烷微菌属(Methanosphaerula palustris)FutR(SEQ ID NO:13)、坦纳菌属(tannerella sp.)FutS(SEQ ID NO:14)、粪拟杆菌FutU(SEQ ID NO:15)、丁酸弧菌属FutV(SEQ ID NO:16)、普雷沃菌属FutW(SEQ ID NO:17)、乔治普氏菌(parabacteroides johnsonii)FutX(SEQ ID NO:18)、肠道疣微菌(Akkermansia muciniphilia)FutY(SEQ ID NO:19)、肠道沙门氏菌FutZ(SEQ ID NO:20)、拟杆菌FutZA(SEQ ID NO:21)。适合于梭状芽孢杆菌(Clostridium bolteae)FutP的序列(在N-末端不含有13个额外的氨基酸)(SEQ ID NO:11)也显示在校准中。

[0056] 图5A和图5B是两幅凝胶照片，显示了12种新型α(1,2)-岩藻糖转移酶中每种变种的结构。图5A显示了后-吉布森组装PCR。图5B显示了凝胶纯化的RI/Xho1变体片段。

[0057] 图6A和图6B是两张显示岩藻糖基化的低聚糖产物薄层色谱的照片，所述岩藻糖基化的低聚糖产物是在大肠杆菌培养物中使用α(1,2)-岩藻糖转移酶变种制备的。图6A显示了来自2毫升培养上清液中的岩藻糖基化的低聚糖产物。图6B显示了来自0.20D_{600}细胞当量的全细胞加热提取物的岩藻糖基化低聚糖产物。

[0058] 图7是一张图表显示了宿主细菌生长曲线，所述宿主细菌表达包含α(1,2)-岩藻糖转移酶基因WbgL、FutN、Fut0、FutQ、和FutX的质粒，该表达发生在乳糖存在的情况下将色氨酸引入培养基中之后(即，lac+trp)。

[0059] 图8是一张SDS-PAGE凝胶照片显示了宿主细菌产生的蛋白质，所述宿主细菌在引入后表达包含α(1,2)-岩藻糖转移酶基因WbgL、FutN、Fut0、FutQ、和FutX的质粒。

[0060] 图9A和图9B是两张薄层色谱照片，显示了引入后7小时或者24小时之后，在表达选择性α(1,2)-岩藻糖转移酶变种WbgL、FutN、FutO、FutQ和FutX的大肠杆菌培养物中产生的岩藻糖基化低聚糖产物。图9A显示了来自2毫升培养上清液中的岩藻糖基化的低聚糖产物。图9B显示了来自0.2OD600细胞当量的全细胞加热提取物的岩藻糖基化低聚糖产物。

[0061] 图10A和图10B是两张薄层色谱的照片，显示了在表达FutN的大肠杆菌进行两个不同的1.5L发酵轮之后的岩藻糖基化低聚糖产物:图10A)36B和图10B)37A。36B的培养产率是33克/升而37A的产率是36.3克/升。

[0062] 图11是携带普通拟杆菌FutN基因的pG217质粒测绘图。

[0063] 图12是示意图显示了LacIq启动子、功能性lacY基因的插入和lacA的删除。

[0064] 图13是示意图，显示了使用FRT重组删除内源性wcaJ基因。

[0065] 图14是大肠杆菌W3110染色体的示意图，显示了插入携带卡那霉素抗性基因的DNA片段(来源于转座子Tn5)和野生型LacZ插入lon基因。

具体实施方式

[0066] 虽然一些研究证明人类乳汁聚糖可以用作抗菌剂防粘剂，但是产生足够量的这种质量适合于人体使用的试剂困难重重并且造价昂贵，这限制了其大规模实验并本公众认可。需要一种适当的方法以合理的成本产生足够量的合适的聚糖。在这里所描述的发明之前，已经进行了一些努力使用明显不同的合成方法进行聚糖合成。一些化学途径可以合成低聚糖(Flowers,H.M.Methods Enzymol 50,93-121(1978);Seeberger,P.H.Chem Commun(Camb)1115-1121(2003))，但是进行这些反应的反应物十分昂贵并且可能有毒(Koeller,K.M.&Wong,C.H.Chem Rev 100,4465-4494(2000))。工程有机体表达的酶(Albermann,C.,Piepersberg,W.&Wehmeier,U.F.Carbohydr Res 334,97-103(2001);Bettler,E.,Samain,E.,Chazalet,V.,Bosso,C.,et al.Glycoconj J 16,205-212(1999);Johnson,K.F.Glycoconj J 16,141-146(1999);Palcic,M.M.Curr Opin Biotechnol 10,616-624(1999);Wymer,N.&Toone,E.J.Curr Opin Chem Biol 4,110-119(2000))提供了一种精确并有效的合成方法(Palcic,M.M.Curr Opin Biotechnol 10,616-624(1999));Crout,D.H.&Vic,G.Curr Opin Chem Biol 2,98-111(1998))，但是反应物的高成本，尤其是糖核苷酸的高成本限制其低价的大规模公共生产。对微生物进行遗传工程设计表达糖基转移酶，所述糖基转移酶是从细菌先天核苷酸糖文库中合成低聚糖多必须的(Endo,T.,Koizumi,S.,Tabata,K.,Kakita,S.&Ozaki,A.Carbohydr Res330,439-443(2001);Endo,T.,Koizumi,S.,Tabata,K.&Ozaki,A.Appl Microbiol Biotechnol 53,257-261(2000);Endo,T.&Koizumi,S.Curr Opin StructBiol 10,536-541(2000);Endo,T.,Koizumi,S.,Tabata,K.,Kakita,S.&Ozaki,A.Carbohydr Res 316,179-183(1999);Koizumi,S.,Endo,T.,Tabata,K.&Ozaki,A.Nat Biotechnol 16,847-850(1998))。然而，这里所描述的发明之前，有持续增长的需要来确定并定性额外的糖基转移酶，所述额外的糖基转移酶可以有效用于在代谢工程细菌宿主中合成HMOS。

[0067] 人类乳汁聚糖

[0068] 人类乳汁包含各种各样种类丰富的中性和酸性低聚糖(Kunz,C.,Rudloff,S.,Baier,W.,Klein,N.,and Strobel,S.(2000).Annu Rev Nutr 20,699-722;Bode,L.

(2006).J Nutr 136,2127-130)。已经在人类乳汁重识别出超过130种不同的复合物低聚糖,并且他们的结构多样性和丰富程度是人类所特有的。虽然这些分子可能不能直接被婴幼儿用作营养,但是他们仍然在建立健康的内脏微生态环境中起到至关重要的作用(Marcobal,A.,Barboza,M.,Froehlich,J.W.,Block,D.E.,et al.J Agric Food Chem 58,5334-5340(2010)),在预防疾病中起到至关重要的作用(Newburg,D.S.,Ruiz-Palacios,G.M.&Morrow,A.L.Annu Rev Nutr 25,37-58(2005))并且在建立免疫功能时起到至关重要的作用(Newburg,D.S.&Walker,W.A.Pediatr Res 61,2-8(2007))。尽管几百万年来与人类乳汁低聚糖(HMOS)的接触使病原体已经具有更多的方法来阻遏HMOS预防靶细胞吸附和抑制感染的能力。但利用HMOS作为病原体粘附抑制剂还是可以解决目前迅速发展的抗菌素耐药性危机。通过生物合成产生的人类乳汁低聚糖代表解决社会最棘手问题的一类新型治疗剂的先导化合物。

[0069] 用于有效的、工业规模合成HMOS的一个选择性策略是细菌的代谢工程设计。该方法包括构建能够过表达异源糖基转移酶的微生物菌株,将前体糖通过膜运输引入细菌细胞液中,并具有增加的再生核苷酸糖库用于生物合成前体(Dumon,C.,Samain,E.,and Priem,B.(2004).Biotechnol Prog20,412-19;Ruffing,A.,and Chen,R.R.(2006).Microb Cell Fact 5,25)。这一方法的关键方面是选择在微生物宿主中过表达的异源糖基转移酶。糖基转移酶的选择可以显著的影响所需合成的低聚糖的最终产量,已知根据动力学、底物特异性、对供体和受体分子亲合性、稳定性和溶解性不同,酶可以发生很大变化。一些来源于不同细菌种类的糖基转移酶已经被确定并根据其催化HMOS在大肠杆菌宿主菌株中生物合成的能力来定性(Dumon,C.,Bosso,C.,Utille,J.P.,Heyraud,A.,and Samain,E.(2006).Chembiochem 7,359-365;Dumon,C.,Samain,E.,and Priem,B.(2004).Biotechnol Prog 20,412-19;Li,M.,Liu,X.W.,Shao,J.,Shen,J.,Jia,Q.,Yi,W.,Song,J.K.,Woodward,R.,Chow,C.S.,and Wang,P.G.(2008).Biochemistry 47,378-387)。识别其他具有更快动力学、更好核苷酸糖供体和/或受体分子亲合性、或者更好细菌宿主内稳定性的糖基转移酶可以显著的改善治疗有效性HMOS的产率。在这里所描述的发明之前,化学合成HMOS是可能的,但是由于立体结构-特异性问题、前体有效性、产物纯度和高成本的问题受到一定局限(Flowers,H.M.Methods Enzymol 50,93-121(1978);Seeberger,P.H.Chem Commun(Camb)1115-1121(2003);Koeller,K.M.&Wong,C.H.Chem Rev 100,4465-4494(2000))。本发明克服了上述所有缺点,通过提供新的策略来经济的制造大量的人类乳汁低聚糖(HMOS),用于食物增补剂。优势包括有效的表达酶、岩藻糖基化低聚糖产物(2'-岩藻糖基乳糖(2'-FL)、乳糖二岩藻四糖(LDFT)、乳-N-岩藻五糖I(LNF I),和乳-N-二岩藻六糖I(LDFH I))改善的稳定性和/或溶解性和对宿主有机体减少的毒性。本发明特点在于新型的α(1,2)-岩藻糖转移酶,适合在生产菌株中表达,与目前在本领域中使用的α(1,2)-岩藻糖转移酶相比,本发明菌株具有增加的效率和岩藻糖基化人类乳汁低聚糖(HMOS)产率。

[0070] 如下面所详细描述的,大肠杆菌(或者其他细菌)被设计成产生商业上可行水平的选择的岩藻糖基化低聚糖(即,2'-岩藻糖基乳糖(2'-FL)、乳糖二岩藻四糖(LDFT)、LDHF I或者乳-N-岩藻五糖I(LNF I))。例如,在细菌发酵过程中产量>5克/升。在其他实施方案中,所述岩藻糖基化低聚糖产物,比如2′-岩藻糖基乳糖(2′-FL),乳糖二岩藻四糖(LDFT),LDHF I,和乳-N-岩藻五糖I(LNF I)的产率大于10克/升,大于15克/升,大于20克/升,大于25克/

升，大于30克/升，大于35克/升，大于40克/升，大于45克/升，大于50克/升，大于55克/升，大于60克/升，大于65克/升，大于70克/升，或者大于75克/升。

[0071] 人类乳汁聚糖在传染性疾病中的作用

[0072] 人类乳汁聚糖包括未结合的低聚糖及其糖基结合物，在保护并发展幼儿胃肠道(GI)区域方面发挥重要作用。中性的岩藻糖基化低聚糖包括2'-岩藻糖基乳糖(2'-FL)，能够保护幼儿不感染一些重要的病原体。在各种哺乳动物中发现的乳汁低聚糖区别很大，并且人类乳汁中的组合物是独特的(Hamosh M.,2001Pediatr Clin North Am,48:69-86;Newburg D.S.,2001 Adv Exp Med Biol,501:3-10)。而且，人类乳汁中聚糖水平在哺乳过程中是变化的，并且在个体之间也有很大区别(Morrow A.L.et al.,2004JPediatr,145:297-303;Chaturvedi P et al.,2001Glycobiology,11:365-372)。已经识别出大约200种不同的人类乳汁低聚糖，并且简单的抗原决定簇的组合引起这些多样性(Newburg D.S.,1999Curr_Med Chem,6:117-127;Ninonuevo M.et al.,2006J Agric Food Chem,54:7471-74801)。

[0073] 人类乳汁低聚糖由5种单糖组成：右旋葡萄糖(Glc)、D-半乳糖(Gal)、N-乙酰氨基葡萄糖(GlcNAc)、L-岩藻糖(Fuc)和唾液酸(N-乙酰基神经氨酸，Neu5Ac，NANA)。人类乳汁低聚糖通常根据其化学结构被分成两个组：中性化合物，包含与乳糖(Galβ 1-4Glc)核心相连的右旋葡萄糖(Glc)、D-半乳糖(Gal)、N-乙酰氨基葡萄糖(GlcNAc)和L-岩藻糖(Fuc)；和酸性化合物，包括相同的糖和通常相同的核心结构，加NANA(Charlwood J.et al.,1999Anal_Biochem,273:261-277;Martín-Sosa et al.,2003J Dairy Sci,86:52-59;Parkkinen J.and Finne J.,1987Methods Enzymol,138:289-300;Shen Z.et al.,2001J Chromatogr A,921:315-321)。

[0074] 大约70-80％的人类乳汁中的低聚糖是岩藻糖基化的，并且其合成途径被认为是按照图1所示的方式进行。较小比例的低聚糖是唾液酸化的或者既是岩藻糖基化又是唾液酸化的，但是其合成途径并不是完全定义的。对酸性(唾液酸化的)低聚糖的了解部分的受到测量这些化合物的方法的限制。用分析中性和酸性低聚糖的敏感的、可再生的方法已经被设计。人类乳汁低聚糖是可以通过幼儿肠道的低聚糖，非常有效，不易消化(Chaturvedi，P.,Warren,C.D.,Buescher,C.R.,Pickering,L.K.&Newburg,D.S.Adv Exp Med Biol 501，315-323(2001))。

[0075] 人类乳汁聚糖抑制肠道病原体与其受体结合

[0076] 人类乳汁聚糖与肠道病原体细胞受体具有结构同源性因此可以起到假目标受体的作用。例如，病原菌株弯曲杆菌属特异性结合包含H-2的聚糖，即，2′-岩藻糖-N-乙酰氨基乳糖或者2′-岩藻糖基乳糖(2′FL)；2′-FL及其他包含H-2抗原决定簇的聚糖抑制弯曲杆菌属的结合性和传染性。同样，包含2-连接的岩藻糖部分的人类乳汁低聚糖可以在体内有力的抑制一些致泻性大肠杆菌病原体。一些主要的人嵌杯样病毒，特别是诺如病毒也与2-连接的岩藻糖基化聚糖结合，并且该结合可以被人类乳汁2-连接的岩藻糖基化聚糖所抑制。在墨西哥一群以母乳喂养的孩子中，具有高水平2-连接的岩藻糖低聚糖的人类乳汁的消耗与降低的诺如病毒、弯曲杆菌属细菌、大肠杆菌-相关腹泻ST和所有原因造成的中度-到-重度腹泻的风险有关(Newburg D.S.et al.,2004Glycobiology,14:253-263;Newburg D.S.et al.,1998Lancet,351:1160-1164)。一些病原体使用唾液酸化的聚糖作为其宿主受

体,例如流行性感冒(Couceiro,J.N.,Paulson,J.C.&Baum,L.G.Virus Res 29,155-165(1993))、副流感(Amonsen,M.,Smith,D.F.,Cummings,R.D.&Air,G.M.J Virol 81,8341-8345(2007),和轮状病毒(Kuhlenschmidt,T.B.,Hanafin,W.P.,Gelberg,H.B.&Kuhlenschmidt,M.S.Adv Exp Med Biol 473,309-317(1999))。所述sialyl-Lewis X抗原决定簇被幽门螺杆菌(Mahdavi,J.,Sondén,B.,Hurtig,M.,Olfat,F.O.,et al.Science 297,573-578(2002))、绿脓杆菌(Scharfman,A.,Delmotte,P.,Beau,J.,Lamblin,G.,et al.Glycoconj J17,735-740(2000))、和一些诺如病毒菌株(Rydell,G.E.,Nilsson,J.,Rodriguez-Diaz,J.,Ruvoën-Clouet,N.,et al.Glycobiology 19,309-320(2009))所使用。

[0077] 新型α(1,2)岩藻糖转移酶的识别

[0078] 本发明提供了一种新型α(1,2)-岩藻糖转移酶。本发明还提供了一种核酸构建物(即,一种质粒或者载体),其携带新型α(1,2)-岩藻糖转移酶的核酸序列,用于在宿主细菌中表达所述新型α(1,2)-岩藻糖转移酶。本发明还提供了用于产生岩藻糖基化的低聚糖的方法,这里所描述的,通过在适当的宿主生产细菌中表达新型α(1,2)-岩藻糖转移酶产生岩藻糖基化低聚糖。

[0079] 不是所有的α(1,2)岩藻糖转移酶都可以利用乳糖作为受体底物。受体底物包括,例如,碳水化合物、低聚糖、蛋白质或者糖基蛋白质、脂质或者糖脂,例如,N-乙酰氨基葡萄糖、N-乙酰氨基乳糖、半乳糖、岩藻糖、唾液酸、葡萄糖、乳糖、或者其任何结合。本发明优选的α(1,2)岩藻糖转移酶利用鸟苷二磷酸-岩藻糖作为供体,乳糖是所述供体的受体。

[0080] 之前已经进行了一种用于确定新型α(1,2)岩藻糖转移酶的方法(如PCT/US2013/051777中所述,通过引证在此全部并入本文),所述新型α(1,2)岩藻糖转移酶能够利用乳糖作为受体,并且所述方法使用以下步骤:1)进行计算性检索序列数据库从而定义宽范围的任意已知的、乳糖-利用性α(1,2)岩藻糖转移酶的单一序列同族体;2)使用来自步骤(1)的目录,衍生已知检索曲线,该检索曲线包含公共序列和/或目录所列成员均包含的结构基序,例如通过使用计算机程序,例如MEME(基序启发的多EM,在http://meme.sdsc.edu/meme/cgi-bin/meme.cgi处获得)或者PSI-BLAST(位点特异迭代BLAST,可以从ncbi.nlm.nih.gov/blast处获得,从cnx.org/content/m11040/latest/处获得额外的信息);3)检索序列数据库(例如,使用计算机程序,例如PSI-BLAST或者MAST(基序校准检索工具,可以从http://meme.sdsc.edu/meme/cgi-bin/mast.cgi处获得)),使用这里衍生的检索曲线进行查询,确定“候选序列”,其中,所述候选序列与原始乳糖-利用性α(1,2)岩藻糖转移酶的简单序列同源性是40%或更小;4)筛选科技文献并扩大“候选有机体”列表,所述有机体的特点在于已知能够表达α(1,2)岩藻糖-聚糖;5)只筛选这些来源于“候选有机体”的“候选序列”,产生“候选乳糖-利用性酶”列表;和6)表达“候选乳糖-利用性酶”并检验乳糖-利用性α(1,2)岩藻糖转移酶活性。

[0081] 序列分析工具的MEME程序组(meme.sdsc.edu/meme/cgi-bin/meme.cgi)可以用作PSI-BLAST的替代。使用程序“MEME”发现序列基序。因此这些基序能够通过使用程序“MAST”来检索序列数据库。BLAST和PSI-BLAST检索算法是其他已知的替换方法。

[0082] 为了识别其他新型的α(1,2)岩藻糖转移酶,使用是指预先确定的乳糖-利用性α(1,2)岩藻糖转移酶蛋白质序列产生多重序列校准查询:螺杆菌幽门futC(SEQ ID NO:1)、

H.mustelae FutL(SEQ ID NO:2)、普通拟杆菌futN(SEQ ID NO:3)和大肠杆菌O126wbgL SEQ ID NO:4)。这些序列校准和序列一致性百分比显示在图3中。进行迭代的PSI-BLAST,使用FASTA-型多重序列对准进行查询,并且在NCBI BLAST+版本2.2.29的本地拷贝上运行NCBI PSI-BLAST程序。起始位置-PSI-BLAST产生特异性划线基质文件(.pssm),然后使用该程序调整迭代同源性检索运行数值。重复这一过程产生更大组的候选物,并且每次运行的结果用于进一步改善所述基质。

[0083] 这种PSI-BLAST检索产生最初2515个采样数。其中787个采样数与FutC具有大于22%的序列一致性。396个采样数的氨基酸长度大于275。对采样进行补充分析,包括根据对FutC的一致性百分比分类,用BLAST将序列与现存的α(1,2)-岩藻糖转移酶库存量(已知的α(1,2)-岩藻糖转移酶),并手动注释采样序列,确定来源于细菌的、天然存在于胃肠道的序列。通过这种筛选识别出的新型α(1,2)岩藻糖转移酶的注释列表显示在表1中。表1提供了发现候选酶的细菌种类、GenBank登记号码、GI标识号码、氨基酸序列和与FutC的序列同一性%。

[0084] 在识别的采样中,12种新型α(1,2)-岩藻糖转移酶被进一步分析其功能性生产力:产黑素普雷沃菌FutO、梭状芽孢杆菌(Clostridium bolteae)+13FutP、毛螺菌科FutQ、甲烷微菌属(Methanosphaerula palustris)FutR、坦纳菌属(tannerella sp.)FutS、粪拟杆菌FutU、丁酸弧菌属FutV、普雷沃菌属FutW、乔治普氏菌(parabacteroides johnsonii)FutX、肠道疣微菌(Akkermansia muciniphilia)FutY、肠道沙门氏菌FutZ、拟杆菌FutZA。对于梭状芽孢杆菌(Clostridium bolteae)FutP,注释代表错误引发甲硫氨酸密码子。因此,本发明包括在注释FutP的N-末端具有额外13个氨基酸的FutP(衍生自天然上游DNA序列的非框架设计),在这里命名为梭状芽孢杆菌(Clostridium bolteae)+13FutP。下面表2显示了12种被识别的新型α(1,2)-岩藻糖转移酶和4种预先识别的α(1,2)-岩藻糖转移酶之间的序列一致性。

[0085] 表2.序列一致性

[0086]

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
螺杆菌幽门 futC	1		70.10	21.99	20.82	27.68	27.36	23.56	23.28	23.62	25.75	23.72	24.05	22.29	24.19	22.92	22.29
H.mustelae futL	2	70.10		23.87	19.88	26.38	28.21	24.30	23.38	24.62	25.31	25.31	24.47	23.56	25.15	23.55	23.26
普通拟杆菌 futN	3	21.99	23.87		25.16	32.05	28.71	28.94	25.79	37.46	32.27	26.11	61.27	71.63	27.67	25.15	84.75
大肠杆菌 O126 wbgL	4	20.82	19.88	25.16		24.25	22.73	22.32	26.04	25.45	24.77	21.49	23.29	26.71	24.63	21.45	25.16
产黑素普雷沃菌 FutO YP_003814512.1	5	27.68	26.38	32.05	24.25		36.96	31.63	35.74	35.16	55.74	30.28	30.03	32.80	30.09	26.28	31.83
梭状芽孢杆菌+13 FutP WP_002570768.1	6	27.36	28.21	28.71	22.73	36.96		37.87	35.10	33.77	36.91	35.74	29.58	31.39	27.67	26.33	29.13
毛螺菌科. FutQ WP_009251343.1	7	23.56	24.30	28.94	22.32	31.63	37.87		29.87	29.17	32.90	51.02	28.53	30.00	27.69	24.00	27.74
甲烷微菌属 FutR YP_002467213.1	8	23.28	23.38	25.79	26.04	35.74	35.10	29.87		28.71	38.24	31.41	25.39	28.08	30.65	23.93	25.55
坦纳菌属. FutS WP_021929367.1	9	23.62	24.62	37.46	25.45	35.16	33.77	29.17	28.71		34.41	30.03	35.71	36.27	26.48	21.75	36.60
粪拟杆菌 FutU WP_005675707.1	10	25.75	25.31	32.27	24.77	55.74	36.91	32.90	38.24	34.41		31.21	29.94	33.33	29.28	24.46	33.01
丁酸弧菌属 FutV WP_022772718.1	11	23.72	25.31	26.11	21.49	30.28	35.74	51.02	31.41	30.03	31.21		27.62	26.20	26.46	22.15	26.52
普雷沃菌属 FutW WP_022481266.1	12	24.05	24.47	61.27	23.29	30.03	29.58	28.53	25.39	35.71	29.94	27.62		57.60	25.79	22.15	59.01
乔治普氏菌 FutX WP_008155883.1	13	22.29	23.56	71.63	26.71	32.80	31.39	30.00	28.08	36.27	33.33	26.20	57.60		28.71	24.00	74.02
肠道疣微菌 FutY YP_001877555	14	24.19	25.15	27.67	24.63	30.09	27.67	27.69	30.65	26.48	29.28	26.46	25.79	28.71		21.45	28.08
肠道沙门氏菌 FutZ WP_023214330	15	22.92	23.55	25.15	21.45	26.28	26.33	24.00	23.93	21.75	24.46	22.15	22.15	24.00	21.45		24.62
拟杆菌 FutZA WP_022161880.1	16	22.29	23.26	84.75	25.16	31.83	29.13	27.74	25.55	36.60	33.01	26.52	59.01	74.02	28.08	24.62	

[0087] 根据α(1,2)岩藻糖转移酶的氨基酸序列(即,在表1中),本领域普通技术人员使用本领域已知的标准方法可以容易的设计变种并构建变种。例如,所述变种包括核蛋白体的结合位点,并且进行了密码子优化从而在宿主细菌生产菌株(即,大肠杆菌)中表达,并具有常见的6-齿限制酶切位点或者存在于所述宿主菌株中的内源性限制酶识别的位点(即,EcoK限制酶切位点),移除从而使大肠杆菌宿主菌株中的克隆和表达变简单。在一种优选的实施方案中,所述变种用下列结构构建:EcoRI位点-T7g10RBS-α(1,2)FT变种-XhoI位点。表3显示了12种α(1,2)岩藻糖转移酶的样品变种的核酸序列(起始甲硫氨酸ATG密码子是粗字

体)。

[0088] 表3．12种新型α(1,2)-岩藻糖转移酶变种的核酸序列

细菌/基因名称	序列	SEQ ID NO:
FutO	CAGTCAGTCAGAATTCAAGAAGGAGATATACATATGAAAATCGTCAAAATCC TGGGCGGTCTGGGCAATCAGATGTTCCAGTATGCTCTGTACCTGAGCCTGCAA GAAAGTTTTCCAAAAGAACGTGTGGCCCTGGACCTGTCCTCCTTCCACGGCTA TCACCTGCATAATGGCTTTGAGCTGGAGAACATTTTCTCCGTTACCGCTCAGA AAGCATCCGCCGCAGATATCATGCGTATTGCTTATTACTACCCGAACTATCTG CTGTGGCGCATTGGCAAACGTTTTCTGCCGCGTCGTAAAGGTATGTGCCTGGA ATCTAGCTCCCTGCGTTTCGATGAAAGCGTTCTGCGTCAGGAAGGTAACCGTT ATTTTGACGGTTACTGGCAAGACGAACGCTACTTCGCAGCCTATCGTGAAAA AGTGCTGAAGGCTTTCACCTTTCCTGCATTCAAACGCGCAGAAAACCTGAGCC TGCTGGAAAAACTGGACGAAAACAGCATTGCTCTGCATGTTCGTCGCGGTGA TTACGTAGGTAATAACCTGTACCAAGGCATCTGTGACCTGGACTACTACCGTA CCGCTATCGAGAAAATGTGTGCACACGTTACTCCGTCTCTGTTTTGTATCTTTT CCAACGACATCACGTGGTGCCAGCAGCACCTGCAACCGTACCTGAAGGCCCC TGTGGTGTACGTTACTTGGAACACCGGTGTTGAATCCTACCGCGATATGCAGC TGATGTCCTGCTGCGCACATAACATCATCGCGAATAGCTCCTTCTCTTGGTGG GGTGCTTGGCTGAATCAGAACCGTGAAAAAGTTGTTATCGCCCCGAAAAAAT GGCTGAACATGGAAGAATGTCACTTCACGCTGCCGGCAAGCTGGATCAAAAT TTAGCTCGAGTGACTGACTG	276
FutP	CAGTCAGTCAGAATTCAAGAAGGAGATATACATATGGTGATTATCAAAATGA TGGGTGGTCTGGGCAACCAGATGTTCCAGTACGCACTGTACAAAGCATTCGA GCAGAAGCACATCGATGTGTATGCAGACCTGGCATGGTACAAAAACAAATCC GTGAAATTTGAACTGTACAACTTCGGCATTAAAATCAACGTAGCATCCGAGA AAGACATCAACCGTCTGAGCGATTGCCAGGCGGACTTTGTTTCCCGCATCCGC CGTAAAATCTTTGGTAAAAAAAAGAGCTTCGTATCTGAAAAAAATGACTCCT GCTATGAAAACGACATCCTGCGTATGGACAACGTTTATCTGAGCGGTTATTGG CAGACCGAAAAATACTTCTCTAACACGCGTGAGAAGCTGCTGGAGGATTATT CCTTCGCTCTGGTAAACTCTCAGGTGTCCGAATGGGAAGACTCCATTCGCAAC AAAAACAGCGTTAGCATCCATATCCGTCGTGGTGATTATCTACAGGGCGAAC TGTATGGTGGTATTTGCACCTCTCTGTACTACGCCGAAGCAATCGAGTACATT AAAATGCGTGTTCCGAACGCAAAATTCTTCGTTTTCTCTGATGACGTTGAATG GGTTAAACAGCAAGAAGACTTCAAAGGCTTCGTAATCGTTGATCGCAACGAG TATTCTAGCGCTCTGTCCGATATGTACCTGATGTCCCTGTGCAAGCATAACAT TATTGCTAACTCCTCTTTCAGCTGGTGGGCAGCTTGGCTGAACCGTAACGAAG AAAAAATTGTAATCGCGCCGCGCCGTTGGCTGAACGGCAAGTGCACCCCAGA TATCTGGTGTAAAAAATGGATTCGTATCTAGCTCGAGTGACTGACTG	277
FutQ	CAGTCAGTCAGAATTCAAGAAGGAGATATACATATGGTGATCGTACAGCTGA GCGGCGGTCTGGGCAACCAGATGTTCGAATACGCGCTGTACCTGAGCCTGAA AGCAAAAGGCAAAGAAGTGAAAATTGACGATGTTACGTGTTACGAGGGCCCT GGCACCCGTCCGCGTCAACTGGATGTTTTTGGTATCACGTACGATCGCGCGTC TCGTGAGGAGCTGACTGAGATGACGGACGCGAGCATGGATGCGCTGTCTCGT GTTCGTCGCAAACTGACCGGTCGCCGCACTAAAGCGTACCGCGAACGCGACA TCAACTTCGATCCACTGGTTATGGAAAAAGACCCGGCACTGCTGGAAGGCTG TTTCCAGTCTGACAAATACTTTCGTGATTGCGAAGGCCGCGTGCGCGAAGCGT ATCGTTTCCGCGGCATTGAATCCGGCGCGTTCCCGCTGCCGGAAGACTATCTG CGCCTGGAAAAGCAGATCGAAGATTGTCAGTCCGTATCCGTACACATCCGTC GTGGCGACTACCTGGACGAATCTCATGGTGGTCTGTACACCGGCATTTGTACT GAGGCGTACTATAAAGAGGCTTTTGCTCGCATGGAACGTCTGGTTCCGGGCG CACGTTTCTTCCTGTTCTCTAACGATCCAGAATGGACTCGTGAGCACTTTGAG AGCAAGAACTGCGTTCTGGTTGAAGGTAGCACCGAAGACACGGGTTACATGG ACCTGTACCTGATGAGCCGCTGCCGCCACAATATTATTGCCAACTCTTCTTTC	278

[0089]

[0090]

	AGCTGGTGGGGCGCTTGGCTGAATGAGAACCCTGAGAAAAAAGTCATCGCAC CGGCTAAATGGCTGAACGGTCGTGAGTGCCGTGATATCTATACCGAACGCAT GATTCGTCTGTAGCTCGAGTGACTGACTG	
FutR	CAGTCAGTCAGAATTCAAGAAGGAGATATACATATGATCATTGTTCGTCTGA AAGGCGGTCTGGGCAACCAACTGTCTCAGTATGCACTGGGCCGTAAGATCGC GCATCTGCACAATACCGAACTGAAACTGGACACCACTTGGTTCACCACTATCT CCTCCGACACTCCACGTACCTACCGTCTGAACAATTATAACATCATCGGCACT ATTGCATCCGCAAAGGAAATCCAGCTGATCGAACGTGGTCGCGCGCAAGGCC GTGGCTACCTGCTGTCTAAAATTTCTGATCTGCTGACTCCGATGTACCGTCGT ACCTACGTCCGTGAACGTATGCATACCTTCGATAAAGCTATCCTGACCGTTCC GGACAACGTGTACCTGGATGGTTACTGGCAGACCGAAAAGTACTTCAAAGAC ATCGAAGAAATCCTGCGCCGTGAGGTTACGCTGAAAGATGAACCGGATAGCA TCAACCTGGAAATGGCTGAACGTATTCAGGCTTGCCACAGCGTTTCCCTGCAC GTGCGTCGTGGCGACTACGTTTCCAACCCGACCACTCAACAATTCCACGGCTG TTGCTCCATTGACTACTACAACCGCGCTATCTCTCTGATTGAAGAAAAAGTGG ATGACCCGTCTTTCTTTATTTTTTCTGACGATCTGCCGTGGGCTAAAGAAAACC TGGACATCCCTGGCGAAAAAACCTTCGTTGCGCATAACGGCCCGGAAAAAGA GTATTGCGATCTGTGGCTGATGTCTCTGTGCCAGCACCATATCATCGCAAACT CTTCTTTCAGCTGGTGGGGTGCCTGGCTGGGTCAAGACGCCGAAAAGATGGT GATCGCGCCGCGTCGCTGGGCCCTGTCCGAGAGCTTTGACACTTCTGACATCA TTCCGGACTCTTGGATTACTATCTAGCTCGAGTGACTGACTG	279
FutS	CAGTCAGTCAGAATTCAAGAAGGAGATATACATATGGTACGCATTGTGGAAA TCATCGGCGGTCTGGGTAACCAGATGTTCCAGTACGCATTCTCCCTGTACCTG AAAAACAAATCTCACATCTGGGACCGTCTGTATGTGGACATCGAGGCGATGA AAACCTACGATCGTCACTATGGTCTGGAACTGGAGAAAGTTTTCAATCTGAGC CTGTGTCCAATCTCTAACCGTCTGCACCGCAACCTGCAAAAACGCTCCTTCGC AAAACACTTTGTAAAGAGCCTGTACGAGCACTCTGAATGCGAGTTCGACGAA CCGGTGTACCGTGGCCTGCGTCCTTATCGCTATTATCGCGGCTACTGGCAAAA CGAAGGTTACTTCGTTGATATTGAACCGATGATCCGTGAGGCTTTTCAGTTCA ACGTTAACATCCTGAGCAAAAAGACTAAAGCGATCGCATCCAAAATGCGCCG TGAACTGTCCGTATCTATCCATGTTCGCCGTGGTGATTACGAAAACCTGCCGG AAGCGAAAGCGATGCATGGCGGTATTTGTTCTCTGGACTATTACCACAAAGC GATCGACTTCATCCGCCAGCGTCTGGATAATAACATCTGTTTCTATCTGTTCTC CGACGATATCAATTGGGTAGAAGAAAACCTGCAACTGGAAAACCGTTGCATC ATCGACTGGAACCAGGGCGAAGATAGCTGGCAGGACATGTACCTGATGAGCT GCTGCCGCCACCACATTATCGCAAACAGCTCTTTCTCCTGGTGGGCGGCATGG CTGAATCCAAACAAGAACAAAATCGTACTGACCCCGAACAAATGGTTCAACC ATACTGACGCAGTGGGTATCGTCCCAAAGTCCTGGATTAAAATTCCTGTGTTT TAGCTCGAGTGACTGACTG	280
FutU	CAGTCAGTCAGAATTCAAGAAGGAGATATACATATGAAAATCGTTAAAATCC TGGGCGGCCTGGGTAACCAGATGTTTCAGTACGCCCTGTTCCTGTCTCTGAAA GAACGCTTCCCGCATGAACAGGTGATGATTGACACCAGCTGCTTCCGCAATTA CCCACTGCACAACGGTTTCGAAGTGGATCGTATCTTCGCCCAGAAAGCACCG GTTGCCTCTTGGCGTAACATCCTGAAGGTTGCCTACCCGTACCCGAACTACCG TTTCTGGAAAATCGGTAAATACATCCTGCCTAAACGTAAAACCATGTGTGTAG AGCGTAAAAACTTCAGCTTTGACGCCGCAGTCCTGACCCGTAAAGGCGATTG CTACTATGATGGCTACTGGCAGCATGAGGAATATTTCTGTGATATGAAAGAA ACGATTTGGGAGGCTTTCTCCTTCCCTGAGCCGGTTGATGGTCGTAACAAGGA GATCGGTGCCCTGCTACAGGCATCTGATAGCGCTTCCCTGCACGTTCGTCGCG GTGACTACGTGAACCACCCACTGTTTCGTGGTATTTGTGACCTGGACTATTAT AAACGTGCCATCCACTACATGGAAGAACGCGTCAACCCACAGCTGTACTGCG TTTTCAGCAACGATATGGCCTGGTGCGAGTCCCACCTGCGTGCACTGCTGCCA GGCAAAGAAGTAGTTTATGTTGACTGGAACAAGGGTGCGGAATCTTACGTTG ATATGCGTCTGATGAGCCTGTGCCGTCACAACATCATCGCTAACTCTTCTTTC AGCTGGTGGGGCGCATGGCTGAACCGTAACCCGCAGAAAGTGGTGGTAGCGC CGGAACGTTGGATGAACAGCCCGATTGAAGACCCAGTGAGCGACAAATGGAT TAAACTGTAGCTCGAGTGACTGACTG	281

[0091]

FutV	CAGTCAGTCAGAATTCAAGAAGGAGATATACATATGATCATCATCCAGCTGA AAGGTGGCCTGGGCAACCAAATGTTCCAGTACGCGCTGTACAAATCCCTGAA AAAACGTGGTAAAGAAGTTAAAATTGATGACAAAACTGGCTTCGTGAACGAC AAACTGCGTATCCCGGTACTGTCCCGTTGGGGTGTTGAGTACGATCGTGCAAC CGACGAAGAGATTATTAACCTGACCGACTCCAAAATGGACCTGTTCTCTCGCA TCCGCCGTAAACTGACTGGCCGCAAAACGTTCCGTATCGACGAAGAATCCGG TAAATTCAACCCGGAAATCCTGGAAAAAGAGAACGCTTATCTGGTGGGTTAT TGGCAGTGCGACAAGTACTTCGACGACAAAGATGTGGTTCGCGAAATTCGTG AAGCGTTCGAGAAAAAACCGCAGGAGCTGATGACCGACGCCAGCTCTTGGTC TACTCTACAGCAGATTGAATGCTGCGAGTCCGTATCCCTGCACGTACGTCGTA CTGATTACGTGGACGAGGAACATATTCATATCCATAACATCTGTACGGAAAA ATACTATAAAAACGCCATTGATCGTGTGCGTAAACAGTACCCGAGCGCAGTG TTCTTCATCTTCACCGATGATAAAGAATGGTGCCGCGACCACTTTAAAGGTCC GAACTTCATCGTAGTCGAACTGGAAGAAGGCGACGGTACCGACATCGCTGAA ATGACTCTGATGTCCCGCTGTAAACATCACATCATCGCTAATTCTAGCTTTAG CTGGTGGGCGGCGTGGCTGAACGACTCCCCGGAAAAAATCGTGATCGCTCCT CAGAAATGGATTAACAACCGCGACATGGACGATATTTACACCGAGCGTATGA CTAAAATCGCACTGTAGCTCGAGTGACTGACTG	282
FutW	CAGTCAGTCAGAATTCAAGAAGGAGATATACATATGCGCCTGGTTAAAATGA TCGGCGGTCTGGGTAATCAGATGTTCATCTACGCGTTTTACCTACAGATGCGT AAGCGTTTCTCCAACGTTCGTATCGACCTGACCGATATGATGCACTACAACGT ACACTATGGCTACGAACTGCACAAAGTTTTCGGTCTGCCGCGCACCGAGTTCT GTATGAACCAGCCTCTGAAAAAGGTTCTGGAGTTCCTGTTCTTCCGTACCATT GTTGAACGTAAACAGCACGGTCGTATGGAGCCGTATACTTGCCAGTATGTTTG GCCGCTGGTTTACTTTAAGGGCTTCTATCAGTCCGAACGTTACTTCTCCGAAG TTAAGGACGAAGTTCGTGAGTGTTTCACCTTCAATCCGGCACTGGCGAATCGT TCTTCCCAACAGATGATGGAACAGATCCAGAATGATCCTCAGGCTGTCTCTAT CCACATCCGTCGTGGCGACTATCTGAATCCGAAGCACTACGACACTATCGGTT GTATCTGTCAGCTGCCGTATTACAAGCACGCCGTTTCCGAAATTAAAAAGTAC GTTTCTAACCCTCACTTTTACGTTTTCTCCGAAGACCTGGATTGGGTCAAAGC AAACCTGCCGCTGGAAAACGCACAGTACATCGATTGGAACAAAGGCGCAGAT AGCTGGCAGGATATGATGCTGATGAGCTGTTGCAAACACCACATTATCTGTA ACTCCACCTTTAGCTGGTGGGCGGCGTGGCTGAACCCATCTGTCGAAAAAACC GTGATCATGCCGGAACAGTGGACGTCTCGTCAAGATTCCGTGGACTTTGTGGC TAGCTGTGGCCGTTGGGTCCGTGTTAAAACGGAGTAGCTCGAGTGACTGACT G	283
FutX	CAGTCAGTCAGAATTCAAGAAGGAGATATACATATGCGTCTGATCAAGATGA TCGGCGGCCTGGGTAACCAGATGTTTATCTACGCGTTCTACCTGAAAATGAAA CACCATTACCCGGATACGAACATCGATCTGTCTGACATGGTTCATTATAAAGT TCACAACGGTTATGAGATGAACCGTATCTTTGACCTGAGCCAGACTGAATTTT GCATCAACCGTACCCTGAAAAAAATCCTGGAGTTCCTGTTCTTCAAAAAAATC TACGAACGTCGCCAGGACCCGTCTACTCTGTATCCATACGAAAAACGTTATTT TTGGCCGCTGCTGTACTTTAAAGGTTTCTACCAGTCTGAACGCTTCTTCTTCGA TATCAAAGACGACGTTCGTAAAGCCTTCTCTTTTAACCTGAACATCGCTAACC CGGAAAGCCTGGAACTGCTGAAACAGATCGAAGTTGACGACCAAGCTGTTTC TATCCACATCCGCCGTGGTGACTACCTGCTGCCGCGTCACTGGGCAAACACGG GTTCCGTGTGCCAGCTGCCGTATTACAAGAACGCGATCGCGGAAATGGAGAA CCGTATTACTGGCCCGAGCTACTACGTGTTCTCTGATGATATCTCTTGGGTTAA AGAAAACATCCCGCTGAAGAAAGCGGTCTACGTGACGTGGAACAAGGGCGA AGACAGCTGGCAGGATATGATGCTGATGAGCCACTGTCGTCACCACATTATCT GTAATTCTACGTTCTCCTGGTGGGGTGCTTGGCTGAACCCACGTAAAGAGAAA ATCGTCATCGCGCCGTGTCGCTGGTTCCAGCATAAAGAAACCCCGGACATGTA CCCGAAAGAATGGATCAAAGTACCGATTAACTAGCTCGAGTGACTGACTG	284
FutZ	CAGTCAGTCAGAATTCAAGAAGGAGATATACATATGTATTCTTGCCTGTCTGG TGGCCTGGGTAACCAAATGTTTCAATACGCAGCAGCGTATATCCTGAAGCAG TATTTTCAGTCTACCACTCTGGTCCTGGATGATAGCTATTACTATTCCCAGCCG AAACGTGATACCGTTCGTAGCCTGGAACTGAATCAGTTCAACATCTCTTATGA TCGTTTTAGCTTCGCGGATGAAAAAGAGAAGATCAAACTGCTGCGCAAATTC	285

[0092]

	AAACGTAACCCGTTCCCTAAACAGATTTCCGAGATCCTGTCTATTGCGCTGTT CGGCAAATACGCGCTGTCCGACCGTGCATTTTACACCTTCGAAACTATCAAAA ACATCGACAAAGCGTGCCTGTTCTCCTTTTACCAGGACGCCGATCTGCTGAAT AAATATAAGCAGCTGATCCTGCCGCTGTTCGAACTGCGCGATGACCTGCTGGA TATCTGCAAGAACCTGGAACTGTATTCCCTGATCCAACGCAGCAACAATACCA CTGCACTGCATATCCGCCGTGGCGACTACGTGACCAACCAGCACGCCGCGAA ATACCACGGCGTGCTGGACATCAGCTACTATAACCACGCAATGGAATACGTG GAACGTGAACGCGGCAAACAGAACTTCATTATCTTCAGCGATGATGTACGTT GGGCACAGAAAGCGTTTCTGGAGAACGATAATTGCTACGTGATTAACAACTC CGACTACGATTTCTCTGCGATCGATATGTATCTGATGTCTCTGTGCAAAAACA ACATCATCGCAAATTCCACCTACTCCTGGTGGGGTGCGTGGCTGAACAAATAC GAGGACAAACTGGTTATCTCTCCGAAACAATGGTTTCTGGGTAACAACGAAA CCTCTCTGCGTAACGCGTCTTGGATCACCCTGTAGCTCGAGTGACTGACTG	
FutZA	CAGTCAGTCAGAATTCAAGAAGGAGATATACATATGCGTCTGATCAAGATGA CCGGTGGCCTGGGTAACCAGATGTTCATCTACGCGTTTTATCTGCGTATGAAA AAACGTTATCCGAAAGTTCGTATTGATCTGTCTGATATGGTTCATTATCACGTT CACCACGGCTATGAAATGCACCGTGTTTTCAATCTGCCGCACACCGAATTTTG CATCAACCAGCCGCTGAAAAAAGTGATCGAGTTCCTGTTTTTCAAAAAGATTT ACGAACGTAAACAGGACCCTAATTCTCTGCGTGCATTCGAGAAGAAGTATCT GTGGCCGCTGCTGTACTTCAAAGGTTTCTATCAATCTGAGCGCTTCTTTGCTGA CATCAAAGACGAGGTTCGTAAAGCATTCACCTTTGACTCTTCTAAAGTGAACG CTCGCTCTGCCGAACTGCTGCGTCGCCTGGATGCCGATGCTAACGCGGTTAGC CTGCACATTCGTCGCGGTGACTATCTACAGCCGCAGCATTGGGCTACCACTGG TTCTGTCTGCCAGCTGCCGTACTACCAGAACGCGATCGCTGAAATGAACCGTC GCGTTGCTGCCCCGAGCTACTACGTTTTCAGCGATGACATCGCGTGGGTGAAG GAAAACATCCCTCTACAGAACGCAGTGTACATCGACTGGAATAAAGGCGAAG AAAGCTGGCAGGATATGATGCTGATGAGCCACTGCCGCCACCACATTATCTGT AACAGCACCTTCTCTTGGTGGGGCGCGTGGCTGGACCCGCACGAGGACAAAA TTGTAATCGTTCCGAATCGTTGGTTCCAGCATTGCGAAACTCCTAACATCTAT CCGGCAGGCTGGGTGAAAGTTGCGATTAATTAGCTCGAGTGACTGACTG	286

[0093] 在这里所描述的任意方法中，所述α(1,2)-岩藻糖转移酶基因或者基因产物可能是变体或者其功能性的片段。这里所公开的基因或者基因产物的变体与这里所描述的核酸或者氨基酸序列具有50％，55％，60％，65％，70％，75％，80％，85％，90％，95％，96％，97％，98％，或者99％的序列一致性。

[0094] 这里公开的变体还包括这里所描述的基因或者基因产物的同族体、直系同源物或者旁系同源物，与这里特指的基因或者基因产物维持相同的生物功能。这些变体可以与在这里描述的方法中使用的基因互换使用。这些变体说明同源性或者一致性百分比，比如50％，55％，60％，65％，70％，75％，80％，85％，90％，95％，96％，97％，98％，或者99％一致的保守区域对于生物功能是重要的，尤其是在功能性区域，例如，催化结构域。

[0095] 在涉及两个或者更多个核酸或者多肽序列的上下文中，术语“一致性％”指的是两个或者更多个序列或者子序列是相同的或者具有指定百分比的氨基酸残基或者核苷酸是相同的，当比较并排列进行最大一致性时，当使用下列序列比较运算或者目测检查的方法来测量时。例如，一致性％相对于序列编码区域的长度被比较或者具体片段或者其功能性区域的长度。

[0096] 对于序列对比，一般一个序列用作参考序列，针对此序列比较检测序列。当使用序列比较运算时，向电脑中输入检测序列和参考序列，必要时，指定子序列坐标，并且指定序列运算程序参数。然后，根据指定的程序参数，序列比较运算计算检测序列相对于参考序列的序列一致性百分比。

[0097] 使用检索运算(例如BLAST和PSI-BLAST)确定一致性百分比(Altschul et al.，1990，J Mol Biol 215:3,403-410;Altschul et al.,1997,Nucleic Acids Res 25:17,

3389-402).对于PSI-BLAST检索,使用下列示范性参数:(1)期望阈值是10;(2)Gap成本是Existence:11和Extension:1;(3)使用的基质是BLOSUM62;(4)对于低复杂性区域的过滤是“on”。

[0098] 通过突变可以向这里所描述的任意基因或者基因产物的核酸序列或者氨基酸序列中引入变化,导致编码蛋白质或者酶的氨基酸序列发生改变,但不改变所的蛋白质或者酶的功能性能力。例如,可以对这里公开的所有序列中的任意序列进行核苷酸取代作用,从而导致在“非必需”氨基酸残基处发生氨基酸取代作用。“非必需”氨基酸残基是在序列某一位置的残基,此位置的残基相对于多肽的野生型序列发生改变时不会改变多肽的生物活性,而“必需”的氨基酸残基是指维持生物活性所必须的位置处的残基。例如,在蛋白质家族成员之间保守的氨基酸残基不可能发生突变。然而其他氨基酸残基(例如,在蛋白质家族成员之间保守性较低的氨基酸残基)可能不是其活性必需的,因此可以发生变化。因此,本发明的另一方面有关于编码这里所公开的蛋白质或者酶,所述蛋白质或者酶与这里公开的氨基酸序列相比包含氨基酸残基的改变,但是被改变的氨基酸残基对维持其活性(即,岩藻糖转移酶活性)是非必需的。

[0099] 与这里所描述的任何基因相比,能够编码基本上维持功能性能力的蛋白质的分离的核酸分子可以通过引入一种或者一种以上核苷酸取代作用、填加或者删除相应的核苷酸序列来产生,从而向编码的蛋白质中引入一种或者一种以上氨基酸取代作用、填加或者删除。

[0100] 通过标准技术可以向核酸序列中引入突变,从而改变编码的氨基酸序列,所述突变例如定点诱变和PCR-调节的致突变作用。优选的,保守性氨基酸取代发生在一种或者一种以上预知的非必需氨基酸残基上。“保守性氨基酸取代作用”是将氨基酸残基替换为具有类似侧链的氨基酸残基。本领域中以及定义了具有相似侧链的氨基酸残基族。某些氨基酸具有侧链,含有一个以上可分类的特征。这些族包括具有碱性侧链的氨基酸(例如、赖氨酸、精氨酸、组氨酸)、具有酸性侧链的氨基酸(例如、天冬氨酸、谷氨酸)、带有不带电的极性侧链的氨基酸(例如、甘氨酸、天门冬酰胺、谷氨酰胺、丝氨酸、苏氨酸、酪氨酸、色氨酸、胞嘧啶)、具有非极性侧链的氨基酸(例如、丙氨酸、缬氨酸、白氨酸、异亮氨酸、脯氨酸、苯基丙氨酸、甲硫氨酸、酪氨酸、色氨酸)、具有β-侧链的氨基酸(例如、苏氨酸、缬氨酸、异亮氨酸)和具有芳香族侧链的氨基酸(例如、酪氨酸、苯基丙氨酸、色氨酸、组氨酸)。因此,在给定多肽上的预知的非必需氨基酸残基被来自相同侧链族的另一个氨基酸残基所取代。做为选择,在另一个实施方案中,在所有或者部分给定的编码序列中随机引入突变,例如,通过饱和致突变作用,则所得的突变株可以被筛选是否具有给定的多肽生物活性,从而确定维持活性的突变株。相反的,本发明还提供了具有能够提高或者增加内源性生物活性突变的变体。在所述核酸序列致突变作用之后,通过本领域已知的任意重组技术表达编码的蛋白质并测定所述蛋白质的活性。这里所公开的变体给定生物活性的增加、减少或者消除可以容易的被本发明所属领域普通技术人员,通过测定调节低聚糖修饰、合成或者降解作用能力来调节(通过检测产物)。

[0101] 本发明还提供了这里所描述的基因或者基因产物的功能性片段。对于这些序列来说,片段和在这里所提供的其他物质被定义为全部的一部分,小于全部。而且,片段的尺寸可以是多聚核苷酸或者多肽序列内单个核苷酸或者氨基酸到比全部多聚核苷酸或者多肽

序列较少的核苷酸或者氨基酸。最后，片段的定义是完整多聚核苷酸或者多肽序列的任意部分，即上面极端定义的中间部分。

[0102] 例如，这里所公开的蛋白质或者酶的片段或者被这里所公开的基因所编码的蛋白质或者酶的片段可以是10到20个氨基酸、10到30个氨基酸、10到40个氨基酸、10到50个氨基酸、10到60个氨基酸、10到70个氨基酸、10到80个氨基酸、10到90个氨基酸、10到100个氨基酸、50到100个氨基酸、75到125个氨基酸、100到150个氨基酸、150到200个氨基酸、200到250个氨基酸、250到300个氨基酸、300到350个氨基酸、350到400个氨基酸、400到450个氨基酸，或者450到500个氨基酸。本发明所包括的片段包括维持其功能性片段的片段。因而，所述片段优选的保持催化结构域，所述催化结构域对于功能活性是必须的或者是重要的。使用这里的序列信息可以产生或者确定片段，并且所述片段可以使用本领域已知的标准方法来检测器功能活性。例如，通过本领域已知的任意重组技术表达编码的蛋白质并测定所述蛋白质的活性。通过测量合成或者修饰底物低聚糖的能力来测定所述片段的生物功能，或者相反的，通过测量分解代谢低聚糖底物的能力来测量所述片段的生物功能。

[0103] 在本发明上下文中，如这里所使用的“功能等价物”指的是与野生型岩藻糖转移酶相比能够显示出基本上相似的活性的基因或者所得编码的蛋白质变体或其片段。具体地说，岩藻糖转移酶活性指的是能够将岩藻糖通过α-(1,2)-键传递到受体底物中。如这里所使用的，“基本上相似的活性”指的是其活性程度在野生型岩藻糖转移酶活性程度的5％、10％、20％、30％、40％或者50％以内。

[0104] 为了检测乳糖-利用性岩藻糖基转移酶活性，在表达候选酶(或变体)的宿主有机体中评价岩藻糖基化的低聚糖(即，2’-岩藻糖基乳糖(2’-FL))的产生，并且其包含细胞质的鸟苷二磷酸-岩藻糖和乳糖库。岩藻糖基化低聚糖的产生说明候选酶-编码序列起到了乳糖-利用性α(1,2)岩藻糖转移酶的作用。

[0105] 工程设计的大肠杆菌从而产生人类乳汁低聚糖2’-岩藻糖基乳糖(2’-FL)

[0106] 这里所描述的是基因筛选方法，所述方法用于确认新型的α(1,2)岩藻糖转移酶(α(1,2)FTs)，用于在代谢工程设计的大肠杆菌中合成岩藻糖-连接的低聚糖。尤其感兴趣的是能够合成人类乳汁低聚糖(HMOS)2’-岩藻糖基乳糖(2’-FL)的α(1,2)FTs。2’-岩藻糖基乳糖(2’-FL)是一种人类乳汁中最大量存在的岩藻糖基化低聚糖，并且这种低聚糖保护新生儿不受细菌性病原体例如空肠弯曲菌导致的传染性腹泻感染(Ruiz-Palacios,G.M.,et al.(2003).J Biol Chem 278,14112-120;Morrow,A.L.et al.(2004).J Pediatr 145,297-303;Newburg,D.S.et al.(2004).Glycobiology 14,253-263)。其他所关心的α(1,2)FTs是能够合成人类乳汁低聚糖(HMOS)乳糖二岩藻四糖(LDFT)、乳-N-岩藻五糖I(LNFI)或者乳-N-二岩藻六糖I(LDFH I)的FTs。

[0107] 人类乳汁中岩藻糖低聚糖的合成途径在图1中表示出来。在结构上讲，2’-岩藻糖基乳糖(2’-FL)由岩藻糖分子与乳糖的半乳糖部分通过α(1,2)键连接(Fucα1-2Galβ1-4Glc)。来自螺杆菌幽门菌株26695的α(1,2)FT也叫做FutC，已经被用于催化2’-岩藻糖基乳糖(2’-FL)在代谢工程性大肠杆菌中合成(Drouillard,S.et al.(2006).Angew Chem Int Ed Engl 45,1778-780)。

[0108] 使用标准分子生物技术将候选α(1,2)FT(即，变种)克隆进入表达质粒中。该质粒利用强有力的左侧启动子噬菌体λ(叫做PL)直接表达候选基因(Sanger,F.et al.(1982).J

Mol Biol 162,729-773)。所述启动子是可控制的,例如,trp-cI构建物被稳定的整合到大肠杆菌宿主基因组(在ampC位点)中,并且通过向生长培养基中加入色氨酸进行控制。使用对温度敏感的cI阻断剂逐步诱导完成蛋白质表达。已经描述了另一个类似控制策略(与温度无关的表达系统)(Mieschendahl et al.,1986,Bio/Technology 4:802-808)。该质粒还携带大肠杆菌rcsA基因从而上调鸟苷二磷酸-岩藻糖合成,这是岩藻糖-连接的低聚糖合成的一种至关重要的前体。另外,所述质粒携带一种β-内酰胺酶(bla)基因和一种天然的thyA(胸苷酸合酶)基因,其中,所述β-内酰胺酶(bla)基因用于通过氨苄青霉素选择(为了方便起见在实验室中)将所述质粒维持在宿主菌株中,所述天然thyA(胸苷酸合酶)基因是thyA-宿主中的替换性选择方法。替代性可选择的标记物包括proBA基因,来弥补脯氨酸营养缺陷型(Stein et al.,(1984),J Bacteriol 158:2,696-700(1984)或者purA,来弥补腺嘌呤营养缺陷型(S.A.Wolfe,J.M.Smith,J Biol Chem 263,19147-53(1988))。为了用作质粒可选择的标记物,这些基因中的每个都首先在宿主细胞染色体中失活,然后在质粒上提供基因的野生型拷贝。做为选择,所述质粒上可以使用耐药性基因,例如β-内酰胺酶(该基因已经在如上所述的表达质粒上表达,从而允许用氨苄青霉素选择)。氨苄青霉素选择是本领域内已知的,在标准实验手册中已经被描述了,例如在Maniatis et al.,(1982)Molecular cloning,a laboratory manual(分子克隆,实验室手册).Cold Spring Harbor Laboratory(冷泉港实验室),Cold Spring(冷泉),NY.中的描述。

[0109] 下面提供了这种表达质粒的核酸序列pEC2-(T7)FutX-rcsA-thyA(pG401)。带下划线的序列代表了FutX变种,使用标准重组DNA技术,其可以容易的被任意一种这里所描述的新型α(1,2)FT所代替。

[0110] TCGCGCGTTTCGGTGATGACGGTGAAAACCTCTGACACATGCAGCTCCCGGAGACGGTCACAGCTTGT
CTGTAAGCGGATGCCGGGAGCAGACAAGCCCGTCAGGGCGCGTCAGCGGGTGTTGGCGGGTGTCGGGGCTGGCTTA
ACTATGCGGCATCAGAGCAGATTGTACTGAGAGTGCACCATATATGCGGTGTGAAATACCGCACAGATGCGTAAGG
AGAAAATACCGCATCAGGCGCCTCCTCAACCTGTATATTCGTAAACCACGCCCAATGGGAGCTGTCTCAGGTTTGT
TCCTGATTGGTTACGGCGCGTTTCGCATCATTGTTGAGTTTTTCCGCCAGCCCGACGCGCAGTTTACCGGTGCCTG
GGTGCAGTACATCAGCATGGGGCAAATTCTTTCCATCCCGATGATTGTCGCGGGTGTGATCATGATGGTCTGGGCA
TATCGTCGCAGCCCACAGCAACACGTTTCCTGAGGAACCATGAAACAGTATTTAGAACTGATGCAAAAAGTGCTCG
ACGAAGGCACACAGAAAAACGACCGTACCGGAACCGGAACGCTTTCCATTTTTGGTCATCAGATGCGTTTTAACCT
GCAAGATGGATTCCCGCTGGTGACAACTAAACGTTGCCACCTGCGTTCCATCATCCATGAACTGCTGTGGTTTCTG
CAGGGCGACACTAACATTGCTTATCTACACGAAAACAATGTCACCATCTGGGACGAATGGGCCGATGAAAACGGCG
ACCTCGGGCCAGTGTATGGTAAACAGTGGCGCGCCTGGCCAACGCCAGATGGTCGTCATATTGACCAGATCACTAC
GGTACTGAACCAGCTGAAAAACGACCCGGATTCGCGCCGCATTATTGTTTCAGCGTGGAACGTAGGCGAACTGGAT
AAAATGGCGCTGGCACCGTGCCATGCATTCTTCCAGTTCTATGTGGCAGACGGCAAACTCTCTTGCCAGCTTTATC
AGCGCTCCTGTGACGTCTTCCTCGGCCTGCCGTTCAACATTGCCAGCTACGCGTTATTGGTGCATATGATGGCGCA
GCAGTGCGATCTGGAAGTGGGTGATTTTGTCTGGACCGGTGGCGACACGCATCTGTACAGCAACCATATGGATCAA
ACTCATCTGCAATTAAGCCGCGAACCGCGTCCGCTGCCGAAGTTGATTATCAAACGTAAACCCGAATCCATCTTCG
ACTACCGTTTCGAAGACTTTGAGATTGAAGGCTACGATCCGCATCCGGGCATTAAAGCGCCGGTGGCTATCTAATT
ACGAAACATCCTGCCAGAGCCGACGCCAGTGTGCGTCGGTTTTTTTACCCTCCGTTAAATTCTTCGAGACGCCTTC
CCGAAGGCGCCATTCGCCATTCAGGCTGCGCAACTGTTGGGAAGGGCGATCGGTGCGGGCCTCTTCGCTATTACGC

CAGCTGGCGAAAGGGGGATGTGCTGCAAGGCGATTAAGTTGGGTAACGCCAGGGTTTTCCCAGTCACGACGTTGTA
AAACGACGGCCAGTGCCAAGCTTTCTTTAATGAAGCAGGGCATCAGGACGGTATCTTTGTGGAGAAAGCAGAGTAA
TCTTATTCAGCCTGACTGGTGGGAAACCACCAGTCAGAATGTGTTAGCGCATGTTGACAAAAATACCATTAGTCAC
ATTATCCGTCAGTCGGACGACATGGTAGATAACCTGTTTATTATGCGTTTTGATCTTACGTTTAATATTACCTTTA
TGCGATGAAACGGTCTTGGCTTTGATATTCATTTGGTCAGAGATTTGAATGGTTCCCTGACCTGCCATCCACATTC
GCAACATACTCGATTCGGTTCGGCTCAATGATAACGTCGGCATATTTAAAAACGAGGTTATCGTTGTCTCTTTTTT
CAGAATATCGCCAAGGATATCGTCGAGAGATTCCGGTTTAATCGATTTAGAACTGATCAATAAATTTTTTCTGACC
AATAGATATTCATCAAAATGAACATTGGCAATTGCCATAAAAACGATAAATAACGTATTGGGATGTTGATTAATGA
TGAGCTTGATACGCTGACTGTTAGAAGCATCGTGGATGAAACAGTCCTCATTAATAAACACCACTGAAGGGCGCTG
TGAATCACAAGCTATGGCAAGGTCATCAACGGTTTCAATGTCGTTGATTTCTCTTTTTTTAACCCCTCTACTCAAC
AGATACCCGGTTAAACCTAGTCGGGTGTAACTACATAAATCCATAATAATCGTTGACATGGCATACCCTCACTCAA
TGCGTAACGATAATTCCCCTTACCTGAATATTTCATCATGACTAAACGGAACAACATGGGTCACCTAATGCGCCAC
TCTCGCGATTTTTCAGGCGGACTTACTATCCCGTAAAGTGTTGTATAATTTGCCTGGAATTGTCTTAAAGTAAAGT
AAATGTTGCGATATGTGAGTGAGCTTAAAACAAATATTTCGCTGCAGGAGTATCCTGGAAGATGTTCGTAGAAGCT
TACTGCTCACAAGAAAAAAGGCACGTCATCTGACGTGCCTTTTTTATTTGTACTACCCTGTACGATTACTGCAGCT
CGAGCTAGTTAATCGGTACTTTGATCCATTCTTTCGGGTACATGTCCGGGGTTTCTTTATGCTGGAACCAGCGACA
CGGCGCGATGACGATTTTCTCTTTACGTGGGTTCAGCCAAGCACCCCACCAGGAGAACGTAGAATTACAGATAATG
TGGTGACGACAGTGGCTCATCAGCATCATATCCTGCCAGCTGTCTTCGCCCTTGTTCCACGTCACGTAGACCGCTT
TCTTCAGCGGGATGTTTTCTTTAACCCAAGAGATATCATCAGAGAACACGTAGTAGCTCGGGCCAGTAATACGGTT
CTCCATTTCCGCGATCGCGTTCTTGTAATACGGCAGCTGGCACACGGAACCCGTGTTTGCCCAGTGACGCGGCAGC
AGGTAGTCACCACGGCGGATGTGGATAGAAACAGCTTGGTCGTCAACTTCGATCTGTTTCAGCAGTTCCAGGCTTT
CCGGGTTAGCGATGTTCAGGTTAAAAGAGAAGGCTTTACGAACGTCGTCTTTGATATCGAAGAAGAAGCGTTCAGA
CTGGTAGAAACCTTTAAAGTACAGCAGCGGCCAAAAATAACGTTTTTCGTATGGATACAGAGTAGACGGGTCCTGG
CGACGTTCGTAGATTTTTTTGAAGAACAGGAACTCCAGGATTTTTTTCAGGGTACGGTTGATGCAAAATTCAGTCT
GGCTCAGGTCAAAGATACGGTTCATCTCATAACCGTTGTGAACTTTATAATGAACCATGTCAGACAGATCGATGTT
CGTATCCGGGTAATGGTGTTTCATTTTCAGGTAGAACGCGTAGATAAACATCTGGTTACCCAGGCCGCCGATCATC
TTGATCAGACGCATATGTATATCTCCTTCTTGAATTCTAAAAATTGATTGAATGTATGCAAATAAATGCATACACC
ATAGGTGTGGTTTAATTTGATGCCCTTTTTCAGGGCTGGAATGTGTAAGAGCGGGGTTATTTATGCTGTTGTTTTT
TTGTTACTCGGGAAGGGCTTTACCTCTTCCGCATAAACGCTTCCATCAGCGTTTATAGTTAAAAAAATCTTTCGGA
ACTGGTTTTGCGCTTACCCCAACCAACAGGGGATTTGCTGCTTTCCATTGAGCCTGTTTCTCTGCGCGACGTTCGC
GGCGGCGTGTTTGTGCATCCATCTGGATTCTCCTGTCAGTTAGCTTTGGTGGTGTGTGGCAGTTGTAGTCCTGAAC
GAAAACCCCCCGCGATTGGCACATTGGCAGCTAATCCGGAATCGCACTTACGGCCAATGCTTCGTTTCGTATCACA
CACCCCAAAGCCTTCTGCTTTGAATGCTGCCCTTCTTCAGGGCTTAATTTTTAAGAGCGTCACCTTCATGGTGGTC
AGTGCGTCCTGCTGATGTGCTCAGTATCACCGCCAGTGGTATTTATGTCAACACCGCCAGAGATAATTTATCACCG
CAGATGGTTATCTGTATGTTTTTTATATGAATTTATTTTTTGCAGGGGGGCATTGTTTGGTAGGTGAGAGATCAAT
TCTGCATTAATGAATCGGCCAACGCGCGGGGAGAGGCGGTTTGCGTATTGGGCGCTCTTCCGCTTCCTCGCTCACT
GACTCGCTGCGCTCGGTCGTTCGGCTGCGGCGAGCGGTATCAGCTCACTCAAAGGCGGTAATACGGTTATCCACAG
AATCAGGGGATAACGCAGGAAAGAACATGTGAGCAAAAGGCCAGCAAAAGGCCAGGAACCGTAAAAAGGCCGCGTT
GCTGGCGTTTTTCCATAGGCTCCGCCCCCCTGACGAGCATCACAAAAATCGACGCTCAAGTCAGAGGTGGCGAAAC

CCGACAGGACTATAAAGATACCAGGCGTTTCCCCCTGGAAGCTCCCTCGTGCGCTCTCCTGTTCCGACCCTGCCGC
TTACCGGATACCTGTCCGCCTTTCTCCCTTCGGGAAGCGTGGCGCTTTCTCATAGCTCACGCTGTAGGTATCTCAG
TTCGGTGTAGGTCGTTCGCTCCAAGCTGGGCTGTGTGCACGAACCCCCCGTTCAGCCCGACCGCTGCGCCTTATCC
GGTAACTATCGTCTTGAGTCCAACCCGGTAAGACACGACTTATCGCCACTGGCAGCAGCCACTGGTAACAGGATTA
GCAGAGCGAGGTATGTAGGCGGTGCTACAGAGTTCTTGAAGTGGTGGCCTAACTACGGCTACACTAGAAGAACAGT
ATTTGGTATCTGCGCTCTGCTGAAGCCAGTTACCTTCGGAAAAAGAGTTGGTAGCTCTTGATCCGGCAAACAAACC
ACCGCTGGTAGCGGTGGTTTTTTTGTTTGCAAGCAGCAGATTACGCGCAGAAAAAAAGGATCTCAAGAAGATCCTT
TGATCTTTTCTACGGGGTCTGACGCTCAGTGGAACGAAAACTCACGTTAAGGGATTTTGGTCATGAGATTATCAAA
AAGGATCTTCACCTAGATCCTTTTAAATTAAAAATGAAGTTTTAAATCAATCTAAAGTATATATGAGTAAACTTGG
TCTGACAGTTACCAATGCTTAATCAGTGAGGCACCTATCTCAGCGATCTGTCTATTTCGTTCATCCATAGTTGCCT
GACTCCCCGTCGTGTAGATAACTACGATACGGGAGGGCTTACCATCTGGCCCCAGTGCTGCAATGATACCGCGAGA
CCCACGCTCACCGGCTCCAGATTTATCAGCAATAAACCAGCCAGCCGGAAGGGCCGAGCGCAGAAGTGGTCCTGCA
ACTTTATCCGCCTCCATCCAGTCTATTAATTGTTGCCGGGAAGCTAGAGTAAGTAGTTCGCCAGTTAATAGTTTGC
GCAACGTTGTTGCCATTGCTACAGGCATCGTGGTGTCACGCTCGTCGTTTGGTATGGCTTCATTCAGCTCCGGTTC
CCAACGATCAAGGCGAGTTACATGATCCCCCATGTTGTGCAAAAAAGCGGTTAGCTCCTTCGGTCCTCCGATCGTT
GTCAGAAGTAAGTTGGCCGCAGTGTTATCACTCATGGTTATGGCAGCACTGCATAATTCTCTTACTGTCATGCCAT
CCGTAAGATGCTTTTCTGTGACTGGTGAGTACTCAACCAAGTCATTCTGAGAATAGTGTATGCGGCGACCGAGTTG
CTCTTGCCCGGCGTCAATACGGGATAATACCGCGCCACATAGCAGAACTTTAAAAGTGCTCATCATTGGAAAACGT
TCTTCGGGGCGAAAACTCTCAAGGATCTTACCGCTGTTGAGATCCAGTTCGATGTAACCCACTCGTGCACCCAACT
GATCTTCAGCATCTTTTACTTTCACCAGCGTTTCTGGGTGAGCAAAAACAGGAAGGCAAAATGCCGCAAAAAAGGG
AATAAGGGCGACACGGAAATGTTGAATACTCATACTCTTCCTTTTTCAATATTATTGAAGCATTTATCAGGGTTAT
TGTCTCATGAGCGGATACATATTTGAATGTATTTAGAAAAATAAACAAATAGGGGTTCCGCGCACATTTCCCCGAA
AAGTGCCACCTGACGTCTAAGAAACCATTATTATCATGACATTAACCTATAAAAATAGGCGTATCACGAGGCCCTT
TCGTC(SEQ ID NO:287)

[0111] 表达构建物被转入宿主菌株,有效用于产生2'-岩藻糖基乳糖(2'-FL)。生物合成的2'-岩藻糖基乳糖(2'-FL)要求增加的乳糖和鸟苷二磷酸-岩藻糖细胞文库的产生(图2)。野生型大肠杆菌K12原养型菌株W3110被选作亲本背景,检验候选物催化2'-岩藻糖基乳糖(2'-FL)产生的能力(Bachmann,B.J.(1972).Bacteriol Rev 36,525-557).使用的具体W3110衍生物预先通过引入(在ampC位点)色氨酸-可诱导的PtrpBcI+阻断剂暗盒进行修饰,产生大肠杆菌菌株,被称为GI724(LaVallie,E.R.et al.(2000).Methods Enzymol 326,322-340)。GI724的其他特征包括lacIq和lacPL8启动子突变。在用低水平外源色氨酸诱导之后,大肠杆菌GI724能够经济的生产来自噬菌体λPL启动子处的重组蛋白质(LaVallie,E.R.et al.(1993).Biotechnology(N Y)11,187-193;Mieschendahl,et al.(1986).Bio/Technology 4,802-08)。对这些菌株进行其他的遗传改变,从而促进2'-岩藻糖基乳糖(2'-FL)的生物合成。通过一些使用染色体的λ红色重组(Court,D.L.et al.(2002).Annu Rev Genet 36,361-388)和一般化的P1噬菌体传导在菌株GI724中实现这一目的。

[0112] 首先,通过同时删除内源性的β-半乳糖苷酶基因(lacZ)和乳糖操纵子阻遏基因(lacI)来设计大肠杆菌宿主菌株积聚细胞内乳糖的能力。在构建这些删除期间,lacIq启动子直接放置在乳糖渗透酶基因lacY的上游。这种修饰的菌株维持其从培养基运输乳糖的能

力(通过LacY),但是删除了负责乳糖分解的lacZ(β-半乳糖苷酶)基因野生型拷贝。因此,当在外源乳糖存在时,培养修饰的菌株,产生细胞内乳糖库。图12显示了$P_{lacIq}lacY^{+}$染色体构建物示意图。

[0113] 下面显示了$P_{lacIq}lacY^{+}$染色体构建物的基因组DNA序列(SEQ ID NO:288):

[0114] CACCATCGAATGGCGCAAAACCTTTCGCGGTATGGCATGATAGCGCCCGGAAGAGAGTCAAGTGTAGGC
TGGAGCTGCTTCGAAGTTCCTATACTTTCTAGAGAATAGGAACTTCGGAATAGGAACTTCGGAATAGGAACTAAGGA
GGATATTCATATGTACTATTTAAAAAACACAAACTTTTGGATGTTCGGTTTATTCTTTTTCTTTTACTTTTTTATCA
TGGGAGCCTACTTCCCGTTTTTCCCGATTTGGCTACATGACATCAACCATATCAGCAAAAGTGATACGGGTATTATT
TTTGCCGCTATTTCTCTGTTCTCGCTATTATTCCAACCGCTGTTTGGTCTGCTTTCTGACAAACTCGGGCTGCGCAA
ATACCTGCTGTGGATTATTACCGGCATGTTAGTGATGTTTGCGCCGTTCTTTATTTTTATCTTCGGGCCACTGTTAC
AATACAACATTTTAGTAGGATCGATTGTTGGTGGTATTTATCTAGGCTTTTGTTTTAACGCCGGTGCGCCAGCAGTA
GAGGCATTTATTGAGAAAGTCAGCCGTCGCAGTAATTTCGAATTTGGTCGCGCGCGGATGTTTGGCTGTGTTGGCTG
GGCGCTGTGTGCCTCGATTGTCGGCATCATGTTCACCATCAATAATCAGTTTGTTTTCTGGCTGGGCTCTGGCTGTG
CACTCATCCTCGCCGTTTTACTCTTTTTCGCCAAAACGGATGCGCCCTCTTCTGCCACGGTTGCCAATGCGGTAGGT
GCCAACCATTCGGCATTTAGCCTTAAGCTGGCACTGGAACTGTTCAGACAGCCAAAACTGTGGTTTTTGTCACTGTA
TGTTATTGGCGTTTCCTGCACCTACGATGTTTTTGACCAACAGTTTGCTAATTTCTTTACTTCGTTCTTTGCTACCG
GTGAACAGGGTACGCGGGTATTTGGCTACGTAACGACAATGGGCGAATTACTTAACGCCTCGATTATGTTCTTTGCG
CCACTGATCATTAATCGCATCGGTGGGAAAAACGCCCTGCTGCTGGCTGGCACTATTATGTCTGTACGTATTATTGG
CTCATCGTTCGCCACCTCAGCGCTGGAAGTGGTTATTCTGAAAACGCTGCATATGTTTGAAGTACCGTTCCTGCTGG
TGGGCTGCTTTAAATATATTACCAGCCAGTTTGAAGTGCGTTTTTCAGCGACGATTTATCTGGTCTGTTTCTGCTTC
TTTAAGCAACTGGCGATGATTTTTATGTCTGTACTGGCGGGCAATATGTATGAAAGCATCGGTTTCCAGGGCGCTTA
TCTGGTGCTGGGTCTGGTGGCGCTGGGCTTCACCTTAATTTCCGTGTTCACGCTTAGCGGCCCCGGCCCGCTTTCCC
TGCTGCGTCGTCAGGTGAATGAAGTCGCTTAAGCAATCAATGTCGGATGCGGCGCGAGCGCCTTATCCGACCAACAT
ATCATAACGGAGTGATCGCATTGTAAATTATAAAAATTGCCTGATACGCTGCGCTTATCAGGCCTACAAGTTCAGCG
ATCTACATTAGCCGCATCCGGCATGAACAAAGCGCAGGAACAAGCGTCGCA

[0115] 第二,通过删除wcaJ基因(编码尿苷二磷酸-葡萄糖脂质载体转移酶)删除宿主大肠杆菌菌株合成柯拉酸(一种细胞外荚膜多糖)的能力(Stevenson,G.et al.(1996).J Bacteriol 178,4885-893)。在wcaJ无效的背景下,鸟苷二磷酸-岩藻糖在大肠杆菌细胞质中聚集。(Dumon,C.et al.(2001).Glycoconj J 18,465-474)。图13显示了wcaJ染色体删除的示意图。

[0116] 大肠杆菌携带ΔwcaJ::FRT突变的染色体区域的序列显示如下(SEQ ID NO:289):

[0117] GTTCGGTTATATCAATGTCAAAAACCTCACGCCGCTCAAGCTGGTGATCAACTCCGGGAACGGCGCAGC
GGGTCCGGTGGTGGACGCCATTGAAGCCCGCTTTAAAGCCCTCGGCGCGCCCGTGGAATTAATCAAAGTGCACAACA
CGCCGGACGGCAATTTCCCCAACGGTATTCCTAACCCACTACTGCCGGAATGCCGCGACGACACCCGCAATGCGGTC
ATCAAACACGGCGCGGATATGGGCATTGCTTTTGATGGCGATTTTGACCGCTGTTTCCTGTTTGACGAAAAAGGGCA
GTTTATTGAGGGCTACTACATTGTCGGCCTGTTGGCAGAAGCATTCCTCGAAAAAAATCCCGGCGCGAAGATCATCC
ACGATCCACGTCTCTCCTGGAACACCGTTGATGTGGTGACTGCCGCAGGTGGCACGCCGGTAATGTCGAAAACCGGA
CACGCCTTTATTAAAGAACGTATGCGCAAGGAAGACGCCATCTATGGTGGCGAAATGAGCGCCCACCATTACTTCCG
TGATTTCGCTTACTGCGACAGCGGCATGATCCCGTGGCTGCTGGTCGCCGAACTGGTGTGCCTGAAAGATAAAACGC

TGGGCGAACTGGTACGCGACCGGATGGCGGCGTTTCCGGCAAGCGGTGAGATCAACAGCAAACTGGCGCAACCCGTT
GAGGCGATTAACCGCGTGGAACAGCATTTTAGCCGTGAGGCGCTGGCGGTGGATCGCACCGATGGCATCAGCATGAC
CTTTGCCGACTGGCGCTTTAACCTGCGCACCTCCAATACCGAACCGGTGGTGCGCCTGAATGTGGAATCGCGCGGTG
ATGTGCCGCTGATGGAAGCGCGAACGCGAACTCTGCTGACGTTGCTGAACGAGTAATGTCGGATCTTCCCTTACCCC
ACTGCGGGTAAGGGGCTAATAACAGGAACAACGATGATTCCGGGGATCCGTCGACCTGCAGTTCGAAGTTCCTATTC
TCTAGAAAGTATAGGAACTTCGAAGCAGCTCCAGCCTACAGTTAACAAAGCGGCATATTGATATGAGCTTACGTGAA
AAAACCATCAGCGGCGCGAAGTGGTCGGCGATTGCCACGGTGATCATCATCGGCCTCGGGCTGGTGCAGATGACCGT
GCTGGCGCGGATTATCGACAACCACCAGTTCGGCCTGCTTACCGTGTCGCTGGTGATTATCGCGCTGGCAGATACGC
TTTCTGACTTCGGTATCGCTAACTCGATTATTCAGCGAAAAGAAATCAGTCACCTTGAACTCACCACGTTGTACTGG
CTGAACGTCGGGCTGGGGATCGTGGTGTGCGTGGCGGTGTTTTTGTTGAGTGATCTCATCGGCGACGTGCTGAATAA
CCCGGACCTGGCACCGTTGATTAAAACATTATCGCTGGCGTTTGTGGTAATCCCCCACGGGCAACAGTTCCGCGCGT
TGATGCAAAAAGAGCTGGAGTTCAACAAAATCGGCATGATCGAAACCAGCGCGGTGCTGGCGGGCTTCACTTGTACG
GTGGTTAGCGCCCATTTCTGGCCGCTGGCGATGACCGCGATCCTCGGTTATCTGGTCAATAGTGCGGTGAGAACGCT
GCTGTTTGGCTACTTTGGCCGCAAAATTTATCGCCCCGGTCTGCATTTCTCGCTGGCGTCGGTGGCACCGAACTTAC
GCTTTGGTGCCTGGCTGACGGCGGACAGCATCATCAACTATCTCAATACCAACCTTTCAACGCTCGTGCTGGCGCGT
ATTCTCGGCGCGGGCGTGGCAGGGGGATACAACCTGGCGTACAACGTGGCCGTTGTGCCACCGATGAAGCTGAACCC
AATCATCACCCGCGTGTTGTTTCCGGCATTCGCCAAAATTCAGGACGATACCGAAAAGCTGCGTGTTAACTTCTACA
AGCTGCTGTCGGTAGTGGGGATTATCAACTTTCCGGCGCTGCTCGGGCTAATGGTGGTGTCGAATAACTTTGTACCG
CTGGTCTTTGGTGAGAAGTGGAACAGCATTATTCCGGTGCTGCAATTGCTGTGTGTGGTGGGTCTGCTGCGCTCCG

[0118] 第三,通过向lon基因中引入无效突变来增加细胞质鸟苷二磷酸-岩藻糖库的数量。Lon是一种腺苷酸-5′-三磷酸盐(ATP)-依赖性的细胞内蛋白酶,负责降解RcsA,它是大肠杆菌中柯拉酸生物合成的阳性翻译调节蛋白。(Gottesman,S.&Stout,V.Mol Microbiol 5,1599-1606(1991)).在lon无效的背景下,RcsA是稳定的,RcsA水平增加,在大肠杆菌中负责鸟苷二磷酸-岩藻糖合成的基因被上调节,并且细胞内鸟苷二磷酸-岩藻糖浓度增加。所述lon基因几乎全部被删除并且被插入的功能性、野生型但是启动子更少的大肠杆菌$lacZ^+$基因(Δlon::(kan,$lacZ^+$)所取代。λ红色重组法用来进行所述构建。图14显示了插入lon位点的kan,$lacZ^+$的示意图。

[0119] 下面表示了插入大肠杆菌中lon区域lacZ+周围的基因组DNA序列(SEQ ID NO:290):

[0120] GTGGATGGAAGAGGTGGAAAAAGTGGTTATGGAGGAGTGGGTAATTGATGGTGAAAGGAAAGGGTTGGT
GATTTATGGGAAGGGGGAAGGGGAAGAGGGATGTGGTGAATAATTAAGGATTGGGATAGAATTAGTTAAGGAAAAAG
GGGGGATTTTATGTGGGGTTTAATTTTTGGTGTATTGTGGGGGTTGAATGTGGGGGAAAGATGGGGATATAGTGAGG
TAGATGTTAATAGATGGGGTGAAGGAGAGTGGTGTGATGTGATTAGGTGGGGGAAATTAAAGTAAGAGAGAGGTGTA
TGATTGGGGGGATGGGTGGAGGTGGAGTTGGAAGTTGGTATTGTGTAGAAAGTATAGGAAGTTGAGAGGGGTTTTGA
AGGTGAGGGTGGGGGAAGGAGTGAGGGGGGAAGGGGTGGTAAAGGAAGGGGAAGAGGTAGAAAGGGAGTGGGGAGAA
AGGGTGGTGAGGGGGGATGAATGTGAGGTAGTGGGGTATGTGGAGAAGGGAAAAGGGAAGGGGAAAGAGAAAGGAGG
TAGGTTGGAGTGGGGTTAGATGGGGATAGGTAGAGTGGGGGGTTTTATGGAGAGGAAGGGAAGGGGAATTGGGAGGT
GGGGGGGGGTGTGGTAAGGTTGGGAAGGGGTGGAAAGTAAAGTGGATGGGTTTGTTGGGGGGAAGGATGTGATGGGG
GAGGGGATGAAGATGTGATGAAGAGAGAGGATGAGGATGGTTTGGGATGATTGAAGAAGATGGATTGGAGGGAGGTT

GTGGGGGGGGTTGGGTGGAGAGGGTATTGGGGTATGAGTGGGGAGAAGAGAGAATGGGGTGGTGTGATGGGGGGGTG
TTGGGGGTGTGAGGGGAGGGGGGGGGGGTTGTTTTTGTGAAGAGGGAGGTGTGGGGTGGGGTGAATGAAGTGGAGGA
GGAGGGAGGGGGGGTATGGTGGGTGGGGAGGAGGGGGGTTGGTTGGGGAGGTGTGGTGGAGGTTGTGAGTGAAGGGG
GAAGGGAGTGGGTGGTATTGGGGGAAGTGGGGGGGGAGGATGTGGTGTGATGTGAGGTTGGTGGTGGGGAGAAAGTA
TGGATGATGGGTGATGGAATGGGGGGGGTGGATAGGGTTGATGGGGGTAGGTGGGGATTGGAGGAGGAAGGGAAAGA
TGGGATGGAGGGAGGAGGTAGTGGGATGGAAGGGGGTGTTGTGGATGAGGATGATGTGGAGGAAGAGGATGAGGGGG
TGGGGGGAGGGGAAGTGTTGGGGAGGGTGAAGGGGGGATGGGGGAGGGGGAGGATGTGGTGGTGAGGGATGGGGATG
GGTGGTTGGGGAATATGATGGTGGAAAATGGGGGGTTTTGTGGATTGATGGAGTGTGGGGGGGTGGGTGTGGGGGAG
GGGTATGAGGAGATAGGGTTGGGTAGGGGTGATATTGGTGAAGAGGTTGGGGGGGAATGGGGTGAGGGGTTGGTGGT
GGTTTAGGGTATGGGGGGTGGGGATTGGGAGGGGATGGGGTTGTATGGGGTTGTTGAGGAGTTGTTGTAATAAGGGG
ATGTTGAAGTTGGTATTGGGAAGTTGGTATTGTGTAGAAAGTATAGGAAGTTGGAAGGAGGTGGAGGGTAGATAAAG
GGGGGGGTTATTTTTGAGAGGAGAGGAAGTGGTAATGGTAGGGAGGGGGGGTGAGGTGGAATTGGGGGGATAGTGAG
GGGGTGGAGGAGTGGTGGGGAGGAATGGGGATATGGAAAGGGTGGATATTGAGGGATGTGGGTTGTTGGGGGTGGAG
GAGATGGGGATGGGTGGTTTGGATGAGTTGGTGTTGAGTGTAGGGGGTGATGTTGAAGTGGAAGTGGGGGGGGGAGT
GGTGTGGGGGATAATTGAATTGGGGGGTGGGGGAGGGGAGAGGGTTTTGGGTGGGGAAGAGGTAGGGGGTATAGATG
TTGAGAATGGGAGATGGGAGGGGTGAAAAGAGGGGGGAGTAAGGGGGTGGGGATAGTTTTGTTGGGGGGGTAATGGG
AGGGAGTTTAGGGGGTGTGGTAGGTGGGGGAGGTGGGAGTTGAGGGGAATGGGGGGGGGATGGGGTGTATGGGTGGG
GAGTTGAAGATGAAGGGTAATGGGGATTTGAGGAGTAGGATGAATGGGGTAGGTTTTGGGGGTGATAAATAAGGTTT
TGGGGTGATGGTGGGAGGGGTGAGGGGTGGTAATGAGGAGGGGATGAGGAAGTGTATGTGGGGTGGAGTGGAAGAAG
GGTGGTTGGGGGTGGTAATGGGGGGGGGGGTTGGAGGGTTGGAGGGAGGGGTTAGGGTGAATGGGGGTGGGTTGAGT
TAGGGGAATGTGGTTATGGAGGGGTGGAGGGGTGAAGTGATGGGGGAGGGGGGTGAGGAGTTGTTTTTTATGGGGAA
TGGAGATGTGTGAAAGAAAGGGTGAGTGGGGGTTAAATTGGGAAGGGTTATTAGGGAGGTGGATGGAAAAATGGATT
TGGGTGGTGGTGAGATGGGGGATGGGGTGGGAGGGGGGGGGGAGGGTGAGAGTGAGGTTTTGGGGGAGAGGGGAGTG
GTGGGAGGGGGTGATGTGGGGGGGTTGTGAGGATGGGGTGGGGTTGGGTTGGAGTAGGGGTAGTGTGAGGGAGAGTT
GGGGGGGGGTGTGGGGGTGGGGTAGTTGAGGGAGTTGAATGAAGTGTTTAGGTTGTGGAGGGAGATGGAGAGGGAGT
TGAGGGGTTGGGAGGGGGTTAGGATGGAGGGGGAGGATGGAGTGGAGGAGGTGGTTATGGGTATGAGGGAAGAGGTA
TTGGGTGGTGAGTTGGATGGTTTGGGGGGATAAAGGGAAGTGGAAAAAGTGGTGGTGGTGTTTTGGTTGGGTGAGGG
GTGGATGGGGGGTGGGGTGGGGAAAGAGGAGAGGGTTGATAGAGAAGTGGGGATGGTTGGGGGTATGGGGAAAATGA
GGGGGGTAAGGGGAGGAGGGGTTGGGGTTTTGATGATATTTAATGAGGGAGTGATGGAGGGAGTGGGAGAGGAAGGG
GGGGTGTAAAGGGGGATAGTGAGGAAAGGGGTGGGAGTATTTAGGGAAAGGGGGAAGAGTGTTAGGGATGGGGTGGG
GGTATTGGGAAAGGATGAGGGGGGGGGTGTGTGGAGGTAGGGAAAGGGATTTTTTGATGGAGGATTTGGGGAGAGGG
GGGAAGGGGTGGTGTTGATGGAGGGGGGGGTAGATGGGGGAAATAATATGGGTGGGGGTGGTGTGGGGTGGGGGGGG
TTGATAGTGGAGGGGGGGGGAAGGATGGAGAGATTTGATGGAGGGATAGAGGGGGTGGTGATTAGGGGGGTGGGGTG
ATTGATTGGGGAGGGAGGAGATGATGAGAGTGGGGTGATTAGGATGGGGGTGGAGGATTGGGGTTAGGGGTTGGGTG
ATGGGGGGTAGGGAGGGGGGATGATGGGTGAGAGGATTGATTGGGAGGATGGGGTGGGTTTGAATATTGGGTTGATG
GAGGAGATAGAGGGGGTAGGGGTGGGAGAGGGTGTAGGAGAGGGGATGGTTGGGATAATGGGAAGAGGGGAGGGGGT
TAAAGTTGTTGTGGTTGATGAGGAGGATATGGTGGAGGATGGTGTGGTGATGGATGAGGTGAGGATGGAGAGGATGA
TGGTGGTGAGGGTTAAGGGGTGGAATGAGGAAGGGGTTGGGGTTGAGGAGGAGGAGAGGATTTTGAATGGGGAGGTG
GGGGAAAGGGAGATGGGAGGGTTGTGGTTGAATGAGGGTGGGGTGGGGGGTGTGGAGTTGAAGGAGGGGAGGATAGA

GATTGGGGATTTGGGGGGTGGAGAGTTTGGGGTTTTGGAGGTTGAGAGGTAGTGTGAGGGGATGGGGATAAGGAGGA
GGGTGATGGATAATTTGAGGGGGGAAAGGGGGGGTGGGGGTGGGGAGGTGGGTTTGAGGGTGGGATAAAGAAAGTGT
TAGGGGTAGGTAGTGAGGGAAGTGGGGGGAGATGTGAAGTTGAGGGTGGAGTAGAGGGGGGGTGAAATGATGATTAA
AGGGAGTGGGAAGATGGAAATGGGTGATTTGTGTAGTGGGTTTATGGAGGAAGGAGAGGTGAGGGAAAATGGGGGTG
ATGGGGGAGATATGGTGATGTTGGAGATAAGTGGGGTGAGTGGAGGGGAGGAGGATGAGGGGGAGGGGGTTTTGTGG
GGGGGGTAAAAATGGGGTGAGGTGAAATTGAGAGGGGAAAGGAGTGTGGTGGGGGTAAGGGAGGGAGGGGGGGTTGG
AGGAGAGATGAAAGGGGGAGTTAAGGGGATGAAAAATAATTGGGGTGTGGGGTTGGTGTAGGGAGGTTTGATGAAGA
TTAAATGTGAGGGAGTAAGAAGGGGTGGGATTGTGGGTGGGAAGAAAGGGGGGATTGAGGGTAATGGGATAGGTGAG
GTTGGTGTAGATGGGGGGATGGTAAGGGTGGATGTGGGAGTTTGAGGGGAGGAGGAGAGTATGGGGGTGAGGAAGAT
GGGAGGGAGGGAGGTTTGGGGGAGGGGTTGTGGTGGGGGAAAGGAGGGAAAGGGGGATTGGGGATTGAGGGTGGGGA
AGTGTTGGGAAGGGGGATGGGTGGGGGGGTGTTGGGTATTAGGGGAGGTGGGGAAAGGGGGATGTGGTGGAAGGGGA
TTAAGTTGGGTAAGGGGAGGGTTTTGGGAGTGAGGAGGTTGTAAAAGGAGGGGGAGTGAATGGGTAATGATGGTGAT
AGTAGGTTTGGTGAGGTTGTGAGTGGAAAATAGTGAGGTGGGGGAAAATGGAGTAATAAAAAGAGGGGTGGGAGGGT
AATTGGGGGTTGGGAGGGTTTTTTTGTGTGGGTAAGTTAGATGGGGGATGGGGGTTGGGGTTATTAAGGGGTGTTGT
AAGGGGATGGGTGGGGTGATATAAGTGGTGGGGGTTGGTAGGTTGAAGGATTGAAGTGGGATATAAATTATAAAGAG
GAAGAGAAGAGTGAATAAATGTGAATTGATGGAGAAGATTGGTGGAGGGGGTGATATGTGTAAAGGTGGGGGTGGGG
GTGGGTTAGATGGTATTATTGGTTGGGTAAGTGAATGTGTGAAAGAAGG

[0121] 第四，一种thyA(胸苷酸合酶)突变通过P1转导被引入菌株中。当不存在外源胸腺嘧啶时，thyA菌株不能制造DNA并死亡。通过在多拷贝质粒上提供野生型thyA基因可以弥补这一缺陷(Belfort,M.,Maley,G.F.,and Maley,F.(1983).Proc Natl Acad Sci U S A 80,1858-861)。这里使用的互补作用是维持质粒的方法。

[0122] 另一种对增加游离乳糖细胞质库(由此2'-岩藻糖基乳糖(2'-FL)的最后产量被增加)很有效的修饰是整合lacA突变。LacA是一种乳糖乙酰转移酶，只有当高水平的乳糖聚积在所述大肠杆菌细胞质中时才有活性。高细胞内渗透性(例如，由高细胞内乳糖池引起的)可以抑制细菌繁殖，并且大肠杆菌进化出一种适合于保护其自身免受细胞内部由乳糖引起的渗透性的机制，该机制通过用LacA使更多的细胞内乳糖"绑上"乙酰基，并且积极地从细胞中排出所述乙酰-乳糖(Danchin,A.Bioessays 31,769-773(2009))。在被设计产生2'-岩藻糖基乳糖(2'-FL)或者其他人类乳汁低聚糖的大肠杆菌中产生乙酰-乳糖是不受欢迎的，因为这会减少总回收率。而且，副产品乙酰-乳糖会使低聚糖提纯方案变得复杂。lacA突变的整合能够解决这些问题。次-最佳产生岩藻糖基化的低聚糖的方法存在于缺少柯拉酸途径和lon蛋白酶中的一个或者两个突变的菌株中。在不包含lacA突变的菌株中会发生乳糖向一种副产品(乙酰-乳糖)的转化。上面提供了lacA删除的示意图和相应的基因组序列(SEQ ID NO:288)。

[0123] 该菌株用于检测不同的α(1,2)FT候选物，并整合上述所有遗传修饰和具有下列基因型：

[0124] ΔampC::$P_{trp}{}^{B}$cI，Δ(lacI-lacZ)::FRT,P_{lacIq}lacY^{+}，ΔwcaJ::FRT,thyA::Tn10，Δlon:(npt3,lacZ^{+})，ΔlacA

[0125] 分析了藏匿不同的α(1,2)FT候选表达质粒的大肠杆菌菌株。菌株在选择性培养基(缺少胸腺嘧啶)中生长到早期指数生长期。然后加入乳糖直至最终浓度为0.5％，并且加入

色氨酸(200μ M)来诱导每个候选α(1,2)FT从PL启动子处表达。在诱导期末端(大约24小时),每个菌株等于OD600单位并收获培养物上清液。制备并通过薄层色层分析法(TLC)分析溶解产物检测是否存在2'-岩藻糖基乳糖(2'-FL)。

[0126] 图11显示了质粒pG217的地图,其携带普通拟杆菌FutN。质粒pG217的序列如下所示(SEQ ID NO:291):

[0127] TCTAGAATTCTAAAAATTGATTGAATGTATGCAAATAAATGCATACACCATAGGTGTGGTTTAATTTGA
TGCCCTTTTTCAGGGCTGGAATGTGTAAGAGCGGGGTTATTTATGCTGTTGTTTTTTTGTTACTCGGGAAGGGCTTT
ACCTCTTCCGCATAAACGCTTCCATCAGCGTTTATAGTTAAAAAAATCTTTCGGAACTGGTTTTGCGCTTACCCCAA
CCAACAGGGGATTTGCTGCTTTCCATTGAGCCTGTTTCTCTGCGCGACGTTCGCGGCGGCGTGTTTGTGCATCCATC
TGGATTCTCCTGTCAGTTAGCTTTGGTGGTGTGTGGCAGTTGTAGTCCTGAACGAAAACCCCCCGCGATTGGCACAT
TGGCAGCTAATCCGGAATCGCACTTACGGCCAATGCTTCGTTTCGTATCACACACCCCAAAGCCTTCTGCTTTGAAT
GCTGCCCTTCTTCAGGGCTTAATTTTTAAGAGCGTCACCTTCATGGTGGTCAGTGCGTCCTGCTGATGTGCTCAGTA
TCACCGCCAGTGGTATTTATGTCAACACCGCCAGAGATAATTTATCACCGCAGATGGTTATCTGTATGTTTTTTATA
TGAATTTATTTTTTGCAGGGGGGCATTGTTTGGTAGGTGAGAGATCAATTCTGCATTAATGAATCGGCCAACGCGCG
GGGAGAGGCGGTTTGCGTATTGGGCGCTCTTCCGCTTCCTCGCTCACTGACTCGCTGCGCTCGGTCGTTCGGCTGCG
GCGAGCGGTATCAGCTCACTCAAAGGCGGTAATACGGTTATCCACAGAATCAGGGGATAACGCAGGAAAGAACATGT
GAGCAAAAGGCCAGCAAAAGGCCAGGAACCGTAAAAAGGCCGCGTTGCTGGCGTTTTTCCATAGGCTCCGCCCCCCT
GACGAGCATCACAAAAATCGACGCTCAAGTCAGAGGTGGCGAAACCCGACAGGACTATAAAGATACCAGGCGTTTCC
CCCTGGAAGCTCCCTCGTGCGCTCTCCTGTTCCGACCCTGCCGCTTACCGGATACCTGTCCGCCTTTCTCCCTTCGG
GAAGCGTGGCGCTTTCTCATAGCTCACGCTGTAGGTATCTCAGTTCGGTGTAGGTCGTTCGCTCCAAGCTGGGCTGT
GTGCACGAACCCCCCGTTCAGCCCGACCGCTGCGCCTTATCCGGTAACTATCGTCTTGAGTCCAACCCGGTAAGACA
CGACTTATCGCCACTGGCAGCAGCCACTGGTAACAGGATTAGCAGAGCGAGGTATGTAGGCGGTGCTACAGAGTTCT
TGAAGTGGTGGCCTAACTACGGCTACACTAGAAGGACAGTATTTGGTATCTGCGCTCTGCTGAAGCCAGTTACCTTC
GGAAAAAGAGTTGGTAGCTCTTGATCCGGCAAACAAACCACCGCTGGTAGCGGTGGTTTTTTTGTTTGCAAGCAGCA
GATTACGCGCAGAAAAAAAGGATCTCAAGAAGATCCTTTGATCTTTTCTACGGGGTCTGACGCTCAGTGGAACGAAA
ACTCACGTTAAGGGATTTTGGTCATGAGATTATCAAAAAGGATCTTCACCTAGATCCTTTTAAATTAAAAATGAAGT
TTTAAATCAATCTAAAGTATATATGAGTAAACTTGGTCTGACAGTTACCAATGCTTAATCAGTGAGGCACCTATCTC
AGCGATCTGTCTATTTCGTTCATCCATAGTTGCCTGACTCCCCGTCGTGTAGATAACTACGATACGGGAGGGCTTAC
CATCTGGCCCCAGTGCTGCAATGATACCGCGAGACCCACGCTCACCGGCTCCAGATTTATCAGCAATAAACCAGCCA
GCCGGAAGGGCCGAGCGCAGAAGTGGTCCTGCAACTTTATCCGCCTCCATCCAGTCTATTAATTGTTGCCGGGAAGC
TAGAGTAAGTAGTTCGCCAGTTAATAGTTTGCGCAACGTTGTTGCCATTGCTACAGGCATCGTGGTGTCACGCTCGT
CGTTTGGTATGGCTTCATTCAGCTCCGGTTCCCAACGATCAAGGCGAGTTACATGATCCCCCATGTTGTGCAAAAAA
GCGGTTAGCTCCTTCGGTCCTCCGATCGTTGTCAGAAGTAAGTTGGCCGCAGTGTTATCACTCATGGTTATGGCAGC
ACTGCATAATTCTCTTACTGTCATGCCATCCGTAAGATGCTTTTCTGTGACTGGTGAGTACTCAACCAAGTCATTCT
GAGAATAGTGTATGCGGCGACCGAGTTGCTCTTGCCCGGCGTCAATACGGGATAATACCGCGCCACATAGCAGAACT
TTAAAAGTGCTCATCATTGGAAAACGTTCTTCGGGGCGAAAACTCTCAAGGATCTTACCGCTGTTGAGATCCAGTTC
GATGTAACCCACTCGTGCACCCAACTGATCTTCAGCATCTTTTACTTTCACCAGCGTTTCTGGGTGAGCAAAAACAG
GAAGGCAAAATGCCGCAAAAAAGGGAATAAGGGCGACACGGAAATGTTGAATACTCATACTCTTCCTTTTTCAATAT
TATTGAAGCATTTATCAGGGTTATTGTCTCATGAGCGGATACATATTTGAATGTATTTAGAAAAATAAACAAATAGG

GGTTCCGCGCACATTTCCCCGAAAAGTGCCACCTGACGTCTAAGAAACCATTATTATCATGACATTAACCTATAAAA
ATAGGCGTATCACGAGGCCCTTTCGTCTCGCGCGTTTCGGTGATGACGGTGAAAACCTCTGACACATGCAGCTCCCG
GAGACGGTCACAGCTTGTCTGTAAGCGGATGCCGGGAGCAGACAAGCCCGTCAGGGCGCGTCAGCGGGTGTTGGCGG
GTGTCGGGGCTGGCTTAACTATGCGGCATCAGAGCAGATTGTACTGAGAGTGCACCATATATGCGGTGTGAAATACC
GCACAGATGCGTAAGGAGAAAATACCGCATCAGGCGCCTCCTCAACCTGTATATTCGTAAACCACGCCCAATGGGAG
CTGTCTCAGGTTTGTTCCTGATTGGTTACGGCGCGTTTCGCATCATTGTTGAGTTTTTCCGCCAGCCCGACGCGCAG
TTTACCGGTGCCTGGGTGCAGTACATCAGCATGGGGCAAATTCTTTCCATCCCGATGATTGTCGCGGGTGTGATCAT
GATGGTCTGGGCATATCGTCGCAGCCCACAGCAACACGTTTCCTGAGGAACCATGAAACAGTATTTAGAACTGATGC
AAAAAGTGCTCGACGAAGGCACACAGAAAAACGACCGTACCGGAACCGGAACGCTTTCCATTTTTGGTCATCAGATG
CGTTTTAACCTGCAAGATGGATTCCCGCTGGTGACAACTAAACGTTGCCACCTGCGTTCCATCATCCATGAACTGCT
GTGGTTTCTGCAGGGCGACACTAACATTGCTTATCTACACGAAAACAATGTCACCATCTGGGACGAATGGGCCGATG
AAAACGGCGACCTCGGGCCAGTGTATGGTAAACAGTGGCGCGCCTGGCCAACGCCAGATGGTCGTCATATTGACCAG
ATCACTACGGTACTGAACCAGCTGAAAAACGACCCGGATTCGCGCCGCATTATTGTTTCAGCGTGGAACGTAGGCGA
ACTGGATAAAATGGCGCTGGCACCGTGCCATGCATTCTTCCAGTTCTATGTGGCAGACGGCAAACTCTCTTGCCAGC
TTTATCAGCGCTCCTGTGACGTCTTCCTCGGCCTGCCGTTCAACATTGCCAGCTACGCGTTATTGGTGCATATGATG
GCGCAGCAGTGCGATCTGGAAGTGGGTGATTTTGTCTGGACCGGTGGCGACACGCATCTGTACAGCAACCATATGGA
TCAAACTCATCTGCAATTAAGCCGCGAACCGCGTCCGCTGCCGAAGTTGATTATCAAACGTAAACCCGAATCCATCT
TCGACTACCGTTTCGAAGACTTTGAGATTGAAGGCTACGATCCGCATCCGGGCATTAAAGCGCCGGTGGCTATCTAA
TTACGAAACATCCTGCCAGAGCCGACGCCAGTGTGCGTCGGTTTTTTTACCCTCCGTTAAATTCTTCGAGACGCCTT
CCCGAAGGCGCCATTCGCCATTCAGGCTGCGCAACTGTTGGGAAGGGCGATCGGTGCGGGCCTCTTCGCTATTACGC
CAGCTGGCGAAAGGGGGATGTGCTGCAAGGCGATTAAGTTGGGTAACGCCAGGGTTTTCCCAGTCACGACGTTGTAA
AACGACGGCCAGTGCCAAGCTTTCTTTAATGAAGCAGGGCATCAGGACGGTATCTTTGTGGAGAAAGCAGAGTAATC
TTATTCAGCCTGACTGGTGGGAAACCACCAGTCAGAATGTGTTAGCGCATGTTGACAAAAATACCATTAGTCACATT
ATCCGTCAGTCGGACGACATGGTAGATAACCTGTTTATTATGCGTTTTGATCTTACGTTTAATATTACCTTTATGCG
ATGAAACGGTCTTGGCTTTGATATTCATTTGGTCAGAGATTTGAATGGTTCCCTGACCTGCCATCCACATTCGCAAC
ATACTCGATTCGGTTCGGCTCAATGATAACGTCGGCATATTTAAAAACGAGGTTATCGTTGTCTCTTTTTTCAGAAT
ATCGCCAAGGATATCGTCGAGAGATTCCGGTTTAATCGATTTAGAACTGATCAATAAATTTTTTCTGACCAATAGAT
ATTCATCAAAATGAACATTGGCAATTGCCATAAAAACGATAAATAACGTATTGGGATGTTGATTAATGATGAGCTTG
ATACGCTGACTGTTAGAAGCATCGTGGATGAAACAGTCCTCATTAATAAACACCACTGAAGGGCGCTGTGAATCACA
AGCTATGGCAAGGTCATCAACGGTTTCAATGTCGTTGATTTCTCTTTTTTTAACCCCTCTACTCAACAGATACCCGG
TTAAACCTAGTCGGGTGTAACTACATAAATCCATAATAATCGTTGACATGGCATACCCTCACTCAATGCGTAACGAT
AATTCCCCTTACCTGAATATTTCATCATGACTAAACGGAACAACATGGGTCACCTAATGCGCCACTCTCGCGATTTT
TCAGGCGGACTTACTATCCCGTAAAGTGTTGTATAATTTGCCTGGAATTGTCTTAAAGTAAAGTAAATGTTGCGATA
TGTGAGTGAGCTTAAAACAAATATTTCGCTGCAGGAGTATCCTGGAAGATGTTCGTAGAAGCTTACTGCTCACAAGA
AAAAAGGCACGTCATCTGACGTGCCTTTTTTATTTGTACTACCCTGTACGATTACTGCAGCTCGAGTTAGGATACCG
GCACTTTGATCCAACCAGTCGGGTAGATATCCGGTGCTTCGGAGTGCTGGAACCAACGGCTCGGCACAATAACAGTC
TTATCCATATTAGGGTTCAGCCAGGCACCCCACCAAGAAAACGTGCTGTTACAAATGATGTGATGTTTGCAATGAGA
CATCAGCATCATATCCTGCCAGGAGTCTTCATCAGTGTTCCAGTCAATATAAACCGCATTCTGCAGTGGCAGATTTT
CTTTAACCCACGCGATATCGTCGGAGAAGATATAGTAAGATGGGCTAGCAACACGACGGGACATTTCCGCGATAGCA

TTCTGGTAATACGGCAGCTGGCACACGGAACCGGTAGTAGCCCAGTGTTTCGGCTGCAGATAGTCACCACGACGAAT
GTGCAGGGAAACCGCGTTTTCATCTTTGTCCAGGATTTCCAGCATGTTCAGGCTGCGGGAATTTGCTTTGTTCTTAT
CAAAGGTGAAGGATTCACGCACTTCGTCTTTGATATCAGCGAAGAAACGCTCGCTCTGATAGAAACCTTTAAAGTAC
AGCAGCGGCCAGAAATACTTCTTCTCGAACGCACGCAGAGAGTTCGGCGCCTGCTTGCGTTCGTAGATTTTTTTAAA
AAACAGGAATTCGATAACTTTTTTCAGCGGTTGGTTGATGCAGAATTCGGTGTGCGGCAGGTTGAACACGCGGTGCA
TTTCGTAACCGTAATGGACTTTGTAATGCATCATGTCGCTCAGGTCGATACGGACCTTCGGGTAATACTTTTTCATA
CGCAGATAGAAAGCATAGATAAACATCTGGTTGCCCAGACCGCCAGTCACTTTGATCAGACGCATTATATCTCCTTC
TTG

[0128] 从培养肉汤后发酵产物中纯化通过代谢工程设计的大肠杆菌细胞产生的岩藻糖基化低聚糖。示范性的过程包括五个步骤。(1)净化:收获发酵肉汤并且通过早制备离心机中以6000xg处理30分钟沉淀,以除去细胞。每个生物反应器运行产率大约是5-7升部分澄清的上清液。(2)在粗糙的碳上收获产物:一个装满粗糙的碳(六偏磷酸钠12x40TR)的柱,体积大约为1000毫升(尺寸5厘米直径x 6厘米长度)用1柱体积(CV)的水平衡并用澄清的培养上清液以40毫升/分的流苏装载。该柱具有大约120克糖的容量。在装载和糖捕获之后,用1.5CV的水洗涤柱并用2.5CV50%的乙醇或者25%异丙醇洗提(在此步骤中较少浓度的乙醇(25-30%)就足够进行产物洗提)。该溶剂洗提步骤释放大约95%的柱上总结合糖和一小部分有色体。在第一步骤,收获最大量的糖是主要目标。污染物再溶解不是目的。(3)蒸发:来自捕获柱的2.5升的乙醇或者异丙醇洗提液在56℃下进行旋转蒸发并在水中产生糖浆。该步骤可以使用的替换性的方法包括冷冻干燥法或者喷雾干燥法。(4)在精细碳和离子交换介质上进行快速色谱法:柱(GE医疗HiScale50/40,5x40厘米,最大压力20bar)与Biotage Isolera One FLASH色谱系统相连,所述系统填充有750毫升的Darco活性碳G60(100-筛):硅藻土535(粗糙的)1:1混合物(两种柱填充物都来自Sigma公司)。所述柱用5CV的水平衡并使用硅藻土定量装载器或者直接注入装载来自步骤3的糖(10-50克,取决于2'-岩藻糖基乳糖(2'-FL)与污染物乳糖的比例)。所述柱与蒸发的光散射(ELSD)检测器相连检测色谱法期间洗提的糖的峰值。异丙醇、乙醇或者甲醇分别运行四步梯度从而从单糖(如果存在的话)、乳糖和有色体中分离2'-岩藻糖基乳糖(2'-FL)。在120毫升瓶子、池里自动收集糖峰值所对应的部分直接用于步骤5。在某些纯化工程中,运行时间长于正常的发酵步骤,使包含2'-岩藻糖基乳糖(2'-FL)的部分通过阴离子交换柱和阳离子交换柱,可以去掉过度的蛋白质/DNA/焦糖体污染物。能够成功的实现这些目的的树脂是Dowex 22。

[0129] 已经成功的使用这里所描述的基因筛查方法确定新型的α(1,2)FT在代谢工程大肠杆菌宿主菌株中有效的生物合成2'-岩藻糖基乳糖(2'-FL)。筛选结果概括在表1中。

[0130] 宿主菌株的产生

[0131] 大肠杆菌K-12是一种被广泛研究的细菌,在微生物生理学和遗传学一级商业开发中已经广泛的作为研究主体进行各种工业应用。亲本种大肠杆菌的天然栖息地是哺乳动物的大肠。大肠杆菌K-12具有安全使用的历史,并且其衍生物用于许多工业应用中,包括产生适用于人类给药和消费的化学品和药物。大肠杆菌K-12本来是在1922年从恢复期白喉病人中分离出来的。由于其缺乏毒性特征,容易在普通实验室介质上生长,已经被广泛的用于微生物生理学和遗传学研究,她已经变成标准细菌学菌株用于微生物研究、教课和产生适用于工业和医药的产物。大肠杆菌K-12目前被认为是一种致衰弱的有机体可以在实验室环境

下维持70年。因此，在正常情况下K-12不适于移植入人类和其他动物的大肠中。关于这种非常著名的菌株的其他信息可以在以下网址中发现：http://epa.gov/oppt/biotech/pubs/fra/fra004.htm.除了大肠杆菌K12之外，多种细菌菌株可以被用于产生宿主菌株，例如，多种细菌菌株可以用于低聚糖生物合成方法，例如，草生欧文氏杆菌(成团泛菌)、弗氏柠檬细菌、柠檬泛菌、胡萝卜软腐病果胶杆菌或者黄单胞菌。还可以使用杆菌类的细菌，包括枯草杆菌、地衣芽孢杆菌、凝结芽孢杆菌、嗜热杆菌、侧孢芽胞杆菌、巨大芽孢杆菌、霉菌样杆菌、短小芽胞杆菌、迟缓芽胞杆菌、蜡样芽胞杆菌和环状杆菌。同样，使用本发明所述方法可以对乳杆菌属和乳球菌属进行修饰，包括但是不局限于嗜酸乳杆菌、唾液乳杆菌、植物乳杆菌、瑞士乳杆菌、戴耳布吕克氏乳杆菌、鼠李糖乳杆菌、保加利亚乳杆菌、卷曲乳杆菌、加氏乳杆菌、干酪乳杆菌、罗伊氏乳杆菌、詹氏乳杆菌和乳酸乳球菌。嗜热生物链球菌和费氏丙酸杆菌(Propinibacterium freudenreichii)也属于适合于这里所描述的发明的细菌种类。同样作为本发明一部分的是菌株，进行这里所描述的修饰，来源于肠道球菌种类(例如，屎肠球菌和嗜热生物肠道球菌)、双歧杆菌属(例如，牛角椒双歧杆菌、婴儿双岐杆菌和两岐双岐杆菌)、芽孢乳杆菌属、Micromomospora spp.、小球菌属、红球菌属和假单胞菌属(例如，荧光假单胞菌和绿脓杆菌)。

[0132] 适当的宿主菌株易于进行基因操作，例如，他们维持表达构建物、积累所需终产物的前体，例如，维持乳糖库和鸟苷二磷酸-岩藻糖库，并积累最终产品，例如，2'-岩藻糖基乳糖(2'-FL)。这种菌株在定义的最低限度培养基中生长良好，所述最低限度培养基包含简单的盐并通常含有单一碳源。如上所述进行工程设计的菌株用于产生理想的岩藻糖基化的低聚糖，这种菌株在最低限度培养基中生长。生物反应器中使用的示范性的最低限度培养基(最小"FERM"培养基)如下所述。

[0133] Ferm(10升)：最低限度培养基包括：

[0134] 40g $(NH_4)_2HPO_4$

[0135] 100g KH_2PO_4

[0136] 10g $MgSO_4.7H_2O$

[0137] 40g NaOH

[0138] 1X Trace元素：

[0139] 1.3g NTA(次氮基三乙酸)

[0140] 0.5g $FeSO_4.7H_2O$

[0141] 0.09g $MnCl_2.4H_2O$

[0142] 0.09g $ZnSO_4.7H_2O$

[0143] 0.01g $CoCl_2.6H_2O$

[0144] 0.01g $CuCl_2.2H_2O$

[0145] 0.02g H_3BO_3

[0146] 0.01g $Na_2MoO_4.2H_2O$(pH 6.8)

[0147] 10升水

[0148] DF204抗泡沫(0.1毫升/升)

[0149] 150克甘油(最初的批量生长)，随后用90％甘油-1％ MgSO4-1X痕量元素饲料，不同时间采用不同速率。

[0150] 合适的生产宿主细菌菌株是与来源细菌菌株不同的菌株，所述来源细菌菌株中可以识别出编码岩藻糖转移酶的核酸序列。

[0151] 在乳糖存在的情况下培养具有这里所描述的特征的细菌，并且检查来自细菌本身或者来自细菌培养上清液中的岩藻糖基化的低聚糖。纯化岩藻糖基化的低聚糖用于治疗性或者营养性产物，或者细菌直接在这些产物中应用。

[0152] 实施例

[0153] 实施例1::新颖α(1,2)-岩藻糖转移酶的识别

[0154] 为了识别其他新颖的α(1,2)岩藻糖转移酶，使用CLCbio Main Workbench程序包6.9版本进行校准运算产生多重序列的校准查询(CLCbio,10Rogers Street#101,剑桥,马萨诸塞02142,美国)使用四个之前确定的乳糖-利用性α(1,2)岩藻糖转移酶蛋白质序列:螺杆菌幽门futC(SEQ ID NO:1)、H.mustelae FutL(SEQ ID NO:2)、普通拟杆菌futN(SEQ ID NO:3)和大肠杆菌0126wbgL(SEQ ID NO:4)。图3显示了序列校准和四个预先确定的乳糖-利用性α(1,2)岩藻糖转移酶蛋白质序列之间的序列同一性百分比。进行迭代的PSI-BLAST，使用FASTA-型多重序列对准进行查询，并且在NCBI BLAST+版本2.2.29的本地拷贝上运行NCBI PSI-BLAST程序。使用PSI-BLAST产生起始位置产生特异性划线基质文件(.pssm)，然后使用该程序调整迭代同源性检索运行数值。重复这一过程产生更大组的候选物，并且每次运行的结果用于进一步改善所述基质。

[0155] 起始位置-特异性划线基质文件的一部分显示如下：

[0156]

Last position-specific scoring matrix computed

		A	R	N	D	C	Q	E	G	H	I	L	K	M	F	P	S	T	W	Y	V
1	M	-1	-1	-2	-3	-2	0	-2	-3	-2	1	2	-1	6	0	-3	-2	-1	-2	-1	1
2	A	2	-2	0	4	-2	-1	1	-1	-1	-2	-3	-1	-2	-3	-1	1	-1	-3	-3	-1
3	F	-2	-3	-3	-4	-3	-3	-3	-3	-1	0	0	-3	0	7	-4	-3	-2	1	3	-1
4	K	0	3	0	-1	-2	1	0	-1	-1	-3	-3	3	-2	-3	-1	2	0	-3	-2	-2
5	V	-1	-3	-3	-4	-1	-3	-3	-4	-3	4	2	-3	1	0	-3	-2	-1	-3	-1	3
6	V	-1	-3	-3	-3	-1	-3	-3	-4	-3	4	1	-3	1	-1	-3	-2	0	-3	-1	3
7	Q	-1	4	0	-1	-3	4	1	-2	0	-3	-2	3	-1	-3	-2	0	-1	-3	-2	-3
8	I	-1	-3	-3	-4	-1	-2	-3	-4	-3	3	2	-3	1	0	-3	-2	-1	-3	-1	3
9	C	-1	-1	0	-1	5	3	0	-2	4	-2	-2	0	-1	-2	-2	0	2	-2	-1	-1
10	G	0	-3	-1	-1	-3	-2	-2	6	-2	-4	-4	-2	-3	-3	-2	0	-2	-3	-3	-3
11	G	0	-3	-1	-1	-3	-2	-2	6	-2	-4	-4	-2	-3	-3	-2	0	-2	-3	-3	-3
12	L	-2	-2	-4	-4	-1	-2	-3	-4	-3	2	4	-3	2	0	-3	-3	-1	-2	-1	1
13	G	0	-3	-1	-1	-3	-2	-2	6	-2	-4	-4	-2	-3	-3	-2	0	-2	-3	-3	-3
14	N	-2	-1	6	1	-3	0	0	-1	1	-4	-4	0	-2	-3	-2	1	0	-4	-2	-3
15	Q	-1	1	0	0	-3	6	2	-2	0	-3	-2	1	-1	-3	-1	0	-1	-2	-2	-2
16	M	-1	-2	-3	-4	-2	-1	-2	-3	-2	1	3	-2	5	0	-3	-2	-1	-2	-1	1
17	F	-2	-3	-3	-4	-3	-3	-4	-3	-1	0	0	-3	0	7	-4	-3	-2	1	3	-1
18	Q	-1	0	-1	-1	-3	5	1	-2	0	1	-1	1	0	-2	-2	-1	-1	-2	-2	0
19	Y	-2	-2	-3	-3	-3	-2	-3	-3	1	-1	-1	-2	-1	5	-3	-2	-2	2	6	-1
20	A	4	-1	-1	-1	-1	-1	-1	0	-2	-2	-2	-1	-1	-2	-1	2	0	-3	-2	-1
21	F	-2	-3	-3	-4	-3	-3	-4	-3	-1	0	0	-3	0	7	-4	-3	-2	1	3	-1
22	A	3	-2	-1	-2	-1	-1	-1	4	-2	-2	-2	-1	-2	-3	-1	1	-1	-3	-2	-1
23	K	-1	0	-1	-2	-3	0	-1	-3	1	-2	-2	3	-1	2	-2	-1	-1	1	6	-2
24	S	2	-1	-1	-2	-1	-1	-1	-1	-2	-1	1	-1	0	-1	-1	3	0	-3	-2	0
25	L	-2	3	-2	-3	-2	-1	-2	-3	-2	1	3	0	1	0	-3	-2	-1	-2	-1	0
26	Q	0	0	0	-1	-2	4	1	-2	-1	-1	0	0	3	-2	-2	2	0	-2	-2	-1
27	K	-1	2	0	-1	-3	1	0	-2	-1	-2	-2	4	-1	-3	-1	0	2	-3	-2	-2
28	H	-1	0	0	-2	-3	0	0	-2	6	1	-1	2	-1	-1	-2	-1	-1	-3	0	0
29	S	-1	-1	3	-1	-2	-1	-1	-2	0	-1	1	-1	0	1	-2	1	0	0	4	-1
30	N	-1	-1	4	0	-3	-1	-1	3	0	-3	-3	-1	-2	0	-3	0	-1	-1	4	-3
31	T	-1	-2	-1	-2	-2	-1	-2	-2	-2	1	-1	-1	-1	-2	5	0	3	-3	-2	0
32	P	-1	0	-2	-1	-3	0	-1	-2	-2	-3	-3	2	-2	-4	7	-1	-1	-4	-3	-3
33	V	-1	-3	-3	-4	-1	-2	-3	-4	-3	2	2	-3	1	-1	-3	-2	0	-3	-1	4
34	L	-2	3	-2	-3	-2	-1	-2	-3	0	0	2	0	1	1	-3	-2	-1	0	4	-1
35	L	-2	-3	-4	-4	-2	-3	-3	-4	-3	3	3	-3	1	3	-3	-3	-1	-1	1	1
36	D	-2	-2	1	6	-4	0	1	-2	-1	-4	-4	-1	-3	-4	-2	0	-1	-5	-3	-4

[0157] 所使用的PSI-BLAST命令行如下所示：

[0158] psiblast-db＜LOCAL NR database name＞-max_target_seqs2500-in_msa＜MSA

file in FAST format＞-out＜results output file＞-outfmt“7sskingdoms sscinames scomnames sseqid stitle evalue length pident”-out_pssm＜PSSM file output＞-out_ascii_pssm＜PSSM(ascii)output＞-num_iterations 6-num_threads 8

[0159] 这种PSI-BLAST检索产生最初2515个采样数。其中787个采样数与FutC具有大于22％的序列一致性。396个采样数的氨基酸长度大于275。对采样进行补充分析，包括根据对FutC的一致性百分比分类，用BLAST将序列与现存的α(1,2)-岩藻糖转移酶库存量(已知的α(1,2)-岩藻糖转移酶)，并手动注释采样序列，确定来源于细菌的、天然存在于胃肠道的序列。通过这种筛选识别出的新型α(1,2)岩藻糖转移酶的注释列表显示在表1中。表1提供了发现候选酶的细菌种类、GenBank登记号码、GI标识号码、氨基酸序列和与FutC的序列同一性％。

[0160] 对四种已知α(1,2)FT进行的多重序列校准用于PSI-BLAST查询，12种新确定的α(1,2)FT显示在图4中。

[0161] 实施例2：新型α(1,2)FT的验证

[0162] 为了检测乳糖-利用性岩藻糖基转移酶活性，在表达候选酶(即，变体)的宿主有机体中评价岩藻糖基化的低聚糖(即，2’-岩藻糖基乳糖(2’-FL))的产生，并且其包含细胞质的鸟苷二磷酸-岩藻糖和乳糖库。岩藻糖基化低聚糖的产生说明候选酶-编码序列起到了乳糖-利用性α(1,2)岩藻糖转移酶的作用。在所有识别的采样中，对12种新型α(1,2)岩藻糖转移酶进行进一步分析，分析其产生2′-岩藻糖转移酶的能力：产黑素普雷沃菌FutO、梭状芽孢杆菌(Clostridium bolteae)+13FutP、毛螺菌科FutQFutP、甲烷微菌属(Methanosphaerula palustris)FutR、坦纳菌属(tannerella sp.)FutS、粪拟杆菌FutU、丁酸弧菌属FutV、普雷沃菌属FutW、乔治普氏菌(parabacteroides johnsonii)FutX、肠道疣微菌(Akkermansia muciniphilia)FutY、肠道沙门氏菌FutZ、拟杆菌FutZA。

[0163] 构造包括12种新型α(1,2)FT的变种，结构如下：EcoRI-T7g10RBS-syngene-XhoI.图5A和图5B显示了PCR装配和凝胶提纯后的变体片段。

[0164] 通过标准分子生物技术将候选α(1,2)FT(即，变种)克隆进入是示范性的表达质粒pEC2-(T7)-Fut syngene-rcsA-thyA中.该质粒利用强有力的左侧启动子噬菌体1(叫做PL)直接表达候选基因(Sanger,F.et al.(1982).J Mol Biol 162,729-773).所述启动子是可控制的，例如，trp-cI构建物被稳定的整合到大肠杆菌宿主基因组(在ampC位点)中，并且通过向生长培养基中加入色氨酸进行控制。使用对温度敏感的cI阻断剂逐步诱导完成蛋白质表达。已经描述了另一个类似控制策略(与温度无关的表达系统)(Mieschendahl et al.,1986,Bio/Technology 4:802-808).该质粒还携带大肠杆菌rcsA基因从而上调鸟苷二磷酸-岩藻糖合成，这是岩藻糖-连接的低聚糖合成的一种至关重要的前体。另外，所述质粒携带一种β-内酰胺酶(bla)基因和一种天然的thyA(胸苷酸合酶)基因，其中，所述β-内酰胺酶(bla)基因用于通过氨苄青霉素选择(为了方便起见在实验室中)将所述质粒维持在宿主菌株中，所述天然thyA(胸苷酸合酶)基因是thyA-宿主中的替换性选择方法。

[0165] 表达构建物被转入宿主菌株，有效用于产生2’-岩藻糖基乳糖(2’-FL)。用于实验不同α(1,2)FT候选物的宿主菌株整合上述所有遗传修饰，如上所述，并且具有以下基因型：

[0166] ΔampC::P_{trp}^{B}cI，Δ(lacI-lacZ)::FRT，P_{lacIq}lacY^{+}，ΔwcaJ::FRT，thyA::Tn10，Δlon:(npt3，lacZ^{+})，ΔlacA

[0167] 分析含有不同α(1,2)FT候选物表达质粒的大肠杆菌菌株。菌株在选择性培养基(缺少胸腺嘧啶)中生长到早期指数生长期。然后加入乳糖使其最后浓度为0.5％,并加入色氨酸(200μ M)诱导从PL启动子处表达每个候选α(1,2)FT。在诱导期末端(大约24小时),收获培养物上清液和细胞。从全细胞中制备热提取物,并且每个菌株0.20D600单位当量被用于通过薄层色层分析法(TLC)分析2'-岩藻糖基乳糖(2'-FL)的存在,同时每个菌株有2毫升相应的澄清的培养物上清液。

[0168] 图6显示了由α(1,2)FT-表达细菌产生的低聚糖,通过培养物上清液和细菌细胞提取物的薄层色谱分析确定。通过WbgL(用作参照)、FutO、FutP、FutQ、FutR、FutS、FutU、FutW、FutX、FutZ和FutZA的外源表达产生2′-岩藻糖基乳糖(2′FL)。

[0169] 表4概括了每个候选变种的岩藻糖转移酶活性,如上所述通过2′-岩藻糖基乳糖(2′FL)合成筛确定。12种候选α(1,2)FT中的11种被发现具有乳糖-利用性岩藻糖转移酶活性。

[0170] 表4. 2′-岩藻糖基乳糖(2′FL)合成筛结果

[0171]

	变种	24h OD (诱导的)	2'-FL 培养介质	2'-FL 细胞提取物			
大肠杆菌	WbgL	9.58	5	5	pG204	pEC2-WbgL-rcsA-thyA	E640
产黑素普雷沃菌	FutO	12.2	3	2	pG393	pEC2-(T7)FutO-rcsA-thyA	E985
梭状芽孢杆菌	FutP	10.4	1	2	pG394	pEC2-(T7)FutP-rcsA-thyA	E986
毛螺菌科	FutQ	10.6	3	4	pG395	pEC2-(T7)FutQ-rcsA-thyA	E987
甲烷微菌属	FutR	11.9	0	1	pG396	pEC2-(T7)FutR-rcsA-thyA	E988
坦纳菌属	FutS	11.3	2	3	pG397	pEC2-(T7)FutS-rcsA-thyA	E989
粪拟杆菌	FutU	12.1	0	2	pG398	pEC2-(T7)FutU-rcsA-thyA	E990
丁酸弧菌属	FutV	11.3	0	1	pG399	pEC2-(T7)FutV-rcsA-thyA	E991
普雷沃菌属	FutW	10.5	3	3	pG400	pEC2-(T7)FutW-rcsA-thyA	E992
乔治普氏菌	FutX	10.7	3	5	pG401	pEC2-(T7)FutX-rcsA-thyA	E993
肠道疣微菌	FutY	9.1	0	0	pG402	pEC2-(T7)FutY-rcsA-thyA	E994
肠道沙门氏菌	FutZ	11.0	0	3	pG403	pEC2-(T7)FutZ-rcsA-thyA	E995
拟杆菌	FutZA	9.9	3	3	pG404	pEC2-(T7)FutZA-rcsA-thyA	E996

[0172] 实施例3:表达新型α(1,2)FT的培养物的表征

[0173] 对表达新型α(1,2)FT FutO、FutQ和FutX的细菌被进一步的表征。具体地说,检验增殖比率和外源α(1,2)FT实验。

[0174] 包含岩藻糖转移酶WbgL(质粒pG204)、FutN(质粒pG217)和新型α(1,2)FT FutO(质粒pG393)、FutQ(质粒pG395)、和FutX(pG401)的表达质粒被引入宿主细菌菌株。例如,这里所利用的宿主菌株具有以下基因型:ΔampC::P_{trp}^{B}cI,Δ(lacI-lacZ)::FRT,P_{lacIq}lacY^{+},ΔwcaJ::FRT,thyA::Tn10,Δlon:(npt3,lacZ^{+}),ΔlacA

[0175] 在乳糖存在的情况下,通过添加色氨酸来诱导表达每个外源岩藻糖转移酶的细菌培养物(为了诱导外源岩藻糖转移酶的表达)。通过在以下时间点,在A600下记录分光光度计读数监控培养物的生长:诱导前4小时和1小时,在诱导时(时间0),和诱导后3小时、7小时和24小时。结果显示在图7中,并且显示外源岩藻糖转移酶的表达不会防止细胞增殖。而且,适合表达新型α(1,2)岩藻糖转移酶FutO、FutQ、和FutX的细菌培养物的生长曲线与表达已知的α(1,2)FT酶WbgL和FutN的生长曲线相似。

[0176] 同时,对在诱导后表达每个岩藻糖转移酶的细菌培养物评价蛋白质表达。按照如前所述诱导培养物,并且从细菌培养物中制备蛋白质溶解产物,在诱导的时候(0小时)、3小

时、7小时和24小时之后。在SDS-PAGE凝胶上运行蛋白质溶解产物，并染色检验每个时间点的蛋白质分布。如图8所示，对于表达外源FutN、FutO和FutX的细胞培养物，在诱导后7小时和24小时在大约20-28kDa附近显示增加的蛋白质条带。这些结果显示所述诱导导致外源岩藻糖转移酶显著的表达。

[0177] 最后，额外的薄层色谱分析用于评价表达新型α(1,2)FT FutO、FutQ、和FutX的细菌培养物产生2′-岩藻糖基乳糖(2′FL)的效力和产率，与已知的岩藻糖转移酶WbgL和FutN相比。在第7小时和第24小时诱导培养物并进行薄层色谱。图9A显示了2′-岩藻糖基乳糖(2′FL)在所述细胞上清液中的水平。在细菌细胞中发现的2′-岩藻糖基乳糖(2′FL)水平也被检验。如图9B所示，显示了诱导后第7小时和第24小时后，来自表达新型α(1,2)FT FutO、FutQ和FutX的细菌中的细胞溶解产物产生的2′-岩藻糖基乳糖(2′FL)。

[0178] 实施例4:FutN显示出增加的产生2′-岩藻糖基乳糖(2′FL)的效率

[0179] 从培养肉汤后发酵产物中纯化通过代谢工程设计的大肠杆菌细胞表达普通拟杆菌FutN产生的岩藻糖基化低聚糖。

[0180] 收获发酵肉汤并且通过早制备离心机中以6000xg处理30分钟沉淀，以除去细胞。每个生物反应器运行产率大约是5-7升部分澄清的上清液。一个装满粗糙的碳(六偏磷酸钠12x40TR)的柱，体积大约为1000毫升(尺寸5厘米直径x 6厘米长度)用1柱体积(CV)的水平衡并用澄清的培养上清液以40毫升/分的流苏装载。该柱具有大约120克糖的容量。在装载和糖捕获之后，用1.5CV的水洗涤柱并用2.5CV 50％的乙醇或者25％异丙醇洗提(在此步骤中较少浓度的乙醇(25-30％)就足够进行产物洗提)。该溶剂洗提步骤释放大约95％的柱上总结合糖和一小部分有色体。来自捕获柱的2.5升的乙醇或者异丙醇洗提液在56℃下进行旋转蒸发并在水中产生糖浆。柱(GE医疗HiScale50/40，5x40厘米，最大压力20bar)与Biotage Isolera One FLASH色谱系统相连，所述系统填充有750毫升的Darco活性碳G60(100-筛)：硅藻土535(粗糙的)1：1混合物(两种柱填充物都来自Sigma公司)。所述柱用5CV的水平衡并使用硅藻土定量装载器或者直接注入装载来自步骤3的糖(10-50克，取决于2’-岩藻糖基乳糖(2’-FL)与污染物乳糖的比例)。所述柱与蒸发的光散射(ELSD)检测器相连检测色谱法期间洗提的糖的峰值。异丙醇、乙醇或者甲醇分别运行四步梯度从而从单糖(如果存在的话)、乳糖和有色体中分离2’-岩藻糖基乳糖(2’-FL)。在120毫升瓶子中自动收集相对于糖峰值的部分，入库。

[0181] 图10A和图10B显示了两个发酵运行的结果。培养物生长136小时(运行36B)或者112小时(运行37A)，通过薄层色谱分析产生的2’-岩藻糖基乳糖(2’-FL)的水平。如图10A和图10B所示，在培养的第40小时产生2′-岩藻糖基乳糖，并且产量继续增加直到发酵过程结束。由36B产生的2’-岩藻糖基乳糖(2’-FL)产率是33克每升。由37A产生的2’-岩藻糖基乳糖(2’-FL)产率是36.3克每升。该结果显示外源FutN的表达适合于高产量的产生2′-岩藻糖基乳糖产物。

[0182]

表 1. 适合于新颖 α（1，2）-岩藻糖转移酶的 PSI-BLAST 多重序列校准查询采样

细菌名称	登记号	GI No.	基因名称[细菌的]	% 同源性 FutC	序列名	序列	SEQ ID NO
幽门螺杆菌	AAD2986 9.1	48085 99	α-1,2-岩藻糖转移酶 [幽门螺杆菌]	98	Fu tC	MAFKVVQICGGLGNQMFQYAFAKSLQKHSNTPVLLDITSFDWSDRKMQLELFPINLPYASA KEIAIAKMQHLPKLVRDALKCMGFDRVSQEIVFEYEPELLKPSRLTYFYGYFQDPRYFDAISP LIKQTFTLPPPPENNKNNNKKEEEYHRKLSLILAAKNSVFVHIRRGDYVGIGCQLGIDYQKK ALEYMAKRVPNMELFVFCEDLEFTQNLDLGYPFMDMTTRNKEEEAYWDMLLMQSCQHGII ANSTYSWWAAYLIENPEKIIIGPKHWLFGHENILCKEWVKIESHFEVKSQKYNA	1
雪貂螺杆菌；雪貂螺杆菌 12198	YP_00351 7185.1	29127 7413	α-1,2-岩藻糖转移酶 [雪貂螺杆菌 12198]	70.85	Fu tL	MDFKIVQVHGGLGNQMFQYAFAKSLQTHLNIPVLLDTTWFDYGNRELGLHLFPIDLQCASA QQIAAAHMQNLPRLVRGALRRMGLGRVSKEIVFEYMPELFEPSRIAYFHGYFQDPRYFEDISP LIKQTFTLPHPTEHAEQYSRKLSQILAAKNSVFVHIRRGDYMRLGWQLDISYQLRAIAYMAK RVQNLELFLFCEDLEFVQNLDLGYPFVDMTTRDGAAHWDMMLMQSCKHGIITNSTYSWW AAYLIKNPEKIIIGPSHWIYGNENILCKDWVKIESQFETKS	2
多形杆状菌；普通拟杆菌 ATCC 8482；多形杆状菌属 4_3_47FAA；多形杆状菌属 3_1_40A；普通拟杆菌 PC510；普通拟杆菌 CL09T03C04；普通拟杆菌 dnLKV7；普通拟杆菌 CAG:6	YP_00130 0461.1	15000 5717	糖基转移酶家族蛋白 [普通拟杆菌 ATCC 8482]	24.83	Fu tN	MRLIKVTGGLGNQMFIYAFYLRMKKYYPKVRIDLSDMMHYKVHYGYEMHRVFNLPHTEFC INQPLKKVIEFLFFKKIYERKQAPNSLRAFEKKYFWPLLLYFKGFYQSERFFADIKDEVRESFTF DKNKANSRSLNMLEILDKDENAVSLHIRRGDYLQPKHWATTGSVCQLPYYQNAIAEMSRRV ASPSYYIFSDDIAWVKENLPLQNAVYIDWNTDEDSWQDMMLMSHCKHHIICNSTFSWWGA WLNPNMDKTVIVPSRWFQHSEAPDIYPTGWIKVPVS	3
大肠杆菌；大肠杆菌 UMEA 3065-1	WP_0215 54465.1	54525 9828	蛋白质 [大肠杆菌]	23.13	W bg L	MSIIRLQGGLGNQLFQFSFGYALSKINGTPLYFDISHYAENDDHGGYRLNNLQIPEEYLQYYT PKINNIYKLLVRGSRLYPDIFLFLGFCNEFHAYGYDFEYIAQKWKSKKYIGYWQSEHFFHKHI LDLKEFFIPKNVSEQANLLAAKILESQSSLSIHIRRGDYIKNKTATLTHGVCSLEYYKKALNKI RDLAMIRDVFIFSDDIFWCKENIETLLSKKYNIYYSEDLSQEEDLWLMSLANHHIIANSSFSW WGAYLGSSASQIVIYPTPWYDITPKNTYIPIVNHWINVDKHSSC	4

[0183]

					Fu		MGDYKIVELTCGLGNQMFQYAFAKALQKHLQVPVLLDKTWYDTQDNSTQFSLDIFNVDLE
					tD		YATNTQIEKAKARVSKLPGLLRKMFGLKKHNIAYSQSFDFHDEYLLPNDFTYFSGFFQNAKY
胆型螺旋杆菌；胆型螺旋杆菌 ATCC 43879	WP_0052 19731.1	49136 1813	预测的蛋白质 [胆型螺旋杆菌]	36.79			LKGLEQELKSIFYYDSNNFSNFGKQRLELILQAKNSIFIHIRRGDYCKIGWELGMDYYKRAIQ
							YIMDRVEEPKFFIFGATDMSFTEQFQKNLGLNENNSANLSEKTITQDNQHEDMFLMCYCKH
							AILANSSYSFWSAYLNNDANNIVIAPTPWLLDNDNIICDDWIKISSK
					W		MEVKIIGGLGNQMFQYATAFAIAKRTHQNLTVDISDAVKYKTHPLRLVELSCSSEFVKKAWPF
					bs		EKYLFSEKIPHFMKKGMFRKHYVEKSLEYDPDIDTKSINKKIVGYFQTEKYFKEFRHELIKEF
	AAO3769	37788	岩藻糖转移酶		J		QPKTKFNSYQNELLNLIKENDTCSLHIRRGDYVSSKIANETHGTCSEKYFERAIDYLMNKGV
大肠杆菌	8.1	088	[大肠杆菌]	25.94			INKKTLLFIFSDDIKWCRENIFFNNQICFVQGDAYHVELDMLLMSKCKNNIISNSSFSWWAA
							WLNENKNKTVIAPSKWFKKDIKHDIIPESWVKL
					W		MIVMKISGGLGNQLFQYAVGRAIAIQYGVPLKLDVSAYKNYKLHNGYRLDQFNINADIANE
					bl		DEIFHLKGSSNRLSRILRRLGWLKKNTYYAEKQRTIYDVSVFMQAPRYLDGYWQNEQYFSQ
	BAA3363	37216	可能的 β-D-半乳糖苷 2-α-L-岩藻糖基转移酶 [霍乱弧菌]		A		IRAVLLQELWPNQPLSINAQAHQIKIQQTHAVSIHVRRGDYLNHPEIGVLDIDYYKRAVDYIK
							EKIEAPVFFVFSNDVAWCKDNFNFIDSPVFIEDTQTEIDDLMLMCQCQHNIVANSSFSWWAA
霍乱弧菌	2.1	82		25.94			WLNSNVDKIVIAPKTWMAENPKGYKWVPDSWREI
							MIVSSLRGGLGNQMFTYAMVKAMALRNNVPFAFNLTTDFANDEVYKRKLLLSYFALDLPEN
							KKLTFDFSYGNYYRRLSRNLGCHILHPSYRYICEERPPHFFESRLISSKITNAFLEGYWQSEKYF
脆弱杆菌；脆弱杆菌 NCTC 9343；脆弱杆菌 YCH46；脆弱杆菌 HMW 615	YP_09911 8.1	53713 126	α-1,2-岩藻糖转移酶 [脆弱杆菌 YCH46]	24.58	Bf t2		LDYKQEIKEDFVIQKKLEYTSYLELEEIKLLDKNAIMIGVRRYQESDVAPGGVLEDDYYKCA
							MDIMASKVTSPVFFCFSQDLEWVEKHLAGKYPVRLISKKEDDSGTIDDMFLMMHFRNYIIS
							NSSFYWWGAWLSKYDDKLVIAPGNFINKDSVPESWFKLNVR
					W		MSIVVARLAGGLGNQMFQYAKGYAESVERNSYLKLDLRGYKNYTLHGGFRLDKLNIDNTF
					bg		VMSKKEMCIFPNFIVRAINKFPKLSLCSKRFESEQYSKKINGSMKGSVEFIGFWQNERYFLEH
大肠杆菌；大肠杆菌 KTE84	WP_0015 92236.1	48635 6116	蛋白质 [大肠杆菌]	24.25	N		KEKLREIFTPININLDAKELSDVIRCTNSVSVHIRRGDYVSNVEALKIIHGLCTERYYIDSIRYL
							KERFNNLVFFVFSDDIEWCKKYKNEIFSRSDDVKFIEGNTQEVDMWLMSNAKYHIIANSSFS
							WWGAWLKNYDLGITIAPTPWFEREELNSFDPCPEKWVRIEK
							MKIVKILGGLGNQMFQYALYLSLQESFPKERVALDLSSFHGYHLHNGFELENIFSVTAQKAS
			糖基转移酶 家族 11 [产黑素普雷沃菌 ATCC				AADIMRIAYYYPNYLLWRIGKRFLPRRKGMCLESSSLRFDESVLRQEGNRYFDGYWQDERY
产黑素普雷沃菌；产黑素普雷沃菌 ATCC 25845	YP_00381 4512.1	30234 6214	25845]	31.1	Fu tO		FAAYREKVLKAFTFPAFKRAENLSLLEKLDENSIALHVRRGDYVVGNNLYQGICDLDYYRTAI
							EKMCAHVTPSLFCIFSNDITWCQQHLQPYLKAPVVYVTWNTGVESYRDMQLMSCCAHNIIA
							NSSFSWWGAWLNQNREKVVIAPKKWLNMEECHFTLPASWIKI

[0184]

梭状芽孢杆菌（Clostridium bolteae）；梭状芽孢杆菌（Clostridium bolteae）90A9；梭状芽孢杆菌（Clostridium bolteae）90B3；梭状芽孢杆菌（Clostridium bolteae）90B8	WP_0025 70768.1	48863 4090	蛋白质 [梭状芽孢杆菌（Clostridium bolteae）]	29.86	Fu tP	MFQYALYKAFEQKHIDVYADLAWYKNKSVKFELYNFGIKINVASEKDINRLSDCQADFVSRI RRKIFGKKKSFVSEKNDSCYENDILRMDNVVYLSGYWQTEKYFSNTREKLLEDYSFALVNSQ VSEWEDSIRNKNSVSIHIIRRGDYLQGELYGGICTSLYYAEAIEYIKMRVPNAKFFVFSDDVEW VKQQEDFKGFVIVDRNEYSSALSDMYLMSLCKHNIIANSSFSWWAAWLNRNEEKIVIAPRR WLNGKCTPDIWCKKWIRI	11
毛螺科菌 3_1_57FAA_CT1	WP_0092 51343.1	49654 5268	蛋白质 [毛螺科菌 3_1_57FAA_CT1]	29.25	Fu tQ	MVIVQLSGGLGNQMFEYALYLSLKAKGKEVKIDDVTCYEGPGTRPRQLDVFGITYDRASRE ELTEMTDASMDALSRVRRKLTGRRTKAYRERDINFDPLVMEKDPALLEGCFQSDKYFRDCE GRVREAYRFRGIESGAFPLPEDYLRLEKQIEDCQSVSVHIRRGDYLDESHGGLYTGICTEAYY KEAFARMERLVPGARFFLFSNDPEWTREHIFESKNCVLVEGSTEDTGYMDLYLMSRCRHNIIA NSSFSWWGAWLNENPEKKVIAPAKWLNGRECRDIYTERMIRL	12
甲烷微菌属（Methanosphaerula palustris）；甲烷微菌属（Methanosphaerula palustris）E1-9c	YP_00246 7213.1	21985 2781	糖基转移酶家族蛋白 [甲烷微菌属（Methanosphaerula palustris）E1-9c]	28.52	Fu tR	MIIVRLKGGLGNQLSQYALGRKIAHLHNTELKLDTTWFTTISSDTPRTYRLNNYNIIGTIASA KEIQLIERGRAQGRGYLLSKISDLLTPMYRRTYVRERMHTFDKAILTVPDNVYLDGYWQTEK YFKDIEEILRREVTLKDEPDSINLEMAERIQACHSVSLHVRRGDYVSNPTTQQFHGCCSIDYY NRAISLIEEKVDDPSFFIFSDDLPWAKENLDIPGEKTFVAHNGPEKEYCDLWLMSLCQHIIIA NSSFSWWGAWLGQDAEKMVIAPRRWALSESFDTSDIIPDSWITI	13
坦那菌属（Tannerella sp.）CAG:118	WP_0219 29367.1	54718 7521	糖基转移酶家族 11 [坦那菌属（Tannerella sp.）CAG:118]	28.38	Fu tS	MVRIVEIIGGLGNQMFQYAFSLYLKNKSHIWDRLYVDIEAMKTYDRHYGLELEKVFNLSLCP ISNRLLHRNLQKRSFAKHFVKSLYEHSECEFDEPVYRGLRPYRYYRGYWQNEGYFVDIEPMIR EAFQFNVNILSKKTKAIASKMRRELSVSIHVRRGDYENLPEAKAMHGGICSLDYYHKAIDFI RQRLDNNICFYLFSDDINWVEENLQLENRCIIDWNQGEDSWQDMYLMSCCRHHIIANSSFS WWAAWLNPNKNKIVLTPNKWFNHTDAVGIVPKSWIKIPVF	14
类拟杆菌（Bacteroides caccae）；类拟杆菌（Bacteroides caccae）ATCC 43185	WP_0056 75707.1	49192 5845	蛋白质 [类拟杆菌（Bacteroides caccae）]	28.09	Fu tU	MKIVKILGGLGNQMFQYALFLSLKERFPHEQVMIDTSCFRNYPLHNGFEVDRIFAQKAPVAS WRNILKVAYPYPNYRFWKIGKYILPKRKTMCVERKNFSFDAAVLTRKGDCYYDGYWQHEE YFCDMKETIWEAFSFPEPVDGRNKEIGALLQASDSASLHVRRGDYVNHPLFRGICDLDYYK RAIHYMEERVNPQLYCVFSNDMAWCESHLRALLPGKEVVYVDWNKGAESYVDMRLMSLC RHNIIANSSFSWWGAWLNRNPQKVVVAPERWMNSPIEDPVSDKWIKL	15

[0185]

					Fu		MIIIQLKGGLGNQMFQYALYKSLKKRGKEVKIDDKTGFVNDKLRIPVLSRWGVEYDRATDE
	WP_0227	55102	蛋白质［丁酸弧菌属		Fu		EIINLTDSKMDLFSRIRRKLTGRKTFRIDEESGKFNPEILEKENAYLVGYWQCDKYFDDKDVV
	WP_0227	55102	蛋白质［丁酸弧菌属		Fu		REIREAFEKKPQELMTDASSWSTLQQIECCESVSLHVRRTDYVDEEHIHHHNICTEKYYKNAI
	72718.1	8636	AE2015］	27.8	tV	16	DRVRKQYPSAVFFIFTDDKEWCRDHFKGPNFIVVELEEGDGTDIAEMTLMSRCKHHIIANSSF
丁酸弧菌属 AE2015	72718.1	8636	AE2015］	27.8	tV	16	SWWAAWLNDSPEKIVIAPQKWINNRDMDDIYTERMTKIAL
					Fu		MRLVKMIGGLGNQMFIYAFYLQMRKRFSNVRIDLTDMMHYNVHYGYELHKVFGLPRTEFC
			未定性的蛋白		t		MNQPLKKVLEFLFFRTIVERKQHGRMEPYTCQYVWPLVYFKGFYQSERYFSEVKDEVRECF
	WP_0224	54826	质［普雷沃菌		W		TFNPALANRSSQQMMEQIQNDPQAVSIHIRRGDYLNPKHYDTIGCICQLPYYKHAVSEIKKY
普雷沃菌 CAG:891	81266.1	4264	CAG:891］	27.4	W	17	VSNPHFYVFSEDLDWVKANLPLENAQYIDWNKGADSWQDMMLMSCCKHHIICNSTFSWW
普雷沃菌 CAG:891	81266.1	4264	CAG:891］	27.4	W	17	AAWLNPSVEKTVIMPEQWTSRQDSVDFVASCGRWVRVKTE
					Fu		MRLIKMIGGLGNQMFIYAFYLKMKHHYPDTNIDLSDMVHYKVHNGYEMNRIFDLSQTEFCI
			糖基转移酶[约		Fu		NRTLKKILEFLFFKKIYERRQDPSTLYPYEKRYFWPLLIYFKGFYQSERFFFDIKDDVRKAFSFN
			氏副杆状菌（紫		Fu		LNIANPESLELLKQIEVDDQAVSIHIRRGDYLLPRHWANTGSVCQLPYYKNAIAEMENRITGP
约氏副杆状菌；拟杆菌	WP_0081	49543	单胞菌属		tX		SYYVFSDDISWVKENIPLKKAVYVTWNKGEDSWQDMMLMSHCRHHIICNSTFSWWGAWL
CL02T12C29	55883.1	1188	johnsonii）］	26.69	tX	18	NPRKEKIVIAPCRWFQHKETPDMYPKEWIKVPIN
					Fu		MRLFGGLGNQLFQYAFLFALSRQGGKARLETSSYEHDDKRVCELHHFRVSLPIEGGPPPWAF
			糖基转移酶家		Fu		RKSRIPACLRSLFAAPKYPHFREEKRHGFDPGLAAPPRRHTYFKGYFQTEQYFLHCREQLCR
网络肠道细菌			族蛋白［网络		Fu		EFRLKTPLTPENARILEDIRSCCSISLHIRRTDYLSNPYLSPPPLEYYLRSMAEMEGRLRAAGA
（Akkermansia			肠道细菌		Fu		PQESLRYFIFSDDIEWARQNLRPALPHVHVDINDGGTGYFDLELMRNCRHHIIANSTFSWWA
muciniphila）；网络肠道细			（Akkermansia		Fu		AWLNEHAEKIVIAPRIWFNREEGDRYHTTDDALIPGSWLRI
菌（Akkermansia			muciniphila）		Fu		
muciniphila）ATCC	YP_00187	18773	ATCC		tY		
BAA-835	7555.1	5443	BAA-835］	25.67	tY	19	
					Fu		MYSCLSGGLGNQMFQYAAAYILKQYFQSTTLVLDDSYYYSQPKRDTVRSLELNQFNISYDR
					Fu		FSFADEKEKIKLLRKFKRNPFPKQISEILSIALFGKYALSDRAFYTFETIKNIDKACLFSFYQDA
肠道沙门氏菌；肠道沙门					Fu		DLLNKYKQLILPLFELRDDLLDICKNLELYSLIQRSNNTTALHIRRGDYVTNQHAAKYHGVL
氏菌亚属 鼠伤血清型	WP_0232	55522	岩藻糖转移酶		tZ		DISYYNHAMEYVERERGKQNFIIFSDDVRWAQKAFLENDNCYVINNSDYDFSAIDMYLMSL
ATCC BAA-1673	14330.1	1695	[肠道沙门氏菌]	25.99	tZ	20	CKNNIIANSTYSWWGAWLNKYEDKLVISPKQWFLGNNETSLRNASWITL
					Fu		MRLIKMTGGLGNQMFIYAFYLRMKKRYPKVRIDLSDMVHYHVHHGYEMIIRVFNLPHTEFC
			糖基转移酶 家		Fu		INQPLKKVIEFLFFKKIYERKQDPNSLRAFEKKYLWPLLIYFKGFYQSERFFADIKDEVRKAFT
			族 11［多形杆状		Fu		FDSSKVNARSAELLRRLDADANAVSLHIIRRGDYLQPQHWATTGSVCQLPYYQNAIAEMNRR
	WP_0221	54774	菌属		tZ		VAAPSYYVFSDDIAWVKENIPLQNAVYIDWNKGEESWQDMMLMSHCRHHIICNSTFSWWG
多形杆状菌属 CAG:633	61880.1	8823	CAG:633］	26.01	A	21	AWLDPHEDKIVIVPNRWFQHCETPNIYPAGWVKVAIN

[0186]

梭状芽孢杆菌属 CAG:306	WP_0222 47142.1	54783 9506	α-1 2-岩藻糖转移酶 [梭状芽孢杆菌属 CAG:306]	34.28		MEKIKIVKLQGGMGNQMFQYAFGKGLESKFGCKVLFDKINYDFLQKTIINNTGKNAEGICV RKYELGIFNLNIDFATAEQIQECIGEKLNKACYLPGFIRKIFNLSKNKTVSNRIFEKKYGEYDE EILKDYSLAYYDGYFQNPKYFEDISDKIKKEFTLPEIKNHDIYNKKLLEKITQFENSVFIHVRR DDYLNINCEIDLDYYQKAVKYILKHIENPKFFVFCAEDPDYIKNHFDIGYDFELVGENNKTQ DTYYENMRLMMACKHAIIANSSYSWWAAWLSDYDNKIVIAPTPWLPGISNEIICKNWIQIKR GISNE	22
牙周脓肿普雷沃菌 306；牙周脓肿普雷沃菌 306 菌株 F0472	WP_0094 34595.1	49700 4957	蛋白质 [牙周脓肿普雷沃菌 306]	32.11		MKIVKILGGLGNQMFQYALYLSLQESFPKERVALDLSCFNGYHLHNGFELERIFSLTAQKASA ATIMRIAYYYPNYLLWRIGKRLLPRRKTMCLESSTFRYDESVLTREGNRYFDGYWQDERYFV ACREKVLKAFTFPAFKRTENLSLLRKLDKNSVAIHVRRGDYIGNQLYQGICDLDYYRAAIDKI STYVTPSVFCIFSNDIAWCQTHLQPYLKAPVVYVTWNTGTESYRDMQLMSCCAHNIIANSSF SWWGAWLNQNNEKVVIAPKRWLNMDDCQFPLPASWVKI	23
肠道菌（Brachyspira sp.）CAG:484	WP_0219 17109.1	54713 9308	糖基转移酶家族 11 [肠道菌 CAG:484]	30.14		MQLVKLMGGLGNQMFQYAFAKALGDKNILFYGDYKKHSLRKVELNRFKCKAVYIPRELFK YLKFVFTKFDKIEYMRSGIYVPEYLNRDGNHIYIGFWQTEKYFKQIRPRLLKDFTPRKKLDR ENAGIISKMQQINSVSVHIRRTDYVDESHIYGDTNLDYYKRAIEYISSKIENPEFFFSDDMAY VKEKFAGLKFPHSFIDINSGNNSYKDLILMKNCKHNIIANSTFSWWGAWLNENEEKIVIAPAK WFVTGENDKDIVPDEWIKL	24
玫瑰海旋菌（Thalassospira profundimaris）；玫瑰海旋菌（Thalassospira profundimaris）WP0211	WP_0088 89330.1	49616 4823	糖基转移酶家族 11 [玫瑰海旋菌（Thalassospira profundimaris）]	30		MVIVKLLGGLGNQMFQYATGRAVASRLDVELLLDVSAFAHYDLRRYELDDWNITARLATSE ELARSGVTAAPPSFFDRIARFLRIDLPVNCFREASFTYDPRILEVSSPVYLDGYWQSERYFLDI EKKLRQEFQLKASIDANNHSFKKKIDGLGKQAVSLHVRRGDYVTNPQTASYHGVCSLDYYR AAVDYIAEHVSDPCFFVFSDDLEWVQTNLNIKQPIVLVDANGPDNGAADMALMMACRHHII ANSSFSWWGSWLNPLNDKIIVAPKKWFGRANHDTTDLVPDSWVRL	25
醋酸杆菌 CAG:267	WP_0220 78656.1	54745 9369	α-1 2-岩藻糖转移酶 [醋酸杆菌 CAG:267]	29.9		MAVSPQESKYSAHVSPDKPLRIVRLGGGLGNQMFQYAFGLAAGDVLWDNTSFLTNHYRSFD LGLYNISGDFASNEQIKKCKNEIRFKNILPRSIRKKFNLGKFIYLKTNRVCERQINRYEPELLSK DGDVYYDGVFQTEKYFKPLRERLLHDFTLTKPLDAANLDMLAKIRAADAVAVHIRRGDYLN PRSPFTYLDKDYFLNAMDYIGKRVDKPHIFFISSDTDWVRTNIQTAYPQTITVEINDEKHGYFD LELMRNCRHNIIANSTFSWWGAWLNTNPDKIVVAPKQWFRPDAAEYSGDIVPNDWIKL	26
木质素厌氧降解产氢菌（Dysgonomonas mossii）；木质素厌氧降解产氢菌（Dysgonomonas mossii）DSM 22836	WP_0068 42165.1	49389 6281	蛋白质 [木质素厌氧降解产氢菌（Dysgonomonas mossii）]	29.9		MVTVLLSGGLGNQMFQYAAAKSLAIRLNTALSVDLYTFSKKTQATVRPYELGIFNIEDVVET SSLKAKAVIKARPFIQRHRSFFQRFGVFTDTYAILYQPTFEALTGGVIMSGYFQNESYFKNISE LLRKDFSFKYPLIGENKDVAGQISENQSVAVHIRRGDYLNKNSQSNFAILEKDYYEKAINYIS AHVKNPEFYVFSEDFDWIKDNLNLNFKEFPVTFIDWNKGKDSYIDMQLMSLCKHNIIANSSFSW WSAWLNNSEERKIVAPERWFVDEQKNELLDCFYPQGWIKI	27

[0187]

梭状芽孢杆菌属 KLE 1755	WP_0216 36924.1	54539 6671	糖基转移酶，家族 11 [梭状芽孢杆菌属 KLE 1755]	29.83	>gi|545396671|ref|WP_021636924.1| 糖基转移酶，家族 11 [梭状芽孢杆菌属 KLE 1755]MIIIEISGGLGNQMFQYALGQKFISMGKEVKYDLSFYNDRVQTLRQFELDIFDLDCPVA SNSELSRFGKGNSLKSRLKQKLGWDKEKIYEENLDLGYQPRIFELDDIYLSGYWQSELYFKD IREQILRLYTFPIQLDYMNGVFLRKIENSNSVSIHIRRGDYLNENNLKIYGNICTLNYYNKALQ IIAKKITNPIIFVFTNDIEWVRKELEIPNMVIVDCNSGKLSYWDMYLMSKCKANIVANSSFSW WGAWLNKNENRIIISPKRWLNNHEQTSTLCDNWIRCGDD	28
椎实螺黄杆菌（Gillisia limnaea）；椎实螺黄杆菌（Gillisia limnaea）DSM 15749	WP_0069 88068.1	49404 5950	α-1,2-岩藻糖转移酶 [椎实螺黄杆菌（Gillisia limnaea）]	29.28	MFISKNTVIIKLVGGLGNQMFQFAIAKIIAEKESEVLVDITFYTELTENTKKFPRHFSLGIFNS SFAIASKKEIDYFTKLSNFNKFKKKLGLNYPTIFHESSFNFKAQVLELKAPIYLNGYFQSFRYF LGKEYVIRKIFKFPDEALDKDNDNIKRKIIGKTSVSLHIRRGDYVVNNKKTQQFHGNCTIDYYY QSAIAYLSSKLTDFNLIFFSDDIHWVRQQFKNISNQKIYVSGNLNHNSWKDMYLMSLCDHNII ANSSFSWWGAWLNKNPEKIIIAPKRWFADTEQDKNSIDLIPSEWYRI	29
嗜甲基菌属（Methylotenera mobilis）；嗜甲基菌属（Methylotenera mobilis）JLW8	YP_00304 8467.1	25399 6403	糖基转移酶家族蛋白 [嗜甲基菌属（Methylotenera mobilis）JLW8]	29.19	MLVSRIIGGLGNQMFEYAAARAASLRISVQLKLDLSGFETYDLHAYGLNNFNIVEDVAKKDD YFIGAPESLLKKIKKYLRGLIQLESFRESDLSFDSKVLELNDNTYLDGYWQCERYFIDFDKQI RQDFSFKFAPDALNQRYLELIDSVNAVSVHIRRGDYVSNSTTNEIHGVCDLDYYQRAAEFMR ARIGPENLHIFVFSDDTDWVKENISFGSDTTFISHNDAAKNYEDMRLMSACKHHIIANSSFS WWAAWLNPSKQKVVIAPRQWFKSTLLNSDDIVPASWVRL	30
Runella slithyformis；Runella slithyformis DSM 19594	YP_00465 8567.1	33821 4504	糖基转移酶家族蛋白 [Runella slithyformis DSM 19594]	29.14	MIIVKLSGGLGNQLFQYAFGRIILATVNQKELKLDTSALTKTSDWTNRSYALDAFNIRAQEAT PEEIKALAGKPNRLLQRVGRKVGITPIQYFQEPHFHFYSSALSIKSSHYLEGYWQSEKYFEAIT PILREEFAFTISPSTHAQTIKEKISNGTSVSIHLRRGDYVVKTSKANRYLRPLTMDYYQKAIDYI NQRVKNPNFFLFSDDIKWAKSQVTFPPTTHFSTGTSAHEDLWLMTHCRHHIIANSTFSWWGA WLNQQPDKIVIAPQKWFSTERFDTKDLLPEPWIQL	31
河豚毒素假交替单胞菌；河豚毒素假交替单胞菌 ANT/505	WP_0029 58454.1	48904 8235	α-1,2-岩藻糖转移酶 [河豚毒素假交替单胞菌]	29.1	MIKVKAIGGLGNQLFQYATARAIAEKRGDGVVVDMSDFSSYKTHPFCLNKFRCKATYESKP KLINKLLSNEKIRNLLQKLGFIKKYYFETQLPFNEDVLLNNSINYLTGYFQSEKYFLSIRECLL DELTLIEDLNIAETAVSKAIKNANKNSISIHIRRGDYVSNEGANKTHGVCDSDYFKKALNYFSE RKLLDEHTELFIFSDDIEWCRNNLSFDYKMNFVDGSSERPEVDMVLMSQCKHQVISNSTFS WWGAWLNKNDEKVVVAPKEWFKSTDLDSTDIVPNQWIKL	32
未培养细菌	EKE0667 9.1	40698 5989	糖基转移酶家族 11 [未培养细菌]	28.67	MLTLKLKGGLGNQMFQYAASHNLAKNKKTKINFDLSFFSDIEVRDIKRDYLLDKFNISADISF DQKNSISGFRKFLVKVISKFFGEVFYYRLKFLSSKYLDGYFQSEKYFKNVEEDIRKDFTLKDE MGVEAKKIEQQIVNSKNSVSLHIRRGDYVVDDLKTNIYHGVCNLDYYKRSIKYLKENFGEINI FVFSDDIAWVKENLAFENLQFVSRPDIKDYEELMLMSKCEHNIIANSSFSWWGAWLNENKN KIIIAPKEWFQKFNINEKHIVPKSWIRL	33

[0188]

梭状芽孢杆菌属 KLE 1755	WP_0216 36949.1	54539 6696	糖基转移酶，家族 11 [梭状芽孢杆菌属 KLE 1755]	28.57		MVIVQLSGGLGNQMFEYALYLSLKAKGKVVKIDDITCYEGPGTRPKQLDVFGVSYERATKQ ELTEMTDSSLDPVSRIRRKLTGRKTKAYREKDINFDPQVMERDPALLEGCFQSEKYFQDCRE QVREAYRFRGIESGAYPLPEAYRRLEKEIADCKSVSVHIRRGDYLEESHGGLYTGICTEQYYQ EAFARMEKEVPGAKFFLFSNDPDWTREHFKGENRILVEGSTEDTGYLDLYLMSKCKHNIIAN SSFSWWGAWLNDNPEKKVTAPARWLNGRECRDIYTERMIRI	34
粪梭弗兰西斯菌；粪梭弗兰西斯菌粪梭亚属 ATCC 25015	WP_0042 87502.1	49041 4974	α-1,2-岩藻糖转移酶 [粪梭弗兰西斯菌]	28.57		MKIIKIQGGLGNQMFQYAFYKSLKNNCIDCYVDIKNYDTYKLHYGFELNRIFKNIDLSFARK YHKKFVLGKLFSIIPSKFIVKFNKNYILQKNFAFDKAYFEIDNCYLDGYWQSEKYFKKITKDI YDAFTFEPLDSINFEFLKNIQDYNLVSIHVRRGDYVNHIPLHGGICDLEYYNKAISFIRSKVAN VHFLVFSNDILWCKDNLKLDRVTYIDHNRWMDSYKDMHLMSLCKHNIIANSSFSWWGAWL NQNDDKIVIAPSKWFNDDKINQKDICPNSWVRI	35
荧光假单胞菌；荧光假单胞菌 NCIMB 11764	WP_0173 37316.1	51590 6733	蛋白质 [荧光假单胞菌]	28.52		MVIAHLIGGLGNQMFQYAAARALSSAKKEPLLLDTSSFESYTLHQGFELSKLFAGEMCIARD KDINIIVLSWQAFPRIRNFLHRPKLAFLRKASLIIEPSFHIYWNGIQKAPADCYLMGYWQSERY FQDAAEEIRKDFTFKLNMSPQNIATADQILNTNAISLHVRRGDYVNNSVYAACTVEYYQAAI QLLSKRVDAPTFFVFSDDIDWVKNNLNIGFPHCYVNHNKGSESYNDMRLMSMCQHNIIANS SFSWWGAWLNSNADKIVVAPKQWFINNTNVNDLFPPAWVTL	36
苹螺菌属 YR522	WP_0081 17381.1	49539 2680	糖基转移酶家族 11 [苹螺菌属 YR522]	28.48		MIATRLIGGLGNQMFQYAAGRALALRVGSPLLLDVSGFANYELRRYELDGFRIDATAASAQQ LARLGVNATPGTSLLARVLRKVWPQPADRILREASFTYDARIFQASAPVYLDGYWQSERYFA RIRQHLLDEFTLKGDWGSDNAAMAAQIATAGAGAVSLHVRRGDYVSNAHTAQYHGVCSLD YYRDAVAHIGGRVEAPHFFVFSDDHEWVRENLQIGHPATFVQINSADHGIYDMMLMKSCRH HIIANSSFSWWGAWLNPAEDKIVVAPQRWFKDATNDTRDLIPAAWVRL	37
纽织普雷沃菌（Prevotella histicola）；纽织普雷沃菌（Prevotella histicola） F0411	WP_0088 22166.1	49609 7659	蛋白质[纽织普雷沃菌（Prevotella histicola）]	28.43		MKIVKILGGLGNQMFQYALYSLKETFPQENVTVDLSCFHGYHLHNGFEIARIFSLHPDKAT VMEILRIAYYYPNYFFWQIGKRVLPQRKTMCTESTKLLFDKSVLQREGDRYFDGYWQDERY FIDCRRTILNTFKFPPFTDDNNLALLKKMDTNSVSIHVRRGDYVVGNKLYQGICDLNYYREAI MKISSYISPSMFCVFSNDIEWCRDNLESFIKAPIYYVDWNSGTESYRDMQLMSCCGHNIIANS SFSWWGAWLNQNSSKIVIAPKRWINLKNCGFMLPSRWVKI	38
黄杆菌属 WG21	WP_0174 94954.1	51606 4371	蛋白质 [黄杆菌属 WG21]	28.42		MIVVQLIGGLGNQLFQYAAAKALALQTKQKFSLDVSQFESYKLHNYALNHFNVISKNYKKP NRYLRKIKSFYQKNVFYKEVDFGYNPDLIHLKGGIIFLEGYFQSEKYFIKYEKEIREDFELRTP LKKETKAAIAKIESVNSVSIHIRRGDYINNPLHNTSKEEYYNKALEIVENKINNPVYFVFSDD MEWVKANFSTKQETIFIDFNDASTNFEDLKLMTSCKHNIIANSSFSWWGGWLNKNPDKIVIA PKRWFNDDSINTNDIIPTNWVKI	39

[0189]

弗兰极地杆菌（Polaribacter franzmannii）	WP_0189 44517.1	51777 4309	蛋白质［弗兰极地杆菌（Polaribacter franzmannii）］	28.42		40
极地杆菌属 MED152	YP_00767 0847.1	47232 1325	糖基转移酶家族 11［极地杆菌属 MED152］	28.42		41
甲烷球菌（Methanococcus maripaludis）；甲烷球菌（Methanococcus maripaludis）C7	YP_00132 9558.1	15040 2264	糖基转移酶家族蛋白［甲烷球菌（Methanococcus maripaludis）C7］	28.19		42
披毛菌属 SCGC AAA018-N21	WP_0182 93379.1	51710 4561	蛋白质［披毛菌属 SCGC AAA018-N21］	28.15		43
稻螺旋菌（Azospira oryzae）；脱氯藻（Dechlorosoma suillum）PS	YP_00502 6324.1	37248 6759	Glycosyl 转移酶家族 11［苏氏脱氯菌（Dechlorosoma suillum）PS］	28.04		44
帕鲁普雷沃菌（Prevotella paludivivens）	WP_0184 63017.1	51727 4199	蛋白质［帕鲁普雷沃菌（Prevotella paludivivens）］	28		45

[0190]

凡寨堤芽兰氏菌（Gramella forsetii）；凡寨堤芽兰氏菌（Gramella forsetii）KT0803	YP_86060 9.1	12043 4923	α-1,2-岩藻糖转移酶 [凡寨堤芽兰氏菌（Gramella forsetii） KT0803]	27.96		MSNKNPVIVEIMGGLGNQMFQFAVAKLLAEKNSSVLLVDTNFYKEISQNLKDFPRYFSLGIFD ISYKMGTENGMVNFKNLSFKNRVSRKLGLNYPKIFKEKSYRFDADLFNKKTPIYLKGYFQSY KYFIGVESKIRQWFEFPYENLGVGNEEIKSKILEKTSVSVHIIRRGDYVVENKKTKEFHGNCSLE YYKNAITYFLDIVKEFNIVFFSDDISWVRDEFKDLPNEKVFVTGNLHENSWKDMYLMSLCD HNIIANSSFSWWAAWLNNNSEKNVIAPKKWFADIDQEQKSLDLLPPSWIRM	46
嗜中性铁氧化菌（Mariprofundus ferrooxydans）；嗜中性铁氧化菌（Mariprofundus ferrooxydans）PV-1	WP_0098 49029.1	49753 4831	α-1,2-岩藻糖转移酶 [嗜中性铁氧化菌（Mariprofundus ferrooxydans）]	27.92		MIIVQFTGGLGNQMFQYALGRRLSLLHDVELKFDLSFYQHDILRDFMLDRFQVNGQVATEK EIEAYTNTPIFALDRPLLDRLVRWGLYRGIVSVSDEPPGKQALMVYNSRVLQAPRNTYVQGY WQSEKYFMPIRQKLLDDFSLVDKADQANGAMLEKIRQCHSVSLHVRRGDYVSNPLTNHSH GTCGLEYYEKAIALIGSKVDDPHFFVFSDDPEWTRDHLKCRFPMTYVTCNSADSCEWDMEL MRHCRDHIIANSSFSWWGAWLNMNPDKVVVAPAAWFNNFSADTSDLIPDSWVRI	47
蜡样芽胞杆菌；蜡样芽胞杆菌 VD107	WP_0021 74293.1	48810 2896	蛋白质 [蜡样芽胞杆菌]	27.91		MKIIQVSSGLGNQMFQYALYKKISLNDNDVFLDSSTSYMMYKNQHNGYELERIFHIKPRHA GKEIIDNLSDLDSELISRIRRKLFGAKKSMYVELKEFEYDPIIFEKKETYFKGYWQNYNYFKD IFQELRKDFVFTEKLDKRNEKLANEIRNKNSVSIHIRRGDYYYLNKVYFEKFGNIANLEYYLK AINLVKKKIEDPKFYIFSDDIDWAQKNINLTNDVVYISHNQGNESYKDMQLMSLCKHNIIANS TFSWWGAFLNNNDDKIVVAPKKWINIKGLEKVELFPENWITY	48
厚壁菌门细菌 CAG:534	WP_0223 52106.1	54795 1299	蛋白质 [厚壁菌门细菌 CAG:534]	27.81		MIIIRMTGGLGNQMFQYALYLKLRAMGKEVKMDDFTEYEGREARPLSLWAFGIEYDRASRE ELCRMTDGFLDPVSRIRRKLFGRKSLEYMEKDCNFDPEILNRDPAYLTGYFQSEKYFADIEEE VRQAFRFSERIWEGIPSQLLERIRSYEQQIKTTMAVSVHIRRGDYLQNEEAYGGICTERYYKT AIEYVKKRQQDASFFVFTNDPDYAGEWILKNFGQEKERFVLIEGTQEENGYLDLYLMSLCR HHILANSSFSWWGAYLNPSREKMVIVPHKWFGNQECRDIYMENMIRIAKEQS	49
无机营养微好氧氧化菌（Sideroxydans lithotrophicus）；无机营养微好氧氧化菌（Sideroxydans lithotrophicus）ES-1	YP_00352 5501.1	29161 5344	糖基转移酶家族 11 [无机营养微好氧氧化菌（Sideroxydans lithotrophicus） ES-1]	27.81		MVISNIIGGLGNQMFQYAAARALSLKLEVPLKLDISGFTNYALHQGFELDRIFGCKIEIASEAD VHEILGWQSASGIRRVVSRPGMSIFRRKGFVVEPHFSYWNGIRKITGDCYLAGYWQSEKYFL DAAVEIRKDFSFKLPLDSHNAELAEKIDQENAVSLHIRRGDYANNPLTAATHGLCSLDYYRKS IKHIAGQVRNPYFFVFSDDIAWVKDNLEIEFPSQYVDYNHGSMSFNDMRLMSLCKHHIIANS SFSWWGAWLNPNPEKVVIAPERWFANRTDVQDLLPPGWVKL	50

[0191]

						MIVSQIIGGLGNQMFQYATGRALSHRLHDTFFLDLDGFSGYQLHQGFELSNVFQCEVNVATR SQMQALLGWRSFSSVRRLLMKRSLKWARGHRVMIEPHFIHYWSRFAEINEGCYLSGYWQSE RYFKPIENIIRQDFKFNHLLKGVNLDLAQQMTEVNSVSLHVRRGDYASDANTNHTHGLCPL DYYRDAILYIAQNTVAPSFFIFSDDIEWCREHLKLSFPATYIDHNKGSNSYCDMQLMSLCHHH IIANSSFSWWGAWLNTRLDKIVIAPKQWFANGNRTDDLIPAEWLVM	51
zata 变形菌 SCGC AB-137-C09	WP_0182 81578.1	51709 2760	蛋白质 [zata 变形菌 SCGC AB-137-C09]	27.81			
肝素黄杆菌（Pedobacter heparinus）；肝素黄杆菌（Pedobacter heparinus）DSM 2366	YP_00309 0434.1	25553 0062	糖基转移酶家族蛋白 [肝素黄杆菌（Pedobacter heparinus）DSM 2366]	27.8		MKIIRFLGGLGNQMFQYAFYKSLQHRFPHVKADLQGYQEYTLHNGFELEHIFNIKVNSVSSF TSDLFYNKKWLYRKLRRILNLRNTYIEEKKLFSFDPSLLNNPKSAYYWGYWQNFQYFEHIA DDLRKDFQFRAPLSAQNQEVLDQTKLSNSISLHIRRGDYIKDPLLGGLCGPEYYQTAINYITS KVNAARFFIFSDDIDWCIANLKLQDCSFISWNKGTSSYIDMQLMSSCKHHIVANSSFSWWAA WLNPNPDKIVIAPEKWTNDKDINVRMSFPQGWISL	52
甲烷单毛杆菌	WP_0189 85060.1	51781 4852	蛋白质 [甲烷单毛杆菌]	27.78		MFQYAMGLSLAENNQTPLKLDLSQFTDYKLHNGFELSKVFNCSAETASVTQIETLLGICKYS FIRRILKNTYLKNLRPAQYVVEPFFGYWDGVNFLGDNVYLEGYWQSQKYFIDYESTIRTHFT FKNILSGENLKLSDRIKGSNSVSLHIRRGDYVTNKNNAFIGTCSLIYYQNAIEYFSTKIADPIFF IFSDDITWAKSNLRLANEIHYFVGHNQGEDSHFDMQLMSLCKHHIIANSSFSWWGAWLNPSK DKIIIAPKKWFASGLNDQDLVPKDWLRI	53
细菌红螺菌（Rhodobacterales bacterium）HTCC2255	WP_0080 33953.1	49530 9205	α-1,2-岩藻糖转移酶 [细菌红螺菌（Rhodobacterales bacterium）HTCC2255]	27.7		MIYTRIRGGLGNQLFQYSAARSLADYLNVSLGLDTREFDENSPYKMSLNHFNIRADLNPPDL IKHKKDGKIAYIIDHIKGNQKKVYKEPFLSFDKNLFSNVDGTYLKGYWQSEKYFLRNRKNIL SDINLIKKTDKFNTINLKEIKKSTSISLHIRRGDYLSNESYNETHGICSLSYYTDAVEYIKNRLG ENIKVFAFSDDPDWVLENLKLSVDIKIINNNTSANSFEDLRLMLNCDHNIIANSSFSWWGAW LNQNPEKIVISPKKWYNKKQLQNADIVPSSWLKY	54
盐泽螺旋藻	WP_0173 02658.1	51587 2075	蛋白质 [盐泽螺旋藻]	27.69		MAKIIARIRGGIGNQIFIYAAARRLELINNAELVLDSVSGFVHDLQYRQHYQLDHFHIPCRKA TPAERFEPFSRVRRYLKRQLNQRLPFEQRRYVIQESIDFDPRLIEFKPRGTVHLEGYWQSEDY FKDIEATIRQDLQIQPPTDPTNLAIVQHIIHQHTSVAVHIIRFFDQPNADTMNNAPSDYYHRAVE AMETFVPGAHYYLFSDQPEAAKSRIPLPDERVTLVNHNRGNKLAYADLWLMTQCQHFIIANS TFSWWGAWLAENQKKQVIAPGFEKREGVSWWGFKGLLPKQWIKL	55
嗜坏孤菌	WP_0104 33911.1	49811 9755	糖基转移酶家族 11 [嗜坏孤菌]	27.67		MVIVKITGGLGNQLFQYATGSALANKLSCELVLDLSFYPTQTLRKYELAKFNINARVATDREI FLAGGGNDFFSKALKKLGLTSIIFPEYIKEQESIKYVGKIDLCKSGAYLDGYWQNPLYFSQNK IELTREFLPRAQLSPSALAWKDHISQASNSVSLHVRRGDYVENAHTNNIHGTCSLEYYQHAIE KIRSEVHNPVFFVFSDDIEWCKLNLSSLAEVEFVDNTTSAIDDLMLMRQCKHSIIANSTFSW	56

[0192]

					WGAWLKLDGLVIAPRNWFSSASRNLKGIYPKEWHIL	
					MRSVVDIKGGYGNQLFCYSFGYAVSKETGSELIIDTSMLDMNNVKDRNYQLGVLGITYDSHI SYKYGKDFLSRKTGLNRLRKKSAIGFGTVVFKEKEQYVYDPSVFEIKRDTYFDGFWQSSRY FEKYSDDLRKMLKPKKISNAAEKLAEDARDCLSVSVHIRRGDYVVSLGWTLKDDYYIKALDI IKERYGSEPVFFVFSDNKKYADDFFSAAGLKYRLMDYETDDAVRDDMFLMSRCSHNIMANS	57
毛螺科菌 NK4A179	WP_0227 83177.1	55103 9510	蛋白质 [毛螺科菌 NK4A179]	27.65	SYSWWGAFLNDNKDKTVICPETGVWGGDFYPEGWMKVTASSGK	
					MIIVNLYGGLGNQMFQYALGRHLAEKNNTELKLDISAFESYKLRKYELGNLNIIEKFALPEEI SRLSTLPTGKIERFIRKTLRKPVKKPESYIKENITGGFNPKILDLQNNIYLEGYWQSEKYFIEIE DIIRKEFSFKFPATGKNKEILENILNINSVSLHIRRGDYVTNPEVNQVHGVCSLDYYKSCVDFI EKKLESPYFYIFSDDIEWVKNNLQIQSQVYYVDHNTVDNAIEDMRLMFSCKHNILANSSFSW WGAWLNSNPDKMVITPRKWFNTTYDSNDLIPERWIKL	58
未培养细菌	EKE0218 6.1	40698 0610	糖基转移酶家族蛋白 [未培养细菌]	27.57		
					MKIGIIYIVTGPYIKFWNEFYSSSQLYFCVEAEKNYEVFTDSSELASQRLPNVHIMILIEDKGW IVNVSSKSKFICEIRNQLTSYDYIFYLNGNFKFISPIYCDEILPQAEHNYLTALSFSHYLTHIPDH YPYDRNKNCNAFIPYGQGKYYFQGGFYGGRTQFVLSLSFWCRDAIEADFNKKVIARFHDES YINRYLLTQHPKVLNDKYAFQDIWPYEGEYKAIVLNKEEVPEDNNLQEMKQNYIDPSLSFLL NDELKFIPISIVQLYGGLGNQMFGYAFYLYIRHISTQERKLLIDPAPCKRYGNHNGYELPSIFSK ICQDIHISDETKNNIRKLRKGTSLSIEEVRASMPQSFKEKKQPIIFYSGCWQCVTYVETVKDEI KKDFIFDESKLNEPSAQMLRIIRRSNSVSVHIRRNDYLIGNNEFLYGGICTKSYYEKAISQMYT LLKDEPIFIYFTDDPEWVRSNFALDKSYLVDWNKNKDNWQDMYLMSACRHHIIANSSFSW WAAWLGGFPEKKVIAPSTWLNGMQTPDILPTEWIKIPITPDKKILDRICNHLILHSSYMKQLG LNSGKMGVVIFFHIYARYTQNPLYENYAGDLFDELYEEIIKGISFSFLDGLCGIAWAVEYLVH EQFIEGNTDDSLAEIDFKVMQIDPRRFTDYSFETGLEGIACYVLSRLLSPRVCSSSLTLDSVYL KDLTEACRKVPVDKANYTRLFLNYIESKEVGYSFKDVLMQVLNHSEKAFGSDGLTWQTGLT MIMR	59
脆弱杆菌；脆弱杆菌 HMW 616	WP_0058 22375.1	49236 6053	蛋白质 [脆弱杆菌]	27.46		
					MIIIQLKGGLGNQMFQYALYKELRSRGKEVKIDDVTGFVDDELRTPVLQRFGIEYDRATREE VVKLTDSKMDIFSRIRRKLTGRKTCRIDEESGTFNPDILELDEAYLVGYWQSDKYFRNEDVIA QLRQEFQKRPQEIMTDSASWATLQQIECCQSVSLHIRRTDYIDEEHNHIHNLCTEKYYKGAID RIRSQYPSAVFFIFTDDKEWCRNHFRGPNFFVVELAEKENTDIAEMLLMSSCKHHICANSSFS WWSAWLNDSPEKMVIVPNKWINNRDMDDIYTDRMTKMAI	60
丁酸弧菌属 AE3009	WP_0227 78576.1	*55103* *4739*	*蛋白质 [丁酸弧菌属 AE3009]*	27.46		

[0193]

小卵柱杆菌；小卵柱杆菌 CL02T12C04	WP_0043 17929.1	49044 7027	蛋白质 [小卵柱杆菌]	27.43		MKQTIILSGGLGNQMFQYAFFLSMKAKGKSCSLDTTLFQTNKMHNGFELKSVFDIPDSPNQ ASALHSLLIKMLRRYKPKSILTIDEPYTFCPDALESKKSFLMGDWLSPKYFESIKDVVVNAYR FIINIGNKNVDTANEMHGNNSVSIHIRRGDYLKLPYYCVCNENYYRQAIEQIKDRVDNPIFYV FSNEPSWCDSFMKEFRVNFKIVNWNQGKDSYQDMYLMTQCKHNIIANSTFSWWGAWLNN NTDKIIVAPSKWFKNSEHNINCKEWLLIDTSK	61
毛鳞苔脱硫菌 (Desulfospira joergensenii)	WP_0226 64368.1	55091 1345	蛋白质 [毛鳞苔脱硫菌 (Desulfospira joergensenii)]	27.42		MGKKYVETVVNGGLGNQIFQFSAGFALSKRLNLDLVLNISTFDSCQKRNFELYTFPKIKNSFA CIKDDDPGVFSRLRIPFLNFKEKIKQFHESHFFFDPAFFDIREPVRIEGYFQSYKYFEKYSDQL KDILLDIPLTSRLKTVLKVISSKKESVSVHIRRGDYISDQGINEVHGTLNEAYYLNSIKLMEKM FPESFFFLFTTDDPHYVEENFKFLEDTSCIISDNDCLPYEDMYLMANCHHNIIANSSFSWWGA WLNQNPEKIVIAPRKWFSRKILMEKPVMDLLPDDWILL	62
毛螺科菌 10-1	EOS7429 9.1	50781 7890	蛋白质 C819_03052 [毛螺科菌 10-1]	27.39		MNIIRMTGGLGNQMFQYALFLRLKAQGKEVKFDDRTEYKGEEARPILLWAFGIDYPAAGEE EVNELTDGVMKFSHRLRRKLFGRKSKEYREKSCNFDQQILEKEPAYFTGYFQSERYFEEVKE QVRKAFQFSGKIWGSVSKELEERIREYQTKIENKSQMPVSVHIRRGDYLENDEAYGGICTDA YYRKAIEMMEEKFPNTVFYIFSNDTGWAKQWIDHFYKEKSRFIVIEGTTEDTGYLDLFLMSK CRAHIIANSSFSWWGAWLDPDQEKIVIAPSKWVNNQDMKDIYTREMIKISPKGEVR	63
朱丽多形杆菌；朱丽多形杆菌 DSM 17855	WP_0078 32461.1	49510 7639	蛋白质 [朱丽多形杆菌]	27.33		MVVVYVGAGLANRMFQYAFALSLREKGLDVFIDEDSFIPRFDFERTKLDSVFVNVNIQRCDK NSFPLVLREDRFYKLLKRISEYMSDNRYIERWNLDYLPYTHKKASTNCIFIGFWISYKYFQSSE DAVRKAFTFKPLDSIRNVELATKLVTENSVAVHFRKNIDYLKNLPNTCPPSYYYEAINYIKKY VPNPKFYFFSDNWDWVRENIRGVEFTAVDWNPSSGIHSHCDMQLMSLCKHNIIANSTYSWW SAYLNENNNKIVVCPKDWYGGMVKKLDTIIPESWIIING	64
厚壁菌门细菌 CAG:24	WP_0219 16201.1	54712 7421	蛋白质 [厚壁菌门细菌 CAG:24]	27.33		MVIVKMSGGLGNQMFQYALYRKIQQTGKDVKLDLFSFQDKNAFRRFSLDIFPIEYQTANLEE CRKLGECSYRPVDKIRRKMFGLKESYYQEDLDKGYQPEILEMNPVYLDGYWQCERYFQDIR EKILEDYTFPKKISIESSRLQERIKNTESVSIHIRRGDYLDAANYKIYGNICTIEYYQSAISRMR KLCEKPNFYLFSNDPEWAKEIFGDTEDITIVEEDKERPDYEDMFLMSRCKHNIIANSSFSWWA AWLNQNENKRVIAPVKWFNNHSVTDVICDDWIRIDGDHKGA	65
哈氏梭菌（Clostridium hathewayi）CAG:224	WP_0220 31822.1	54729 9420	epsH [哈氏梭菌 (Clostridium hathewayi) CAG:224]	27.3		MIYVNIRGRLGNQLFIYAFARALQKSTNQQITLNYTSFRKHYNNTAMDLEQFNIPEDIMFENS KELPWFANTDGKVIRILRHYFPKLIRSILQKMNVLMWLGDEYVEVKVNKRRDIYIDGFWQS SRYFKSVYKELKNELIPKMEMSKEIKTMGDLINQKESVCVSVRRGDYVTVKKNRDVYYICD EKYLNTSIMRMVELVPNVTWFIFSDDADWVKDNIVFPGEVFYQPPRVTPLETLYLMKACKH FIISNSSFSWWGQYLSNNDNKIVIGPAKWYVDGRKTDIIEEEWIKIEV	66

[0194]

酸性五营菌（Syntrophus aciditrophicus）SB；酸性五营菌（Syntrophus aciditrophicus）	YP_46266 3.1	85860 461	α-1,2-岩藻糖转移酶［酸性五营菌（Syntrophus aciditrophicus）SB］	27.3	MVIVRLTGGIGNQMFQYAAARRVSLVNNAPLFLDLGWFQETGSWTPRKYELDAFRIAGESA SVGDIKDFKSRRQNAFFRRLPLFLKKRIFHTRQTHIIEKSYNFDPEILNLQGNVYLDGYWQSE KYFSDVDSEIRREFSFQTDPAERNRKILERIASCESVSIHIRRGDYVTLPDANAFHGLCTPAYY RLAVEQISRKVVEPVFFVFSDDIAWARGNLKLGFETCFMDQNGPDRGDEDLRLMIACRHHII ANSSFSWWGAWLCSNPEKIVYAPRKWFNNGLDTPDNIPASWIRI	67
类拟杆菌（Bacteroides caccae）；类拟杆菌（Bacteroides caccae）ATCC 43185	WP_0056 78148.1	49193 1393	蛋白质［类拟杆菌（Bacteroides caccae）］	27.27	MKIVKIIGGLGNQMFQYALYLSLKKKYPKEKIKIDISMFETYGLHNGFELKRIFDIDAEYASRE EIRELSFYIKIYKLQRIFRKIFPVRKTECVEKYDFKFMSEVWSNCDRYYEGYWQNWEYFIEA QTEVRSTFTFKKELVGRNAKVIREIQYAKMPVSLHIRRGDYLHHKLFGGLCDLNYYKKAIDY VLNNYDTPQFYLFSNDIEWCKTYILPLVQGYPFILVDWNSGVESYIDMQLMSCCRINIIANSS FSWWAAWLNDSSEKIVIAPKLWAHSPYGKEIQLKSWLLF	68
溶纤维丁酸弧菌	WP_0227 56304.1	55101 1888	蛋白质［溶纤维丁酸弧菌］	27.24	MIIIEMSGGLGNQMFQYALYKSMLHKGLDVTIDKSIYRDVDIHKEQVDLDRFPNVSYIEADR KLSSTLRGYGYNDSIIDKIRNKLNKSKRNLYHEDLDKGYQPEIFEFDNVYLNGYWQCERYFK DIKNEIKKDFIFPCTQSGDDKIKALTIEMESCNSVSLHVRRGDYLKPGLIEIYGNICTEEYYKK SIEYIKERVDNPVFYIFSNDMAWVRDNFKSDDFRYVVNEDGAEFDGMTDMYLMTRCRHNIVA NSSFSWWGAWLNKHDDNIVICPNRWVNTHTVTDIICEDWIRIDV	69
迪氏类拟杆菌（Parabacteroides distasonis）；迪氏类拟杆菌（Parabacteroides distasonis）CL03T12C09	WP_0058 57874.1	49247 6819	蛋白质［迪氏类拟杆菌（迪氏拟杆菌属（Parabacteroides distasonis））］	27.24	MIVGGNDYCKVKVVNIIGGLGNQMFQYAFALSLKEHFPKEEIRIDISHFNYLFVNKVGAANL HNGYELDKIFFNIELKKANAWQLMKLTWFIPNYLISRIARKILPVRNSEYIQNSSDCFFYDPM VYNKQGSCYYEGYWQAIGYYESMRDKLCKIFQHPSPEGKNKQYIENMESSNSVGIHIRRGD YLLSDNFRGICEVDYYKRAIDKILQDGEKHVFYLFSNDQKWCEEYILPLLGNYEIIFVTGNIG RDSCWDMFLMTHCKDLIIANSSFSWWGAFLNKRGGRVVTPKRWMNRNIRYDLWMPEWIRI	70
发光地杆菌（Geobacter uraniireducens）；发光地杆菌（Geobacter uraniireducens）Rf4	YP_00123 0447.1	14826 3741	糖基转移酶家族蛋白［发光地杆菌（Geobacter uraniireducens）Rf4］	27.21	MIIARLQGGLGNQMFQYAVGLHLALTHNVELKIDITMFSDYKWHTYSLRPFNIRESIATEEEI KALTDVKMDRPYKKIDNFLCRLLRKSQKISATHVKEKHFHYDPDILKLPDNVYLDGYWQSE KYFKEIENIIRQTFIIKNPQLGRDKELACKILSTESVCLHIRRGNYVVTDKTTNSVLGPCDLSYY SNCIKSLAGNNKDPHFFVFSNDHEWVSKNLKLDYPTIYVDHNNEDKDYEDLRLMSQCKHHI IANSTFSWWSAWLCSNPDKVIYAPQKWFRVDEYNTKDLLPSNWLIL	71
毛螺科菌 A4	WP_0162 80341.1	51102 6085	蛋白质［毛螺科菌 A4］	27.21	MIIVKIYEGLGNQLFQYAFARSIQVNGKKVFLDTSGYTDQLFPLCRTSTRRRYQLNCFNIRIKF VEKKNIEKYSFLIQEDMFGKLISKLAKLHLWMYKVTIQQNAQEYKESYLNTRGNVYYKGW FQNPKYFSSIRRLLLKEITPKYKIRIPAELRELLQEDNIVAVHCRRGDYQYIRNCLPVNYYKKA MAYMEKKLGVPRYLFFSDDLSWVKRQFGNKDNNYYIEDYGKFFEDYQELMIMSRCRNFIIA	72

[0195]

					NSTFSWAAWLCSYENKVVIMPRVWTYVGGQGVEMSDFPADWIRI	
北极耐冷细菌；北极耐冷细菌 34H	YP_27084 9.1	71282 201	α-1,2-岩藻糖转移酶 [北极耐冷细菌 34H]	27.15	MKVVRVCGGFGNQLFQYAFYLAVKHKFNETTKLDIIHDMASYELHNGYELERIFNLNENYCS AEEKLAVQSTKNIFTKLLKEIKKYTPFIPRTYIKEKKHLHFSYQEVDLGTKDTSIYYRGSWQN PQYFNSIASEIREKLTFPEFTEPKSLALHQEISEHETVAVHIRRGDYLKHKALGGICDLPYYQN AIKEIEGLVEKPLFVIFSDDITWCRANINVEKVRFVDWNSGEQSFQDMHLMSLCTHNIIANSS FSWWGAWLNANPNKIVISPNKWIHYTDSMGIVPSEWIKVETSI	73
海洋细菌（海洋细菌）MED193	WP_0098 10150.1	49749 5952	α-1,2-岩藻糖转移酶 [海洋细菌（海洋细菌）MED193]	26.96	MITSRLHGRLGNQMFQYAAARALAHRLGCGVALDGRGAELRGEGVLTRVFDLPLSAAPKLP PLKQHAPLRYGLWRGLGLAPRFRRERGLGYNTAFETWEDGCYLHGYWQSERYFEEISDLIR ADFTFPDFSNRQNAEMAARIMEDNAISLHVRRGDYVALSAHVLCDQAYYEAALTRLLEGLS QDAPTVYVFSDDPDWAKANLPLPCKKVVVDFNGPETDFEDMRLMSLCKHNIIGNSSFSWW AAWLNANPQKRVAGPANWFGDPKLSNPDILPSQWLKVAP	74
Cesiribacter andamanensis; Cesiribacter andamanensis AMV16	WP_0091 97396.1	49648 8826	糖基转移酶家族 11 [Cesiribacter andamanensis]	26.89	MMIVRLCGGLGNQLFQYAVGKQLSVKNNIPLKIDDSWLRLPDARKYRLQFFQIEEPLASPQE VERFVGPYESQSLYARLYRKVQNMLPRHRRRYFQESGFWAYEPELMRIRSQVFLEGFWQHH AYFTRLHPQVLEALQLREEYRQEPYAVLDQIREDAASVSLHIRRGDYVSDPYNLQFFGVMPL SYYQQAVAYMQEQLHAPTFYIFSDDLDWARAHLKLQAPMVFVDIEGGRKEYLELEAMRLC RHNILANSSFSWWGAYLNTNPHIKRVIAPRQWVADPELKDKVQIQMPPDWILL	75
海洋浮霉状菌（Rhodopirellula sallentina）；海洋浮霉状菌（Rhodopirellula sallentina）SM41	WP_0086 79055.1	49595 4476	糖基转移酶家族 11 [海洋浮霉状菌（Rhodopirellula sallentina）]	26.89	MIATRLIGGLGNQMFQYAYGFSLARRRSERLVLDVSAFESYDLHALAIDQFDISAARMTQAE FARIPGRYRGKSRWAERVANFAGGLQSCDKRPLRLRREKPFGFAEKYLAEGSDLYLDGYWQ SERYFPGLQAELKKEFQLKRGLSDESSRVLDEIQSSMSVAMHVRRGDYVVTNAETLRIYRRLD AEYYRKCLNDLRQRFSNLNVFVFSNDIQWCQDHLDVGLKQRPVTHNDATTAIEDMFLMSQ CDHSIIANSSFSWWAAFLGRSDAQRRVYYPDPWFNPGTLNGDSLGCANWVSESSISVSRPSR AA	76
丁酸弧菌属 AD3002	WP_0227 62282.1	55101 8054	蛋白质 [丁酸弧菌属 AD3002]	26.85	MIIIRMMGGLGNQMFQYALYLQLKALGKEVKIDDVYGFRDDPQRDPVLEKMYGITYTKAS DAEVVDITDSHLDIFSRIRRKLFGRKSHEYIEETGLFDPKVFEFETAYLNGYFQSDKYFPDKE VLAQLRREFVIKPDDVFTSADSWELYRQIRETESVSIHVRRGDYLLPGTVETFGGICDNDYY KRAIDRMVSEHPDAIFFVFTSDKEWCEQNVSGKKFRIVDTKEENDDAADLLLMSLCKHHIL ANSSYSWWSAWMNDSPEKTVIVPSKWLNTKPMDDIYTSRMTKI	77

[0196]

					MVVVKLIGGMGNQMFQYAIGRHLAIKNKCPLYFDHIELENKNTANTPRNYELDIFNVQYQK	
					NPFLQSNRFVAKVYHKLFSVQRIKEPDFTFHPHILNVQGNIHLNGYWQNENYFKEIEEIIRQD	
					FTFKTPANEKIESILQQIAATNSVSLHVRRGDYITLTEANQFHGVCSDTYYQKAIAKIKEAIPA	
					PHLFVFSDDIHWVKQNMPFTEEHTFVDGNTGKNSFEDLRLMAACRHNILANSSFSWWAGW	
环黄长杆菌	WP_0186 11017.1	51744 0157	蛋白质 [环黄长杆菌]	26.78	LNKNPEKMVIAPEKWFRAVHTDIVPPSWIKM	78
					MVTVRLIGGLGNQLFQYAVALSLLEQGYDVKLDASAFESYTLHGGFGLGEYAERLEVATTEE	
					VDMVSRVGRISTLLRKLQGKKSRRVIKESNFSYDEKMLTPEDSHYLVGYFQSELYFNKIRGEL	
			蛋白质		LSALDLKHKLSPYTEASYLAIADASVSVSMHIIRRGDYVSDKAAHNTHGVCSLDYYYAAVTF	
	WP_0196	51845	[Amphritea		FEERYPDVDFYIFSDDIEWVKENLNVQRAIHYISSEEKRFAGEDIYLMSQCDHNIVANSSFSW	
Amphritea japonica	21022.1	0815	japonica]	26.76	WGAWLNANEDKIVVAPRQWYADSNMQRLSKTLVPDTWIRL	79
					MRPVVVDIFGGLGNQMFQYAAAKSLAERLGVRLELDVSMFSGDPLRAFSLGEFAITDHVRG	
					KSRSSLLVRFARSLGFGSSSKCVEPFFHYWEGINEIEAPVHMIIGYWQSEKYFKAYEDLIRRTF	
			糖基转移酶家		SFSACEGVASSGKYAGVSSPMSVSVHLLRRGDYKFQKNVVVVHGILGREYYDAAYSIIKQGCPS	
普通脱硫弧菌；普通脱硫	YP_00243	21888	族蛋白 [普通		ACFFVFTDAINEAVDFFSHWNDVLFVDGNNQYQDMYLMSQCRHHIIANSSYSWWGAWLG	
弧菌'Miyazaki F'	7106.1	7785	脱硫弧菌 'Miyazaki F']	26.76	AFSDGMTVAPKMWFAYDVLKEKSIKDLFPEDWIVL	80
					MIISRITSGLGNQLFQYAVARHLSLKNKTSLYVDLSYYLYQYHDDTSRNFKLGNFSVPYHTLQ	
					QSPVEYVSKATKLLPNRSLRPFFLFQKERQFHFDEQILQSRAGCVILEGFWQSEAYFRDNADT	
			蛋白质 [斯匹		IRRDLQLSGTPSPEFNQYRELIRETPMSVSIHVRRSDYVVNHPEFSQTFGFVGIDYYKRAIELAR	
			茨卑尔根岛无		KELANPRFFVFSDDKEWSKTNLPLGEDSVFVQNTGLNGDVADLVLMSHCQHHIIANSSFSW	
斯匹茨卑尔根岛无毛螺			毛螺旋体属			
旋体属（Spirosoma	WP_0206	52209	（Spirosoma			
spitsbergense）	06886.1	5677	spitsbergense）]	26.76	WGAWLNPNAGKLVITPKNWYKNKPAWNTKDLLPPTWLSI	81
					MNIIRMSGGIGNQMFQYALYLKLVSLGKEVKFDDVTEYELDNARPIMLSVFGIDYPKASREE	
					LVELTDASMDFLSRVRRKIFGRKSGEYHEASADYDETVLEKEHAYLCGCFQSERYFKDIEYE	
	WP_0162	51103	蛋白质 [毛螺		VREAYRFRNVVVPEEIRGGIETYERQIGESLSVSIHIRRGDYLDAADVYGGICTDAYYNQAIR	
毛螺科菌 28-4	92012.1	7988	科菌 28-4]	26.73	YMIKKYENPSFFVFTNDTFWAEKWCEVRERETGKRFTVIKGTDEETGYIDLMLMSRCKAHII	82
					ANSSFSWWGAWLDASPDKCVVAPVKWINTRECRDIYTEDMVRIGSNGKISFSNCSSL	
					MVVVRIWEGLGNQLFQYAYARALSLRTKDRVYLDISEYEMSPKPVRKYELCHFKIKQPVINC	
					GRIFPFVNKDSFYTKNNQYLRYFPAGLIKEEDCYFKRDFCELKGLLYLKGWFQSEKYFKEFE	
					SHIREEIYPRNKIKITRGLRKILNSDNTVSVHIRRGDFGKDHNILPIEYYENSKRVILERVDNPY	
	WP_0163	51104	蛋白质 [毛螺		FIIFSDDILWVKENMNFGLNCFYMDKEYSYKDYEELMIMSRCKHNIIANSTFSWWGAWLNP	
毛螺科菌 COE1	02211.1	8325	科菌 COE1]	26.71	SKDKIVIAPKKWFLYNPKKDFDIVPNDWIRV	83

[0197]

拟杆菌属；拟杆菌属 20_3；迪氏类拟杆菌（迪氏拟杆菌属（Parabacteroides distasonis））CL09T03C24	WP_0058 67692.1	49250 2331	α-1,2-岩藻糖转移酶 [拟杆菌属]	26.69	FuZB	MKIVNIIGGLGNQMFQYAFAVALKAKYPNEEVFIDTQHIYKNAFIKVYHGNNFYHNGYEIDK VFPNATLEPARPKDLMKVSFYIPNQVLARAVRRIFPKRKTEFVTDQQPYVFIPEALSVIDDCY FDGYWMTPLYFDKYRDRILKEFTFRPFDTKENLELEPLLKQDNSVTVHIRRGDYVGSSSFGG ICTLDYYRNAIREAYNLITSPEFFIFSNDQKWCMENMRNEFGDAKVHIFIAHNRGADSYRDM QLLSIARCNILANSSFSWWGAYLNQRKNCFIICPHKWHNTLEYSDLYLPTWIKI	84
杆状菌属 HPS0048	WP_0025 61428.1	48862 4717	蛋白质 [杆状菌属 HPS0048]	26.62		MFVIRLIGGVGNQLFQYTFGQFLRHKFGVEVCYDIVAFDTVDKGRNLELQLLDESLPLFETS NFFFSKYKSWKKRLFLYGFLLKKNNKYYTKYAPEEISLFTEKGLSYFDGWWQYPALLRDTIN NMEDFFIPKQPIPVQIQKYYNEILLNNFAVALHVRRGDYFTSKYAKTYAVCNVEYYTSAVNL MCEKLRSCKFYVFSDDLDWVKSNLILPSNTVYVKNYDINSYWYIYLMSLCRHIIISNSSFSW WGATLNRNFHKIVIAPKYWSTKKNNTLCDNSWIKI	85
多形拟杆菌；多形拟杆菌 dnLKV9	WP_0162 67863.1	51101 3468	蛋白质 [多形拟杆菌]	26.58		MKIINILGGLGNQMFEYAMYLALKNAHSEEEILCSTRSFCGYGLHNGYELGRIFGIQVKEASL LQLTKLAYPFFNYKSWQVMRHWLPVRKTMTRGAINIPFDYSQVMREDSVYYDGYWQNEK NFLHIREEILTAYTFPKFDDEKNQELADIIVKSNAVSCHIRRGDYLKEINMCVCTSSYYAHAIS YMNFEEINPNLYCVFSDDIEWCRNNICELMGEDKKIIFIDWNKGFKSFRDMQLMSLCKHNIIA NSSFSWWGAWLNRNDKKIVVAPTRWIASEVKNDPLCDSWKRIE	86
阿氏脱硫孤菌；阿氏脱硫孤菌 G20	YP_38936 7.1	78357 918	糖基转移酶 [阿氏脱硫孤菌 G20]	26.56		MKFVGVWILGGLGNQMFQFAAAYALAKRMGGELRLDLSGFKKYPLRSYSLDLFTVDTPLW HGLPMSQRRFRIPMDAWTRGSRLPLVPSPPFVMAKEKNFAFSPIVYELQQSCYLYGYWQSYR YFQDVEDDIRTLFSLSRFATLELAPVVAQLNEVESVAVHLRRGDYITDAASNAVHGVCGIDYY QRSMSLVRRSTTKPIFYIFSDEPEVAKKLFATEDDVVVMPSRRQEEDLLLLMSRCKHHIIANSSF SWWAAWLGKRASGLCIAPRYWFARPKLESTYLFDLIPDEWLLL	87
口腔普雷沃菌 CC98A	ETD2159 2.1	56472 1540	蛋白质 HMPREF1199_00667 [口腔普雷沃菌 CC98A]	26.56		MDIVVIFNGLGNQMSQYAFYLAKRKSGSRCHCIFHNVSTGFHNGSELDKVFGIKYEKGIFSK LLSKIYDIFDGIPKLRKKLNSLGIHIIREPRNYDYTASLLPRVSRWGLNYFVGGWHSEKYYTEI LQEIKNTFSFKIDDEIKDIDFYEFYSLIHNDINSVSLHIRRGDYVGANEYSYFQFGGVATLEYY HKAIDEIYQRIENPTFYVFSDDIGWCKTTFLKNNFIFVDCNCGFKSWRDMFLISQCKHHIIAN STFSWWGAWLSIFHNSITICPKEFIKGVVIRDVYPDTWIKLSS	88
丛毛单胞菌 CR	YP_00868 0725.1	55099 0115	糖基转移酶 [丛毛单胞菌 CR]	26.54		MASKISKIIPRIFGGLGNQLFIYAAARRLALVNGAELALDDVSGFVRDIHEYNRHYQLDHFNIP CRKATAAERLEPFARVRRYLKRKWNQRLPFEQRKYLVQESVDFDERLLTFKPRGTVYLEGY WQSEDYFKDIEPQIRADLRIHPPTDTVNQQMAERIRATNAVAVHVRFFDAPAQSALGVGGNN APGDYYQRAIKVMQEQAPDAQYYIFSDQPQAARARIPLRDDHVTLVNHNQCDAVAYADLW LISQCQHFIIANSTFSWWGAWLGKTPESIVIAPGFEKREGAMFWGFRGLLPDRWVKL	89

[0198]

黑美人弧菌；黑美人弧菌 AM115；黑美人弧菌 FTn2；黑美人弧菌 Pon4；黑美人弧菌 SO65	WP_0225 96860.1	55025 0577	WhlA 蛋白质 [黑美人弧菌]	26.51		MKDSRIVKLNGGLGNQMFQFALAFALKKKLNVAVKFDTELLDTNRTEFKLSLERFGLIVDKL TITEKFKYKGLESCKYRKICNWISNFTTINIHKGYYKEKERGVYDRGIFDSNVKYIDGYWQN QEYFNDFRSELLNKFNLNGKVSNHAIQYLKEITSVQNSVSIHVRRGDYLLLLDVYRNLTLDYY SEAIKLVRITNPDSKFFIFSNDINWCKSNFKSVDNAIFVDSTVDEFDDMFLMSKCKTNIIANST FSWWAAWLNNNSGKIVYCPKKWRNDTTEVHKGLPEGWNIIDK	90
德氏硫磺单胞菌（Sulfurospirillum deleyianum）；德氏硫磺单胞菌（Sulfurospirillum deleyianum）DSM 6946	YP_00330 4837.1	26868 0406	糖基转移酶家族蛋白 [德氏硫磺单胞菌（Sulfurospirillum deleyianum）DSM 6946]	26.48		MIIIKIMGGLTSQMHKYALGRVLSLKYNVPLKLDLTWFDNPKSDTPWEYQLDYFNINATIAT VSEIKKLKGNNLFNRIARKIEKFFSIRIYKKSYINKSFISISDFHKLKSDIYLDGEWNGFKYFED YQDTIKNELTLKRGSSINIQNTIKELKSSDNSVFLHIRRGDYLSNKNAAAFHAKCSLDYYYKA IQIVKEKIDNPIFYIFSDDILWVKKNFVINESCRFMEKNQNFEDLLLMSYCKHGITANSGFSLM AGWLNQNKDKMIIVPQTWVNDDRININILNSLEQDNFTIIR	91
大肠杆菌；大肠杆菌 Jurua 18/11；大肠杆菌 180600；大肠杆菌 P0304777.1；大肠杆菌 P0304777.2；大肠杆菌 P0304777.3；大肠杆菌 P0304777.4；大肠杆菌 P0304777.7；大肠杆菌 P0304777.9；大肠杆菌 P0304777.10；大肠杆菌 P0304777.11；大肠杆菌 P0304777.12；大肠杆菌 P0304777.13；大肠杆菌 P0304777.14；大肠杆菌 P0304777.15	WP_0015 81194.1	48631 8742	糖基转移酶 11 家族蛋白质 [大肠杆菌]	26.47		MTFIVRLTGGLGNQMFQYALARSLAKKYNARLKLDISYYHNQPHKDTPRTFELNQLCIVDNI LNSSSFSEKFLYIYDKLRVKLSKKISLPYFRNIVTPVNFNCIDFAEDKDYYFLGHFQELSNIYSI DESLRSEFKPNQEIMNLAHQSKIYELIKQSRGSVALHIRRGDYVVTNKNAAEHHGVIGLSYYV NALSYLENVSEFFDVFVFSDDPEWARKNIKNSRNLFFCDEGNCRYSKKYSTIDMYLMSQCD HFIIANSTYSWWAAWLGNYPSKHVVAPARWNANNSPYPILQNWKAIHE	92
厚壁菌门细菌 CAG:24	WP_0219 14998.1	54710 9632	蛋白质 [厚壁菌门细菌 CAG:24]	26.44		MVGVQLSGGLGNQMFEYALYLKLKSMGKDVRIDDVTCYGAQEKQRVNQLSVFGVSYFHM TKQEYEQITDSSMSPLHRARRLLCGRKDLSYREASCNYDPEILRREPALLLGYFQTERYFADI KDQVREAFTFRNLTLTKESAAMEQQMKECESVSVHIRRGDYLTPANQALFGGICDLDYYHR AVAEIRKRKPDVKFFLFSNDMEWTKEHFCGSEFVPVEGNSEQAGEQDLYLMSCCKNHILAN SSFSWWGAWLDNGKDKLVIAPEKWMNGRGCCDIYTDEMIRV	93

[0199]

Amphritea japonica	WP_0196 22926.1	51845 2719	蛋白质 [Amphritea japonica]	26.42		94
多形杆状菌 salyersiae；多形杆状菌 salyersiae WAL 10018 = DSM 18765 = JCM 12988	WP_0059 23045.1	49268 9153	蛋白质 [多形杆状菌 salyersiae]	26.41		95
脆弱杆菌；脆弱杆菌 CL03T00C08；脆弱杆菌 CL03T12C07	WP_0057 86334.1	49224 1663	蛋白质 [脆弱杆菌]	26.38		96
北欧杆状菌；北欧杆状菌 CL02T12C05	WP_0074 86843.1	49475 1435	蛋白质 [北欧杆状菌]	26.37		97
蛋白丁酸孤菌（Butyrivibrio proteoclasticus）；蛋白丁酸孤菌（Butyrivibrio proteoclasticus）B316	YP_00382 9743.1	30266 9783	糖基转移酶 11 [蛋白丁酸孤菌（Butyrivibrio proteoclasticus）B316]	26.37		98
栖瘤胃普雷沃菌；栖瘤胃普雷沃菌 23	YP_00357 4648.1	29467 4032	家族 11 糖基转移酶[栖瘤胃普雷沃菌 23]	26.33		99

[0200]

					MKIIKIIGGLGNQMFQYALAIALQQQYKDEEIRLDLNCFRGYNKHQGYLLDEIFGRRFRAAS LQEVARLAWPYPHYQLWRVGSRVLPRRQTMVCEPADGSFSPDVLTLEGNRYYDGYWQDER YFKAYRKEIIEAFKFSPFVGDGNRHVENMLRNERFASLHVRRGDYLNDALYQNTCGIDYYQ RAISQMNAMANPSCYFIFSDDIAWCKTHIEPLCEGHRPYYIDWNKGKEAYRDMQLMALCK YHIIANSSFSWWGAWLNDAEDGITIAPQQWYSHGNKPSPASESWIKV	100
丹参胃善雷沃菌；丹参胃善雷沃菌 DSM 15606	WP_0071 35533.1	49422 3898	蛋白质 [丹参胃善雷沃菌]	26.33		
					MNIVRISDGLGNQMFQYAYARKISILSRQRTYLDIRFINNEDLVKKGNHVQFRKKLGHRKYG LSHFNVSLQIADLKMLSHWEYLIQSNCMQQLIYSLSMQDKWIWRYRHEEVNYDGMLSKVE LLFPTYYQGYFFALKYYDDIKHILQHDFSLKDKMKLLPELRDALYNRNTISLHVRRGDFLEI NRDISGSEYYEKAVQMIGSKVESPIFLIFSDDIEWVKEHIRIPNDKIYVSGIGYEDYEELTIMKH CKHNIIANSTFSYWAAYLNSNKDKIVICPKHWRERIIPKDWICI	101
毛螺科菌 COE1	WP_0162 99568.1	51104 5640	蛋白质 [毛螺科菌 COE1]	26.3		
					MIVVNVNAGLANQMFHYAFGRGLEAKGWNIYFDQTNFKPRKEWSFENVQLQDAFPNLGL KMMPEGKFKWICVNNTNKLSKGLHLAMINLHNLIGDEKYIFETTYGYDPDIEKEITKNCILK GFWQSEKYFAHCKDDIRKQFSFLPFDEEKNIVIMNKMVKENSVAIHLRKGADYLKSELMGK GLCGVEYYIKAIEYIKKNIDNPVFYVFTDNPVWVKNNLPKFDYILVDWNEVAGKKNFRDMQ LMSCAKHNIIANSTYSWWGAWLNPNPNKIVIGPAKFFNPINNFFSSSDIMCEDWVKI	102
朵丽多形杆菌；朵丽多形杆菌 5_1_36/D4	WP_0078 42931.1	49511 8115	α-1,2-岩藻糖转移酶 [朵丽多形杆菌]	26.28		
					MLSKDPGMITTRLHGRLGNQMFQYAAGRALAARLGVPLALDSRGAKLRGEGVLTRVFDLP LAQPLSLPPLKQDAPLRYAAWRLTGRTPRFRREQGLGYNPAFETWGDDSYLHGYWQSEAYF DSIADQIRQDFTFPEFSNSQNREMAQRIAGSTAISLHVRRGDYVALAAAHVLCDQAYYEAALT RILEGVEGSPTVYVFSDDPNWAKENLPLPCEKVVVDFNGPDTDFEDMRLMSLCQHNIIGNSS FSWWAAWLNTHINEKRVAGPAHWFGNPKLQNPDILPESWLKISV	103
海洋细菌（Roseobacter sp.）SK209-2-6	WP_0082 10047.1	49548 5361	α-1,2-岩藻糖转移酶 [海洋细菌（Roseobacter sp.）SK209-2-6]	26.28		
					MIYSRIRGGLGNQLFQYCVARSLADNLGTSLGLDVRDFNENSPYLMGLKHFNIRADFNPPG MIEHKKNGYFRYLIDVVNGKQKFVYKEPHLNFDKNIFSLPNSSYLKGYWQTEKYFIKNKVN ILNDLKIISHQSDKNKTISSKIANNTSVSLHIIRRGDYISNSAYNSTHGTCSLAYYTNAVNFLVN KIGGNFKVFAFSDDPEWVSSNLKLPVDICFVKNNSSEYNYEDLRLMSECNHNIIANSSFSWW GAWLNTNHNKTVITPCKWYADNSTKNADITPSNWIKI	104
α 变形菌门 SCGC AAA076-C03	WP_0200 56701.1	51890 0826	蛋白质 [α 变形菌门 SCGC AAA076-C03]	26.26		
					MGGGGQDLRLFFELMLYNISLPLCFDYKTLVKYFYSNDKSLKYNFPLQYIRYATRSKYHKLY WLALKHYKYFYDEDPQGDNIVKMYLNNSLEKHAYPFGYFQNLIYFDEIDSIIREEFCLKIPLK PHNQALKFKIEKTENSVFLHVRLGDYLKMEATDGGYVRLGKTYYQSALEILKTRLGQPHIFI FSNDIEWCEKNLCNLLDFTGCHIEFVKANGEGNAAEEMELMRACKHAVIANSTFSWWASYL IDNPDKQIIMPTQVFNDTRRIPKSNMLAKKGYILIDPFWGMHSIV	105
胆型螺旋杆菌；胆型螺旋杆菌 WiWa	WP_0040 87499.1	49018 8900	蛋白质 [胆型螺旋杆菌]	26.26		

[0201]

青枯菌 GA3-3	WP_0108 13809.1	49851 3378	糖基转移酶家族蛋白 [青枯菌 GA3-3]	26.26	MIVTRVIGGLGNQMFQYAAGRALARRLGVPLKIDSSGFADYPLHNYGLHHFALKAVQAGDR EIPSGRAENRWAKALRRFGLGTELRVFRERGFAVDPEVMKLPDGTYLDGYWQSESYFAEMT QELRRDFQIATPPTSENAEWLARIGGDEGAVSIHVRRGDYVVTNASANAVHGICSLDYYMRA ARYVAENIGVKPTFYVFSDDPDWVAGNLHLGHETRYVRHNDSARNYEDLRLMSACRHHIIA NSTFSWWGAWLNASEKKVVIAPAQWFRDEKYDTRDLLPPTWTKL	106
小卵柱杆菌；小卵柱杆菌 3_8_47FAA	WP_0043 03999.1	49043 1888	蛋白质 [小卵柱杆菌]	26.25	MVVVYIAAGLANKMFQYAFSRGLMSHGLDVFLDQTSFQPEWSFEDIALEEVFPNIEIKNAPN NMFSLAYKKDLLSRIYRRMSAFFPNNRYLMERPFIYDELIYKKATNNCIFCGLWQTELYFNFC ERDVRRNFVFTPFQDDQNIKLAEKMKNENSVAIHIRKGADYLKRNIWDGTCSVEYYNQAIN YLKEHVSNPVFYLFTDNPEWVEENLKNIDYKLVDWNPVSGKQSYRDMQLMSCAKHNIIAN STYSWWGAWLNNNPQKIVVAPKIWFNPKIEKAPYIIPDRWIRL	107
韦斯特洛克氏菌 (Loktanella vestfoldensis)	WP_0199 55906.1	51879 9952	蛋白质 [韦斯特洛克氏菌 (Loktanella vestfoldensis)]	26.23	MIITKLIGGLGNQMFQYAAGRSLAMRHGVPLLLDITELRSYPKHQGYQFEDVFAGRFEIAGLI PLIRVLGRKARKVPKTVAVVSPKWPPMGDHVWVRQRTHDYDAAFESIGADCYLSGFWQSE KYFATIAPQIRESFRFKEALTGANAAIASRMKEAPSAAIHIRRGDYVVTDKGAHAFHGLCAWD YYDAAIDHISRHEPDARFFVFSDDVVAAQERFANRQRAEVVAVNSGRHSYRDMMLMAQCK HQIIANSTFSWWAAWLNQNPDKIVVAPGTWFSGNDGQIKDIYCKDWIVI	108
黄杆菌属 ACAM 123	WP_0169 91189.1	51555 8304	蛋白质 [黄杆菌属 ACAM 123]	26.14	MDVVIIFNGLGNQMSQYAFYSQKKKINNSTYFVPFCKDHNGLELETVFSLNTKETLIQKSLYI LFRILLTDRLKIVSDPLKWILNLFKCKIVKESFNYNYNPEYLKPSKGITFYYGGWHAEKYFAK ENQQIKSVFEFTGDLGKINKEHVKDIASTNAVSLHVRRGDFMNEANIGLFGGVSTKAYFEGA IKLIATKVDHPHFFVFSNDMDWVKENLSMDTVTYVTCNSGKDSWKDMCLMSLCQHNIIPNS TFSWWGAWLNKNPHKIVVCPSRFLNNDTYTDIYPDSWVKISDY	109
脆弱杆菌；脆弱杆菌 3_1_12	WP_0057 79407.1	49221 9620	糖基转移酶家族 11 [脆弱杆菌]	26.1	MMKLVRMTGGLGNQMFIYAFYIQMKTIFPELRIDMSEMKKYKLHNGYELEDVFSIRPQTISA HKWLKRVIVYAFFSIIREKSEEELSIHKYTQHKRWPLVYYKGFFQSELFFKESSDTIRDIFSFNT ENANFRTKEWAKIIKEQRSSVSIHIRRGDYTSAKNKIKYGNICTEEYYQKAISIILKKEPKAFF HIFSDDVEWTKAHLKIIHHLPHQYISWNKGPDSWQDMMLMSLCRHNIIANSSFSWWGAWLN AYKDKTVIAPSRWSNVKKTPHILPESWISIDI	110
潘氏无毛螺旋体 (Spirosoma panaciterrae)	WP_0205 98002.1	52208 6793	蛋白质 [潘氏无毛螺旋体 (Spirosoma panaciterrae)]	26.09	MIISRVTSGLGNQLFQYAAARSLSLRNKTAFYVDLSYYLYEYPDDTSRSFKLGFFSVPYRILQ ESPVEYLSKSTKLFPNRSLRPFFLFLKEKQFHFDPTILQAHAGCVIMEGFWQSECYFRDHAEII RRELQLSKSPSSEFEGYHQQIQATPVPVSVHVRRGDYVVNHPEFSKTFGFIGLDYYKTAIRHLT KTIKNPHFYVFSDDKEWARANLPLPTDSVFVTNTGPSGDVADLVLMSTCHHHIIANSSFSWW GAWLNPNPDKLVITPKLWYKNQPTWNTKDLLPPTWVSL	111

[0202]

未培养细菌	EKE06672.1	406985982	糖基转移酶家族11 [未培养细菌]	26.09		MIITKLTGGLGNQLFQYAIGRNLIYINGSDLKLDVSEYDVSNKGNFRHYALDKFNTIQNFASK KETNNFKFGVFKKWLYKSGIVKNKNYFLEKKFNFDKEILKIKDNAFLQGYWQSEKYFIGIRD ILLQEFSLKENIELKFGEILKEINESNSVSIIHVRRGDYVKNPKNLSFHGVCSPKYYSESTSKIAS LIEKPVFFVFSDDIEWVKENLNITFPVVYLSGIKNIKSYEELVLMSKCKHNIIANSSFSWWGA WLNTNQKKIVIAPKRWFNDVKLDTTDLIPENWIRI	112
嗜热藻（Thermosynechococcus elongatus）；嗜热藻（Thermosynechococcus elongatus）BP-1	NP_681784.1	22298537	α-1,2-岩藻糖转移酶［嗜热藻（Thermosynechococcus elongatus）BP-1］	26.07		MIIVHLCGGLGNQMFQYAAGLAAAHRIGSEVKFDTHWFDATCLHQGLELRRVFGLELPEPSS KDLRKVLGACVHPAVRRLLAGHFLHGLRPKSLVIQPHFHYWTGFEHLPDNVYLEGYWQSER YFSNIADIIRQQFRFVEPLDPHNAALMDEMQSGVSVSLHIRRGDYFNNPQMRRVHGVDLSEY YPAAVATMIEKTNAERFYVFSDDPQWVLEHLKLPVSYTVVDHNRGAASYRDMQLMSACRH HIIANSTFSWWGAWLNPRPDKVVIAPRHWFNVDVFDTRDLYCPGWIVL	113
科尔韦尔氏菌（Colwellia piezophila）	WP_019028213.1	51785 8213	蛋白质［科尔韦尔氏菌（Colwellia piezophila）］	26.03		MKIVKIIGGLGNQMFQYALAIALQERWKDEEIKLDLHGFNGYHKHQGYQLDMLFGHRFEA ATLTDVAQLAWPYPHYQLWRVGSRLLPKRRSMLCEPSKGLLPSDVLKQKGSLYYDGYWQD ERYFRAIRPQIMAAFKFPDFTDRRNLETEKRLKASEAVSIHVRRGDYLDDVLFQGTCNIAYY QRAIARLCQLKTPVFCIFSNDMAWCKVHIEPLLHGKEILYVDWNRGKESYRDLQLMTLCRH HIIANSSFSWWGAWLSKAEDGITIAPRHWYAHDAKPSPAAERWIKV	114
斑状毒雷沃菌（Prevotella maculosa）	WP_019966794.1	51881 0840	蛋白质［斑状毒雷沃菌（Prevotella maculosa）］	26			115
肠道沙门氏菌；肠道沙门氏菌亚属 沙门华盛顿菌 ATCC 9607；肠道沙门氏菌亚属 沙门古巴菌 CFSAN001083；肠道沙门氏菌亚属 沙门古巴菌 CFSAN002050；肠道沙门氏菌亚属 沙门古巴菌 CVM42234	YP_008261369.1	52586 0034	岩藻糖转移酶［肠道沙门氏菌亚属 沙门古巴菌 CFSAN002050］	25.99		MYSCLSGGLGNQMFQYAAAYILKQYFQSTTLVLDDSYYYSQPKRDTVRSLELNQFNISYDR FSFADFEKEKIKLLRKFKRNPFPKQISEILSIALFGKYALSDRAFYTFETIKNIDKACLFSFYQDA DLLNKHKQLILPLFELRDDLLDICKNLELYSLIQRSNNTTALHIRRGDYVVTNQHAAKYHGVL DISYYNHAMEYVERERGKQNFIIFSDDVRWAQKAFLENDNCYVINNSDYDFSAIDMYLMSL CKNNIIANSTYSWWGAWLNKYEDKLVISPKQWFLGNNETSLRNASWITL	116

[0203]

					MKKVIFSGGLGNQMFQYAFYLFLKKKGIKAVIDNSLYSEFKMHNGFELIKVFDIKESIYRTYF LKVHLIFIKLLMKIPPVRKLSCKDDVIPIGDHEFDPPYARFYLGYWQSKKIVNYVIEELRAQFI FRNIPQMTIEKGDFLSSINSVSIHIRRGDYMGIPAYQGICNEIYYERAISFMKEHFLNPRFYVFS NDSIWAKLFLEKFDIDMEIIVTPPIYSYWDMYLMSRCRNHIIANSTFSWWAAVLNINKDKIVIS PTIFKKDECIDIIFDDWVKISNI	117
多形杆状菌属 3_2_5	WP_0086 59600.1	49593 5021	蛋白质 [多形杆状菌属 3_2_5]	25.94		
					MIMLQMTGGMGNQMFTYALYRSLRQKGKEVCIEDFTHYDTPEKNCLQTVFHLDYRKADRE VYQRLTDSEPDFLHKVKRKLTGRKEKIYQEKDAIIFEPEVFQTDDVYMIGYFQSGRYFEKAVF DLRKDFTFAWNTFPEKAKKLREQMQAESSVSLHIRRGDYMNGKFASIYGNICTDAYYEAAR RYMKEHFGDCRFYLFTDDAEWGRQQESEDTVYVDASEGAGAYVDMALMSCCRHHIIANSS FSWWGAWLDENPDKTVIAPAKWLNISEGKDIYAGLCNCLIDANGSVQGE	118
梭状芽孢杆菌属 CAG:510	WP_0221 24550.1	54766 2453	蛋白质 [梭状芽孢杆菌属 CAG:510]	25.86		
					MIVTRLIGGLGNQLFQYAFGHSLARSTYQTLLIDDSAFIDYRLHPLAIDHFTISASRLSDADRS RVPGKFLRTPVGRALDKVSRFVPGYQGVLPVRREKPFGFRESLLARESDLYLDGYWQSEKFF PGLRGSLREEFQLREQPSETTRRLSAQMKSENSVAIHVRRGDYVVTSAKAKQIYRTLDADYYR RCLLDLAAHETDLKLYLFSNDVPWCESNLDVGIPFTPVQHTDGATAHEDLHLIAQCRHVVIA NSTFSWWGAYLGQLHPTRRVYYPEPWFHPGTLDGSAMGCDDWISEASLEEQSSLKSSRRAA	119
橄榄红小梨形菌（Rhodopirellula europaea）；橄榄红小梨形菌（Rhodopirellula europaea）SH398	WP_0086 65459.1	49594 0880	糖基转移酶家族蛋白 [橄榄红小梨形菌（Rhodopirellula europaea）]	25.86		
					MIIVKLKGGMGNQMFQYAIGRNLATKLGTQLRLDLTFLLDRSPRKDFVFRDYDLDIFALDVA FAGPTDLKPFTQFRISHLTKIYNIFPRLLGRPYVISEPHFHFSEAILKSSDNVYLDGYWQSEKY FKEIENSIRDDFKFRQPLEGRAAEMAAQIKNEDRAVCLNVRRADFVTSKKAQEFHGFIGLDY YQKAVDLLVSKVGPLHLFIFSDDVDWCAANLKFNYPTTFVTKDYSGKKYEAYLQLMTLCR HYIIPNSTFAWWGAWLNSDPNKIVIAPKQWFKEASIDTTDIIPSTWIRL	120
未培养细菌	EKD2370 2.1	40687 3590	糖基转移酶家族蛋白 [未培养细菌]	25.82		
					MIIVKLKGGLGNQMFQYALGKSLALYYDKPLKIDADAYIKNNEGYVPRDFSLSKFNIELDLYQ EADKERVGFILKNNFLAKKLRNYFLKKGKYKGKYIIENPDNLGLFKKELFENHNESMYIDG YWQSYLYFNNIRECLIKEFNLKPEYTKEMTEIMQRINETNSVAVHIRRGDYVVKLGWTLDTTY YKKAIAEIVKNVDNPKFYVFSDDTDWVRSNLQFLDNAVFIGECNLFDYQELWLMSTCKHNII SNSTFSWWGAWLNQNDHQVVVSPSAWINGMSVETTSLIPDSWKRV	121
蜡样芽胞杆菌；蜡样芽胞杆菌 AH1271	WP_0005 87678.1	44651 0160	蛋白质 [蜡样芽胞杆菌]	25.74		
					MDIIRMEGGLGNQLFQYALYRQLQFMGRTVKMDVTTEYGREHDRQQMLWAFDVHYEEAT QEEINRLTDGFMDLPSRIRRKLTGRRTKKYAEADSNFDPQVLLKTPVYLTGYFQSEKYFKDV EGILHTELGFSDRIYDGISEVFADQIRNYQKQIRETESVSLHVRRGDYLEHPEIYGMSCTMEY YQAGVRYIRERHPDAEIFVFTNDPVFTEKWLQENFLGDFTLIQGTSEETGYLDLMLMSQCKH QIMANSSFSWWGAWLNPNKDKIVVAPEPWFGDRNFHDIYTEEMIRISPRGEVKKHG	122
厚壁菌门细菌 CAG:95	WP_0224 99937.1	54830 9386	蛋白质 [厚壁菌门细菌 CAG:95]	25.74		

[0204]

口部善雷沃菌（Prevotella oris）；口部善雷沃菌（Prevotella oris）F0302	WP_0043 74901.1	49050 8875	α-1,2-岩藻糖转移酶［口部善雷沃菌（Prevotella oris）］	25.74		MIAATLFGGLGNQMFIYATVKALSLHYQVPMAFNLNHGFANDYKYHRKLELCKFNCQLPTA KWITFDYRGELNIKRISRRIGRNLLCPNYQFVIEEEPFHYEKRLFEFTNKNIFLEGYWQSPCYF ENYSKEIRADFQLKVPLSKEMLEEIYALKATGKTLVMLGIRRYQEVEGRDICTYKLCDKEYYI KAITYIQERIPNALFVVFTQDKEWATTHLPKGAEFYFVKDKQDEYATVADMFLMTQCTHAIIS NSTFYWWGAWLQCTTKNHIVIAPDSFINSDCVCKEWIILKRNSLC	123
大肠杆菌	AAO3771 9.1	37528 734	岩藻糖转移酶［大肠杆菌］	25.73		MYSCLSGGLGNQMFQYAAAYILQRKLKQRSLVLDDSYFLDCSNRDTRRRFELNQFNICYDR LTTSKEKKEISIIRHVNRYRLPLFVTNSIFGVLLKKNYLPEAKFYEFLNNCKLQVKNGYCLFS YFQDATLIDSHRDMILPLFQINEDLLHLCNDLHIYKKKVICENANTTSLHIRRGDYITNPHASKF HGVLPMDYYEKAIRYIEDVQGEQVIIVFSDDVKWAENTFANQPNYYVVNNSECEYSAIDMF LMSKCKNNIIANSTYSWWGAWLNTFEDKIVVSPRKWFAGNNKSKLTMDSWINL	124

[0205]

Leeia oryzae	WP_018150480.1	51689_0767	蛋白质 [Leeia oryzae]	25.71			MIIVKIIGGLGNQMMQYAFAHACAKRLGVPFKLDITAFESYKLWPYGLHNFEITAPIASLEEIE HAKSMGVITETSFRFDDSLVSAVKDGMYLDGYWADYRYSESVWGELKPVFTLMDPLTPEQ QALAMNLSAPNAVALHVRRGDYVTNPNCFLLPQQYYRDAIKLVLDQQPDAVFYCFSDDPD WVEAIILDIPAPKVVVRGQGIDNGFVDMILMSKARHRIVANSTFSIWASRLADQDGLTIVPSQ FFRKDDPWLLQVYGEVLQPCYPPQWRVVDVTGDGKKEAENTSTALLQIAGGDVRGRKLRI GVWGFYEEFYQNNYIFLNKNAPIGHELLKPFNQLYQYGQAHNLEFVTLDLVADLSTLDAVLF FDAPNMRSPLVSSVMQLDIKKYLCLLECELIKPDNWQQSLHELFTRIFTWHDGLVDNHRYIK VNYVTDLMPWIESAQSLTAPFEETARKGYLQKKLICNISGNKLVSHPFELYSKRIEVIRWFESH HPEHFDLYGMGWSASDYPSYKGKIDDKLEVLKGYRFSLCYENAKELPGYITEKIIDCFKAGV VPVYSGAPNIADWIPDNCFIDSGKFPDTDALYTYLISMTEEVHADYLENIRQFFLGGKAYPFS ADAFINTITRTIVQDCLFPHERTDVSVVVPNYNHGNFVVSAITSALNQNVSVELLVLDNASTD DSWSQLQFFADYPQVRLIRNRWNIGVQHNWNHATWLATGRYVVMLSADDLLLPGHLEQAV KRLDENPASSLYYTPCLWINEHDQPLGTLNHPGHLESDYVVGGRDEISDLLKFDSYITPSAAVI RRETLNRIGSMNLHLKGAIDWDLWIRIAEISPAFIFRKQPGVCYRQHSGNNSVDFYASTAPLE DHIRIVESIIDRKVAVKYLLKAKEEIIAHLDNRASSYPENQIQHLLSRINNIKDYLRKGAGPVIS VIIPTKNRPGLLANALESLTYQTFKDFEVVIHNDGGCDIGGIVDFFSDQLQISYVRSSQSGGAA ASRNRALKLAKGRIIAYLDDDDVYLDSHLEKLVDAYKGRSEKFIYTNCEYLIQERKEGRLIEL GRERRYAGISYSRAQLLVSNFIPTPTWSHTKELIDTIGDFDESLEILEDWDFLLRASKVTEFYQ VNATTVEVRSDRSRDDHITLRANADKLLAYHQKIYAKHPVENESILANRQSLINSLSNRQDVT PKNENSYQGWVNARQPNELAVQILAERMMLQWSKQYQFMIVMVVKQSQQNLLANTIDSF CQQLYSGWKLIVISDFEAPDESFINNEVLGWLTLETVEDENLLTQAFNGVLAEVPSDWVTILP VGTRLTSTALLKVGDRLLLNGGACVIYTDHDYVSDDGMIKDPVLKPAFNLDMLRSQDYIGS SIFFRTDSLAAVGGFASFPGARTYEACFRMLDNYGPQTIEHLPEPVMTFPENQPENSLRVAAM QLALEEHLHRNNISASIEEGYVTGTFLVQYHHSEQPFVSIIIPNKDKIHEFLAPCIETLMKVTQY PAFEVIIVDNQSTDPDTLSYYEEIESRFANNVKVIQYDNPFNFSAQCNLGAESARGDFILFLNN DTEIVQANWLERMMQHAQRNDVGVVGARLVFPETVTIQHAGIVLGGKYPDEVFQFPYMNF PVDKDVSLNRTKVVQNYSAVTGACLLVRKSLYQQVGGMNEQNLAVLYGDVDLCLRIRQLH KSVVWTPFSTLVHHTGKTLNSNSDHEKHLMMVIQTRQEREYMLSHWLDIIANDPYYHRLL DKSECNGTIDCTHTPLWDDIPSARPRLQGMALVGGSGEYRVNNMPFRTLERSALAEIVLSNMT SKARLPSITELARNAPDVFVVQNALADEFIRMLEMYKKYLPSVFRIQMLDDLLTEIPDASSFK RHFQKNWRDAKARLRKSLKFCDRLIVSTEPLRTFAEDMIDDIIVVPNMLERSVWGDLVSKRR AGKKPRVGWVGAQQHAGDLALMTDVVKATGHEVDWVFQGMCPDDIRPYVAEVNTEWLT YDKYPQGIAALNLDLAIAPLEINAFNEAKSNLRLLEYGALGWPVICTDIYPYQTNNAPVCRV PNDASAWIEAIRSHIADLDATAQKGDQLRQWVHDHYMIEDHAQEWLSALTRPAGK	125

[0206]

					MFQYAAARALSLRHSASLAADLTWFSQQFDVQTTPREYALPAFRLNLPEADKRIVATFRLNP	
					TELRIVSFLRHRICFPSRFLPRHITELSFDYWDGFRDILPPAYLDGYWQSERYFSDYPDIRADF	
					SMLSISEQAAWMSAKIASVQDSISLHIRRGDYVNSLATRKAHGIDTERYYAKALEWIADRIG	
					AATIFAFSDDPRWVRANFDFGKHKGIVVDGSWTAHEDMHLMSLCSHHIIANSSFSWWGAW	
非洲脱硫弧菌；非洲脱硫弧菌 PCS	WP_0059 84173.1	49283 0219	糖基转移酶家族 11 [非洲脱硫弧菌]	25.68	LSTSQGITIAPKSWFSNPHIWTPDVCPATWERIPC	126
					MAKGKIIVMRLFGGLGNQLFQYAFLFALSRQGGKARLETSSYEHDDKRVCELHHFRVSLPIE	
					GGPPPWAFRKSRIPACLRSLFAAPKYPHFREEKRHGFDPGLAAPPRRHTYFKGYFQTEQYFL	
网络肠道细菌（Akkermansia muciniphila）CAG:154	WP_0221 96965.1	54778 6341	糖基转移酶家族 11 [网络肠道细菌（Akkermansia muciniphila）CAG:154]	25.66	HCREQLCREFRLKTPLTPENARILEDIRSCCSISLHIRRTDYLSNPYLSPPPLEYYLRSMAEME	127
					GRLRAADAPQESLRYFIFSDDIEWARQNLRPALPHVHVDINDGGTGYFDLELMRNCRHHHIA	
					NSTFSWWAAWLNEHAEKIVIAPRIWFNREEGDRYHTDDALIPGSWLRI	
					MKIVKLQGGLGNQMFQYAIARTLETNKKKDIFLDLSFLRMNNVSTDCFTARDFELSIFPHLR	
					AKKLNSLQEKFLLSDRVRYKFIRKIANINFHKINQLENEIVGIPFGIKNVYLDGFFQSESYFKHI	
木质素厌氧降解产氢菌（Dysgonomonas mossii）；木质素厌氧降解产氢菌（Dysgonomonas mossii）DSM 22836	WP_0068 43524.1	49389 7667	蛋白质 [木质素厌氧降解产氢菌（Dysgonomonas mossii）]	25.66	RFDLIKDFEFPELDTRNFALKKTIVNNNSVSIHIIRRGDYVVHLKNANTYHGVLSLEYYLNCIKR	128
					IGEETKEQLSFFIFSDDPEYASKSLSFLPNMQIVDWNLGKNSWKDMALMLACKHHHIANSSFS	
					WWGAWLSERNGITYAPVKWFNNESQYNINNIIPSDWVII	
					MDIVLIFNGLGNQMSQYAFYMSKKKFVPQSKCMYYKGASNNHNGSELDKLFDIKYSETFFC	
					KLILLLFKLYENIPRLRKYFHILGINIVSEPQNYDYNESILKKKTRFGITLYKGGWHSEKYFLA	
口部普雷沃菌（Prevotella oris）；口部普雷沃菌（Prevotella oris）F0302	WP_0043 72410.1	49050 6359	糖基转移酶家族 11 [口部普雷沃菌（Prevotella oris）]	25.66	NKQDVLNTFSFKIAKEDKNFIDLAKSIEEDTNSVSLHVRRGDYLNISPTDHYQFGGVATTNY	129
					YKNAVSYMLKRNKQAHFYIFSDDITWCKAEYKDLMPTFIECNKKNKSWRDMLLMSLCTNH	
					INANSTFSWWGAWLSTKNGITICPTEFIHNVVTRDIYPETWVQL	
					MIIVRLMGGMGNQLFQYATAFALSKRKSEPLVLDTRFFDHYTLHGGYKLDIHFNISARILSKEE	
					ESLYPNWQANLLLRYPIIDRAFKKWHVERQFTYQDRIYRMKRGQALLGYWQSELYFQEYR	
Pseudogulbenkiania ferrooxidans 2002；Pseudogulbenkiania ferrooxidans	WP_0089 52440.1	49623 9055	糖基转移酶家族 11 [Pseudogulbenkiania ferrooxidans]	25.66	KEISAEFTLKEQSSVTAQQISVAMQGGNSVAVHIRRGDYLSNPSALRTHGICSLGYYNHAMSL	130
					LNERINDAQFYIFSDDIAWAKENIKIGKTSKNLIFIEGESVETDFWLMTQSKHHIIANSTFSWW	
					GAWLANNTDEQLVICPSPWFDDKNLSETDLIPKSWIRLNKDLPV	
					MYSCLSGGLGNQMFQYAAAYILKQYFQSTTLVLDDSYYYSQPKRDTVRSLELNQFNISYDR	
					FSFTDEKEKIKLLRKFKRNPFPKKISEILSIALFGKYALSDSAFYAVETIKNIDKACLFSFYQDA	
					DLLNKHKQLILPLFELRDDLLDICKNLDVYPLILRNNNTTALHIIRRGDYLTNQHAAKYHGVL	
	WP_0002	44620			DTSYYNNAMEYVERERGKQNFIIFSDDVKWAQKAFLGNENCYIVNNGDYDYSAIDMYLMS	
肠道沙门氏菌	86641.1	8786	蛋白质 [肠道沙门氏菌]	25.66	LCKNNIIANSTYSWWGAWLNKSEDKLVISPKQWFLGNNETSLRNASWIIL	131

[0207]

肉杆菌属 WN1359	YP_00871 8688.1	55464 9642	糖基转移酶家族 11 [肉杆菌属 WN1359]	25.59	MLIVKVYGGIGNQMFQYSFYKYLQKNNDDVFLDISDYKVHNHHNGFELIDVFNIEVKQAD MSKFKGHVSSKNSIFYRLTSKLFKRNILGYSEFMDSNGISIVRNEKILTDHYFIGFWQDVLYL QSVEEEIKEAFNFKNVAIGKQNLELISLSESVESVSVHIRKGDYANNSDLSDICDLEYYEEAM KIIDSKVSEPLYFIFSDDIEWCKQKFGKRDNLIYVDWNIAKKSYIDMLLMSKCKHNIIANSTFS WWGAWLNNNSKKIVICPKTWDRKKNENHLLLNDWIAI	132
普雷沃菌 CAG:1185	WP_0219 64668.1	54722 7670	蛋白质 [普雷沃菌 CAG:1185]	25.58	MMKIIVNMACGLANRMFQYSYYLFLMHKGYNVKVDFYNSAKLAIEKVAWNDIFPKARIE QASFSDILKSGGGSDVISKIRRKYLPFLSSVVNMPTAFDANLPVENKKLQYIIGVFQNANMVE AVEEDVKRCFKFQPFTDERNLKLQNEMQSCESVAIIVRKGKDYAQRIWYQNTCPIEYYQNA IRLISEKVNNPKLYVFTDNPEWVKEHFKDFPYTLVEGNPASGWGSHFDMQLMSVCKHNIISN STYSWWSAFLNVHNEKIVIGPKVWFNPDSCSEFTSERILCKDWIAV	133
月形单胞菌属 CM52	WP_0096 45343.1	49733 1130	糖基转移酶，家族 11 [月形单胞菌属 CM52]	25.58	MFQYAMASSVARRAGEILKLDLSWIRQMEKKLSADDIYGLGIFSFDEKFSTSNEVQKFLPSG KFSAKIYRAVNRRMPFSWRRVLEEGGMGWHPQIMEIRRSVYFYMGYWQSEKYFSDFIQEIR KDFTFREEVRQSIEERRPIVEKIRKSDAVSLHIRRGDYAQNPALGEIFLSFTMQYYIDAARYISE RVKTPVFFIFSDDIPWAKENLPLPYEVCYIDDNIQTNEREIGHKSKGYEDMYLMTQCQHNIIA NSSFSWWGAWLNHNPNKIVVAPKKWCNGSFNYADIVPEQWVKL	134
北欧多形杆状菌；北欧多形杆状菌 CL02T12C05	WP_0074 86621.1	49475 1213	蛋白质 [北欧多形杆状菌]	25.57	MEIVFIFNGLGNQMSQYALYLSKRNLGCKVRYAYNIRSLSDHNGFELDRVFGITYPNNLFNK CINIIYRLLFANKYLFLVQKMIYVLRQMNVYSIKEKDNYDYDYKILTRHKGIVLYYGGWHSE KYFLSNADIIKDKFRFNISKLNSESLVLYHRLSSLNAVALHVRRGDYMAPEHYNVFGCVCGIE YYKAAIQYIQSQILNPVFIVFSNDIEWVKENITGIQMIFVDFNKKENSWMDMCLMSCCEHNII SNSTFSWWGAWLNNNKNKIVVCPKYFMSNIDTKDIYPESWIKI	135
杆菌（Parabacteroides merdae）；杆菌（Parabacteroides merdae）ATCC 43184；杆菌（Parabacteroides merdae）CL09T00C40	WP_0056 35503.1	49185 5386	蛋白质 [杆菌（Parabacteroides merdae）]	25.54	MKKKDIILRVWGGVGNQLFIYAFAKVLSLITDCKVTLDIRTGFANDGYKRVYRLGDFSISLLP ALRFYTLLSFAQRKMPYIRHLLAYKFDFFEEDQKYPLETLDSFFKIYSDKNLYLQGYWQYFD FSSYRDVLLKDLRFEVEINNTYLYYSDLIEKSNAVAIHFRRIQYEPVSISIDYYKKAIKYISENVE NPTFFIFSDDINWCRENLSINGICFVENFKDELYELKLMSQCNHFIIANSTFSWWGAWLSVN ADKKVIMPDGYTDVSMNGSIVHI	136
丁酸弧菌属 NC2007	WP_0227 68139.1	55102 4004	蛋白质 [丁酸弧菌属 NC2007]	25.51	MIIIQLKGGLGNQMFQYALYKELKHRGRDVKIDDESGFIGDKLRVPVLDRFGVEYDRATKDE VIALTDSKMDIFSRIRRKLTGRKTFRIDEMEGIFDPKILETENAYLVGYWQSEKYFTSPEVIEQI QEAFGKRPQEIMHDSVSWSTLQQIECCESVSIHVRRTDYMDAEHIKIHNLCSEKYYKNAISKI REEHPNAVFFIFTDDKEWCKEHFKGPKFITVELQEGEFTDVADMLLMSRCKHHIIANSSFSW WSAWLNDSPEKIVIAPSKWINNKKMDDIYTERMTKVAI	137

[0208]

小卵性杆菌；小卵性杆菌 ATCC 8483；小卵性杆菌 CL02T12C04	WP_0043 02233.1	49043 0100	蛋白质 [小卵性杆菌]	25.5		MIVVYSNAGLANRMFHYALYKALEVKGIDVYFDEKSYVPEWSFETTTLMDVFPNIQYRESL QFKRASKKTFLDKIVIHCSNLFGGRYYVVNYRFKYDDKLFTKLETNQDLCLIGLWQSEKYFM DVRQEIQKCFQYRSFVDDKNVKTAQQMLSENSVAIHVRKGADYQQNRIWKNTCTIDYYRL AIDYIRMHVQNPVFYVFTDNKDWVIENFTDLDYTLCDWNPTSGKQNYLDMQLMSCAKHN VIANSTYSWWGAWLNENSDKIVIAPKRWFNKIVTPDILPEQWIKI	138
Mesotoga prima MesG1.Ag.4.2；Mesotoga prima	YP_00634 6113.1	38984 4033	糖基转移酶家族蛋白 [Mesotoga prima MesG1.Ag.4.2]	25.5		MRVVWFGGGLGNQMFQYGLYCFLKKNNQEVKADCTQYSTTPMNNGFELERLFNLDIAHA NLDVISKLTGGNRLSPRKVIWKLFRKPKVYFEEKIPFSFDPDVLKGNNRYLKGYWQNMNYL EPCAKELRDVFTFPAFSSDNNKRLADEIAKVEAVGVHFRRGDFLKSSNLGLFGGICSDQYYL RAIQTMENTVVEPVFYVFCDDPQWAKNSFSDARFTVIDWNIGSNSYRDMQLMSLCKHNIIA NSTFSWWAAWLNRNPNRTVIAPERMVNRDLDFSGIFPNDWIRLQG	139
梭状芽孢杆菌属 KLE 1755	WP_0216 39228.1	54539 9562	糖基转移酶，家族 11 [梭状芽孢杆菌属 KLE 1755]	25.49		MIVLKLQGGLGNQMFEYAFARTIQEQKKDKKLILDTSDFQYDKQREYSLGHFILNENIEIDSS GKFNLWYDQRKNPLLKVGFKFWPKFQFQTLKLFGIYVWDYAKYIPVDVSKKHKNILLHGL WQSDKYFSQISEIIRKEFAVKDEPSQGNKAWLERISSANAVCVHIIRRGDFLAKGSVLLTCSNS YYLKAMEIISKKVNEPEFFIFSDDIEDVKKIFEFPGYQITLVNQSNPDYEELRLMSKCKHFIAN STFSWWSSLLSENEDKVIVAPRLWYSDGRDTSALMRDEWIIIDNE	140
普通拟杆菌（Bacteroides plebeius ）CAG:211	WP_0220 52991.1	54732 1746	糖基转移酶 家族 11 [普通拟杆菌（Bacteroides plebeius ） CAG:211]	25.42		MDLVTLSGGLGNQMFQFAFYWALKKRGKKVFLYKNKLAAKEHNGYELQTLFGVEEKCVD GLWMTRLLGCPLLGKILKHILFPHIKIRERVLYNYSIYLPLFERNGLHWVGYWQSEKYFQDVA DDIRRIFCFDHLSLNPATSAALKCMSEQVAVSVHIIRRGDYYLPCNVATYGGLCTVEYYENAIR YVKERYPQAVFYVFSDDLDWVRENIPSAGKMVFVDWNRGKDSWQDMFLMSKCHHNILAN SSFSWWGAWLNTHPEKLVIAPERWANCPAPDALPDGWVRIEGVSRR	141
卵磷脂密螺旋体（Treponema lecithinolyticum）；卵磷脂密螺旋体（Treponema lecithinolyticum）ATCC 700332	WP_0216 86002.1	54544 8980	糖基转移酶，家族 11 [卵磷脂密螺旋体（Treponema lecithinolyticum ）]	25.4		MAIKIVKISGGLGNQMFCYAFACALQKCGHKVYVDTSLYRKATVHSGIDFCHNGLETERLF GIKFDFADTADVRRLSTSAEGLLNRIRRKYFTKKTHYIDTVFKYTPELLSDKNDCYLEGYWQ TEKYFLPIEKDIRRLFTFRPTLSEKSAAVQSALQAQQAAVLSASIIVRRGDFLNTKTLNVCTE TYYNNAIKYAVKKHAVSRFYIFSDDIPWCREHLCFCNAHAVFIDWNTGNDSWQDMALMSM CRCNIIANSSFSWWAAWLNNASDKTVLAPAIWNRRQLEYVDRYYGYDYSDIVPESWIRIPID	142
艾格茨氏杆菌（Bacteroides eggerthii）；艾格茨氏杆菌（Bacteroides eggerthii） DSM 20697	WP_0042 91980.1	49041 9682	糖基转移酶[艾格茨氏杆菌（Bacteroides eggerthii）]	25.34		MRLIKMTGGLGNQMFIYAFYLRMKKRHTNTRIDLSDMMHYNVVHHGYEMHRVFNLPKTEF CINQPLKKVIEFLFFKKIYERKQDPSSLLPFDKKYLWPLLYFKGFYQSERFFADMENDIRIAFT FNSDLFNEKTQAMLTQIKHNEHAVSLHIRRGDYLEPKHWKTTGSVCQLPYYLNAITEMNKRI EQPSYVVFSDDIAWVKENLPLPQAVFIDWNKGAESWQDMMLMSHCRHHIICNSTFSWWGA WLNPRENKTVIMPERWFQHCDTPNIYPDGWIKVPVN	143

[0209]

粪便杆菌（Bacteroides stercoris）；粪便杆菌（Bacteroides stercoris）ATCC 43183	WP_0056 56005.1	49189 1563	糖基转移酶[粪便杆菌（Bacteroides stercoris）]	25.34		MRFIKMTGGLGNQMFIYAFYMRMKKHYSNTRIDLSDMVHYKAHNGYEMHIRVFNLPPIEFRI NQPLKKVIEFLFFKKIYERKQVPSSLVPYDKKYFWPLLYFKGFYQSERFFADMADDIRKAFTF NPRLSNRKTKEMSEQIDHDENAVSIHVRRGDYLEPKYWKTTGCVCQLPYYLNAIAEMNKRI SQPSYYVFSDDIAWVKENLPLPKAFFIDWNKGAESWQDMMLMSRCRHHIICNSTFSWWGA WLNPRENKTVIMPERWFRHCETPDICPDKWIKVPINQPDSIQ	144
蛋白丁酸弧菌（Butyrivibrio proteoclasticus）；蛋白丁酸弧菌（Butyrivibrio proteoclasticus）B316	YP_00383 1842.1	30267 1882	糖基转移酶11[蛋白丁酸弧菌（Butyrivibrio proteoclasticus）B316]	25.34		MIIIQLKGGMGNQMFQYALYRQLKKLGREVKIDDETGFVDDELRIPVLQRFGISYDKATREEI VKLTDSKMDIFSRIRRKLTGRKTFRIDEESGIFDPRILEVEDAYLVGYWQSDKYFANEEVEKEI REAFEKRPQEVMQDSVSWTILQQIECCESVSLHIRRTDYIDEEHIIHHNICTEKYYKSAIDEVR NQYPSAVFFIFTDDKDWCRQHIFRGPNFFVVDLDEDTNTDIAEMTLMSRCKHIIILANSSFSW WAAWLNDNPGKIVIAPSKWINNRKMDDIYTARMKKIAI	145
海洋细菌（海洋细菌）GAI101	WP_0082 28724.1	49550 4071	α-1,2-岩藻糖转移酶[海洋细菌（海洋细菌）GAI101]	25.34		MSPIVHFPSDRLLRYEHLNSLWKTAMIYTRLLARLGNQMFQYAAGRGLAARLGVDFTVDSR RAVHKGDGVLTRVFDLDWAAPENMPPAQHERPLAYYAWRGLRRDPKIYRENGLGYNAAFE TLPDNTYLHGYWQCERYFAHIADDIRAAFVPRHPMSAQNADMARRIASGPSVSLHVRRGD YLTVGAHGICDQTYYDAALAAVMQGLPSPTVYVFSDDPQWAKDNLPLTFEKVVVDFNGPD SDYEDMRLMSLCQHNVIANSSFSWWGAWLNANPQKRVAGPANWFSNPKLSNPDILPSRWIR I	146
Thalassobacter arenae；Thalassobacter arenae DSM 19593	WP_0210 99615.1	54466 6256	α-1,2-岩藻糖转移酶，[Thalassobacter arenae]	25.34		MGQDMIYSRIFGGLGNQLFQYATARAVSLRQGVELVLDTRLAPPGSHWAFGLDHFNISARIA EPSELPPSKDNFFKYVMWRAFGHIDPAFMRERGLGYQSRIAQAPDGTYLHGYFQSERYFADV LDHLENELRIVTPPDTRNAEYADRIASAGHTVSLHVRRGDYVETSKSNSTHATCDEAYYLRA LARLSEGKSDLKVFVFSDDPEWVRDNLKLPYDTTPVGHNGPDKPHEDLRLMSCCSDHVIAN STFSWWGGWLDRRPEARVVGPAKWFNNPKLVNPDILPERWIAI	147
口部普雷沃菌（Prevotella oris）；口部普雷沃菌（Prevotella oris）C735	WP_0043 77401.1	49051 1493	蛋白质[口部普雷沃菌（Prevotella oris）]	25.33		MKIIKIIGGLGNQMFQYALAVALQKKWKDEEIKLDLHGFNGYHKHQGYQLDEIFGHIRFKAA SLKEVAQLAWPYPHYQLWRVGSRLLPKRKTMVCESADCRFQSDLLNLEGSLYYDGYWQDE RYFKAFRTEIIEAFKFTPLVGDSNRKVENMLKEGRFASLHVRRGDYLKEPLFQSTCDIAYYQR AISRLNQMADPYCYLIFSNDIAWCKTHIEPLCDGRRTHYVVDWNHGKESYRDMQLMTFCKH HIIANSSFSWWGAWLSTANDGITIAPHQWYANDRKPSPAAEAWLKL	148
颊炎普雷沃菌（Prevotella oulorum）；颊炎普雷沃菌（Prevotella oulorum）F0390	WP_0043 80180.1	49051 4606	蛋白质[颊炎普雷沃菌（Prevotella oulorum）]	25.33		MKIVRIIGGLGNQMFQYALALALKQQQENEEVKLDLSAFRGYKKHGGFQLVQCFGTTLPAA TWQEVAQLAWYYPHYQLWRLGHRVLPVCKTMLKEPDNGAFLPEVLQRKGDAYYEGCWQ DERYFSHYRPAILQAFTFPTFTNPRNLAMQQQINTTESVAIHVRRGDYLHDALFRNTCGLAYF QRAITCILQHVAHPVFYVFSDDMAWCRQHIQPLLQTNEAVFVDWNHGKASICDLHLMTLCR HHIIANSSFSWWGAWLSPHQAGWIIAPKQWYAHEEKMSPAAERWLKL	149

[0210]

潘氏无毛螺旋体（Spirosoma panaciterrae）	WP_0205 96174.1	52208 4965	蛋白质 [潘氏无毛螺旋体（Spirosoma panaciterrae）]	25.33	MNRRVAVQLKGGLGNQLFQYALGRRLSLQLEAELLFDCSVLENRIPVTNFTFRSFDLDMFRI AGRVATPSDLPLFPKSASIRSPWPHLVQLARLWKQGYSYVYERGFAYNPKMLRQLSDRVYLN GYWQSYRYFEDIAATLRADCSFPDPLPDSAVGLAGQINATNSICLHIRRTDFLQVPLHQVSNA DYVGRAIAYMAERVNDPHIFFVFSDDIAWCQTNLRLSYPVVFVPNELAGPKNSLHFRLMRYC KHFITANSTFSWWAAWLSEPSDGKVIVTPQTWFSDSRSIDDLIPANWIRL	150
蛋白丁酸孤菌（Butyrivibrio proteoclasticus）；蛋白丁酸孤菌（Butyrivibrio proteoclasticus）B316	YP_00382 9826.1	30266 9866	糖基转移酶 11 [蛋白丁酸孤菌（Butyrivibrio proteoclasticus）B316]	25.26	MNYVEVKGGLGNQLFQYTFYKYLEKKSGHKVLLHTDFFKNIDSFEEATKRKLGLDRFDCDF VAVSGFISCEKLVKESDYKDSMLSQDEVFYSGYWQNKRFFLEVMDDIRKDLLLKDENIQDE VKELAKELRAVDSVAIHFRRGDYLSEQNKKIFTSLSVDYYQKAIAQLAERNGADLKGYIFTD EPEYVSGIIDQLGSIDIKLMPVREDYEDLYLMSCARHHIIANSSFSWWGAALGDTESGITIAPA KWYVDGRTPDLYLRNWISI	151
丁酸孤菌属 XPD2006	WP_0227 65786.1	55102 1623	蛋白质 [丁酸孤菌属 XPD2006]	25.26	MIIIQLKGGLGNQMFQYALYKELKHRGREVKIDDVSGFVNDKLRVPVLDRFGVEYERATRE EVVELTDSRMDIFSRIRRKLTGRKTYRIDEMEGIFDPAILETENAYLVGYWQSEKYFTSPEVIE QIQEAFGKRPQEIMHDSVSWSTLQQIECCESVSIIHVRRTDYVDAEHIKHHNLCSEKYYKNAIG KIREKHPNAVFFIFTDDKEWCKDHFKGPNFITVELQEGEFTDVADMLLMSRCKHHIIANSSFS WWSAWLNDSPEKMVIAPSKWINNKKMDDIYTERMTRVAI	152
杆状菌属 1_1_6	WP_0087 66093.1	49604 1586	蛋白质 [多形杆状菌属 1_1_6]	25.24	MKIVNITGGLGNQMFQYAFAMALKYRNPQEEVFVDIQHYNTIFFKKFKGINLHNGYEIDKVF PKAKLPVAGVRQLMKFSYWIPNYILSRLGRKFLPIRKKEYIPPYSMNYSYDEKALNWKGDG YFEGYWQSYNHFGDIKEELQKVYAHPKPNQYNAALISNLESCNSVGIHVRRGDYLAEPEFR GICGLDYYEKGIKEILSDEKKYVFFIFSNDMQWCQENIAPLVGDNRIVFISGNKGKDSCWDM FLMTHCKDLIIANSSFSWWGAFLNKKVDRVICPKPWLNRDCNIDIYNPSWILVPCYSEDW	153
脆弱杆菌；脆弱杆菌 YCH46	YP_09985 7.1	53713 865	α-1,2-岩藻糖转移酶 [脆弱杆菌 YCH46]	25.17	MKIVTFQGGLGNQLFQYVVFYLWLDMRCDKDNIYGYYPKKGLRAIINGLEIEKVFEVKLPNS SLSTDLIVKSIKLINKIFKNRQYISTDGRLDVNGVLFEGFWQDKYFWEDVDIVLNFRWPLKL DVTNSFIMTKIQANNSISIHIRRGDYLLPKYRNIYGDICNEEYYQKAIEYILKCVDDPFFFVFS DDIDWAKSIINVSNVTFVNNNKGKDSYIDMFLMSLCHHNIIANSTFSWWAAQLNKHSDKIMI APIRWFKSLFKDPNIFTESWIRI	154
多形杆状菌属 9_1_42FAA	WP_0086 71843.1	49594 7264	α-1,2-岩藻糖转移酶 [多形杆状菌属 9_1_42FAA]	25.17	MIKIVSFSGGLGNQLFQYLLVVYLRECGHQVYGYYNRKWLIGHNGLEVNNVFDIYLPKTNF IVNALVKVIRVLRCLGFKKYVATDTYNNPIAIFYDGYWQDQKYFNIIDSKLSFKKFDLSAENK SILSKIKSNISVALHIRCGDYLSSSNVEIYGGVCTKEYYEKALELVCKIKNVMFFVFSDDIEYA KLLLNLPNAIYVNANVGNSSFIDMYLMANCKVNVIANSTFSYWAARLNQDNILTIYPKKWY NSKYAVPDIFPSEWVGV	155

[0211]

					MIITVKVQGGLGNQMFQYAFGRALSEKHSQDLYLDCSEYLRPSCKREYGLDHFNIRAKKASC GDVKSMVTPHFALRKKLKKIFAVPYSLSPTHILERNFNFQPSILEFNCGYFDGFWQTQKYFSG ISDIVRKDLTFKDAVKYSGGETFAKITSLNSVSLHIIRRGDYVVKVKRTRKRFSVIRAGYFKRAV EYMRSKLDTPHFFIFTDDPKWVSENFPAGEDYTLVSSSGMYEDLFLMAQCRHNIIFNSSFSW WGAWLNGNPGKIVVAPDMWFTPHYKLDYSDVVPEEWIKLNTGYFESKEF	25.17		156
铁锈色假红杆菌 (Pseudorhodobacter ferrugineus)	WP_0227 05649.1	55095 7292	α-1,2-岩藻糖转移酶［铁锈色假红杆菌（Pseudorhodobacter ferrugineus）］	25.17	MIVMQIKGGLGNQMFQYAAGRALSLQTGMPLHLDLRYYRREREHGYGLGAFNIEASPLDES LLPPLPRESPLAWLIWRLGRRGPNLVRENGMGFNPTLSNVTKPAWITGYFQSERYFAAHAATI RAELTPVAAPDLVNARWLAEIAAEPRAVSLHVRRGDYVRDAKAAAKHGSCTPAYYERALA HITARMGTAPVVYAFSDDPAWVRENLRLPAEIRVPGHNDTAGNVEDLRLMSACRHHIVANSS FSWWGAWLNPRADKIVASPARWFADPAFTNPDIWPEAWARIEG	25.17		157
大肠杆菌；大肠杆菌 O127:H6 菌 E2348/69	YP_00232 9683.1	21548 7252	岩藻糖转移酶[大肠杆菌 O127:H6 菌 E2348/69]	25.16	MMYCCLSGGLGNQMFQYAAAYILKQHFPDTILVLDDSYYFNQPQKDTIRHLELDQFKIIFDR FSSKDEKVKINRLRKHKKIPLLNSFLQFTAIKLCNKYSLNDASYYNPESIKNIDVACLFSFYQD SKLLNEHRDLILPLFEIRDDLRVLCHNLQIYSLITDSKNITSIHVRRGDYVNNKHAAKFHGTLS MDYYISAMEYIESECGSQTFIIFTDDVIWAKEKFSKYSNCLVADADENKFSVIDMYLMSLCN NNIIANSTYSWWGAWLNRSEDKLVIAPKQWYISGNECSLKNENWIAM	25.16		158
毛螺科菌 3_1_57FAA_CT1	WP_0163 59991.1	51153 7894	蛋白质［毛螺科菌 3_1_57FAA_CT1］	25.16	MIIIKVMGGLGNQMQQYALYEKFKSIGKNVKLDISWFEDSSVQEKVFARRSLELRQFKDLQF DTCSAEEKEALLGKSGILGKLERKLIPARNKHFYESDIYHSEVFNMSDAYLEGHWACEKYYH DIMPLLQEKIQFPESANSQNITVKKRMKAENSVSIHIRRGDYLLDPENEAMFGGICTNSYYKA AEEYIKSRVPDTHFYLFSDDTAYLRENYHGDEYTIVDWNKGEDSFYDMELMSCCRHNICAN STFSFWGARLNRTPDKIVIRPAKHKNSQEIEPQLLHELWDNWVIIDGDGRIV	25.16		159
溶纤维丁酸弧菌	WP_0227 55397.1	55101 0878	糖基转移酶[溶纤维丁酸弧菌]	25.09	MKPLVSLIVPVLNVEKYLEQCLTSISSQTYDNFEVILVVGKCIDNSENICKKWCEKDHRFRIEP QLKSCLGYARNVGIDAAKGEYIAFCDSDDCITSDFLSCFVDTALKNSSDIVETQFTLCDQNLS PIYDYDRNILGHILGHGFLEYTSAPSVWKYFVKRDIFTSNNLHYPEIRFGEDISMYSLLFSYCN KIDYVEKPTYLYRQVPSSLMNNPQGKRKRYESLFDIIDFVTNEFKTRLLFQKSWLKLLFQLE MHSASIISDSATSDDEAISMRQEISGYLKKVFPVKNTIFEVTALGWGGEIVSSIASKFNTLHGV SSSNMFNRYFFELLEDSTRKKLEEMIINFSPDIFLIDLISEADYLSSYKGNLGTFVKNWKIGFSI FMKMIQTHSNNSSIFLLENYMQQAPDHVDNTNEILKMLYDDIKNHPDIICISPAPDILNRSSEP ELPCIYQLKLVSDKLHTMYSPVINCVETKGGLGNQIFQYVFSKYIEKMTGYRPLLHIGFFDYV KAIPGGTKRIFSLDKLFPDIETTSGKIPCSHVVEEKSFISNPGSDIFYRGYWQDIRYFSDVKDEV LESFNVDTSSMSKDVIDFADTIRNANSIAMHIIRRQDYLNENNVSLFEQLSIDYYKSAVDMIRK	25.09		160

[0212]

					EYADDLVLFIFSDDPEYANSIADSFDIEGFVMPLHKDYEDLYLITLAHHHHIANSTFSLWGALL SARKDGIRIAPRNWFKGTPATNLYPDKWLIL	
酸性质氧弯形菌（Anaeromusa acidaminophila）	WP_018702959.1	51753	蛋白质［酸性质氧弯形菌（Anaeromusa acidaminophila）］	25.08	MFCVRIYGGLGNQMFQYALGRAMAKHYSETAAFDLSWYEQKIKPGFEASVCQYNIELSRK DRPKAWYEPILKRISRHTDKLFMWFGLFFEKKYHYDSTVFERGLCKKNITLDGYWQSYKYF SAIEDDLRRELTIPKEREELIAISRSLPENSVSIHVRRGDYVSNPKANAMHGTCSWEYYQAAI EKMTGLVKEPQYVVFSDDITWTKENLPLPNAMYIGRELGLFDYEELILMSRCKHNIMANSTF SWWGAWLNSNPNKVVIAPRKWFRHKKIKVNDLFPSSWVVL	161
多形杆状菌属 2_1_16	WP_008768986.1	49604 4479	糖基转移酶家族 11［多形杆状菌属 2_1_16］	25.08	MDIVVIFNGLGNQMSQYAFYLAKKKDNLNCHVIFDPKSTNVHNGAELKRVFGIELNRNYLD KIISYFYGYIFNKRIVNKLFSLVGIRMIYEPKNYDYREELLKPSSNFISFYWGGWHSEKYFKDI ELEVKKVFKFPEVTNSPYFTEWFNKIFLDNNSVSIHIRRGDYLDKPSDPYYQFNGVCTIDYYE KAILYLKERILEPNFYIFSNDINWCMKTFGTENMYYVDCNKGKDSWRDMYLMSECRHHINA NSTFSWWAAWLSPYSNGIVLHPKYFIKDIETKDYYPQKWIMIE	162
褐杆状绿菌（Chlorobium phaeobacteroides）；褐杆状绿菌（Chlorobium phaeobacteroides）BS1	YP_001960319.1	18950 0849	糖基转移酶家族蛋白［褐杆状绿菌（Chlorobium phaeobacteroides）BS1］	25.08	MDKVVVHLTGGLGNQMFQYALGRSISINRNCPLLLNTSFYDTYDKFSCGLSRYNVVKAEFIKK NSYYNNKYYRYVIRLLSRYGVACYFGSYYEKKIFSYDEKVYKRSCVSYYGTWQSYGYFDSI RDILLRDYEMVGCLEEEVEKYVSDIKRVDSVSLHIRRGDYFDNKRLQSIHGILTMEYYYKAM SLFPDSSVFYVFSDDIEWVRENLITNTNIVYVVLESDNPENEIYLMSLCKNNIISNSTFSWWG AWLNKNKYKKVIAPRMWYKDNQSSSDLMPSDWCLI	163
伯氏密螺旋体	WP_022932606.1	55131 2724	蛋白质［伯氏密螺旋体］	25.08	MIVISMGGGLGNQMFEYAFYTQLKHLYPKSEIKVDTKYAFPYSHNGIEVFKIFGLNPPEANW KEVHSLVKTYPIEGNKAHFIKFFLYRILRKANLVEREPTSFCKQKDFTEFYNSFFELPQNKSFY LYGPFVNYNYFAAIHNEIMDLYTFPEITDVTNIEYKRKIESSHSISIHIRRGDYITEGVPLVPDA YYREALVYINKKIEDPHFFVFTDDKDYCKSLFSDNQNFTIVEGNTGANSFRDMQLMSLCKH NIIANSTFSFWGAFLNKNSEKIVIAPNIAFKDCSCPYICPDWIIL	164

[0213]

	YP_00511	37535	LPS 生物合成 α-1,2-岩藻糖转移酶 [脆弱杆		MVIAKLFGGLGNQMFIYAAAKGIAQISNQKLTFDIYTGFEDDSRFRRVYELKQFNLSVQESRR WMSFRYPLGRILRKISRKIGFCIPLVNFKFIVEKKPYHFQNEIMRIASFSSIYLEGYFQSYKYFS KIEAQIREDFKFTKEVIGSVEKEASFITNSRYTPVAIGVRRYSEMKGEFGELAVVEHDYYDAAI KYIANKVPNLIFIVFSEDIDWVKKNLKLDYPVYFVTSKKGELAAIQDMYLMSLCNHHIISNSS	25	FYWWGAYLASTNNHIVIAPSVFLNKDCTPIDWVII	165
脆弱杆菌；脆弱杆菌 638R	0943.1	8171	菌 638R]			
	WP_0223	54795	蛋白质 [厚壁菌门细菌		MSGGLGNQMFQYALYMKLTAMGREVKFDDINEYRGEKAWPIMLAVFGIEYPRATWDEIVAF TDGSMDFSKRLKRLFRGRHPIEYVEQGFYDPKVLSFENMYLKGSFQSQRYFEDILEEVQETF RFPELKDMNLPAPLYETTEKYLLRIEGCNAVGLHMYRGDSRSNEELYDGICTEKYYEGAVRF IQDKCPDAKFFIFSNEPKWVKGWVISLMKSQIREDMSREEIRALEDHFVLIENNTEYTGYLD MFLMSRCRHNIISNSSFSWWAAFINENPDKLVTAPSRWVNGVPSEDVYVKGMTLIDEKGRVE RTIKE	25		166
厚壁菌门细菌 CAG:534	52105.1	1298	CAG:534]			
	WP_0223	54797	糖基转移酶家族 11 [厚壁菌门细菌		MVIVKIGDGLGNQMFNYVCGYSVAKHDNDTLLLDTSDVDNSTLRTYDLDKFNIDFTDRESF TNKGFFHKVYKRLRRSLKYNVIYESRTENCPCVLDVYRRKFIRDKYLHGYFQNLCYFKTCK EDIMRQFTPKEPFSAKADELIHRFATENTCSVHVRGGDIKPLSIKYYKDALDKIGEAKKDMR FIVFSNVRNLAEEYIKELGVDAEFIWDLGEFTDIEELFLMKACRRHILSDSTFSRWAALLDEK SEEVFVPFSPDADKIYMPEWIMEEEYDGNEEKR	25		167
厚壁菌门细菌 CAG:882	68748.1	1670	CAG:882]			
副溶血性孤菌；副溶血性孤菌 10329；副溶血性孤菌 10296；副溶血性孤菌 12310；副溶血性孤菌 10290	WP_0054	49163	糖基转移酶家族 11 [副溶血性孤菌]	25	MVTVKVSGGLGNQLFQYAIGCAISNRLSCELLLDTSFYPKQSLRKYELDKFNIKAKVATQKE VFSCGGGDDLLSRFLRKLNLSSLFFPNYIKEKESLVYLAEISHCKSGSFLDGYWQNPQYFSDI KDELVKQIVPIMPLSSPALEWQNIIINTKNCVSLHVRRGDYVNNAHTNSVHGVCDLSYYREA ITNIHETVEKPKFFVFSDDISWCKDNLGSLGHFTYVDNTLSAIDDLMLMSFCEHHIIANSTFS WWGAWLNDHGITIAPKRWFSSVERNNKDLFPEKWLIL	168
	96882.1	9353				
佛茱辛草螺菌；佛茱辛草螺菌 GSF30	WP_0064	49350	糖基转移酶家族蛋白 [佛茱辛草螺菌]	24.92	MIVSRLIGGLGNQMFQYAAGRALALRRGVPFAIDSRAFADYKTHAFGMQCFCADQTEAPSR LLPNPPAEGRLQRLLRRFLPNPLRVYTEKTFTFDEAVLSLPDGIYLDGYWQSEKYFADFADDI RKDFAVKAAPSAPNQAWLELIGRTHSVSLHIRRGDYVSNAAAAAVHGTCDLGYYERAVAHL HQVTGQAPELFVFSDDLDWVATNLQLPYTMHLVRDNDAATNFEDLRLMTACRHHIVANSSF SWWGAWLDGRSESITIAPARWFVADTPDARDLVPQRWVRL	169
	63714.1	9348				
根瘤菌 CF080	WP_0077	49503	Glycosyl 转移酶家族 11 [根瘤菌 CF080]	24.92	MIITRILGGLGNQMFQYAAGRALAIANEAELKLDLIEMGAYKLRPFALDQFNIKAAIAQPDE VPAKPKRGLLRKFTSAFKPDRSSCERIVENGLTFDSRVPALRGSLHLSGYWQSEQYFASSADA IRSDFSLKSPLGPARQDVLARIGAATTPVSIHVRRGDYVTNPSANAVHGTCEPPWYYHEAMRR MLDRAGDASFFVFSDEPQWARDNLQSSRPMVFIEPQNNGRDGEDMHLMAACHAHIIANSSF SWWGAWLNPRPNKHVIAPRQWFRAPDKDDRDIVPATWERL	170

[0214]

蝶骨棘疣微菌（Verrucomicrobium spinosum）	WP_009959380.1	49764 5196	糖基transferase，家族11 [蝶骨棘疣微菌（Verrucomicrobium spinosum）]	24.85		MVISHISEGLGNQMFQYAAGRRLSYHLGTTLKLDDYHYRLHPFRSFQLDRFLITSPIATDAEI SHLCPLEGLARAIRARLPGKLRGATLRLLGNLGLGSPYQPRLHSFKEETPKQPLLIGKVVSER HFHFDPDVLECPDNVCLVGYWQDERYFGEIRDILLRELTLKSPPAGATKAVLERIQRSSSVSL HVRRGDKTKSSSYHCTSLFYCLAAMSEMRARLQAPTFFVFSDDWDWVREQIPCSSSVIHVD HNRAEDVSEDFRLMKSCDIHHIIASSSLSWWAAWLGTNENSFVFSPPADRWLNFSNHIFTADV LPPHWIQLDGSSLLPAQ	171
Fibrella aestuarina; Fibrella aestuarina BUZ 2	YP_007319049.1	43683 3833	糖基转移酶家族11 [Fibrella aestuarina BUZ 2]	24.83		MTANRVLVNSPMVIAKITSGLGNQLFQYALGRHLALQGNTSLWFDLRYFHQEYATDTPRKF KLDRFNVRYNLLDSSPWLYASKATRLLPGRSLRPLIDTRFEADFHFDPTVIRPAAPLTILWGFW QSEKYFAQSTPQIRQELTFNRPLSDTFVGYQQQIEQAEVPISVHVRRGDYVTHPEFSQSFGFV GLAYYQKALAHLQDLFPNATLFFFSDDPDWVRANIVTEQPHVFVQNSGPDADVDDLQLMS LCHHHVIANSSFSWWGAWLNPRPDKVVIGPQRWFANKPWDTKDLLPSGWLRL	172
球形红假单胞菌 CACIA14H1	WP_023656745.1	56338 0195	α-1,2-岩藻糖转移酶 [球形红假单胞菌 CACIA14H1]	24.83		MIHMRLVGGLGNQLFQYACGRAVALRHGTELVLDTRELSRGAAHAVFGLDHFAIRARMGAS ADLPPPRSRVLAYGLWRAGFMAPRFLRERGLGVNPAVLAAGDGTYLHGYFQSEAYFRDVVP QIRPELEIVTPPSDDNLRWASRIAGDDRAVSLHVRRGDYVASAKGQQVHGTCDADYYARAV AAIRARAGIDPRLYVFSDDPHWARDNLALDAETVVLDHNPPGAAVEDMRLMGVCRHHIIAN SSFSWWGAWRNPSAGKVVVAPVRWFADPKLIHNPDICPPEWLRV	173
波罗地红小梨形菌属（Rhodopirellula baltica ）SH 1；波罗地红小梨形菌属（Rhodopirellula baltica ）	NP_86877 9.1	32475 785	fucosyl 转移酶 [波罗地红小梨形菌属（Rhodopirellula baltica ）SH 1]	24.83		MATSAHLHLSDEKQTLDSKASDRDCATTEASASDKTCTISISGGLGNQMLQYAAGRALSIHHH DCSLQLDLKFYSSKRHRSYFLDAFPIQAHRSIKPSFFSQILSKIQSESKHVPTYQEQSKRFDPAF FNTEPPVKIRGYFFSEKYFSPYADQIRTELTPPIPPDQPARDMAIRLKECVSTSLHVRRGDYVT NANARQRFWCCTSEYFEAAIERLPTDSTVFVFSDDIEWAKQNIRSSRTTVYVNDELKKAGSP ETGLRDLWLMTHAKSHIIANSSFSWWGAWLANSEANLTIAPKKWFNDPEIDDSDIVPSSWH RI	174
斯匹茨卑尔根岛无毛螺旋体属（Spirosoma spitsbergense）	WP_020604045.1	52209 2845	蛋白质 [斯匹茨卑尔根岛无毛螺旋体属（Spirosoma spitsbergense）]	24.83		MVVVELMGGLGNQMFQYAFGMQLAHQRQDTLTVSTFLLSNKLLANLRNYTYRPFELCIFGI DKPKASPFNLLRALLPFDLNTSLLRETDDPEAVIPAASARIVCVGYWQSEHYFEEVTVHVRE KFIFRQPFNSFTSRLANNLNGIPNSVFVHIRRGDYVTNKGANAHHGLCDRTYYERAVTFMRE HLENPLFFIFSDDLEWVSQELGPILEPATYVGGNQKNDSWQDMYLMSLCRHAIVANSSFSW WGAWLSPHASKIVVAPKEWFGKPLLPVKTNDLIPNSWIRI	175

[0215]

未培养细菌	EKD7140 2.1	40693 8106	蛋白质 ACD_46C0019 3G0003 [未培养细菌]	24.76		MNAIIPRLTGGIGNQLFIYAAARRMAIANSMNLVIDDTSGFKYDVLYKRFYQLEKFNITSRMA TPTERLEPFSKIRRYLKRKINKTYPFAQRAYITQEKSGFDPRLLVFRPKGNVYLDGYWQSENY FKDIEGIIRQDLIIKSPSDSLNIATAERIKNTLAIAVHVRFFDMVDISDSSNCQSNYYHTAIAKM EEKIPNAHYFIFSDKPVLARLAMPLPDDRITIIDHNIGDMNAYADLWLMSLCKHFVIANSTFS WWGAWLSDNKEKIVIAPDIKITSGVTQWGFDGLIPDEWIKL	176
蕃雷沃菌藻；蕃雷沃菌藻 F0438	WP_0069 50883.1	49400 8437	蛋白质 [蕃雷沃菌藻]	24.75		MDVTVIFNGLGNQMSQYAFYLEKRLRNRQTTYFVLNPRSTYELERLFGIPYRSNLMCRMIYK LLDKAYFSNHIRLKKILRTALNAVGIRLIVEPITRNYSLSNFTHHPGLTFYRGGWHSELNFTSV VTELRRKFIFPPSDDEEFKRISALIIRTQSISLHIRRGDYLDYSEYQGVCTEEYYERAIEYIRSHV ENPVTFFVFSDDKEYAINKFSGDDSFRIVDFNTGENSWRDMQLMSLCRHHILANSTFSWWGA WLDSAPEKIVLHPIYHMRDVPTRDFYPHNWIGISGE	177
嗜热蓝藻 NK55	AHB8795 4.1	56473 7556	α-1,2-岩藻糖转移酶 [嗜热蓝藻 NK55]	24.75		MIIVRLYGGLGNQMFQYAAGLALSLRHAVPLRFDLDWFDGVRLHQGLELHRVFDLDLPRAA PSEMRQVLGSFSHPLVRRLLVRRRLRWLLPQGYALEPHFHYWPGFEALGPKAYLDGYWQSE RYFSEYQDAVRAAFRFAQPLDERNRQIVEEMAACESVSLHVRRGDFVQDPVVRRVHGVDLS AYYPRAVALLMERMREPRFYVFSDDPDWVRANLKLPAPMIVIDHNRGEHSFRDMQLMSAC RHHILANSSFSWWGAWLNSQPHKLVIAPKRWFNVDDFDTRDLYCSGWTVL	178
Coleofasciculus chthonoplastes; Coleofasciculus chthonoplastes PCC 7420	WP_0061 00814.1	49303 1416	Glycosyl 转移酶家族 11 [Coleofasciculus chthonoplastes]	24.73		MLSLNKNFLFVHIPKSCILKEVYIYMISFPNLGKGVRLGNQMFQYAFLRSTARRLGVKFYCPA WSGDSLFTLNDQEERVSQPEGITKQYRQGLNPGFSENALSIQDGTEISGYFQSDKYYDNPDL VRQWFSLKEEKIASIRDRFSRLNFANSVGMHLRFGDVVGQLKRPPMRRSYYKKALSYIPNQ ELILVFSDEPERTKKMLDGLSGNFLFLSGHKNYEDLYLMTKCQHFICSYSTFSWWGAWLGG ERERTVIYPKEGQYRPGYGRKAEGVSCESWIEVQSLRGFLDDYRLVSRLEKRLPKSLMNFFY	179
鹑鸡杆菌	WP_0186 66797.1	51749 6220	糖基转移酶 [鹑鸡杆菌]	24.66		MRLIKMTGGLGNQMFIYAFYLRMKKRHTNTRIDLSDMMHYNVVHHGYEMHHVFNLPKTEF CINQPLKKVIEFLFFKKIYERKQDSSNLLPFDKKYFWPLLYFKGFYQSERFFADMENDIRKAF TFNSGLFNEKTQTMLKQIEHNEHAVSLHVRRGDYLEPKHWKTTGSVCQLPYYINAIAEMNR RIEQPFYVVFSDDIAWVKENLPLPQAVFIDWNKGVESWQDMMLMSHCRHHIICNSTFSWWG AWLNPKENKTVIMPERWFQHCETPNIYPAGWIKVPIN	180
厚壁菌门细菌 CAG:882	WP_0223 67483.1	54796 7507	糖基转移酶 GT11 家族[厚壁菌门细菌 CAG:882]	24.66		MNNVEIMGGLGKQLFQYAFSRYLQKLGVKNVVLRKDFFTIQFPENNGITKREFVLDKYNTR YVAAAGEKTYRDYCDENDYRDDYAIGSDEVLYEGYWQNIDFYNVVRKEMQEELKLKPEFI DNSMAAVEKDMSSCNSVALHIRRSDYLTQVNAQIFEQLTQDYYASAVSIIEQYTHEKPVLYIF SDDPEYAAENMKDFMGCRTVIMPPCEPYQDMYLMTRAKHNIIANSTFSWWGATLNANPDN ITVAPSRWMKGRTVNLYHKDWITL	181

[0216]

					MIAVNVNAGLANQMFHYAFGRGLMAKGLDVCFDQSNFKPRSQWAFELVRLQDAFPSIDIKV	
					MPEGHFKWVFPSLPRNGLERRFQEFMKKWHNFIGDEVYIDEPMYGYVPDMEKCATRNCIY	
					KGFWQSEKYFRHCEDDIRKQFTFLPFDELKNIEVAAKMSQENSVAIHLRKGDDYMQSELMG	
木糖降解杆菌；木糖降解杆菌 CL03T12C04	WP_008021494.1	49529 6741	蛋白质 [木糖降解杆菌]	24.6	KGLCTVDYYMKAIDYMRKHINNPHFYVFTDNPCWVKDNLPEFEYILVDWNEVSGKRNFRD	
					MQLMSCAKHNIIGNSTYSWWAAWLNANQDKIVVGPKRFFNPINSFFSTCDIMCEDWISL	182
					MIGMVIFRAYNGLGNQMFQYALGRHLALLNEAELKIDTTAFADDPLREYELHRLKVQGSIAT	
					PDEIAFFREMENTHPQAYLRLTQKSRLFDPAILSARGNIYLHGFWQTEKYFADIREILLDEFEPI	
					VPAGEDSIKVLSHMKATNAVALHVRRSDYVSNPMTLRHHGVLPLDYYREAVRRIAGMVPDP	
	YP_004197726.1	32241 8503	糖基转移酶家族蛋白 [地杆菌 M18]	24.58	VFFIFSDDPQWAKDNIRLEYPAFCVDAHDASNGHEDLRLMRNCKHFIIANSSFSWWGAWLS	
地杆菌 M18					QNTGKKVVAPLKWFAKPEIDTRDIVPLQWIRI	183
					MITTRLHGRLGNQMFQYAAARGLAARLGTQVALDTRLAESRGEGVLTRVFDLDLAQPDQLP	
					PLKGDGLLRHGAWRLLGLAPRFRREHGLGYNAAIETWDDGTYLHGYWQSERYFAHIAARI	
			α-1,2-岩藻糖基转移酶，[波氏罗伊鲁支氏菌（Ruegeria pomeroyi ）DSS-3]		RADFAFPAFSNSQNAEMAARIGDTDAISLHVRRGDYVALAAHTLCDQRYYAAALTRLLEGV	
波氏罗伊鲁支氏菌（Ruegeria pomeroyi ）DSS-3	YP_168587.1	56698 215		24.57	AGDPVVYLFSDDPAWARDNLALPVQKVVVDFNGPETDFEDMRLMSLCRHNIIGNSSFSWW	
					AAWLNAHPGKRIAAPASWFGDAKLHNPDLLPPDWLKIEV	184
					MIIIQLAGGLGNQMQQYAMYQKLLSLGKKVKLDISWFEEKNRQKNVYARRELELNYFKKA	
					EYEACTEEERKALVGEGGFAGKIKGKLFPGTRKIFRETEMYHPEIFDFEDRYLYGYFACEKYY	
					ADIMEILQEQFVFPPSGNPENQKMAERIADGESVSLHIRRGDYLDAENMAMFGNICTEEYYA	
					GAIREMKKIYPSAHFFVFSDDIPYAKETYSGEEFTVVDINRGKDSFFDIWLMSGCRHNICANS	
	WP_016291997.1	51103 7973	蛋白质 [毛螺科菌 28-4]	24.52	TFSFWGARLNRNKGKVVMRPFIHKNSQKFEPELMHELWKGWVFIDNRGNIC	185
毛螺科菌 28-4						
					MRILVFTGGLGNQMFEYAFYKHLKSCFPKESFYGHYGVKLKEHYGLEINKWFDVTLPPAKW	
					WTLPVVGLFYLYKKLVPNSKWLDLFQREWKHKDAKVFFPFKFTKQYFPKENGWLKWKVD	
			糖基转移酶家族 11 [善雷沃菌 CAG:1092]		EASLCEKNKKLLQVIIHDEETCFVHVRRGDYLASNFKSIFEGCCTLDYYKRALEYMNKNNPK	
善雷沃菌 CAG:1092	WP_021989703.1	54725 4188		24.49	VRFICFSDDLEWMRKNLPMDDSAIYVDWNTGTDSPLDMYMMSQCDNGIIANSSFSYWGAY	
					LGGKKTTVIYPQKWWNMEGGNPNIFMDEWLGM	186
					MVISVLSGGLGNQLFQYAFGLKLAAQLQTELRLERHLLLESKAIARLRQYTPRTYELDTFGVE	
					APAASLMDTVSCLSRVALSDKTALLLRESTLTPNAINNLNNRVRDVVCLGYWQSEEYFRPAT	
	WP_018618567.1	51744 7743	蛋白质 [螺状菌属贵体]	24.41	EQLRKHLVFRKNPAQSRSMADTILSCQNAAFVHIRRGDYVTNTHANQHHGLCDVSYYRRA	
螺状菌属贵体					CEYVKECIPDVQFFVFSDDPDWAKRELGIHLQPARFIDHNRGADSWQDMYLMSLCRHAIVA	
					NSSFSWWGAWLNPVAERLVVAPGQWFVNQPVLSQQIPPHWHCL	187

[0217]

波塞冬海单胞菌（Marinomonas posidonica）IVIA-Po-181；波塞冬海单胞菌（Marinomonas posidonica）	YP_00448 0472.1	33390 6886	糖基转移酶家族蛋白 [波塞冬海单胞菌（Marinomonas posidonica）IVIA-Po-181]	24.34		MIIVDLSGGLGNQMFQYACARSLSIELNLPLKVVYGSLASQTVHNGYELNRVFGLDLEFATE NDMQKNLGFFLSKPILRKIFSKKPLNNLKFQNFFPENSFNYNSSLFSYIKDSGFLQGYWQTEK YFLNHKSQILKDFCFVNMDDETNISIANDIQSGHSISIHVRRGDYLTNLKAKAIHGHCSLDYY LKAIEFLQEKIGESRLFIFSDDPEWVSENIATRFSDVSVIQHNRGVKSFNDMRLMSMCDHHII ANSSFSWWGAWLNPSQNKKIIAPKNWFVTDKMNTIDLIPSSWILK	188
多形杆状菌；多形杆状菌属 4_3_47FAA；多形杆状菌属 3_1_40A；朵丽多形杆菌 5_1_36/D4；普通拟杆菌 PC510；朵丽多形杆菌 CL03T12C01；普通拟杆菌 dnLKV7	WP_0058 39979.1	49242 5792	糖基转移酶家族 11 [多形杆状菌]	24.32		MKIVVFKGGLGNQLFQYAFYKYLSRKDETFYFYNDAWYNVSHNGFELDKYFKTDDLKKCS RFWIILFKTILSKLYHWKIYVVGSVEYQYPNHLFQAGYFLDKKYYDENTIDFKHLLLSEKNQ SLLKDIQNSNSVGVHIRRGDYMTKQNLVIFGNICTQKYYHDAIRIITEKVNDAVFYVFSDDIS WVQTHLDIPNAVYVNWNTGESSIYDMYLMSSCKYNIIANSTFSYWAARLNKKTNMVIYPSK WYNTFTPDIFPESWCGI	189
逸在远洋杆菌（Candidatus Pelagibacter ubique）	WP_0201 69431.1	51901 3556	蛋白质 [逸在远洋杆菌（Candidatus Pelagibacter ubique）]	24.32		MTIRIKLTGGLGNQMFQFATGFAIAKKKNVRLSLDLKYINKRKLFNGFELQKIFNIYSKVSFL NKTLSFKSINFTEILNRIDTTFYNFKEPHFHYTSNILNLPKHSFLDGYWQSELYFNEFATEIKRI FNFSGKLDKSNLLVADDINRNNSISIHIRRGDFLLKQNNNHHTDLKEYYLKAINETSKIFKNP KYFIFSDDTSWTVDNFVIDHPYTIVDINFGARSFLDMYLMSLCKSNIIANSSFSWWSAWLNNN KDKIIYAPKNWFNDKSICTDDLIPESWNIIL	190
多形杆状菌属 CAG:875	WP_0223 53174.1	54795 2428	未定性的 蛋白质 [多形杆状菌属 CAG:875]	24.29		MSVIINMACGLANRMFQYAFYLYLQKEGYDAYVDYFTRADLVHENVDWLRIFPEATFRRAT ARDIRKMGGGHIDCFSRLRRKLLPMTTKVLETSGAFEIILPPKNRDSYLLGAFQSAKMVESVD AEVRRIFTFPEFESGKNQYFQTRLAQENSVGLHIRKGKDYQERIWYKNTCGVEYYRKAVDL MKEKVDSPSFYVFTDNPAWVKENLSWLEYKLVDGNPGSGWGSHCDMQLMSLCKHNIISNS SYSWWGAYLNNTLNKIVVCPRIWFNPESTKDFSSNPLLAEGWISL	191
溶纤维丁酸弧菌	WP_0227 56327.1	55101 1911	蛋白质 [溶纤维丁酸弧菌]	24.29		MIIIKLQGGLGNQLFLYGLYKNLKHLKRDVKMDIESGFEGDELRKPCLDCMNLEYAIATRDE VTDIRDSYMDIFSRIRRKITGRKTFDYYEPEDGNYDPKVLEMTKAYLNGYFQSEKYFGDEES VKALKDELTKGKEDILTSTDLITKIYHDIKNSESVSLHIRRGDYLTPGIIETYGGICTDEYYDK AIAMIRETFPEARFFIFSNDIEWCKEKFAGDKNILFVNTIGINLDSEDNIKIGKSDKDISEYRDL AELYLMSACKHHILANSSFSWWGAWLSDHEGMTIAPSKWLNNKNMTDIYTKDMLLI	192

[0218]

产丁酸盐罗氏菌（Roseburia hominis）；产丁酸盐罗氏菌（Roseburia hominis）A2-183	YP_00483 9455.1	34753 2692	糖基转移酶家族蛋白［产丁酸盐罗氏菌（Roseburia hominis）A2-183］	24.22	MVTVKIGDGMGNQMYNYACGYAAAKRSGFEKLRLDISECDNSTLRDYELDHFRVVYDEKES FPNRTFWQKLYKRLRRDIRYHVIRERDMYAVDARVFVPARRGRYLHGYWQCLGYFEEYLD DLREMFTPAYEQTDAVRELMQQFTQTPTCALHVRGGDLGGPNRAYFQQAIARMQKEKPDV TFIVFTNDLPKAKECLDDGFEARMRYIAEFGEALSDIDEFFLMSACQNQIISNSTYSTWAAYLN TLPGRIVIVPKFHGVEQMALPDWIVLDGGACQKGEIDAV	193
橄榄红小梨形菌（Rhodopirellula europaea）；橄榄红小梨形菌（Rhodopirellula europaea）6C	WP_0086 59200.1	49593 4621	α-1,2-岩藻糖转移酶［橄榄红小梨形菌（Rhodopirellula europaea）］	24.16	MATSVHIPHLSDGKQALDSKAAQQVCSTQAASASDRACTISISGGLGNQMLQYAAGRALSIH HDCPLQLDLKFYSSKRHRSYELDAFPIQAQRWIKPSFFSQVLDKIQGESKSAPTYEEQSKRFD RAFFDIELPARIRGYFFSEKYFLPYADQIRTELTPPVPLDQPARDMAQRLSEGMSTSLHVRRG DYVSNANARQRFWSCTSEYFEAAIEQMPADSTVFVFSDDIEWAKQNIRSSRPTVYVNDELKL AGSPETGLRDLWLMTHAKSHIIANSSFSWWGAWLSGSEANLTIAPKKWFNDPEIDDSDIVPT SWRRI	194
Rudanella lutea	WP_0199 88573.1	51883 2653	蛋白质［Rudanella lutea］	24.16	MVIAKITSGLGNQLFQYALGRHLAIQNQTRLWFDLRYYHRTYETDTPRQFKLDRFSIDYDLL DYSPWLYVSKATRLLPGRSLRPLFDTRKEPHFHLDPAVPNAKGAFITLDGFWQSEGYFASNA ATIRRELTFTRQPGPMYARYRQQIEQTQTPVSVHIRRGDYVSHPEFSQSFGALDDTYYQTALA QINGQFPDATLLVFSDDPEWVRQHIMRFERPHVLVENTGPDADVDDLQLMSLCHHHIIANSSF SWWGAWLNPRPDKRVIAPKQWFRNKPWNTADLIPAGWVRL	195
拟杆菌；二氧化碳噬纤维菌属口腔类 329 菌 F0087；克拉副普氏菌 YIT 11840	WP_0086 18094.1	49589 3515	糖基转移酶[拟杆菌]	24.15	MRLIKMTGGLGNQMFIYAMYLKMKTIFPDVRIDLSDMVHYQVHYGYEMNKVFHLPRTEFC INRSLKKIIEFLLFKTILERKQGGSLVPYTRKYHWPWIYFKGFYQSEKYFAGIEKEVREAFVFD IRRASRRSLRAMQEIKADPHAVSIHVRRGDYLLEKHWKALGCICQSSYYLNALAELEKRVK HPHIYVVFSEDLNWVRQNLPLIKAEFIDWNKGEDSWQDMMLMSHCRHHIICNSTFSWWGA WLNPLPDKIVIAPERWTQTTDSADVVPESWLKVSIG	196
Smaragdicoccus niigatensis	WP_0181 59152.1	51690 6936	蛋白质［Smaragdicoccus niigatensis］	24.08	MADVVVTLAGGLGNQLFQTAYAKNLEARGHRVTLDGTVVRWTRGLHIDPQICGLKILNATP PAPVPGRLAATVLRRALATRLRFGPDGRIVRTQRTLEFDEQYLNLNSPGRYRVEGYWQCERY FSDVGQTVRKVFLDMLGRHVSYNGLSRLPAMADPSSISLHVRRGDYVVTANFIDPLALEYYE RALEELAVPSPRIFVFSDDLDWATRELGRICDVIPVEPDWTSHPGGEIFLMSQCSHHIIANSSFS WWGAWLDGRTSSRVVAPRQWFSLETYSARDIVPDRWTKV	197
脆弱杆菌 CAG:558	WP_0220 12576.1	54727 9005	家族 11 糖基转移酶［脆弱杆菌 CAG:558］	24.05	MIHLILGGGLGNQMFQYAFARSLALQYNENISFNTILYKELKNEERSFSLGHLNINTMCIVET PDENKRIWELFNKQIFHQKIARKILPASIRWWWMSNRNIYANVCGPYKYYIIPRHRSQNTTII HGGFQSWKYFKEHQSMIKAELKVITPISEPNKKILKEIQNSNSICVHIRRGDFLSAQFSPHLEV CNKDYYEKAIKMISSQIENPTFFIFSNTHEDLVWIRKNYNIPQNSVYVDLNNPDYEELRLMY NCKHFILSNSSFSWWAQYLSESKNKIIIAPKIWDKRKGIDFSDIYMPEWIIIK	198

[0219]

						MSFSIDVAAIQRMALVKVDGGLGSQMWQYALSLAVGKSSSFTVKHIDLSWFRHYAKDIRGIE NRFFILNSVFTNINLRLASENERLFFHIALNRYPDSICNFDPDILALKQPTYLGGYYVNAQYVT SAEKEIREAYVFAPAVEESNQAMLQTIHAAPMPVAVHVRRGDYIGSMHEVLTPRYFERAFKIL AAALQPKPTFFVFSNGMEWTKKAFAGLPYDFVYVDANDNDNVAGDLFLMTQCKHFTISNS	
脱硫脱硫弧菌	57592.1	4402	脱硫弧菌]	24.05		SLSWWGAWLSQRAENKTVIMPSKWRGGKSPIPGECMRVEGWHIMCPVE	199
光敏赫夫勒氏菌（Hoeflea phototrophica）；光敏赫夫勒氏菌（Hoeflea phototrophica）DFL-43	WP_0071 99917.1	49437 3839	α-1,2-岩藻糖转移酶,[光敏赫夫勒氏菌（Hoeflea phototrophica）]	24.05		MHGGLGNQLFQYAVGRAVALRTGSELLLDTREFTSSNPFQYDLGHFSIQAKVANSSELPPGK NRPLAYAWWRKFGRSPRFVREQDLGYNARIETIEADCYLHGYFQSQKYFEDIASILWKDLSF RQAISGENASMAERIQSAPSVSMHIIRRGDYLTSAKARSTHGAPDLGYYGRALGEIRARSGSD PVVYLFSDDPDWVRNNMRMDANLVTVAINDGKTAFEDLRLMSLCDHNIVNSTFSWWGAW LNPSLDKIVVAPKRWFADPKLSNPDITPPGWLRLGD	200
霍乱弧菌；霍乱弧菌 O1 str. 87395	WP_0020 30616.1	48795 7217	糖基转移酶，家族 11 [霍乱弧菌]	24.04		MKIISFSGGLGNQLFQYAFYLYLKDNSDFGNIFLDFSFYESQNKRDAVIRNFYGVDSLDIIKQS SYVRGKFLILKLINKFRFFNNLLEFVDKENGLDETLLSTNKVFFDGYWQSYRYVKDYKSNIK ELFSFYDFKGNILEVRKKICQSNSVCMHVRRGDYVAEKNTKLVHGVCSLQYYRDALNNIKN VDNSIDHIFIFSDDIDWVKNNISFDIPVTVVDFVGQSVPDYAEMLLFSCGKHKVIANSTFSWW GAFLSDRNGVIVSPKKWFAKEEKNYDEIFIEGSLRL	201
毛螺科菌 NK4A179	WP_0227 84718.1	55104 1074	蛋白质 [毛螺科菌 NK4A179]	24.03		MIIVRFRGGMGNQMFQYAFLRYLEMKGATLKADLSEFKCMKTHAGYELDKAFDLHPAEAS YKEIRAVADYIPVMHIRFPFSRKVFEILYKKETKRVEAEGPKKSHISEEKYFDMSEDERLHLAS SSEDLYMDGFWIKPDMYDDEVLKCFTFSKTLDEKYKGTIEDEHSCSVHVRCGDYTGTGLDI LGKEYYEKAAEKILSEDADVKFYVFSDDREKAEKLLSPFMKKMVFCDTPASHAYDDMYLM SRCRHHIIANSTFSFWGARLSADKSGITICPKYFDKNNTANRLVHEGWQML	202
Cecembia lonarensis；Cecembia lonarensis LW9	WP_0091 85692.1	49647 6931	Glycosyl 转移酶家族 11 [Cecembia lonarensis]	24.01		MIIMKFMGGLGNQIYQYALGRKLSELHNSFLASDIHIYKNDPDREFVLDKFNIKVKHLPWKV IKLLNSDYALKFDKVFHTEFYHELVLEKALESKDIPRKNNLYLRGSWGNRKYYEDYIDKISD EITLKEKFKTKDFNTVNKKVKNSDSVGIHIRRGDYEKVAHFKNFYGLLPPSYYSAAVDFIGN RIEKSNFFIFSDDTDWVKENLPFLKDSFFVSDIIGSVDYLEFFLLKNCKHQIIANSTFSWWAAR LNSNPAKIVIKPKRWFADDRQQAVYEIEDSYYIKEAIKL	203
小卵性杆菌；小卵性杆菌 ATCC 8483	WP_0042 95547.1	49042 3336	蛋白质 [小卵性杆菌]	24		MKIVNILGGLGNQMFVYAMYLALKEAHPEEEILLCRRSYKGYPLHNGYELERIFGVEAPEA ALSQLARVAYPFFNYKSWQLMRHFLPLRKSMASGTTQIPFDYSEVTRNDNVYYDGYWQNE KNFLSIRDKVIKAFTFPEFRDEKNKALSDKLKSVKTASCHIRRGDYLKDPIYGVCNSDYYTR AITELNQSVNPDMYCIFSDDIGWCKENFKFLIGDKEVVFVDWNKGQESFYDMQLMSLCHY NIIANSSFSWWGAWLNNNDDKVVVAPERWMNKTLENDPICDNWKRIKVE	204

[0220]

科氏多形杆状菌 CAG:162	WP_0221 25287.1	54766 8508	糖基转移酶 家族 11 [科氏多形杆状菌 CAG:162]	23.99		MRLIKMTGGLGNQMFIYAFYLKMKKLFPHTKIDLSDMMHYHVHHGYEMNRVFALPHTEFC INRTLKKLMEFLLCKVVYERKQKNGSMEAFEKKYAWPLIYFKGFYQSERFFADIEDDVRKTF CFNMELINSRSREMMKIIDADEHAVSIHIRRGDYLLLPKFWANAGCVCQLPYYKNAITELEKH ESTPSFYVFSDDIEWVKQNLSLPNAHYIDWNQGNDSWQDMMLMSHCRNHIICNSTFSWWG AWLNPRKNKTVIVPSRWFMKEETPYTYPVSWIKVPIN	205
朵丽多形杆菌；朵丽多形杆菌 DSM 17855；朵丽多形杆菌 CL03T12C01	WP_0078 35585.1	49511 0765	糖基转移酶[朵丽多形杆菌]	23.99		MRLIKVTGGLGNQMFIYAFYLRMKKYYPKVRIDLSDMMHYKVHYGYEMHRVFKLPHTEFC INQPLKKIIEFLFFKKIYERKQAPNSLRAFEKKYFWPLLYFKGFYQSERFFADIKDEVREAFTF DRSKANSRSLDMLDILDKDENAVSLHIRRGDYLQPKHWATTGSVCQLPYYQNAIAEMSKRV TSPSYYIFSDDIVWVRENLPLQNAVYIDWNTGEDSWQDMMLMSHCKHHIICNSTFSWWGA WLNPSIDKTVIVPSRWFQYSETPDIYPTGWIKVPVD	206
多形杆状菌；肠内多形杆状菌 DSM 17393；肠内多形杆状菌 CAG:564	WP_0076 62951.1	49493 6920	蛋白质 [多形杆状菌]	23.97		MIIVRLWGGLGNQLFQYSFGQYLEIETDKKVFYDVASFGTSDQLRKLELCSFIPDIPLYNAYF TRYTGVKNRLFKALFQWSNTYLSFSMFDICLLEKARGKIFLQGYWQEEKYATYFPMQKVLS EWKNPNVLSEIEENIRSAKISVSLHVRRGDYFSPKNINVYGVCTEKYYEQAIDRANSEIEEDK QFFVFSDDILWVKNHVSLPESTVFVPNHEISQFAYIYLMSLCKVNIISNSTFSWWGAYLNQHIK NQLVIAPSRWTFTSNKTLALDSWTKI	207
毛螺科菌 A4	WP_0162 83022.1	51102 8838	蛋白质 [毛螺科菌 A4]	23.95		MIVIHVMGGLGNQLYQYALYEKLRALGREVKLDVYAYRQAEGAEREWRALELEWLEGIRY EVCTAAERQQLLDNSMRLADRVRRRLTGRRDKTVRECAAYMPEIFEMDDVYLYGFWGCEK YYEDIIPLLQEKIVFPESSNPKNADVLRAMAGENAVSVHIRRKDYLTVADGKRYMGICTDAY YKGAFRYITERVERPVFYIFSDDPAFAKTQFCEENMHVVDWNTGRESLQDMALMSRCRHNI CANSTFSIWGARLNRHPDKIMIRPLHHDNYEALDARTVHEYWKGWVLIDADGKV	208
Phaeobacter gallaeciensis；Phaeobacter gallaeciensis DSM 17395 = CIP 105210	YP_00657 4665.1	39999 4425	蛋白质 PGA1_c33070 [Phaeobacter gallaeciensis DSM 17395 = CIP 105210]	23.91		MIITRLHGRLGNQMFQYAAGRALADRLGVSVALDSRGAELRGEGVLTRVFDLDLATPDILPP LRQRAPLGYALWRGLGQHLGTGPKLRREVGLGYNPDFVDWSDNSYLHGYWQSERYFAQS AERIRRDFTFPEYSNQQNAEMAARIGETNAISLHVRRGDYLTLAAHVLCDQAYYEAALAQV LDGLEGQPTVYVFSDDPQWAKENLPLPCDKVVVDFNGADTDYEDMRLMSLCKHNIIGNSSF SWWAAWLNQTPDRRVAGPTKWFGDPKLNNPDILPPDWLRISV	209

[0221]

						MSGGLGNQMFQYALYLKLRSLGREVCFDDKSQYDEETFRNSSQKRRPKHLDIFGITYPSAG	210
						KEELEKLTDGAMDLPSRIRRKILGRKSLEKNDRDFMFDPSFLEETEGYFCGGFQSPRYFAGAE	
						EEVRKAFTPPEELLCPKEGCSRQEQKMLEQSASYAERIRKANCEAADRGVPGGGSASIHLRF	
						GDYVDKGDIYGGICTDAYYDTAIRCLKERDPGMIFFVFSNDEEKAGEWIRYQAERSENLGRG	
						HFVLVKGCDEDHGYLDLYLMTLCRNHVIANSSFSWWASFMCDAPDKMVFAPSIWNNQKDG	
						SELARTDIYADFMQRISPRGTRLSDRPLISVIVTAYNVAPYIGRALDSVCGQTWKNLEIIAVDD	
						GSSDETGAILDRYAAGDSRIQVVHTENRGVSAARNEGIAHARGEYIGFVDGDDRAHPAMYE	
						AMIRGILSSGADMAVVRYREVSAEETLTDAEEQVASFDPVFLRASVLLQQRDAVQCFIRAGMA	
						EEEGKIVLRSAVWNKLFHRRLLRDNRFPEGTSAEDIPFTTRALCLSKKVLCVPEILYDYVVNR	
						QESIMNTGRAERTLTQEIPAWRTHLELLKESGLSDLAEESEYWFYRRMLSYEEEYRRCSETA	
						KEAKELQERILKHRDRILELAEEHSFGRRGDRERLKLYVNSPRQYFLLSDLYEKTVVNWKNR	
厚壁菌门细菌 CAG:791	WP_0218 49028.1	54636 2318	蛋白质 [厚壁菌门细菌 CAG:791]	23.88		PDKT	210
						MRKRIIALNGGLGNQMFQYAFARMLEDRKHCLIEFDTGFYSTVNDRKLAIQNYNIHKYDFC	
						NHEYYNKIRLLFQKIPFVAWLAGTYKEYSEYQLDPRVFLFNYRFYYGYWQNKQYFENISNDI	
蛋白丁酸孤菌 (Butyrivibrio proteoclasticus)；蛋白丁酸孤菌 (Butyrivibrio proteoclasticus) B316	YP_00382 9733.1	30266 9773	糖基转移酶 11 [蛋白丁酸孤菌 (Butyrivibrio proteoclasticus) B316]	23.84		RNELSYIGNVSEKENALLNMLEAHNAIAIHVRRGDYTQEGYNKIYISLSKEYYKRAVSIACK	
						ELGDNNIPLYVFSDDIDWCKANLADIGNVTFVDNTISSSADIDMLMMKKSRCLITANSTFSW	
						WSAWLSDRDDKIVLVPDKWLQDEEKNTKLMKAFICDKWKIVPV	211
						>gi|496043738|ref|WP_008768245.1| 蛋白质 [多形杆状菌属	
						2_1_16]MQVVARIIGGLGNQMFIYATARALALRIDADLILDTQSGYKNDLFKRNFLLDSFCISY	
						RKANCFQKYDYYLGEKVKSLGKKTHFSVIPFMKYISENTSCDFVDGLLKKHILSVYLDGYW	
						QNEAYFKDYASIIKKDFQFCQVNDLRTLSEAEIIKKSITPVAIGVRRYQELNSHQNTKVTDLDF	
多形杆状菌属 2_1_16	WP_0087 68245.1	49604 3738	蛋白质 [多形杆状菌属 2_1_16]	23.81		YQKAINYIESKVDNPTFFIFSEDQEWVKNNLEQKSNFIMISPKEGNYSALNDMYLISLCKHHI	
						VSNSSFYWWGAWLANNKNKIVVASDCFLNPQSIPDSWIKF	212
						>gi|25683031 7|ref|YP_003159045.1| 糖基转移酶家族蛋白 [嗜中性硫酸盐还原菌 DSM	
						4028]MAKIVTRIMGGIGNQLFCYAAARRLALVNHAELVIDDVTGFSRDRVYRRRYRMLDHFNI	
						SARKATNYERMEPFERYRRGLAKYISKKLPFFEREYIEQERIEFDPRFLEYRTYNNIYIDGLWQ	
嗜中性硫酸盐还原菌；嗜中性硫酸盐还原菌 DSM 4028	YP_00315 9045.1	25683 0317	糖基转移酶家族蛋白 [嗜中性硫酸盐还原菌 DSM 4028]	23.76		SENYFKDVEDIIRDDLKIIPPTDLENINIAKKIKNIQNTIAMHVRWFDLPGINLGNNVSTYYYH	
						RAIAMMEQRINAPHYFLFSDNLEAVHSKLDLPEGRVTFVSNNDGDDNAYADLWLMSQCKHF	
						ITANSTFSWWGAWLGESRDSVVLVPRFSPDGGVTSWCFTGLIPERWEQVSSIR	213

[0222]

蔗科普雷沃氏菌（Prevotella pleuritidis）；蔗科普雷沃氏菌（Prevotella pleuritidis）F0068	WP_0215 84236.1	54530 4945	糖基 2-α-L-岩藻糖转移酶[蔗科普雷沃氏菌（Prevotella pleuritidis）]	23.76	MDIVLIFNGLGNQMSQYAFYLAKRQRNNHTVYCVFGPRTQYSLDKLFDIPYRHNAVLVLLY RALDKAHFSNHRWLRRLLRPTLQLLGVKMIVEPLSRDFDMRHFTHQKGIVFYRGGWHSEL NFTAVADAVKRRFRFPEIQDAAVLAVIDRIKSCQSVSLHLRRGDYLGLSEFQGVCTEAYYEHA IAYFESQIESPEYFVFSDDPTYAREQFGADPNFHIIDLNHGEDAWCDLLMMTQCRYNIIANSTF SWWGAWLNDNPSKIVVHPRYHLNGVETRDFYPRNWICIE	214
多形杆状菌属 1_1_14	WP_0087 63191.1	49603 8684	糖基转移酶，家族 11［多形杆状菌属 1_1_14］	23.75	MKVIWFNGNLGNQVFYCKYKEFLHNKYPNETIKYYSNSRSPKICVEQYFRLSLPDRIDSFKV RFVFEFLGKFFRRIPLKFVPKWYCTRKSLNYEASYFEHIYLQDKSFFEKEDSSWLKAKKPDNF SEKYLIFENLICNTNSVAVHIRRGDYIKPGSDYEDLSATDYYFEQAIKKATEVYLDSQFFFSDD LEFVKNNFKGDNIYYVDCNRGADSYLDILLMSQAKINIIANSTFSYWGAYMNHEKKKVMYS DLWFRNESGRQMPNIMLDSWICIETKRK	215
壤霉菌（Agromyces subbeticus）	WP_0228 93737.1	55127 3588	蛋白质［壤霉菌（Agromyces subbeticus）］	23.65	MVGRVGIARRQAADVSCTDGEGLVAWRIRTGEIVLGLQGGIGNQLFEWAFAMALRSIGRRVL FDAVRCRGDRPLMIGPLLPASDWLAAPVGLALAGATKAGLLSDRSWPRLVRQRRSGYDPSV LERLGGTSYLLGTFQSARYFDGVEHEVRAAVRALLEGMLTPSGRRFADELRADPHIRVAVHV RRGDYVSDPNAAVRHGVLGAGYYDQALEHAAALGHVRRVWFSDDLDWVREHLARDDDL LCPADATRHDGGEIALIASCATRIIANSSFSWWGGWLGAPSSPAHPVIAPSTWFADGHSDAAE LVPRDWVRL	216
丹参胃善雷沃菌；丹参胃善雷沃菌 DSM 15606	WP_0071 33870.1	49422 0705	α-1,2-岩藻糖转移酶［丹参胃善雷沃菌］	23.59	MIATTLFGGLGNQMFIYATAKALSLHYRTPMAFNLRQGFEQDYKYQRHLELNHFKCQLPTA KWITFNYKGELNIKRISRRIGRNLLCPHYQFIKEKEPFHIYEKRLFEFTNKNIFLEGYWQSPRYF ENYSDEIRRDFQLKSILPHTITDELQMLKGTGKPLVMLGIRRYQEVKDKKDSPYPLCNKDYYY AKAISHVQEQLPAPLFVVFTQEQAWAMNNLPTNANLYFVKEKDNAWATIADMYLMTQCQH AIISNSTFYWWGAWLQHPIENHIVVAPNNFINRDCVCDNWIILD	217
肉杆菌属 WN1359	YP_00871 8687.1	55464 9641	糖基转移酶[肉杆菌属 WN1359]	23.57	MIFVDLSEGLGNQMFQYAYSRYLQELYGGTLYLNTSSFKRKNSTRSYSLNNFYLYENVKLPS KFRRVIYNFYSKTIRMFIKKVIRMNPYSDKYYFSMIPYGFYVSSQVFKYLTVPTTKRHNIFVM GTWQTNKYFQSINDKIKDELKVKTEPNELNKKLITEINSNQSVCVHIRLGDYTNPEFDYLHV CTSDYYLKGMDYIVSKVKEPNFYIFSNSSSDIEWIKNNYNFKYKVKYIDLNNPDFEDFRLMY NCKHFIISNSTFSWWAQFLSNNDKKIIVAPSKWQKSNENEAKDIYLDIHWKLIEIE	218
丁酸孤菌属 AD3002	WP_0227 62290.1	55101 8062	糖基转移酶[丁酸孤菌属 AD3002]	23.55	MLIIQIAGGLGNQMQQYAMYRKLLKAGADRNIKLDTKWFDEDKQSGVLAKRKLELEYFTG LPLPVCSESERARFTDRSVARKVVEKLVPGMGSRFTESCMYHPEIFELKDKYIEGYFACQKY YDDIMGELQELFVFPTHPDFEEINIKNMNLMNEMEMVPSVSVHIRRGDYLDPENAALFGNIAT DAYYDSAMEYFKAIDPDTHFYIFTNDPEYAREKYADPGRYTIVDHNTGKYSLLDIQLMSHCR GNICANSTFSFWGARLNRRKDKIPVRTLVMRNNQPVTPELMHEYWPGWVLVDKDGKVR	219

[0223]

梭状芽孢杆菌属 KLE 1755	WP_0216 36935.1	54539 6682	糖基转移酶，家族 11 [梭状芽孢杆菌属 KLE 1755]	23.55		MIVIRVMGGLGNQMQQYALYEKFKALGKETRLDTSWFDNASMQENVLARRSLELRFFDNL TYEACTPQEREALLGKEGFFNKLERKLFPSKNKHFYESEMFHPEIFKLDNVYLEGHWACEK YYHDIMPLLQSKIIFPKTDNIQNNMLKNKMNSENSVSIHIRRGDYLDPENAAMFGGICTDSY YKSAEGYIRNRVTNPHFYLFSDDPAYLREHYKGEEYTVVDWNHGADSFYDMELMSCCKHN VCANSTFSFWGARLNRTEKKIVIRPAKHKNSQQAEPERMHIELWENWVIIDEEGRIV	220
多形杆状菌；普通拟杆菌 ATCC 8482；朱丽多形杆菌 DSM 17855；芽孢杆菌 dnLKV3	YP_00130 0694.1	15000 5950	糖基转移酶家族蛋白 [普通拟杆菌 ATCC 8482]	23.47		MKFFVFGGGLGNQLFQYSYYRYLKKKYPSERILGIYPDSLKAIINGIEIDKWFDIELPPTSYLY NKLGILLYRVNRFLYNHGYRLLFCNRVYPQSMKHFFQWGDWQDYSIIKQINIFEFRSELPIGK ENMEFLKKMETCNSISVHIRRGDYLKTDLIHIYGGICTSKYYREAIKFMEQEVEEPFFFFSD DCLYVETEFADIRNKIIISHNRDDRSFFDMYLMAHAKNMILANSTFSCWAAYLNRTAKIIITPD RWVNTDFSKLEALPNEWIKIRV	221
木聚糖帕拉普雷沃氏菌（Paraprevotella xylaniphila）；木聚糖帕拉普雷沃氏菌（Paraprevotella xylaniphila）YIT 11841	WP_0086 26629.1	49590 2050	糖基转移酶[木聚糖帕拉普雷沃氏菌（Paraprevotella a xylaniphila）]	23.47		MRLIKMTGGLGNQMFIYAMYLKMRAVFPDTRIDLSDMVHYRVHYGYEMNKVFNLPRTEFR INRSLKKIIEFLLFKTILERKQGGSLVPYIRKYTHWPWIYFKGFYQSEEYFAGVEKEVREAFVFD VRRVNRKSLCAMQEIMADPDAVSIHVRRGDYLQGKHWKSLGCICQRSYYLNALSELEKRIV HPHYYVFSEDLDWVRQYLPLENAVFIDWNKGEDSWQDMMLMSHCRHHIICNSTFSWWGA WLNPSPDKIVIAPERWTQITTNSADVVPESWLKVSIG	222
陶厄氏菌属 28	WP_0029 30798.1	48902 0296	糖基转移酶家族蛋白 [陶厄氏菌属 28]	23.47		MTDRALIAIVKGGLGNQLFIYAAARAMALRTGRQLYLDAVRGYLADDYGRSFRLNRFPIEA ELMPEQWRVASTLRHPRAKLVRALNKYLPEAWRFYVAERGDTRPGALWNHGRNVKRVTL MGYWQDEAYFLDYAELLRRELGPPMPDAPEVRARGERFAGTESVFLHVRRCRYSPLLDAG YYQKAVDLACAELNKPVFMIFGDDIEWVVNNIDFRGAGYERQDYDESDELADLWLMTRCR HAIIANSSFSWWAAWLGGAAGSGRHVWAPGQSGLALKCAKSWEAVDAQPE	223
变体罕见小球菌（Subdoligranulum variabile）；变体罕见小球菌（Subdoligranulum variabile）DSM 15176	WP_0070 48308.1	49410 7522	α-1,2-岩藻糖转移酶 [变体罕见小球菌（Subdoligranulum variabile）]	23.44		MIYAELAGGLGNQMFIYAFARALGLRCGEAVTLLDRQDWRDGAPAHTACALEGLNLVPEVK ILAEPGFAKRHLPRQNTAKALMIKYEQRQGLMARDWHDWERRCAPVLNLLGLHFATDGYT PVRRGPARDFLAWGYFQSEAYFADFAPTIRAELRAKQAPAGVWAEKIRAAACPVALHLRRG DYCRPENEILQVCSPAYYARAAAAAAAAYPEATLFVFSDDIDWAKEHLDTAGLPAVWMPRG DAVGDLNLMALCRGFILSNSTYSWWAQYLAGEGRTVWAPDRWFAHTKQTALYQPGWHLIE TR	224

[0224]

						MIIVEVMGGLGNQMQQYALYRKLESLGKDARLDVSWFLDKERQTKVLASRKLFLSWFENL PAKYCTQEEKQAILGKNNLIGKLKKKLLGGSNRHFTESDMYHPEIFDLEDAYLSGFWACEAY YADILPMLRSQIHFPDPEKGEGWDLEAAAKNKETMERMKQETSVSIHIRRGDYLDAKNAEM FGGICTDAYYEAAISYIKEQTPDAHFYVFSDDSAYVKNAYPGKEFTVVDWNTGKNSLFDMQ LMSCCNHNICANSTFSFWGARLNPSPDKVMIRPSKHKNSQNIVPEEMKRLWDGWVLIDGKG RII	225
厚壁菌门细菌 CAG:24	WP_0219 16223.1	54712 7527	蛋白质 [厚壁菌门细菌 CAG:24]	23.4		MIITKLNGGLGNQLFEYACARNLQLKYNDVLYLDIEGFKRSPRHYSLEKFKLSSDVRMLPEK DSKSLILLQAISKLNRNLAFKLGPLFGTYIWKSSNYRPLKIKNTRGKKLYLYGYWQSYEYFK ENEAIIKQELNVKTEIPIECSELLKEINKPHSICVHVRRGDYVVSCGFLHCDEAYYNRGINIIIFD KHPDSNVVVFSDDIKWVKANMNFDHPVAYVEVDVPDYETLRLMYMCKHFVMSNSSFSWW ASYLSDNKEKIVVAPSYWLPANKDNKSMYLDNWTIL	226
普雷沃菌 CAG:474	WP_0223 10139.1	54790 6803	糖基转移酶家族 11 [普雷沃菌 CAG:474]	23.39		intestinalis]MRGNRGMIAVKIGDGMGNQLFNYACGYAQARRDGDSLVLDISECDNSTLRDFEL DKFHLKYDKKESFPNRNLGQKIYKNLRRALKYHVIKEREVYHNRDHRYDVNDIDPRVYKK KGLRNKYLYGYWQHLAYFEDYLDEITAMMTPAYEQSETVKKLQEEFKKTPTCAVHVRGGDI MGPAGAYFKHAMERMEQEKPGVRYTVFTNDMERAFEALAPVLESQKKDAVGQAENRLEFV SEMGEFSDVDEFFLMAACQNQILSNSTFSTWAAYLNQNPDKTVIMPDDLLSERMRQKNWIIL K	227
罗氏孤菌（Roseburia intestinalis）；罗氏孤菌（Roseburia intestinalis）L1-82	WP_0068 55899.1	49391 0390	糖基转移酶家族 11 [罗氏孤菌（Roseburia intestinalis）]	23.38		
小卵柱杆菌；小卵柱杆菌 ATCC 8483	WP_0042 96622.1	49042 4433	蛋白质 [小卵柱杆菌]	23.29		MKIVLFTPGLGNQMFQYLFYLYLRDNYPNQNIYGYYNRNILNKHNGLEVDKVFDIQLPPHT VISDASAFFIRALGGLGLKYFIGKDQLSPWKVYFDGYWQNKEYFQNNVDKMRFREGFLNK KNDDILSLIRNTNSVSVHVRRGDYCDSCRKDLFLQSCTPQYYESAISVMKEKFQKPVFFVFS DDIPWVKVNLNIPNAYYIDWNKKENSYLDMYLMSLCTASIIANSTFSFWGAMLGNKKELVI KPKKWIGDEIPEIFPPSWLSL	228
丁酸孤菌属 AE3009	WP_0227 79599.1	55103 5785	糖基转移酶[丁酸孤菌属 AE3009]	23.25		MLIIQIAGGLGNQMQQYALYRKLLKYHPDGVRLDLSWFDSEVQKNMLAKREFELALFKGLP YIECKPEERAAFLDRNAAQKLSGKVLKKLGLRDNANPNVFEESRMFHIPEIFELDNKYIIGYF ACQKYYDDIMGDLCNLFEFPEHLDPELEKKNLELISKMEKENSVSVHIRRGDYLDPENFKIL GNIATDFEYYESAMKYFEDRYEKVHFYIFTSDIEYAREIIFADESKYTIVDWNTGKDSLQDVR LMNHCLGNICANSTFSFWGARLNQRQDKVMIRTYKMRNNQPVDPDTMHDYWKGWILIDE TGREV	229

[0225]

蛋白丁酸弧菌 (Butyrivibrio proteoclasticus)；蛋白丁酸弧菌 (Butyrivibrio proteoclasticus) B316	YP_00382 9712.1	30266 9752	糖基转移酶 11 [蛋白丁酸弧菌 (Butyrivibrio proteoclasticus) B316]	23.23	MTKNEKKLIVKFQGGLGNQLYEYAFCEWLRQQYSDYEVLADLSYYKIRSAHGELGIWNIFP NINIEVASNWDIIKYSDQIPIMYGGKGADRLNSVRTNVVNDRFFSKRKHSYYTEISNTDVSEVI NALNNGIRYFDGYWQNIDYFKGNIEDLRNKLKFSEKCDKYITDEMLRDNAVSLHVRRGDYV GSEYEKEVGLSYYKKAVEYVLDRVDQAKFFIFSDDKYYAETAFEWIDNKTVVAGYDNELAH VDMLLMSRMKNNIIANSTFSLWAAYLNDSMNPLIVYPDVESLDKKTFSDWNGIK	230
纳氏普雷沃菌 (Prevotella nanceiensis)	WP_0183 62656.1	51717 3838	蛋白质 [纳氏普雷沃菌 (Prevotella nanceiensis)]	23.23	MDSQFLKHIKLSGGFGNQLFQYFFGEYLKEKYNCSISFFSEPALDINQLQIHRFFPALRISHNT ELRPYHYSFTQQLAYRCMRKLLLLFPFLNRKVKIENGSNYQNQSFNDTYCFDGYWQSYRYL SAFTPSLQFEDQLINDISADYINAIEQSEAVFLHIRRGDYLNKENQKVFAECPLNYFENAANRI KEDIKNVHIFFVFSNDIQWVKSHILKLNDNEVTFIQNEGNSCDLKDFYLMTRCKHAIISNSTFS WWAAYLINNSDKKVIAPKHWYNDISMNNATKDLIPPTWIRL	231
鲁杰氏菌属 (Ruegeria sp.) R11	WP_0085 62971.1	49583 8392	α-1,2-岩藻糖转移酶 [鲁杰氏菌属 (Ruegeria sp.) R11]	23.23	MIITRLHGRLGNQMFQYAAGRALADRAGVPLALDSRGAILRGEGVLTRVFDLFLADPVHLP PLKQTNPLRYAIWRGIGQKVGAKPYFRRERGLGYNPAFEDWGDNSYLHGYWQSQKYFQNS AERIRSDFTFPAFSNQQNAEMAARIAESTAISLHVRRGDYLTFAAHVLCDQAYYDAALAKVL DGLQGDPIVYVFSDDPQWAKDNLSLPCEKVVVDFNGPETDFEDMRLMSLCQHNIIGNSSFS WWAAWLNQTPGRRVAGPAKWFGDPKLSNPDIFPHDWLRISV	232
耐寒维诺格拉德斯基氏菌属 (Winogradskyella psychrotolerans)) RS-3；耐寒维诺格拉德斯基氏菌属 (Winogradskyella psychrotolerans)	WP_0208 95733.1	52707 2096	α-1,2-岩藻糖转移酶 [耐寒维诺格拉德斯基氏菌属 (Winogradskyella psychrotolerans)]	23.21	MGNQLYEYATAKAMAVALNKKLVIDPRPILKEAPQRHIYDLGLFNIQDEDFGSPFVQWLVRW VASVRLGKFFKTIMPFAWSYQMIRDKEEGFDESLLQQKSRNIVIEGYWQSFKYFESIRPTLLK ELSFKDKPNAINQKYLDEIESVNAVAVHIRRGDYVANPVANAVHGLCDMDYYKKAIAIIKDK VENPYFFIFTDDPDWAEDNFKISEHQKIIKHNIGKQDHEDFRLLTNCKYFIIANSSFSWWGAW LSDYKNKIVISPNKWFNVDAVPITERIPESWIRV	233
毛螺科菌 NK4A179	WP_0227 85342.1	55104 1720	蛋白质 [毛螺科菌 NK4A179]	23.2	MITVRIDGGFGNQMFQYAFFLHLKKTITDNKISVDLNCYNPHGSGDIFTRFKLAPEQAAPSEI KRFHRNSIYHLLRPLDSAGITTNPYYREEDIDDLNSVLNKKRVYLRGYWQDKRYPFSVKDQ LIDCFDLGKMDMTGASAENNVILEQIASEESRSVGVHLRGGDYIGDPVYSGICTPEYYEAAF KHVSEKIKDPVFHIFTNDISMIEKCGLSGKYDLKITDINDEAHGWADLKLMSACRHHIISNSS FSWWAAFLGEATTEASADVINVIPEYMRQGVSAETLRCPCWTTVTSDGRVYPS	234
牙周脓肿普雷沃菌 317 str. F0108；牙周脓肿普雷沃菌 317	WP_0092 30832.1	49652 2549	α-1,2-岩藻糖转移酶 [牙周脓肿普雷沃菌 317]	23.13	MKIVCIKGGLGNQLFEYCRYRSLHRHDNRGVYLHYDRRRTKQHGGVWLDKAFHITLPNEP LRVKLLVMVLKTLRRLHLFKRLYREEDPRAVLIDDYSQHKQYTTNAAEILNFRPFEQLDYAEE IQTTPFAVSVHVRRGDYLLLANKSNFGVCSVHYYLSAAVAVRERHPESRFFVFSDDMEWAKE NLNLPNCVFVEHAQAQPDHADLYLMSLCKGHIIANSTFSFWGAYLSKGSSAIAIYPKQWFAE PTWNVPDIFPAHWMAL	235

[0226]

丁酸弧菌属 XPD2006	WP_0227 65796.1	55102 1633	糖基转移酶[丁酸弧菌属 XPD2006]	23.1		MLIIQIAGGLGNQMQQYAVYTKLRGMGKDVRLDLSWFDPSVQKNMLAPREFELSMFEGVD YTECTAEERDSFLKQGMIANVTGKMLKKLGLRDEANPKVFSEKEMYHPEIFELEDRYIKGYF ACQKYYDDIMGELWEKYTFPAHSDPDLHTRNMALVERMEKETSVSVHIRRGDYLDPSNVEI LGNIATEEYYQGAMDYFSVKDPDTHFYIFTSDHEYARERKFSDESKYTIVDWNSGRNSVQDL MLMSHCKGNICANSTFSFWGARLNRRPDKTVIRTYKMRNNQPVNPDIMHDYWKGWILMD EKGSII	236
溶纤维丁酸弧菌	WP_0227 52717.1	55100 8140	蛋白质 [溶纤维丁酸弧菌]	23.08		MIIIKLQGGLGNQLFLYGLYKNLKHLKRDVKMDIESGFEEDKLRVPCLKSMGLDYEVATRDE IVAIRDSYMDIFSRIRRKITGRKTFDYYEPEDGNFDPRVLEQTHAYLDGYFQSEKYFGDSDDR KKLKDELLKEKIRVLDSSDTLKDLYNMMSSGSSVSLHIRRGDYLTPGIMETYGGICTDEYYDI AMNRIKNEYPDSKFFIFSNDIDWCKEKYGSRDDVIFVDSCDEHEGLTNVSGDQDDIQVQGDI KEHGNNSLRDAAELYLMSACKHHILANSSFSWWGAWLSDHEGMTIAPSKWLNNKNMTDI YTKDMLLI	237
拟柱孢藻 (Cylindrospermopsis raciborskii)；拟柱孢藻 (Cylindrospermopsis raciborskii) CS-505	WP_0062 78973.1	49332 1658	Glycosyl 转移酶家族 11 [拟柱孢藻 (Cylindrosper mopsis raciborskii)]	23.05		MKKTVVLLKGGLGNQMFQYAFARSISLKNSSKLVIDNWSGFTFDYKYHRQYFELGTFSIVGRP ANLTEKFPFWFYFELKSKFFPRLPKVFQQQFYGLLINEVGGEYIPEIEETKISQNCWLNGYWQS PLYFQKHSDSITRELMPPEPMEKHFLELGKLLRETESVALGIRLYEESKNPGSHSSSGELKSHF EINQAILKLRELCNGAKFFVFCTHRSPLLQELALPENTIFVTHDDGYVGSMERMWLLTQCKH HIFTNSTFYWWGAWLSQKFYIQGSQIVFAADNFINSDAIPKHWKPF	238
多形普雷沃氏菌 (Prevotella multiformis)；多形普雷沃氏菌 (Prevotella multiformis) DSM 16608	WP_0073 68154.1	49460 9908	α-1,2-岩藻糖转移酶 [多形普雷沃氏菌 (Prevotella multiformis)]	23.05		MKIVNFQGGLGNQMFIYAFSRYLSRLYPQEKIYGSYWSRSLYVHSAFQLDRIFSLQLPPHNLF TDCISKLARFFERLRLVPVEETPGSMFYNGYWLDKKYWEGIDLSEMFCFRNPDLSAEAGAV LSMIERSNAVSVHIRRGDYQSEEHIEKFGRFCPPDYYRIATERIRQREDDPLFFVFSDDMMWV KSNMDVPNAVYVDCHHGDDSWKDMFLMAKCRHNIIANSTFSFWAAMLNANPDKVVVYP QRWFCWPSPDIFPEMWLPVTEKEIKSSF	239
多形杆状菌属 CAG:462	WP_0223 84635.1	54815 1455	蛋白质 [多形杆状菌属 CAG:462]	23		MIIVNMACGLANRMFQYAFYLSLKERGYNVKVDFYKSATLPHENVPWNDIFPYAEIDQVSN FRVLILGGGANLLSKLRRKYLPSLTNVITMSTAFDTDLQIDDDRKDKYIIGVFQSAAMVEGV CKKVKQCFSFLPFTDLRHLQLEKEMQECESVAIHVRKGNDYQQRIWYQNTCTMDYYRKAI AEIKGKVKDPRFYVFTDNADWVRRNFTIDFDYKMVEGNPVYGWGSHFDMQLMSRCKYNII SNSTYSWWGAYLNANRNKIVICPNIWFNPESCNEYTSCKLLCKGWIAL	240
非洲脱硫弧菌；非洲脱硫弧菌 PCS	WP_0059 84176.1	49283 0222	Glycosyl 转移酶家族 11/Glycosyl 转	23		MRIGILYICTGKYTVFWNHFFTSCEQHFLREHEKHYYIFTDGEIAHLNCNRVHRIEQQHLGW PDSTLKRFHMFERIADTLRQNSDFIVFFNANMVFLRDVGKEFLPTREQALVFHRHPGLFRRPA WLLPYERRPESTAYIPYGSGSIYVCGGVNGGYTQPYLDFVAMLRRNIDIDVERGIIARWHDES HINRFVIGRHYKIGHPGYVYPDRRNLPFPRIIRVIDKASVGGHTFLRGQTPEPAPEEQSKTVAK	241

[0227]

			移酶家族 6 [非洲原疏孤菌]			
						KLRSQLKRPCMPRAAQDEPIILARMMGGLGNQMFIYAAARVLAERQGAQLHLDTGKLSGD SIRQYDLPAFSIDAPLWHIPCGCDRIVQAWFALRHVAAGCGMPKPTMQVLRSGFHLDQRFFSI RHSAYLIGYWQSPHYWRGHEDRVRSSFDLTRFERPHLREALAAVSQPNTISVHLRRGDFRAP KNSDKHLLIDGSYYERARKLLLEMTPQSHFYIFSDEPEEAQRLFAHWENTSFQPRRSQEEDL LLMSRCSASIIANSSFSWWGAWLGRPKQHVIAPRMWFTRDVLMHITYTLDLFPEKWILL	
罗氏菌属 (Roseburia sp.) CAG:100	WP_0225 18697.1	54837 4190	蛋白质 [罗氏菌属 (Roseburia sp.) CAG:100]	22.98		MILIHVMGGLGNQLYQYALYEKMKSLGKKVKLDTYAYNDAAGEDKEWRSLELDRFPAIEY DKATSEDRTKLLDNSGLLTAKIRRKLLGRKDKTIRESKEYMPEIFHMDDVYLYGFWNCERYY EDIIPLLQDKLQFPISNNPRNQQCIEQMQKENAVSIHIRRTDYLTVADGARYMGICTEDYYKG AMAYIEERVSNPVYYYIFSDDVEYAKQHYHQDNMHVVDWNSKADSIYDMQLMSKCKHNIC ANSTFSMWAARLNQNKEKIMIRPLHIIDNYETTTATQVKQNWKNWILLDQNGQVCE	242
毛螺科菌 10-1	WP_0227 42385.1	55099 7676	蛋白质 [毛螺科菌 10-1]	22.96		MTMNIIRMSGGLGSQMFQYALYLKLKSMGKEVKFDDINEYRGEKARPIMLAVFGIEYPRAT WDEITSFTDGSMDLLKRLRRKIFGRKAIEYEEQGFYDPNVLNFDSMYLRGNFQSEKYFQDIK EEVRKLYRFSTLEDMRLPERLYKATKACLDGIESSESVGLHMYRSDSRVDGELYDGICTGNY YKGAVRFIQDKVPDAKFYIFSNEPKWVRGWVVDLIQSQIEGMSPSQVKEMEKRFVMVEA NTEYTGYLDMMLMSKCKHNIISNSSFSWWSAWMNDHPEKVVVAPDRWSSDKEGNEIYTTG MTLVNEKGRVNYTIHENSTVK	243
产黑普雷沃氏菌 (Prevotella nigrescens)；产黑普雷沃氏菌 (Prevotella nigrescens) F0103	WP_0043 62670.1	49049 6500	蛋白质 [产黑普雷沃氏菌 (Prevotella nigrescens)]	22.96		MILSYITGRLGNQLFEYAYARSLLLKRGKNEELILNFSLVRAAGKEIEGFDDNLRYFNVYSYT ELDKDIVLSKGDLLQLFIYILFKLDQKLFRIIKKEKWFSFFRRFGIIFQDYLDNISNLIIPRTKNV FCYGKYENPKYFDDIRSILLKEFTPRIPPLKNNDQLYSVIESTNSVCISIRRGDFLCDKFKDRFL VCDKEYFLEAMEEAKKRISNSTFIFFSDDIEWVRENIHSDVPCYYESGKDPVWEKLRLMYSC KHFIISNSTFSWWAQYLSRNEEKVVIAPDRWSNVPGEKSFLLSNSFIKIPIGILP	244
多形杆状菌属 CAG:875	WP_0223 53235.1	54795 2493	fucosyl 转移酶 [多形杆状菌属 CAG:875]	22.95		MIYVEINGRLGNNMFEIAAAKSLTDEVTLWCKGDWQLNCIKMYSDTLFKNYPIVVKSLPNNIR IYEEPEFTFHPIPYKENQDLLIKGYFQSYKYLDREKVLKLYPCPMPVKLDIEKRFGDILSQYTV VSINVRRGDYLNLPHRHPFVGKKFLERAMLWFGDKVHYIISSDDIEWCKAHFKQFDNVHYL TNSYPLLDLYIQTACHHNIISNSSFSWWGAYLNNHPQKIVIAPHRWFGMSTNINTQDLLPPEW MIEQCVYEPKVFLKALPLHAKYLLKRVLK	245
牙周脓肿普雷沃菌 299 str. F0039；牙周脓肿普雷沃菌 299	YP_00844 4280.1	53235 4444	蛋白质 HMPREF0669_00176 [牙周脓肿普雷沃菌 299 str. F0039]	22.9		MDSQLLKHIKLSGGFGNQLFQYFFGEYLKEKYNCSISFFSEPALDINQLQIHRFFPTLRISHNT ELRRFHYAFTQQLAYRCMRKLLLLFPFLNRKVKIENGSNYQNQSFNDTYCFDGYWQSYRYL SAFTPSLQFEDQLINDISADYINAIEQSEAVFLHIRRGDYLNKENQKVFAECPLNYFENAVNKI KEGNKTYHFFVFSNDIEWVKCHLKLNNNEVTFIQNEGSSCDLKDFYLMTRCKHAIISNSTFS WWAAYLINNNDKKVIAPKRWYNDLSMNNATKDLIPPTWIRL	246

[0228]

木聚糖帕拉普雷沃氏菌（Paraprevotella xylaniphila）；木聚糖帕拉普雷沃氏菌（Paraprevotella xylaniphila）YIT 11841	WP_0086 28783.1	49590 4204	α-1,2-岩藻糖转移酶［木聚糖帕拉普雷沃氏菌（Paraprevotella a xylaniphila）］	22.87	MKIVCLKGGLGNQMFEYCRFRDLMDSGNGKVYLFYDRRRLKQHDGLRLSDCFELELPSCP WGIRLVVWGLKICRAIGVLKRLYDDEKPDAVLIDDYSQHRRFIPNARRYFSFRQFLAELQSGF VQMIRAVDYPVSVHVRRGDYLHPSNSSFVLCGVDYFRQAIAYVRKKKRPDARFFFFSDDMEW VRENLWMEDAVYVEHTELMPDYMDLYLMTLCRGHIISNSTFSFWGAYLAVDGNGMKIYPR RWFRDPTWITPPIFSEEWVGL	247
肽脱硫代硫酸盐弧菌（Dethiosulfovibrio peptidovorans）；肽脱硫代硫酸盐弧菌（Dethiosulfovibrio peptidovorans）DSM 11002	WP_0056 58864.1	49189 7177	糖基转移酶家族 11［肽脱硫代硫酸盐弧菌（Dethiosulfovibrio peptidovorans）］	22.84	MFQYAFGRALALDLGLDLKLDISNFGSDSRPFSLGIYSLTKNIPFGCYLSTSTRLKVKMTKKL RRWGVWGMDKNMPGVLVEPFPPVLVSLDEVLSEKLSHLFVDGYWQSEKYFSRYSDVIRSD FRVIEESSAFLAWKKRMLSEPGGSISVHVRRGDYVVTDSSANRVHGVLPIEYYLRAKEILNTIS DGLVFYVFTDDPVWARNNLCLGDKTIYVSGEDLKDYEELALMSCCDHHVVANSSFSWWGA WLGQDTSTVTIAPGRWFRKMDSSFVIPDNWIKIWT	248
毛螺科菌 10-1	WP_0162 29292.1	51089 6192	蛋白质［毛螺科菌 10-1］	22.83	MIIIQVMGGLGNQLQQYALYRKFVRMGKEARLDISWFLDKEKRGEVLAERELELDYFDRLI YETCTPEEKEQLIGSEGVAGKLKRKFLPGRIRWFHESKIYHPELLQMENMYLSGYFACEKYY ADILYDLREKIQFPVNDHPKNIKMAQEMQERESVSVHLRRGDYLDEKNTAMFGNICTDAYY CKAIEYMKTLCSKPHFYIFSDDIPYVRQRFTGEEYTVVDINHGRDSFFDMWLMSRCRHNICA NSTFSFWGARLNSNDNKIMIRPTIHKNSQVFVKEEMEQLWPGWKFISPDGGIK	249
嗜麦芽密螺旋体（Treponema maltophilum）；嗜麦芽密螺旋体（Treponema maltophilum）ATCC 51939	WP_0165 25279.1	51387 2223	蛋白质［嗜麦芽密螺旋体（Treponema maltophilum）］	22.82	MFCAAFVEALKHAGQKVFVDTSLYNKGTVRSGIDFCHNGLETEHILFGIKFDEADKADVHRL STSAEGLLNRIRRKYFTKKTHYIDTVFRYTPEVLSDKSDRYLEGFWQTEKYFLPIESDIRTLFR FRQPLSEKSAAVQSALQAQEPASLSASIHVRRGDFLHTKTLNVCTETYYNNAIEYAAKKYAV SAFYVFSDDIQWCREHLNFFGARSVFIDWNIGADSWQDMVLMSMCRCNIIANSSFSFWWAA WLNAASDKIVLAPAIWNRRQLEYADRYYGYDYSDVIPETWIRIPI	250
芽孢杆菌；芽孢杆菌 dnLKV3	WP_0162 76676.1	51102 2363	蛋白质［芽孢杆菌］	22.79	MKLVSFTAGLGNQLFQYCFYRYLLNKFPNEKIYGYYNKKWLKKHGGIIIEHFFDVKLPRSTR WINLYGQYLRIIYKCFSCGVSKDDDFEMNRTMFVGYWQDQCFFSGINISYKKNLVISEKNTW LLGEILKCNSVAIHFRRGDYMLPQFKKIFGEVCTVKYYLKSIRKVEEKISEPVFFVFSDDIDW VKQNFTFNKVYFVDWNKGQNSFWDMYLMSQCSANIIANSTFSFWGAYLNKNNPFVIYPQK WVRTNLKQPNIFPKTWMAL	251

[0229]

252	MIVLTLGGGLGNQMFQYGYARYIQKIHREKFIYINDSEVIKEADRFNSLGNLNTVNIKVLPRII SKPLNETERLVRKIMVRLFGVAGFNESAIFQSLNKFGIYYHPSVYKFYESLKTGFPIKIIEGGF QSWKYLETCPEIKQELRVKYEPMGENLRLLNLISQSESVCVHIIRRGDYLSPKYKHLNVCDYQ YYFESMNYIISKLNNPTFFIFSNTSDDLDWIKENYSLPGKIVYVKNDNPDYEELRLMYSCKHF IISNSTFSWWAQYLSNNSGIVIAPEIWNRLNHDGIADLYMPNWITMKVNR			22.71	家族 11 糖基转移酶 [屎肠球菌 DO]	38986 9137	YP_00637 6560.1	屎肠球菌；屎肠球菌 DO；屎肠球菌 EnGen0035
253	MDVVVIFNGLGNQMSQYAYYLAKKKVNPNTKVIFDIMSKHNHYGYDLERAFGIEVNKTLLI KVLQIIYVLSRKFRLFKSVGVRTIYEPLNYDYTPLLMQKGPWGINYYVGGWHISEKNFMNVP DEVKKAFMFREQPNEDRFNEWLQVIRGDNSSVSVHIIRRGDYMNIEPTGYYQLNGVATLDYY HEAIDYIRQYVDTPHFYVFSNDLDWCKEQFGVENFFYIECNQGVNSWRDMYLMSECHYHI NANSTFSWWGAWLCKFEDSITVCPERFIRNVVTKDFYPERWHIKIKSC			22.67	糖基转移酶家族 11 [多形杆状菌]	49044 2319	WP_0043 13284.1	多形杆状菌；多形杆状菌属 2_1_22；多形杆状菌属 2_2_4；多形杆状菌属 D1；木糖降解拟杆菌 SD CC 2a；木糖降解拟杆菌 SD CC 1b；小卵性杆菌 CAG:22
254	MIGFNALGRMGRLANQMFQYASLKGIARNTGVDFCVPYHEEAVNDGIGNMLRTEIFDSFDL QVNVGLLNKGHAPVVQERFFHFDEELFRMCPDHVDIRGYFQTEKYFKHIEDEIREDFTFKDE ILNPCKEMIAGVDNPLALHVRRTDYVTNSANHPPCTLEYYEAALKHFDDDRNVIVFSDDPA WCKEQELFSDDRFMISENFDNRIDLCLMSLCDDFIIANSTYSWWGAWLSANKDKKVIAPVQ WFGTGYTKDHDTSDLIPDGWTRIATA			22.6	糖基转移酶家族 11 [细菌噬菌体 S-SM2]	32678 1960	YP_00432 2362.1	细菌噬菌体 S-SM2
255	MDIIHVLSYGLGNQLSQYAFFINRRQLMQRAYAFYAFKQHNGYELDRIFGLKEGLPWYLQFV RVVFRLGISRRFYSKRTADFVLSLFRIKVIDEAYNYEFDPSLLKPWFGIRILYGGWHDSRYFHP SEAAVRTAFSFPPLDDVNDAILQQIDAVYGVSIHVRRGDYLKGINSNLFGGIATLEYYRNAIG WAITYCKHRSLEIKFYVFSDDIDWCKQNLGLRDAVYVSGNSKTDSWKDILLMSHCRANIIAN STFSWWAAWLNQQPNKVVICPTKFINTDSPNQTIYPAAWHQIEG			22.58	糖基转移酶 [金属还原泥土杆菌 GS-15]	40449 6189	YP_00672 0295.1	金属还原泥土杆菌；金属还原泥土杆菌 GS-15；金属还原泥土杆菌 RCH3
256	MIIVRFHGGLGNQMFEYAFYRYMTNKYGADNVIGDMTWFDRNYSEHQGYELKKVFDIDIP AIDYKTLAKIHEYYPRYHIRFAGLRYLSRMYAKYKNKHILKPTGEYIMDFGPSQYIHNDAFDK LDTNKDYYIEGVFCSDAYIKYYENQIKKDLTFKPNYSQHTKDMLPKIEETNSVAIHVRRGDY VGNVFDIVTPDYYRQAVNYIRERVENPVFFVFSDDMDYIKANFDFLGDFVPVHNCGKDSFQ DMYLISRCRHMIIANSSFSYFGALLGEKDSTIVIAPKKYKADEDLALARENWVLL			22.58	蛋白质 [毛螺科菌 NK4A136]	55103 7245	WP_0227 80989.1	毛螺科菌 NK4A136
257	MGFIVNMACGLANRMFQYSYYLFLKKQGYKVTVDFYRSAKLAHEKVAWNSIFPYAEIKQA SRLKVFLWGGGSDLCSKVRRRYFPSSTNVRTTTGAFDASLPANTARNEYIIGVFLNASIVEAV DDEIKKCFTFLPFTDEMNLRLKKEIEECESVAIHVRKGKDYQSRIWYQNTCSMEYYRKAILQ MKEKLQHSKFYVFTDNVDWVKENFQEIDYTLVEGNPADGYGSHFDMQLMSLCKHNIISNST			22.56	蛋白质 [嗜粪杆菌]	49541 9937	WP_0081 44634.1	嗜粪杆菌；嗜粪杆菌 DSM 18228 = JCM 13818

[0230]

						YSWWSAFLNRNPEKVVIAPEIWFNPDSCDEFRSDRALCKGWIVL	
拟杆菌；二氧化碳嗞纤维菌属，口腔类 329 菌 F0087；克拉副普氏菌 YIT 11840	WP_0086 19736.1	49589 5157	α-1,2-岩藻糖转移酶 [拟杆菌]		22.53	MKIVCLKGGLGNQMFEYCRFRDLMESGHIDEVYLFYDHRRLKQHNGLRLSDCFELELPSCP WGIKLVVWGLKICRAVGVLKRLYDDEKPEAVLIDDYSQHRRFIPNARRYFFRQFLAELQSG FVQMIRAVDYPVSVHVRRGDYLHIPSNSSFGLCGVDYFQQAIAYVRKKRPDARFFFFSDDME WVRENLWMEDAVYVEHTELLPDYVDLYLMTLCRGHIISNSTFSFWGAYLAVDGNGMKIYP RRWFRDPTWTSPPIFSEEWVGL	258
丁酸弧菌属 NCC2007	WP_0227 70361.1	55102 6242	糖基转移酶[丁酸弧菌属 NC2007]		22.47	MLIIQIAGGLGNQMQQYAVYTKLREMGKDVKLDLSWFDPQVQKNMLAPREFELPIFGGTDY EECSAYERDALLKQGAFAAIAGKVLKKLGLRDEANPKVFSEKEMYHPEVFELEDKYIKGYF ACQKYYGDIMDKLQEKFIFPEHSDPDLHARNMALVERMEREPSVSVHIRRGDYLDPSNVEIL GNIATEQYYQGAMDYFTVKEPDTHFYIFTSDIEYAREKFSDESKYTIVDWNNGKNSVQDLM LMSHCKGNICANSTFSFWGARLNKRPDKTVIRTYKMRNNQPVNPQIMHDYWKGWILMDE KGSII	259
木聚糖帕拉普雷沃氏菌（Paraprevotella xylaniphila）；木聚糖帕拉普雷沃氏菌（Paraprevotella xylaniphila）YIT 11841	WP_0086 28536.1	49590 3957	糖基转移酶[木聚糖帕拉普雷沃氏菌（Paraprevotell a xylaniphila）]		22.45	MKILVFTGGLGNQMFAYAFYLYLKRLFPQERFYGLYGKKLSEHYGLEIDKWFKVSLPRQPW WVLPVTGLFYLYKQCVPNSKWLDLNQEICKNPRAIVFFPFKFTKKYIPDDNIWLEWKVDES GLSEKNRLLLSEIRSSDCCFVHVRRGDYLSPTFKSLFEGCCTLSYYQRALKSMKEISPFVKFV CFSDDIQWVKQNLELGNRAVFVDWNSGTDSPLDMYLLMSQCRYGIMANSTFSYWGARLGR KKKRIYYPQKWWNHGTGLPDIFPNTWVKI	260
氢经黏液真杆菌（Blautia hydrogenotrophica）DSM 10507；Blautia；氢经黏液真杆菌（Blautia hydrogenotrophica）CAG:147	WP_0059 44761.1	49274 2598	蛋白质 [经黏液真杆菌（Blautia）]		22.44	MEIHVYLTGRLGNQLFQYAFARHLQKEYGGKIICNIYELEHRSEKAAWVPGKFNYEMSNYK LNDSILIEDIKLPWFADFSNPIIRIVKKVIPRIYFNLMASKGYLLWQKNSYINIPAIRNNEIIVNG WWQDVREFFHDVEAELSNEIVPTTKPISENEYLYNIAERENSVCVSIRGGNYLVPKVKKKLFV CDKEYFYNAIELIKSKVRNAIFIVFSDDLEWVKSYIKLEEKFPECKFYYESGKDTVEEKLRM MTKCKHFIISNSSFSWWAQYLAKNENKIVIAPDAWFTNGDKNGLYIDDWILIPTQTKDM	261
拉弗利地杆菌（Geobacter lovleyi）；拉弗利地杆菌（Geobacter lovleyi）SZ	YP_00195 2981.1	18942 5804	糖基水解酶家族蛋白质 [拉弗利地杆菌（Geobacter		22.44	MITVLLNGGLGNQLFQYAAGRALAEKHDVELLLDLSRLQHPKPGDTPRCFELAPFNIKASLL AEEGRQPLGSYQACMHRLLLKASIPLWGSIILKEQGCGFDPLIFRAPSSCILDGFWQSECYFK QITSLLQQELSLKAPSPALRKASSVLSDATVAVHVRRGDYVTNPAAASFHGICSQDYYQAAV ANILTSYPDSQFLVFSDDPAWCQEHLDLGQPFRLAADFGLNGSAEELVLISRCAHQIIANSSFS	262

[0231]

			lovleyi) SZ]			WWGAWLNPSPHKLVVAPCRWFTDPAITTNDLLPETWVRLP	
毛螺科菌 NK4A136	WP_0227 81176.1	55103 7435	蛋白质 [毛螺科菌 NK4A136]	22.41		MVISHLSGGFGNQLYSYAFAYAVAKARKEELWIDTAIQDAPWFFRNPDILNLNIKYDKRVSYK IGEKKIDKIFNRINFRNAIGWNTKIINESDMPNIDDWFDTCVNQKGNIYIKGNWSYEKLFISV KQEIIDMFTFKNELSKEANDIAQDINSQETSVGIHYRLGDYVKIGIVINPDYFISAMTSMVEK YGNPVFYSFSEDNDWVKKQFEGLPYNIKYVEYSSDDKGLEDFRLYSMCKHQIASNSSYSW WGAYLNNNPNKYIIAPTDYNGGWKSEIYPKHWDVRPFEFLK	263
普通拟杆菌；普通拟杆菌 PC510	WP_0058 40359.1	49242 6440	糖基转移酶家族 11 [普通拟杆菌]	22.37		MFHYKFLLFGGGLGNQIFEYYFYLWLRKKYPNIVFLGCYRKASFKAHNGLEISDVFDVDLP NDGGLSGRFISYVLSVLSRIIPSLSMKANTEYSSKYLLINAYQPNLLFYLNEEKIKFRPFKLDE VNRRLLNSIKMESSVSIIHVRRGDYLFGQYRDIYSNICTLAYYQKAVDKCKGILESPRFFVFSD DIEWARDVFVGREYEFVSNNIGKNSFIDMFLMSNCKIQIIANSTFSYWAAYLSNSLVKIYPAK WINGIERPNIFPDNWIGL	264
树浮霉状菌（Planctomyces brasiliensis）；树浮霉状菌（Planctomyces brasiliensis）DSM 5305	YP_00427 1766.1	32511 0698	糖基转移酶家族蛋白 [树浮霉状菌（Planctomyces brasiliensis）DSM 5305]	22.37	22.37	MIIARIENGLGNQLFKYAAGRALSLKHRTSLYTIPGSVRKPHETFILSKYFNVQAKSVSPFLLQ TGFRLRLLKGYENHSFGFDPRFETTRNNTVVSGNFQSARYFLPFFDQINRELTLKPEVVDGLE SVYPHVLESLRTPNSVCVHIRLGDYVSSGYDICGPEYYAKAISRLQQLHGELRAFVFSDTPQA ASRFLPADIDAQIMSEFPEVRDAARSLTVERSTIRDYFLMQQCRHFVIPNSSFSYWAALLSSSD GDVIYPNRWYIDIDTSPRDLGLAPAEWTPIPLT	265
丁酸孤菌属 AE2015	WP_0227 72730.1	55102 8648	糖基转移酶[T酸孤菌属 AE2015]	22.36		MIILQIAGGLGNQMQQYALYRKLLKCGKTVKLDLSWFGPEIQKNMLAPREFELVLFKDLPFE ICTKEEKDALIKQNLFQKIAGKVSQKLGKSASSNAKVFVETKMYHEEIFDLDDVYITGYFAC QYYYDDVMAELQDLFVFPSHSIPELDQRNAVLASKMEKENSVSVHIRRGDYLSPENVGILG NIASDKYYESAMNYFLEKDENTHFYIFTNDHEYAREHYSDESRYTIIDWNTGKNSLQDLML MSHCKGNICANSTFSFWGARLNKRPDRELVRTLKMRNNQEAQPEIMHEYWKNWILIDENG VIV	266
牛氏变形细菌红细菌（Roseovarius nubinhibens）ISM；牛氏变形细菌红细菌（Roseovarius	WP_0098 13856.1	49749 9658	α-1,2-岩藻糖转移酶,[牛氏变形细菌红细菌（Roseovarius nubinhibens）]	22.34		MTDTPPPSQVITSRLFGGAGNQLFQYAAGRALADRLGCDLMIDARYVAGSRDRGDCFTHFA KARLRRDVALPPAKSDGPLRYALWRKFGRSPRFHRERGLGVDPEFFNLPRGTYLHGYWQSE QYFGPDTDALRRDLTLTTALDAPNAAMAAQIDAAPCPVSFHVRRGDYIAAGAYAAACTPDYY RAAADHLATTLGKPLTCFIFSNDPAWARDNLDLGQDQVIVDLNDEATGHFDMALMARCAH HVIANSTFSWWGAWLNPDPDKLVVAPRNWFATQALHNPDLIPEQWHRL	267

[0232]

nubinhibens)							
真杆菌属 CAG:581	WP_0225 05071.1	54831 5094	蛋白质 [真杆菌属 CAG:581]	22.33		MIEVNIVGQLGNQMFEYACARQLQKKYGGEIVLNTYEMRKETPNFKLSILDYKLSENVKIIS DKPLSSANANNYLVKIMRQYFPNWYFNFMAKRGTFVWKSARKYKELPELNEQLSKHIVLN GYWQCDKYFNDVVDTIREDFTPKYPLKAENEQLLEKIKSTESVCVTIRRGDFMNEKNKDTF YICDDDYFNKALSKIKELCPDCTFFGFSDDVEWIKKNVNFPGEVYFESGNDPVWEKLRLMS ACKHFVLSNSSFSWWAQYLSDNNNKIVVAPDIWYKTGDPKKTALYQDGWNLIHIGD	268
产碱普罗登斯菌	AFH0280 7.1	38328 9327	糖基转移酶 [产碱普罗登斯菌]	22.26		MKINGKESSMKIKQKKIISHLIGGLGNQLFQYATSYALAKENNAKIVIDDRLFKKYKLHGGY RLDKLNIIGEKISSIDKLLFPLILCKLSQKENFIFKSTKKFILEKKTSSFKYLTFSDKEHTKMLIG YWQNAIYFQKYFSELKEMFVPLDISQEQLDLSIQIHAQQSVALHVRRGDYISNKNALAMHGI CSIDYYKNSIQHINAKLEKPFFYIFSNDKLWCEENLTPLFDGNFHIVENNSQEIDLWLISQCQH HIIANSTFSWWGAWLANSDSQIVITPDPWFNKEIDIPSPVLSHWLKLKK	269
肠道沙门氏菌	AFW0480 4.1	41114 6173	糖基转移酶 [肠道沙门氏菌]	22.26		MFSCLSGGLGNQMFQYSAAYILKKNICHAQLIIDDSYFYCQPQKDTPRNFEINQFNIVFDRVT TDEEKRAISKLRKFKKIPLPLFKSNVITEFLFGKSLLTDEDFYKVLKKNQFTVKMNACLFSLY QDSSLINKYRDLILPLFTINDELLQVCQQLDSYGFICEHTNTTSLHIRRGDYVTNPHAAKFHG TLSMNYYSQAMNYVDHKLGKQLFIIFSDDVQWAAEKFGGRSDCYIVNNVNCQFSAIDMYL MSLCNNNIIANSTYSWWGAWLNKSEEKLVIAPRKWFAEDKESLLAVNDWISI	270
德氏硫磺单胞菌（Sulfurospirillum deleyianum）；德氏硫磺单胞菌（Sulfurospirillum deleyianum）DSM 6946	YP_00330 4829.1	26868 0398	蛋白质 Sdel_1779 [德氏硫磺单胞菌（Sulfurospirillum deleyianum） DSM 6946]	22.18		MIIIKIMGGLASQLHKYSVGRALSLKYNTELKLDIFWFDNISGSDTIREYHLDKYNVVVAKIAT EQEIKQFKPNKYLLKINNLFQKFTNWKINYRNYCNESFISLENFNLLPDNIYVVEGEWSGDRYF SHIKFILQKELTLKSEYMDSTNHFLAKQSSDFAHDDNASKLHCTCSLEYYKKALQYISKNLL KMKLLIFSDDLDWLKPNFNFLDNVEFEFVEGFQDYEEFHLMTLSKHNIIANSGFSLFFAWLNI NHNKIIISLSEWVFEEKLNKYIIDNIKDKNILFLENLE	271

[0233]

假孤菌属 FO-BEG1	YP_00508 0114.1	37432 9930	α-1,2-岩藻糖转移酶 [假孤菌属 FO-BEG1]	22.15		MSVASQVRISGAARRRKLKPTLIVRIRGGIGNQLFQYALGRKIALETGMKLRFDRSEYDQYF NRSYCLNLFKTQGLSATESEMSAVLWPAQSFGQTVKLCRKFYPFYQRRYIREDELLQDSETP VLKQSAYLDGYWQTWEIPFSIMEQLRDEITLKKPMVLERLKLLQRIKSGPSAALHVRYGDYS QAHNLQNFGLCSAGYYKGAMDFLTERVPGLTFYVFSDSPERAREVVPQQENVYFSDPMQD GKDHEDLMVMSSCDHIVTANSTFSWWAAFLNGNEDKHVIAPLKWFKNPNLDDSLIVPPHW QRL	272
牙周脓肿善雷沃菌 472 str. F0295；牙周脓肿善雷沃菌 472	WP_0092 36633.1	49652 9942	α-1,2-岩藻糖转移酶 [牙周脓肿善雷沃菌 472]	22.11		MKIVCIKGGLGNQLFEYCRYHGLLRQHNNHGVYLHYDRRRTKQHGGVWLDKAFLITLPTE PWRVKLMVMALKMLRKLHLFKRLYREDDPRAVLIDDYSQHKQFITNAAEILNFRPFAQLDY VDEITSEPFAVSVHVRRGDYLLPANKANFGVCSVHYYLSAAVAVRERHPDARFFVFSDDIEW AKMNLNLPNCVFVEHAQPQPDHADLYLMSLCKGHIIANSTFSFWGAYLSMGSSAIAIYPKQ WFAEPTWNAPDIFLGHWIAL	273
溶纤维丁酸弧菌	WP_0227 52732.1	55100 8155	糖基转移酶[溶纤维丁酸弧菌]	22.08		MLIIRVAGGLGNQMQQYAMYRKLKSLGKEVKLDLSWFDVENQEGQLAPRKCELKYFDGV DFEECTDAERAYFTKRSILTKALNKVFPATCKIFEETEMFHPEIYSFKDKYLEGYFLCNKYYD DILPFIQNEIVFPKHSDPKMQKRNEELMERMDGWHTASIHLRRGDYITEPQNEALFGNIATDA YYDAAIRYVLDKDYQTHFYIFSNDPEYAREHYSDESRYTIVTGNDGDNSLLDMELMSHCRY NICANSTFSFWGARLNKRSDKEMIRTFKMRNNQEVTAREMTDYWKDWILIDEKGNRIF	274
佩尔西卡赖文氏菌 (Lewinella persica)	WP_0205 71066.1	52205 9857	蛋白质 [佩尔西卡赖文氏菌 (Lewinella persica)]	22.04		MVISRLHSGLGNQMFQYAFARRIQLQLNVKLRIDLSILLDSRPPDGYIKREYDLDIFKLSPAYH CNPTSLRILYAPGKYRWSQVVRDLARKGYPVYMEKSFSVDNTLLDSPPDNVIYQGYWQSER YFSEVANTIRKDFAFQHSIQPQSESLAREIRKEDSVCLNIRRKDYLASPTHNVTDETYYENCIQ QMRERFSGARFFLFSDDLVWCREFFADFHIDVVIVGHDHAGPKFGNYLQLMAQCHHYIIPNS TFAWWAAWLGERTGSVIMAPERWFGTDEFDYRDVVPERWLKVPN	275

[0234] 其他实施方案

[0235] 尽管本发明已经结合具体实施方式进行了描述，但之前的描述只起到解释作用并

不能限制本发明的范围，本发明的范围由所附权利要求书定义。其他的方面、优势和修饰也被包括在所附权利要求书记载的范围内。

[0236] 这里所涉及的所有专利和科技文献构成了本领域普通技术人员能够获得的知识。这里引用的所有美国专利和公开的或者未公开的美国专利申请通过引证在此并入本文。这里引用的所有公开的外国专利和专利申请在此通过引证全部并入本文。Genbank和NCBI指明的登记号码也通过引证在此并入本文。这里引用的其他出版的参考文献、文件、原稿和科学文献通过引证在此并入本文。

[0237] 尽管本发明已经参照其优选的实施方案进行了具体的显示和表述，但是本领域普通技术人员应该理解，在不脱离本发明范围的情况下，在形式和细节上可以存在各种各样的变化，本发明的范围由所附的权利要求书概括。

[0001] 序列表

[0002] <110> 格里康辛有限责任公司

[0003] J·M·麦科伊

[0004] M·I·海特曼

[0005] M·梅里吉

[0006] <120>用于在产生岩藻糖基化低聚糖时使用的α(1,2)岩藻糖基转移酶变种

[0007] <130> 37847-517001WO

[0008] <140> PCT/US2015/030823

[0009] <141> 2015-05-14

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[0258] Val Glu Leu Asp Met Leu Leu Met Ser Lys Cys Lys Asn Asn Ile Ile
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[0260] Ser Asn Ser Ser Phe Ser Trp Trp Ala Ala Trp Leu Asn Glu Asn Lys
[0261] 245 250 255
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[0289] Gln Ile Lys Ile Gln Gln Thr His Ala Val Ser Ile His Val Arg Arg
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[0291] Gly Asp Tyr Leu Asn His Pro Glu Ile Gly Val Leu Asp Ile Asp Tyr
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[0294] 180 185 190

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[0296] 195 200 205

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[0304] 260 265 270

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[0306] 275 280

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[0320] Thr Phe Asp Phe Ser Tyr Gly Asn Tyr Tyr Arg Arg Leu Ser Arg Asn

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[0328] Lys Gln Glu Ile Lys Glu Asp Phe Val Ile Gln Lys Lys Leu Glu Tyr

[0329] 130 135 140

[0330] Thr Ser Tyr Leu Glu Leu Glu Glu Ile Lys Leu Leu Asp Lys Asn Ala

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[0333] 165 170 175

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[0371] 130 135 140
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[0374] Asp Tyr Val Ser Asn Val Glu Ala Leu Lys Ile His Gly Leu Cys Thr
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[0378] Asn Leu Val Phe Phe Val Phe Ser Asp Asp Ile Glu Trp Cys Lys Lys
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[0380] Tyr Lys Asn Glu Ile Phe Ser Arg Ser Asp Asp Val Lys Phe Ile Glu
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[0382] Gly Asn Thr Gln Glu Val Asp Met Trp Leu Met Ser Asn Ala Lys Tyr
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[0384] His Ile Ile Ala Asn Ser Ser Phe Ser Trp Trp Gly Ala Trp Leu Lys
[0385] 245 250 255
[0386] Asn Tyr Asp Leu Gly Ile Thr Ile Ala Pro Thr Pro Trp Phe Glu Arg
[0387] 260 265 270
[0388] Glu Glu Leu Asn Ser Phe Asp Pro Cys Pro Glu Lys Trp Val Arg Ile
[0389] 275 280 285
[0390] Glu Lys
[0391] 290
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[0403] Glu Leu Glu Asn Ile Phe Ser Val Thr Ala Gln Lys Ala Ser Ala Ala
[0404] 50 55 60
[0405] Asp Ile Met Arg Ile Ala Tyr Tyr Tyr Pro Asn Tyr Leu Leu Trp Arg
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[0407] Ile Gly Lys Arg Phe Leu Pro Arg Arg Lys Gly Met Cys Leu Glu Ser
[0408] 85 90 95
[0409] Ser Ser Leu Arg Phe Asp Glu Ser Val Leu Arg Gln Glu Gly Asn Arg
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[0411] Tyr Phe Asp Gly Tyr Trp Gln Asp Glu Arg Tyr Phe Ala Ala Tyr Arg
[0412] 115 120 125
[0413] Glu Lys Val Leu Lys Ala Phe Thr Phe Pro Ala Phe Lys Arg Ala Glu
[0414] 130 135 140
[0415] Asn Leu Ser Leu Leu Glu Lys Leu Asp Glu Asn Ser Ile Ala Leu His
[0416] 145 150 155 160
[0417] Val Arg Arg Gly Asp Tyr Val Gly Asn Asn Leu Tyr Gln Gly Ile Cys
[0418] 165 170 175
[0419] Asp Leu Asp Tyr Tyr Arg Thr Ala Ile Glu Lys Met Cys Ala His Val

[0420] 180 185 190

[0421] Thr Pro Ser Leu Phe Cys Ile Phe Ser Asn Asp Ile Thr Trp Cys Gln

[0422] 195 200 205

[0423] Gln His Leu Gln Pro Tyr Leu Lys Ala Pro Val Val Tyr Val Thr Trp

[0424] 210 215 220

[0425] Asn Thr Gly Val Glu Ser Tyr Arg Asp Met Gln Leu Met Ser Cys Cys

[0426] 225 230 235 240

[0427] Ala His Asn Ile Ile Ala Asn Ser Ser Phe Ser Trp Trp Gly Ala Trp

[0428] 245 250 255

[0429] Leu Asn Gln Asn Arg Glu Lys Val Val Ile Ala Pro Lys Lys Trp Leu

[0430] 260 265 270

[0431] Asn Met Glu Glu Cys His Phe Thr Leu Pro Ala Ser Trp Ile Lys Ile

[0432] 275 280 285

[0433] <210> 11

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[0442] Leu Tyr Asn Phe Gly Ile Lys Ile Asn Val Ala Ser Glu Lys Asp Ile

[0443] 35 40 45

[0444] Asn Arg Leu Ser Asp Cys Gln Ala Asp Phe Val Ser Arg Ile Arg Arg

[0445] 50 55 60

[0446] Lys Ile Phe Gly Lys Lys Lys Ser Phe Val Ser Glu Lys Asn Asp Ser

[0447] 65 70 75 80

[0448] Cys Tyr Glu Asn Asp Ile Leu Arg Met Asp Asn Val Tyr Leu Ser Gly

[0449] 85 90 95

[0450] Tyr Trp Gln Thr Glu Lys Tyr Phe Ser Asn Thr Arg Glu Lys Leu Leu

[0451] 100 105 110

[0452] Glu Asp Tyr Ser Phe Ala Leu Val Asn Ser Gln Val Ser Glu Trp Glu

[0453] 115 120 125

[0454] Asp Ser Ile Arg Asn Lys Asn Ser Val Ser Ile His Ile Arg Arg Gly

[0455] 130 135 140

[0456] Asp Tyr Leu Gln Gly Glu Leu Tyr Gly Gly Ile Cys Thr Ser Leu Tyr

[0457] 145 150 155 160

[0458] Tyr Ala Glu Ala Ile Glu Tyr Ile Lys Met Arg Val Pro Asn Ala Lys

[0459] 165 170 175

[0460] Phe Phe Val Phe Ser Asp Asp Val Glu Trp Val Lys Gln Gln Glu Asp

[0461] 180 185 190

[0462] Phe Lys Gly Phe Val Ile Val Asp Arg Asn Glu Tyr Ser Ser Ala Leu
[0463] 195 200 205
[0464] Ser Asp Met Tyr Leu Met Ser Leu Cys Lys His Asn Ile Ile Ala Asn
[0465] 210 215 220
[0466] Ser Ser Phe Ser Trp Trp Ala Ala Trp Leu Asn Arg Asn Glu Glu Lys
[0467] 225 230 235 240
[0468] Ile Val Ile Ala Pro Arg Arg Trp Leu Asn Gly Lys Cys Thr Pro Asp
[0469] 245 250 255
[0470] Ile Trp Cys Lys Lys Trp Ile Arg Ile
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[0481] Asp Asp Val Thr Cys Tyr Glu Gly Pro Gly Thr Arg Pro Arg Gln Leu
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[0483] Asp Val Phe Gly Ile Thr Tyr Asp Arg Ala Ser Arg Glu Glu Leu Thr
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[0485] Glu Met Thr Asp Ala Ser Met Asp Ala Leu Ser Arg Val Arg Arg Lys
[0486] 65 70 75 80
[0487] Leu Thr Gly Arg Arg Thr Lys Ala Tyr Arg Glu Arg Asp Ile Asn Phe
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[0489] Asp Pro Leu Val Met Glu Lys Asp Pro Ala Leu Leu Glu Gly Cys Phe
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[0491] Gln Ser Asp Lys Tyr Phe Arg Asp Cys Glu Gly Arg Val Arg Glu Ala
[0492] 115 120 125
[0493] Tyr Arg Phe Arg Gly Ile Glu Ser Gly Ala Phe Pro Leu Pro Glu Asp
[0494] 130 135 140
[0495] Tyr Leu Arg Leu Glu Lys Gln Ile Glu Asp Cys Gln Ser Val Ser Val
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[0497] His Ile Arg Arg Gly Asp Tyr Leu Asp Glu Ser His Gly Gly Leu Tyr
[0498] 165 170 175
[0499] Thr Gly Ile Cys Thr Glu Ala Tyr Tyr Lys Glu Ala Phe Ala Arg Met
[0500] 180 185 190
[0501] Glu Arg Leu Val Pro Gly Ala Arg Phe Phe Leu Phe Ser Asn Asp Pro
[0502] 195 200 205
[0503] Glu Trp Thr Arg Glu His Phe Glu Ser Lys Asn Cys Val Leu Val Glu

[0504] 210 215 220

[0505] Gly Ser Thr Glu Asp Thr Gly Tyr Met Asp Leu Tyr Leu Met Ser Arg

[0506] 225 230 235 240

[0507] Cys Arg His Asn Ile Ile Ala Asn Ser Ser Phe Ser Trp Trp Gly Ala

[0508] 245 250 255

[0509] Trp Leu Asn Glu Asn Pro Glu Lys Lys Val Ile Ala Pro Ala Lys Trp

[0510] 260 265 270

[0511] Leu Asn Gly Arg Glu Cys Arg Asp Ile Tyr Thr Glu Arg Met Ile Arg

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[0522] 20 25 30

[0523] Leu Asp Thr Thr Trp Phe Thr Thr Ile Ser Ser Asp Thr Pro Arg Thr

[0524] 35 40 45

[0525] Tyr Arg Leu Asn Asn Tyr Asn Ile Ile Gly Thr Ile Ala Ser Ala Lys

[0526] 50 55 60

[0527] Glu Ile Gln Leu Ile Glu Arg Gly Arg Ala Gln Gly Arg Gly Tyr Leu

[0528] 65 70 75 80

[0529] Leu Ser Lys Ile Ser Asp Leu Leu Thr Pro Met Tyr Arg Arg Thr Tyr

[0530] 85 90 95

[0531] Val Arg Glu Arg Met His Thr Phe Asp Lys Ala Ile Leu Thr Val Pro

[0532] 100 105 110

[0533] Asp Asn Val Tyr Leu Asp Gly Tyr Trp Gln Thr Glu Lys Tyr Phe Lys

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[0535] Asp Ile Glu Glu Ile Leu Arg Arg Glu Val Thr Leu Lys Asp Glu Pro

[0536] 130 135 140

[0537] Asp Ser Ile Asn Leu Glu Met Ala Glu Arg Ile Gln Ala Cys His Ser

[0538] 145 150 155 160

[0539] Val Ser Leu His Val Arg Arg Gly Asp Tyr Val Ser Asn Pro Thr Thr

[0540] 165 170 175

[0541] Gln Gln Phe His Gly Cys Cys Ser Ile Asp Tyr Tyr Asn Arg Ala Ile

[0542] 180 185 190

[0543] Ser Leu Ile Glu Glu Lys Val Asp Asp Pro Ser Phe Phe Ile Phe Ser

[0544] 195 200 205

[0545] Asp Asp Leu Pro Trp Ala Lys Glu Asn Leu Asp Ile Pro Gly Glu Lys

[0546] 210 215 220

[0547] Thr Phe Val Ala His Asn Gly Pro Glu Lys Glu Tyr Cys Asp Leu Trp

[0548] 225 230 235 240

[0549] Leu Met Ser Leu Cys Gln His His Ile Ile Ala Asn Ser Ser Phe Ser

[0550] 245 250 255

[0551] Trp Trp Gly Ala Trp Leu Gly Gln Asp Ala Glu Lys Met Val Ile Ala

[0552] 260 265 270

[0553] Pro Arg Arg Trp Ala Leu Ser Glu Ser Phe Asp Thr Ser Asp Ile Ile

[0554] 275 280 285

[0555] Pro Asp Ser Trp Ile Thr Ile

[0556] 290 295

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[0564] Gln Tyr Ala Phe Ser Leu Tyr Leu Lys Asn Lys Ser His Ile Trp Asp

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[0566] Arg Leu Tyr Val Asp Ile Glu Ala Met Lys Thr Tyr Asp Arg His Tyr

[0567] 35 40 45

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[0569] 50 55 60

[0570] Asn Arg Leu His Arg Asn Leu Gln Lys Arg Ser Phe Ala Lys His Phe

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[0572] Val Lys Ser Leu Tyr Glu His Ser Glu Cys Glu Phe Asp Glu Pro Val

[0573] 85 90 95

[0574] Tyr Arg Gly Leu Arg Pro Tyr Arg Tyr Tyr Arg Gly Tyr Trp Gln Asn

[0575] 100 105 110

[0576] Glu Gly Tyr Phe Val Asp Ile Glu Pro Met Ile Arg Glu Ala Phe Gln

[0577] 115 120 125

[0578] Phe Asn Val Asn Ile Leu Ser Lys Lys Thr Lys Ala Ile Ala Ser Lys

[0579] 130 135 140

[0580] Met Arg Arg Glu Leu Ser Val Ser Ile His Val Arg Arg Gly Asp Tyr

[0581] 145 150 155 160

[0582] Glu Asn Leu Pro Glu Ala Lys Ala Met His Gly Gly Ile Cys Ser Leu

[0583] 165 170 175

[0584] Asp Tyr Tyr His Lys Ala Ile Asp Phe Ile Arg Gln Arg Leu Asp Asn

[0585] 180 185 190

[0586] Asn Ile Cys Phe Tyr Leu Phe Ser Asp Asp Ile Asn Trp Val Glu Glu

[0587] 195 200 205

[0588] Asn Leu Gln Leu Glu Asn Arg Cys Ile Ile Asp Trp Asn Gln Gly Glu
[0589] 210 215 220
[0590] Asp Ser Trp Gln Asp Met Tyr Leu Met Ser Cys Cys Arg His His Ile
[0591] 225 230 235 240
[0592] Ile Ala Asn Ser Ser Phe Ser Trp Trp Ala Ala Trp Leu Asn Pro Asn
[0593] 245 250 255
[0594] Lys Asn Lys Ile Val Leu Thr Pro Asn Lys Trp Phe Asn His Thr Asp
[0595] 260 265 270
[0596] Ala Val Gly Ile Val Pro Lys Ser Trp Ile Lys Ile Pro Val Phe
[0597] 275 280 285
[0598] <210> 15
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[0600] <212> PRT
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[0605] Tyr Ala Leu Phe Leu Ser Leu Lys Glu Arg Phe Pro His Glu Gln Val
[0606] 20 25 30
[0607] Met Ile Asp Thr Ser Cys Phe Arg Asn Tyr Pro Leu His Asn Gly Phe
[0608] 35 40 45
[0609] Glu Val Asp Arg Ile Phe Ala Gln Lys Ala Pro Val Ala Ser Trp Arg
[0610] 50 55 60
[0611] Asn Ile Leu Lys Val Ala Tyr Pro Tyr Pro Asn Tyr Arg Phe Trp Lys
[0612] 65 70 75 80
[0613] Ile Gly Lys Tyr Ile Leu Pro Lys Arg Lys Thr Met Cys Val Glu Arg
[0614] 85 90 95
[0615] Lys Asn Phe Ser Phe Asp Ala Ala Val Leu Thr Arg Lys Gly Asp Cys
[0616] 100 105 110
[0617] Tyr Tyr Asp Gly Tyr Trp Gln His Glu Glu Tyr Phe Cys Asp Met Lys
[0618] 115 120 125
[0619] Glu Thr Ile Trp Glu Ala Phe Ser Phe Pro Glu Pro Val Asp Gly Arg
[0620] 130 135 140
[0621] Asn Lys Glu Ile Gly Ala Leu Leu Gln Ala Ser Asp Ser Ala Ser Leu
[0622] 145 150 155 160
[0623] His Val Arg Arg Gly Asp Tyr Val Asn His Pro Leu Phe Arg Gly Ile
[0624] 165 170 175
[0625] Cys Asp Leu Asp Tyr Tyr Lys Arg Ala Ile His Tyr Met Glu Glu Arg
[0626] 180 185 190
[0627] Val Asn Pro Gln Leu Tyr Cys Val Phe Ser Asn Asp Met Ala Trp Cys
[0628] 195 200 205
[0629] Glu Ser His Leu Arg Ala Leu Leu Pro Gly Lys Glu Val Val Tyr Val

[0630] 210 215 220

[0631] Asp Trp Asn Lys Gly Ala Glu Ser Tyr Val Asp Met Arg Leu Met Ser

[0632] 225 230 235 240

[0633] Leu Cys Arg His Asn Ile Ile Ala Asn Ser Ser Phe Ser Trp Trp Gly

[0634] 245 250 255

[0635] Ala Trp Leu Asn Arg Asn Pro Gln Lys Val Val Val Ala Pro Glu Arg

[0636] 260 265 270

[0637] Trp Met Asn Ser Pro Ile Glu Asp Pro Val Ser Asp Lys Trp Ile Lys

[0638] 275 280 285

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[0647] Tyr Ala Leu Tyr Lys Ser Leu Lys Lys Arg Gly Lys Glu Val Lys Ile

[0648] 20 25 30

[0649] Asp Asp Lys Thr Gly Phe Val Asn Asp Lys Leu Arg Ile Pro Val Leu

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[0651] Ser Arg Trp Gly Val Glu Tyr Asp Arg Ala Thr Asp Glu Glu Ile Ile

[0652] 50 55 60

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[0655] Leu Thr Gly Arg Lys Thr Phe Arg Ile Asp Glu Glu Ser Gly Lys Phe

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[0657] Asn Pro Glu Ile Leu Glu Lys Glu Asn Ala Tyr Leu Val Gly Tyr Trp

[0658] 100 105 110

[0659] Gln Cys Asp Lys Tyr Phe Asp Asp Lys Asp Val Val Arg Glu Ile Arg

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[0661] Glu Ala Phe Glu Lys Lys Pro Gln Glu Leu Met Thr Asp Ala Ser Ser

[0662] 130 135 140

[0663] Trp Ser Thr Leu Gln Gln Ile Glu Cys Cys Glu Ser Val Ser Leu His

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[0665] Val Arg Arg Thr Asp Tyr Val Asp Glu Glu His Ile His Ile His Asn

[0666] 165 170 175

[0667] Ile Cys Thr Glu Lys Tyr Tyr Lys Asn Ala Ile Asp Arg Val Arg Lys

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[0669] Gln Tyr Pro Ser Ala Val Phe Phe Ile Phe Thr Asp Asp Lys Glu Trp

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[0671] Cys Arg Asp His Phe Lys Gly Pro Asn Phe Ile Val Val Glu Leu Glu

[0672] 210 215 220

[0673] Glu Gly Asp Gly Thr Asp Ile Ala Glu Met Thr Leu Met Ser Arg Cys

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[0675] Lys His His Ile Ile Ala Asn Ser Ser Phe Ser Trp Trp Ala Ala Trp

[0676] 245 250 255

[0677] Leu Asn Asp Ser Pro Glu Lys Ile Val Ile Ala Pro Gln Lys Trp Ile

[0678] 260 265 270

[0679] Asn Asn Arg Asp Met Asp Asp Ile Tyr Thr Glu Arg Met Thr Lys Ile

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[0681] Ala Leu

[0682] 290

[0683] <210> 17

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[0690] Tyr Ala Phe Tyr Leu Gln Met Arg Lys Arg Phe Ser Asn Val Arg Ile

[0691] 20 25 30

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[0693] 35 40 45

[0694] His Lys Val Phe Gly Leu Pro Arg Thr Glu Phe Cys Met Asn Gln Pro

[0695] 50 55 60

[0696] Leu Lys Lys Val Leu Glu Phe Leu Phe Phe Arg Thr Ile Val Glu Arg

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[0698] Lys Gln His Gly Arg Met Glu Pro Tyr Thr Cys Gln Tyr Val Trp Pro

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[0700] Leu Val Tyr Phe Lys Gly Phe Tyr Gln Ser Glu Arg Tyr Phe Ser Glu

[0701] 100 105 110

[0702] Val Lys Asp Glu Val Arg Glu Cys Phe Thr Phe Asn Pro Ala Leu Ala

[0703] 115 120 125

[0704] Asn Arg Ser Ser Gln Gln Met Met Glu Gln Ile Gln Asn Asp Pro Gln

[0705] 130 135 140

[0706] Ala Val Ser Ile His Ile Arg Arg Gly Asp Tyr Leu Asn Pro Lys His

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[0708] Tyr Asp Thr Ile Gly Cys Ile Cys Gln Leu Pro Tyr Tyr Lys His Ala

[0709] 165 170 175

[0710] Val Ser Glu Ile Lys Lys Tyr Val Ser Asn Pro His Phe Tyr Val Phe

[0711] 180 185 190

[0712] Ser Glu Asp Leu Asp Trp Val Lys Ala Asn Leu Pro Leu Glu Asn Ala

[0713] 195 200 205

[0714] Gln Tyr Ile Asp Trp Asn Lys Gly Ala Asp Ser Trp Gln Asp Met Met
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[0716] Leu Met Ser Cys Cys Lys His His Ile Ile Cys Asn Ser Thr Phe Ser
[0717] 225 230 235 240
[0718] Trp Trp Ala Ala Trp Leu Asn Pro Ser Val Glu Lys Thr Val Ile Met
[0719] 245 250 255
[0720] Pro Glu Gln Trp Thr Ser Arg Gln Asp Ser Val Asp Phe Val Ala Ser
[0721] 260 265 270
[0722] Cys Gly Arg Trp Val Arg Val Lys Thr Glu
[0723] 275 280
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[0962] Val Arg Arg Gly Asp Tyr Ile Gly Asn Gln Leu Tyr Gln Gly Ile Cys

[0963] 165 170 175

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[1172] 145 150 155 160
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[3318] 275 280 285

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[3334] 65 70 75 80

[3335] Val Gln Arg Ile Lys Glu Pro Asp Phe Thr Phe His Pro His Ile Leu

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[3338] 100 105 110

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[3344] 145 150 155 160

[3345] Thr Glu Ala Asn Gln Phe His Gly Val Cys Ser Asp Thr Tyr Tyr Gln

[3346] 165 170 175

[3347] Lys Ala Ile Ala Lys Ile Lys Glu Ala Ile Pro Ala Pro His Leu Phe

[3348] 180 185 190

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[3350] 195 200 205

[3351] Glu Glu His Thr Phe Val Asp Gly Asn Thr Gly Lys Asn Ser Phe Glu

[3352] 210 215 220

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[3354] 225 230 235 240

[3355] Ser Phe Ser Trp Trp Ala Gly Trp Leu Asn Lys Asn Pro Glu Lys Met

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[3357] Val Ile Ala Pro Glu Lys Trp Phe Arg Ala Val His Thr Asp Ile Val

[3358] 260 265 270

[3359] Pro Pro Ser Trp Ile Lys Met

[3360] 275

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[3381] 115 120 125

[3382] Leu Asp Leu Lys His Lys Leu Ser Pro Tyr Thr Glu Ala Ser Tyr Leu

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[3385] 145 150 155 160

[3386] Asp Tyr Val Ser Asp Lys Ala Ala His Asn Thr His Gly Val Cys Ser

[3387] 165 170 175

[3388] Leu Asp Tyr Tyr Tyr Ala Ala Val Thr Phe Phe Glu Glu Arg Tyr Pro

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[3390] Asp Val Asp Phe Tyr Ile Phe Ser Asp Asp Ile Glu Trp Val Lys Glu

[3391] 195 200 205

[3392] Asn Leu Asn Val Gln Arg Ala His Tyr Ile Ser Ser Glu Glu Lys Arg

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[3394] Phe Ala Gly Glu Asp Ile Tyr Leu Met Ser Gln Cys Asp His Asn Ile

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[4316] Arg Arg Gly Asp Phe Leu Glu Ile Asn Arg Asp Ile Ser Gly Ser Glu
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[4353] Tyr Phe Ala His Cys Lys Asp Asp Ile Arg Lys Gln Phe Ser Phe Leu
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[4357] Glu Asn Ser Val Ala Ile His Leu Arg Lys Gly Ala Asp Tyr Leu Lys
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[4407] 210 215 220
[4408] Thr Asp Phe Glu Asp Met Arg Leu Met Ser Leu Cys Gln His Asn Ile
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[4441] Ser Asn Ser Ala Tyr Asn Ser Thr His Gly Thr Cys Ser Leu Ala Tyr
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[4443] Tyr Thr Asn Ala Val Asn Phe Leu Val Asn Lys Ile Gly Gly Asn Phe
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[4920] 260 265 270

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[4922] 275 280 285

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[4940] 85 90 95

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[6406] 50 55 60
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[6436] 290
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[6450] His Lys Gly Asp Gly Val Leu Thr Arg Val Phe Asp Leu Asp Trp Ala
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[6490] 35 40 45
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[6492] 50 55 60
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[6494] 65 70 75 80
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[6496] 85 90 95
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[6506] 165 170 175
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[6517] Asp Arg Arg Pro Glu Ala Arg Val Val Gly Pro Ala Lys Trp Phe Asn
[6518] 260 265 270
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[6538] 85 90 95
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[6558] 245 250 255
[6559] Ala Trp Leu Ser Thr Ala Asn Asp Gly Ile Thr Ile Ala Pro His Gln
[6560] 260 265 270
[6561] Trp Tyr Ala Asn Asp Arg Lys Pro Ser Pro Ala Ala Glu Ala Trp Leu
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[6564] 290
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[6581] 85 90 95
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[6599] 225 230 235 240
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[6630] 130 135 140
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[6632] 145 150 155 160
[6633] Ile Asn Ala Thr Asn Ser Ile Cys Leu His Ile Arg Arg Thr Asp Phe
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[6636] 180 185 190
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[6684] Ala Asn Ser Ser Phe Ser Trp Trp Gly Ala Ala Leu Gly Asp Thr Glu
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[6712] 130 135 140
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[6714] 145 150 155 160
[6715] Val Arg Arg Thr Asp Tyr Val Asp Ala Glu His Ile Lys Ile His Asn
[6716] 165 170 175
[6717] Leu Cys Ser Glu Lys Tyr Tyr Lys Asn Ala Ile Gly Lys Ile Arg Glu
[6718] 180 185 190
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[6720] 195 200 205
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[6724] 225 230 235 240
[6725] Lys His His Ile Ile Ala Asn Ser Ser Phe Ser Trp Trp Ser Ala Trp
[6726] 245 250 255
[6727] Leu Asn Asp Ser Pro Glu Lys Met Val Ile Ala Pro Ser Lys Trp Ile
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[6730] 275 280 285
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[6756] Val Tyr Ala His Pro Lys Pro Asn Gln Tyr Asn Ala Ala Leu Ile Ser
[6757] 145 150 155 160
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[6759] 165 170 175
[6760] Tyr Leu Ala Glu Pro Glu Phe Arg Gly Ile Cys Gly Leu Asp Tyr Tyr
[6761] 180 185 190

[6762] Glu Lys Gly Ile Lys Glu Ile Leu Ser Asp Glu Lys Lys Tyr Val Phe
[6763] 195 200 205
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[6765] 210 215 220
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[6769] 245 250 255
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[6771] 260 265 270
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[6796] 100 105 110
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[6798] 115 120 125
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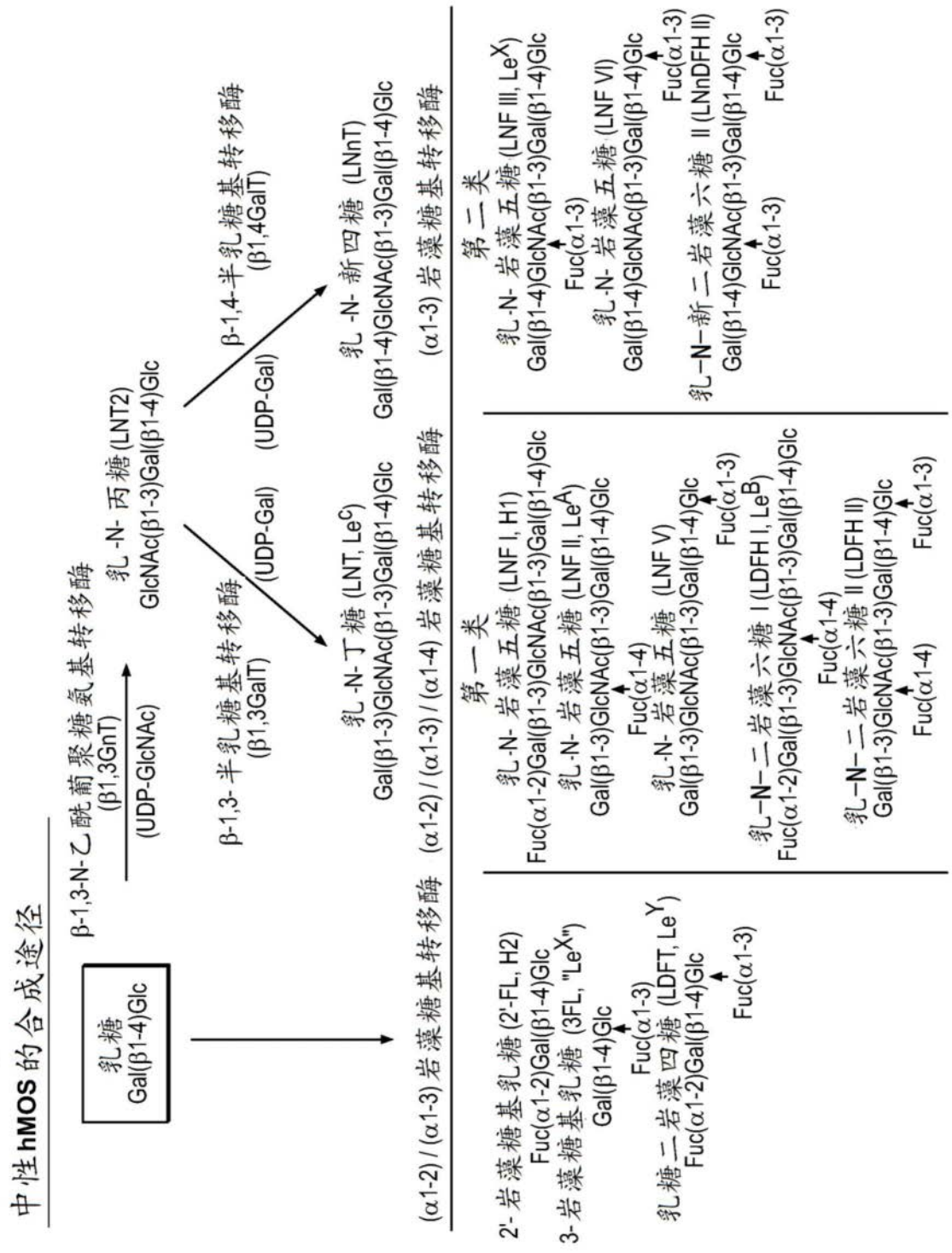

中性hMOS的合成途径
乳糖
Gal(β1-4)Glc
β-1,3-N-乙酰葡聚糖氨基转移酶
(β1,3GnT)
(UDP-GlcNAc)
乳-N-丙糖(LNT2)
GlcNAc(β1-3)Gal(β1-4)Glc
β-1,3-半乳糖基转移酶
(β1,3GalT)
(UDP-Gal)
乳-N-丁糖 (LNT, Le^C)
Gal(β1-3)GlcNAc(β1-3)Gal(β1-4)Glc
β-1,4-半乳糖基转移酶
(β1,4GalT)
(UDP-Gal)
乳-N-新四糖 (LNnT)
Gal(β1-4)GlcNAc(β1-3)Gal(β1-4)Glc
(α1-2)/(α1-3)岩藻糖基转移酶
(α1-2)/(α1-3)/(α1-4)岩藻糖基转移酶
(α1-3)岩藻糖基转移酶
第一类
2'-岩藻糖基乳糖 (2'-FL, H2)
Fuc(α1-2)Gal(β1-4)Glc
3-岩藻糖基乳糖 (3FL, "Le^X")
Gal(β1-4)Glc
Fuc(α1-3)
乳糖二岩藻四糖 (LDFT, Le^Y)
Fuc(α1-2)Gal(β1-4)Glc
Fuc(α1-3)
乳-N-岩藻五糖 (LNF I, H1)
Fuc(α1-2)Gal(β1-3)GlcNAc(β1-3)Gal(β1-4)Glc
乳-N-岩藻五糖 (LNF II, Le^A)
Gal(β1-3)GlcNAc(β1-3)Gal(β1-4)Glc
Fuc(α1-4)
乳-N-岩藻五糖 (LNF V)
Gal(β1-3)GlcNAc(β1-3)Gal(β1-4)Glc
Fuc(α1-3)
乳-N-二岩藻六糖 I (LDFH I, Le^B)
Fuc(α1-2)Gal(β1-3)GlcNAc(β1-3)Gal(β1-4)Glc
Fuc(α1-4)
乳-N-二岩藻六糖 II (LDFH II)
Gal(β1-3)GlcNAc(β1-3)Gal(β1-4)Glc
Fuc(α1-4)
Fuc(α1-3)
第二类
乳-N-岩藻五糖 (LNF III, Le^X)
Gal(β1-4)GlcNAc(β1-3)Gal(β1-4)Glc
Fuc(α1-3)
乳-N-岩藻五糖 (LNF VI)
Gal(β1-4)GlcNAc(β1-3)Gal(β1-4)Glc
Fuc(α1-3)
乳-N-新二岩藻六糖 II (LNnDFH II)
Gal(β1-4)GlcNAc(β1-3)Gal(β1-4)Glc
Fuc(α1-3)
Fuc(α1-3)

图1

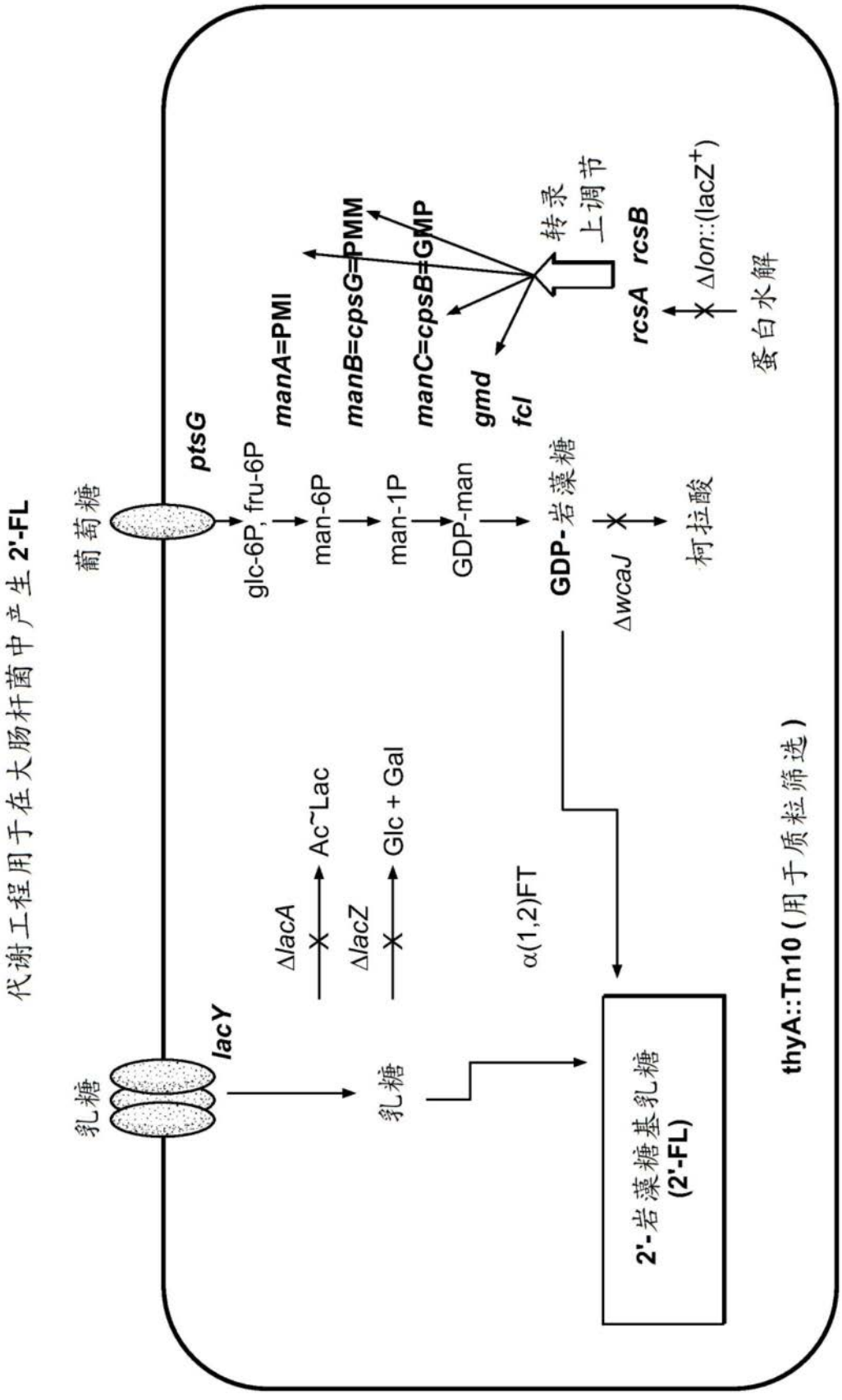

代谢工程用于在大肠杆菌中产生 2'-FL
葡萄糖
ptsG
glc-6P, fru-6P
manA=PMI
man-6P
manB=cpsG=PMM
man-1P
manC=cpsB=GMP
GDP-man
gmd
fcl
GDP-岩藻糖
转录上调节
rcsA rcsB
Δlon::(lacZ+)
蛋白水解
ΔwcaJ
柯拉酸
乳糖
lacY
ΔlacA
Ac~Lac
ΔlacZ
Glc + Gal
乳糖
α(1,2)FT
2'-岩藻糖基乳糖
(2'-FL)
thyA::Tn10 (用于质粒筛选)

图2

		1	2	3	4
螺杆菌幽门futC	1		70.10	23.97	22.57
H.mustelae futL	2	70.10		27.04	21.36
普通拟杆菌futN	3	23.97	27.04		31.23
大肠杆菌O126 wbgL	4	22.57	21.36	31.23	

图3A

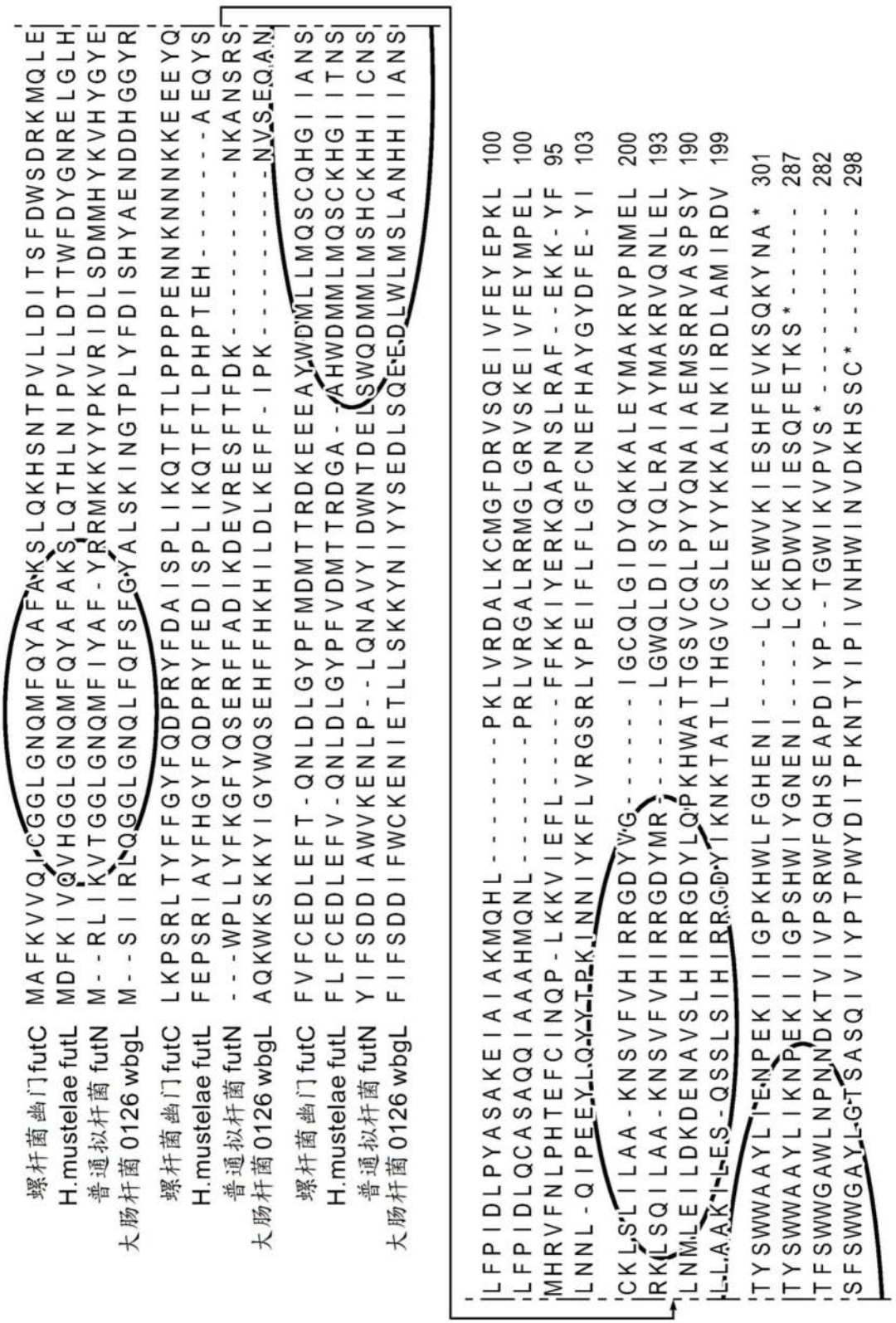

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普通拟杆菌 futN M--RLIKVTGGLGNQMFIYAF-YRRMKKYYPKVRIDLSDMMHYKVHYGYE
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TYSWWAAYLIKNPEKIIIGPSHWIYGNENI----LCKDWVKIESQFETKS*----- 287
TFSWWGAWLNPNNDKTVIVPSRWFQHSEAPDIYP--TGWIKVPVS*---------- 282
SFSWWGAYLGTSASQIVIYPTPWYDITPKNTYIPIVNHWINVDKHSSC*------- 298

图3B

图 4
图 4A
图 4B
图 4C
图 4D
图 4E
图 4F
螺杆菌幽门 futC
H.mustelae futL
普通拟杆菌 futN
大肠杆菌 0126 wbgL
产黑素普雷沃菌 FutO YP_003814512.1
梭状芽孢杆菌 +13 FutP WP_002570768.1
毛螺菌科 FutQ WP_009251343.1
甲烷微菌属 FutR YP_002467213.1
坦纳菌属 FutS WP_021929367.1
粪拟杆菌 FutU WP_005675707.1
丁酸弧菌属 FutV WP_022772718.1
普雷沃菌属 FutW WP_022481266.1
乔治普氏菌 FutX WP_008155883.1
肠道疣微菌 FutY YP_001877555
肠道沙门氏菌 FutZ WP_023214330
拟杆菌 FutZA WP_022161880.1
梭状芽孢杆菌 FutP WP_002570768.1
MAFKVVQICGGLGNQMFQYAFAKSLQKHSNTP--VLLDITSFDWSDR
MDFKIVQVHGGLGNQMFQYAFAKSLQTHLNIP--VLLDTTWFDYGNR
M--RLIKVTGGLGNQMFIYAFYLRMKKYY---PKVRIDLSDMMH---
M--SIIRLQGGLGNQLFQFSFGYALSKINGTP--LYFDISHYAEN--
M-K-IVKILGGLGNQMFQYALYLSLQES-FPKERVALDLSSF-----
m-v-iikmmggl gnqMFQYALYKAFEQK-HID--VYADLAWYKNKSV
M-V-IVQLSGGLGNQMFEYALYLSLKAK-GKEVKID-DVTCYEGPGT
M-I-IVRLKGGLGNQLSQYALGRKIAHL-HNTE-LKLDTTWFTTISS
M-VRIVEIIGGLGNQMFQYAFSLYLKNKSHIWDRLYVDIEAMKT---
M-K-IVKILGGLGNQMFQYALFLSLKER-FPHEQVMIDTSCF-----
M-I-IIQLKGGLGNQMFQYALYKSLKKR-GKEVKID-DKTGFVNDKL
M--RLVKMIGGLGNQMFIYAFYLQMRKRF---SNVRIDLTDMMH---
M--RLIKMIGGLGNQMFIYAFYLKMKHHY---PDTNIDLSDMVH---
M-----RLFGGLGNQLFQYAFLFALSRQGG---KARLETSSYEHDDK
M-YSC--LSGGLGNQMFQYAAAYILKQYFQSTTLVLDDSYYYSQPKR
M--RLIKMTGGLGNQMFIYAFYLRMKKRY---PKVRIDLSDMVH---
M----------FQYALYKAFEQK-HID--VYADLAWYKNKSV

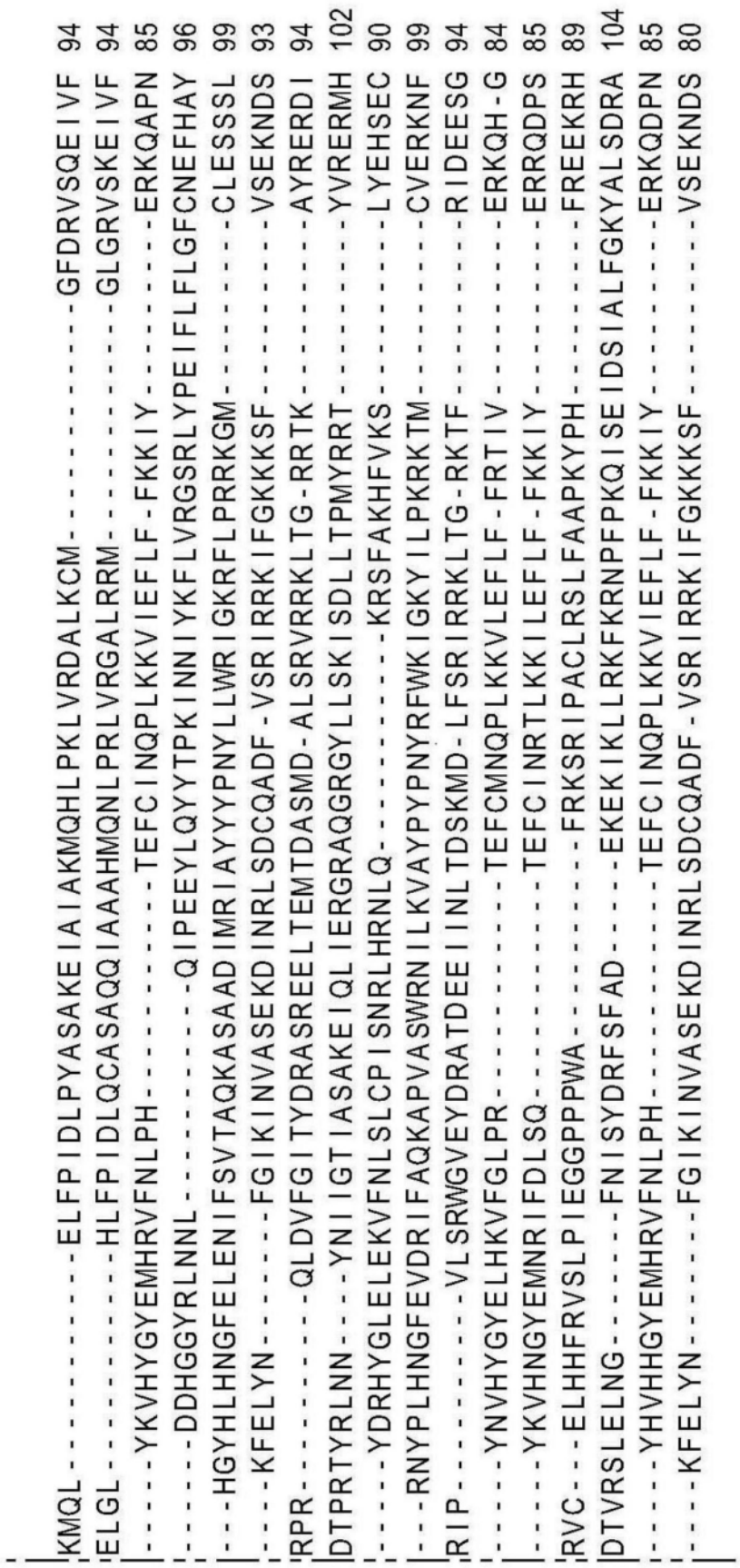


图4B

```
螺杆菌幽门futC      EYEPKLLKPSR-LTYFFGYFQDPRYF--DAISPLIKQTFTLPPPPEN
H.mustelae futL     EYMPELFEPSR-IAYFHGYFQDPRYF--EDISPLIKQTFTLPHPTEH
普通拟杆菌futN      SLRAFEKKYFWPLLYFKGFYQSERFF--ADIKDEVRESFTF----DK
大肠杆菌 0126 wbgL  GYDFEYIAQKWKSKKYIGYWQSEHFFHKHIL--DLKEFFI------P
产黑素普雷沃菌FutO YP_003814512.1  RFDESVLR-QEGNRYFDGYWQDERYF--AAYREKVLKAFTFPAFKRA
梭状芽孢杆菌+13 FutP WP_002570768.1  CYENDILR-M-DNVYLSGYWQTEKYF--SNTREKLLEDYSF-ALVNS
毛螺菌科. FutQ WP_009251343.1  NFDPLVME--KDPALLEGCFQSDKYF--RDCEGRVREAYRFRGIESG
甲烷微菌属FutR YP_002467213.1  TFDKAILT-VPDNVYLDGYWQTEKYF--KDIEEILRREVTLKDEPDS
坦纳菌属. FutS WP_021929367.1  EFDEPVYRGLRPYRYYRGYWQNEGYFV--DIEPMIREAFQFNVNILS
类拟杆菌FutU WP_005675707.1  SFDAAVLT-RKGDCYYDGYWQHEEYF--CDMKETIWEAFSFPEPVDG
丁酸弧菌属FutV WP_022772718.1  KFNPEILE--KENAYLVGYWQCDKYFDDKDVVREIREAFEKKPQE--
普雷沃菌属. FutW WP_022481266.1  RMEPYTCQYVWPLVYFKGFYQSERYF--SEVKDEVRECFTF----NP
乔治普氏菌FutX WP_008155883.1  TLYPYEKRYFWPLLYFKGFYQSERFF--FDIKDDVRKAFSF----NL
肠道疣微菌FutY YP_001877555  GFDPGLAAPPRRHTYFKGYFQTEQYFL--HCREQLCREFRLKTPLTP
肠道沙门氏菌FutZ WP_023214330  FYTFETIKNIDKACLFSFYQDAD---LLNKYKQLILPLFELR----DD
拟杆菌. FutZA WP_022161880.1  SLRAFEKKYLWPLLYFKGFYQSERFF--ADIKDEVRKAFTF----DS
梭状芽孢杆菌FutP WP_002570768.1  CYENDILR-M-DNVYLSGYWQTEKYF--SNTREKLLEDYSF-ALVNS
```

图4C

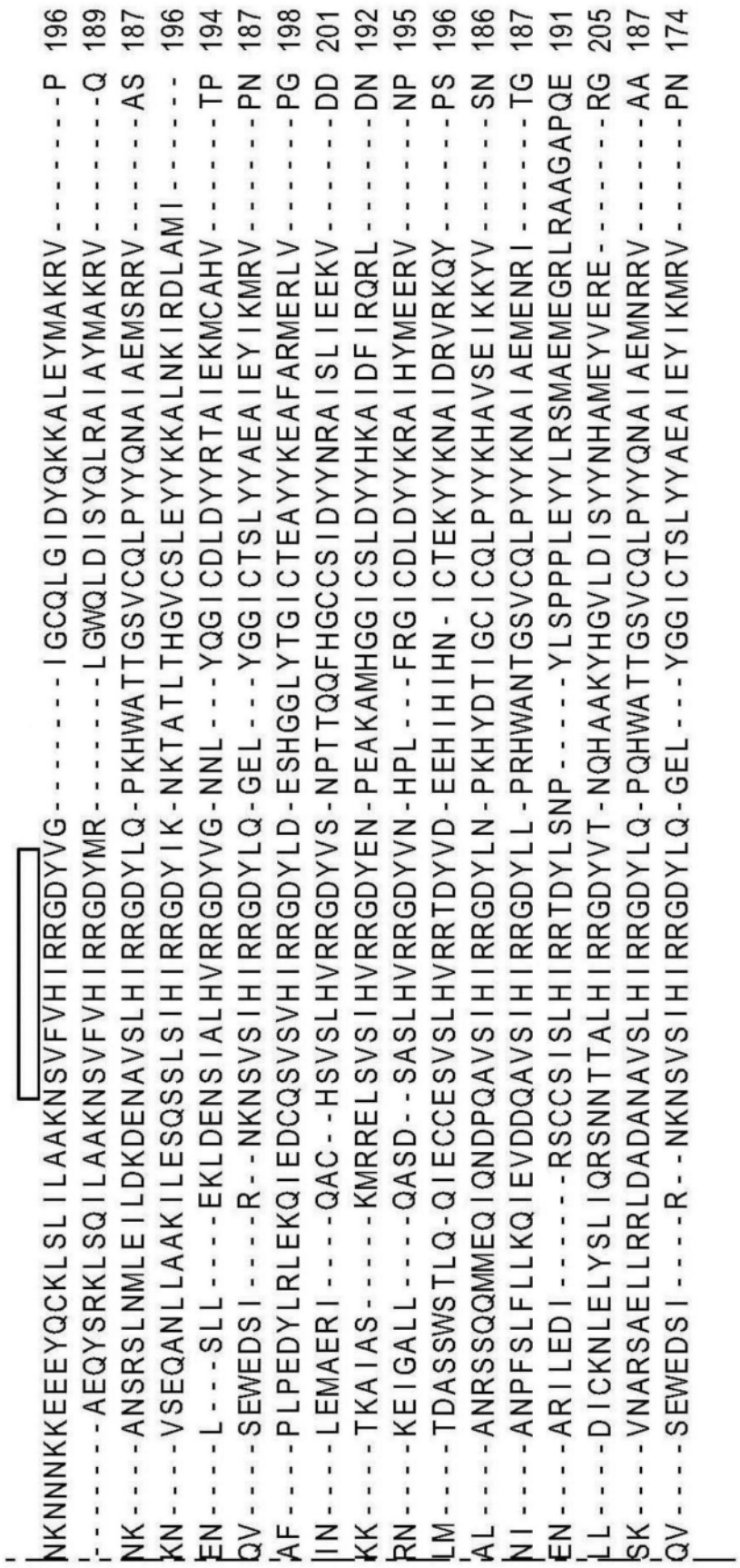

NKNNNKEEEYQCKLSLILAAKNSVFVHIRRGDYVG-------IGCQLGIDYQKKALEYMAKRV-------P 196
-------AEQYSRKLSQILAAKNSVFVHIRRGDYMR-------LGWQLDISYQLRAIAYMAKRV-------Q 189
NK----ANSRSLNMLEILDKDENAVSLHIRRGDYLQ-PKHWATTGSVCQLPYYQNAIAEMSRRV-------AS 187
KN----VSEQANLLAAKILESQSSLSIHIRRGDYIK-NKTATLTHGVCSLEYYKKALNKIRDLAMI------ 196
EN----L---SLL----EKLDENSIALHVRRGDYVG-NNL---YQGICDLDYYRTAIEKMCAHV-------TP 194
QV----SEWEDSI----R--NKNSVSIHIRRGDYLQ-GEL---YGGICTSLYYAEAIEYIKMRV-------PN 187
AF----PLPEDYLRLEKQIEDCQSVSVHIRRGDYLD-ESHGGLYTGICTEAYYKEAFARMERLV-------PG 198
IN----LEMAERI----QAC--HSVSLHVRRGDYVS-NPTTQQFHGCCSIDYYNRAISLIEEKV-------DD 201
KK----TKAIAS-----KMRRELSVSIHVRRGDYEN-PEAKAMHGGICSLDYYHKAIDFIRQRL-------DN 192
RN----KEIGALL----QASD--SASLHVRRGDYVN-HPL---FRGICDLDYYKRAIHYMEERV-------NP 195
LM----TDASSWSTLQ-QIECCESVSLHVRRTDYVD-EEHIHIHN-ICTEKYYKNAIDRVRKQY-------PS 196
AL----ANRSSQQMMEQIQNDPQAVSIHIRRGDYLN-PKHYDTIGCICQLPYYKHAVSEIKKYV-------SN 186
NI----ANPFSLFLLKQIEVDDQAVSIHIRRGDYLL-PRHWANTGSVCQLPYYKNAIAEMENRI-------TG 187
EN----ARILEDI-------RSCCSISLHIRRTDYLSNP-----YLSPPPLEYYLRSMAEMEGRLRAAGAPQE 191
LL----DICKNLELYSLIQRSNNTTALHIRRGDYVT-NQHAAKYHGVLDISYYNHAMEYVERE-------RG 205
SK----VNARSAELLRRLDADANAVSLHIRRGDYLQ-PQHWATTGSVCQLPYYQNAIAEMNRRV-------AA 187
QV----SEWEDSI----R--NKNSVSIHIRRGDYLQ-GEL---YGGICTSLYYAEAIEYIKMRV-------PN 174

图4D

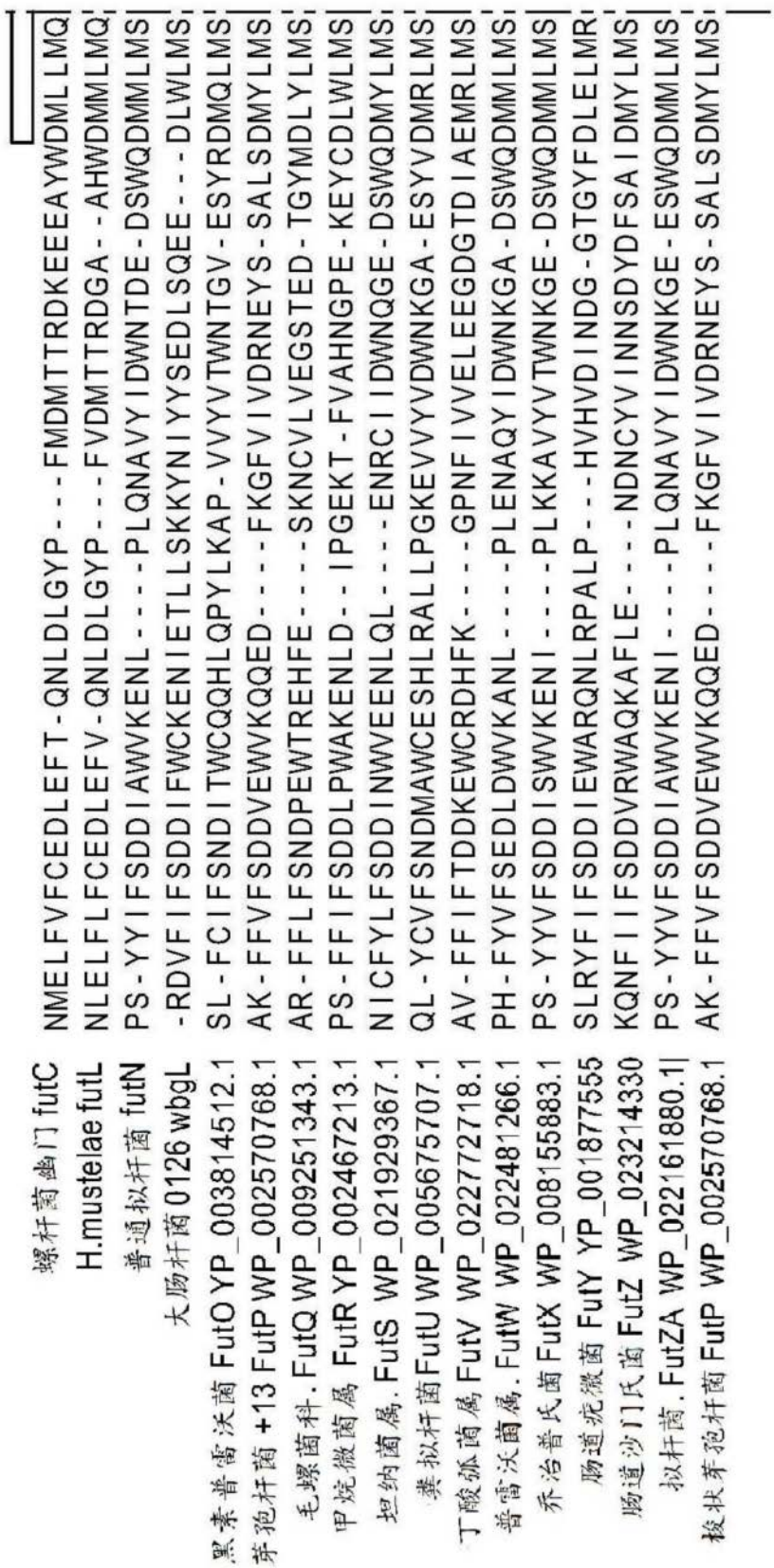

螺杆菌幽门 futC NMELFVFCEDLEFT-QNLDLGYP---FMDMTTRDKEEEAYWDMLLMQ
H.mustelae futL NLELFLFCEDLEFV-QNLDLGYP---FVDMTTRDGA--AHWDMMLMQ
普通拟杆菌 futN PS-YYIFSDDIAWVKENL----PLQNAVYIDWNTDE-DSWQDMMLMS
大肠杆菌 0126 wbgL -RDVFIFSDDIFWCKENIETLLSKKYNIYYSEDLSQEE---DLWLMS
产黑素普雷沃菌 FutO YP_003814512.1 SL-FCIFSNDITWCQQHLQPYLKAP-VVYVTWNTGV-ESYRDMQLMS
梭状芽孢杆菌 +13 FutP WP_002570768.1 AK-FFVFSDDVEWVKQQED----FKGFVIVDRNEYS-SALSDMYLMS
毛螺菌科. FutQ WP_009251343.1 AR-FFLFSNDPEWTREHFE----SKNCVLVEGSTED-TGYMDLYLMS
甲烷微菌属 FutR YP_002467213.1 PS-FFIFSDDLPWAKENLD--IPGEKT-FVAHNGPE-KEYCDLWLMS
坦纳菌属. FutS WP_021929367.1 NICFYLFSDDINWVEENLQL----ENRCIIDWNQGE-DSWQDMYLMS
粪拟杆菌 FutU WP_005675707.1 QL-YCVFSNDMAWCESHLRALLPGKEVVYVDWNKGA-ESYVDMRLMS
丁酸弧菌属 FutV WP_022772718.1 AV-FFIFTDDKEWCRDHFK----GPNFIVVELEEGDGTDIAEMRLMS
普雷沃菌属. FutW WP_022481266.1 PH-FYVFSEDLDWVKANL----PLENAQYIDWNKGA-DSWQDMMLMS
乔治普氏菌 FutX WP_008155883.1 PS-YYVFSDDISWVKENI----PLKKAVYVTWNKGE-DSWQDMMLMS
肠道疣微菌 FutY YP_001877555 SLRYFIFSDDIEWARQNLRPALP---HVHVDINDG-GTGYFDLELMR
肠道沙门氏菌 FutZ WP_023214330 KQNFIIFSDDVRWAQKAFLE----NDNCYVINNSDYDFSAIDMYLMS
拟杆菌. FutZA WP_022161880.1 PS-YYVFSDDIAWVKENI----PLQNAVYIDWNKGE-ESWQDMMLMS
梭状芽孢杆菌 FutP WP_002570768.1 AK-FFVFSDDVEWVKQQED----FKGFVIVDRNEYS-SALSDMYLMS

图4E

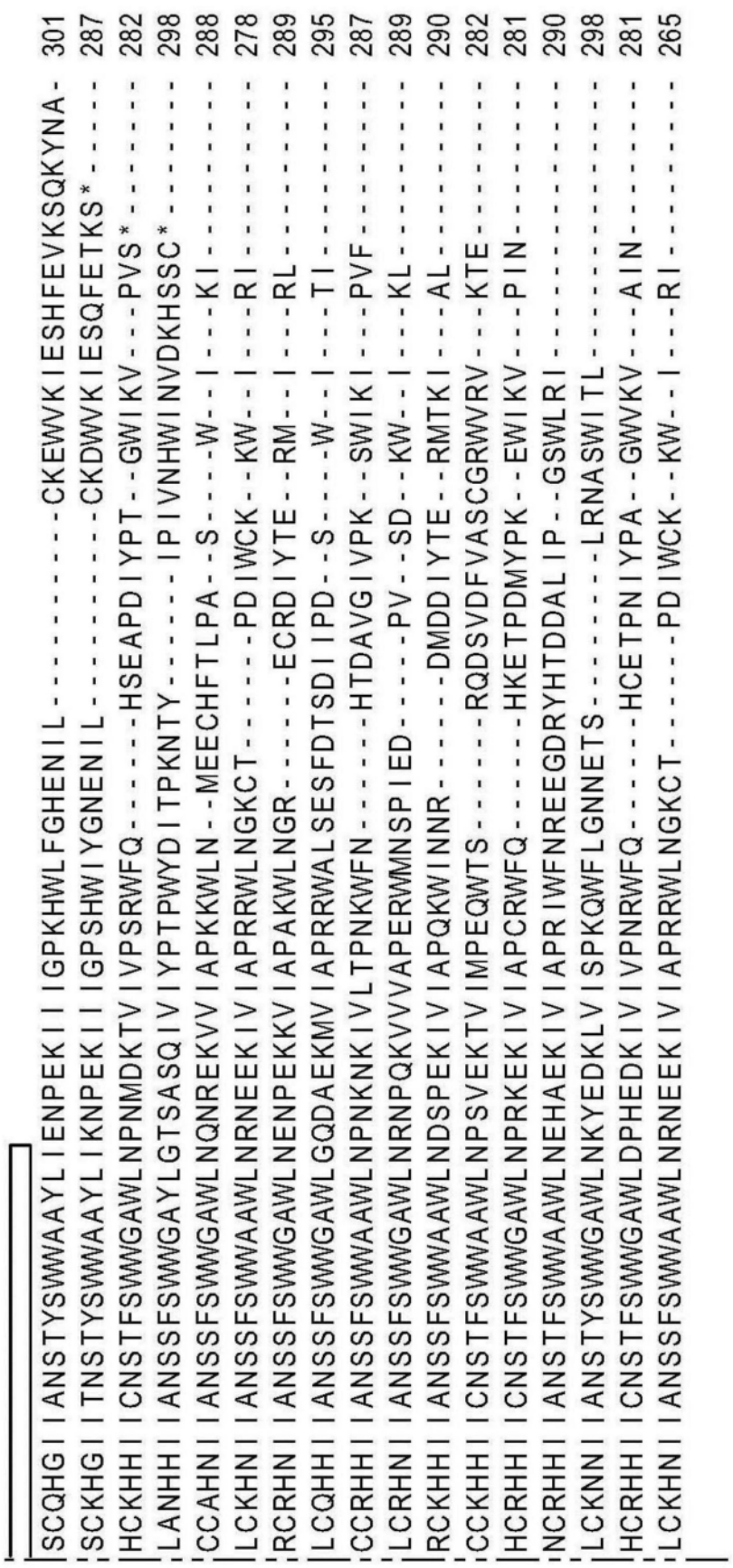

SCQHGIIANSTYSWWAAYLIENPEKII IGPKHWLFGHENIL----------CKEWVKIESHFEVKSQKYNA- 301
SCKHGIITNSTYSWWAAYLIKNPEKII IGPSHWIYGNENIL----------CKDWVKIESQFETKS*----- 287
HCKHHIICNSTFSWWGAWLNPNMDKTVIVPSRWFQ------HSEAPDIYPT--GWIKV---PVS*------- 282
LANHHIIANSSFSWWGAYLGTSASQIVIYPTPWYDITPKNTY------IPIVNHWINVDKHSSC*------- 298
CCAHNIIANSSFSWWGAWLNQNREKVVIAPKKWLN--MEECHFTLPA--S----W---I---KI--------- 288
LCKHNIIANSSFSWWAAWLNRNEEKIVIAPRRWLNGKCT------PDIWCK--KW---I---RI--------- 278
RCRHNIIANSSFSWWGAWLNENPEKKVIAPAKWLNGR------ECRDIYTE--RM---I---RL--------- 289
LCQHHIIANSSFSWWGAWLGQDAEKMVIAPRRWALSESFDTSDIIPD--S----W---I---TI--------- 295
CCRHHIIANSSFSWWAAWLNPNKNKIVLTPNKWFN------HTDAVGIVPK--SWIKI---PVF--------- 287
LCRHNIIANSSFSWWGAWLNRNPQKVVVAPERWMNSPIED-------PV--SD--KW---I---KL--------- 289
RCKHHIIANSSFSWWAAWLNDSPEKIVIAPQKWINNR------DMDDIYTE--RMTKI---AL--------- 290
CCKHHIICNSTFSWWAAWLNPSVEKTVIMPEQWTS---------RQDSVDFVASCGRWVRV---KTE------ 282
HCRHHIICNSTFSWWGAWLNPRKEKIVIAPCRWFQ---------HKETPDMYPK--EWIKV---PIN------ 281
NCRHHIIANSTFSWWAAWLNEHAEKIVIAPRIWFNREEGDRYHTDDALIP--GSWLRI------------- 290
LCKNNIIANSTYSWWGAWLNKYEDKLVISPKQWFLGNNETS----------LRNASWITL------------ 298
HCRHHIICNSTFSWWGAWLDPHEDKIVIVPNRWFQ---------HCETPNIYPA--GWVKV---AIN------ 281
LCKHNIIANSSFSWWAAWLNRNEEKIVIAPRRWLNGKCT------PDIWCK--KW---I---RI--------- 265

图4F

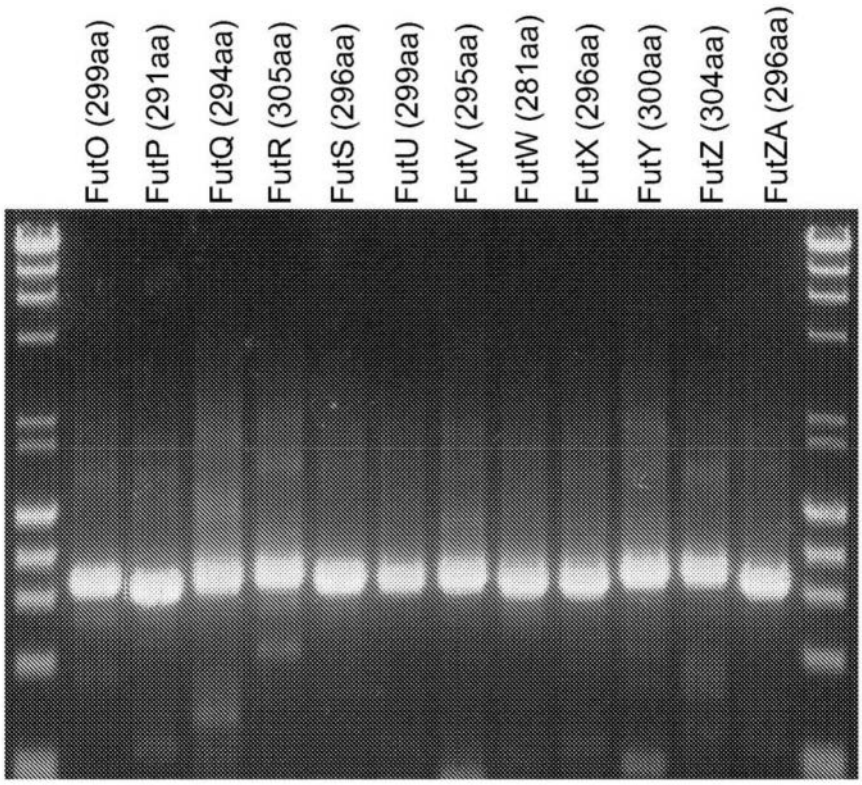

FutO (299aa)
FutP (291aa)
FutQ (294aa)
FutR (305aa)
FutS (296aa)
FutU (299aa)
FutV (295aa)
FutW (281aa)
FutX (296aa)
FutY (300aa)
FutZ (304aa)
FutZA (296aa)
后-吉布森组装 PCR

图5A

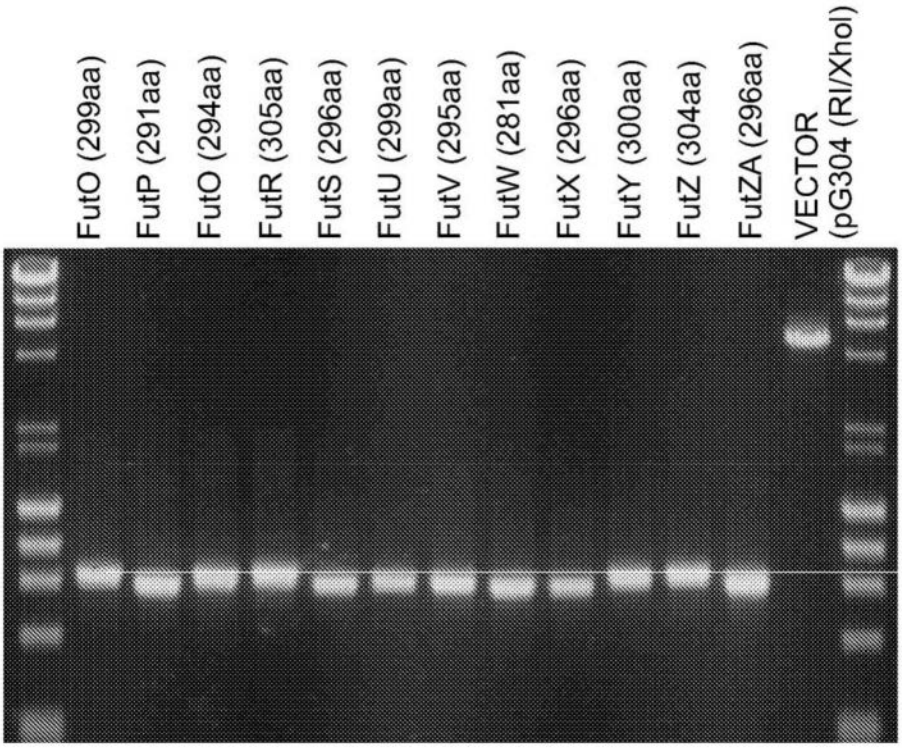

FutO (299aa)
FutP (291aa)
FutO (294aa)
FutR (305aa)
FutS (296aa)
FutU (299aa)
FutV (295aa)
FutW (281aa)
FutX (296aa)
FutY (300aa)
FutZ (304aa)
FutZA (296aa)
VECTOR (pG304 (RI/Xhol)
凝胶纯化的RI/Xhol变种片段

图5B

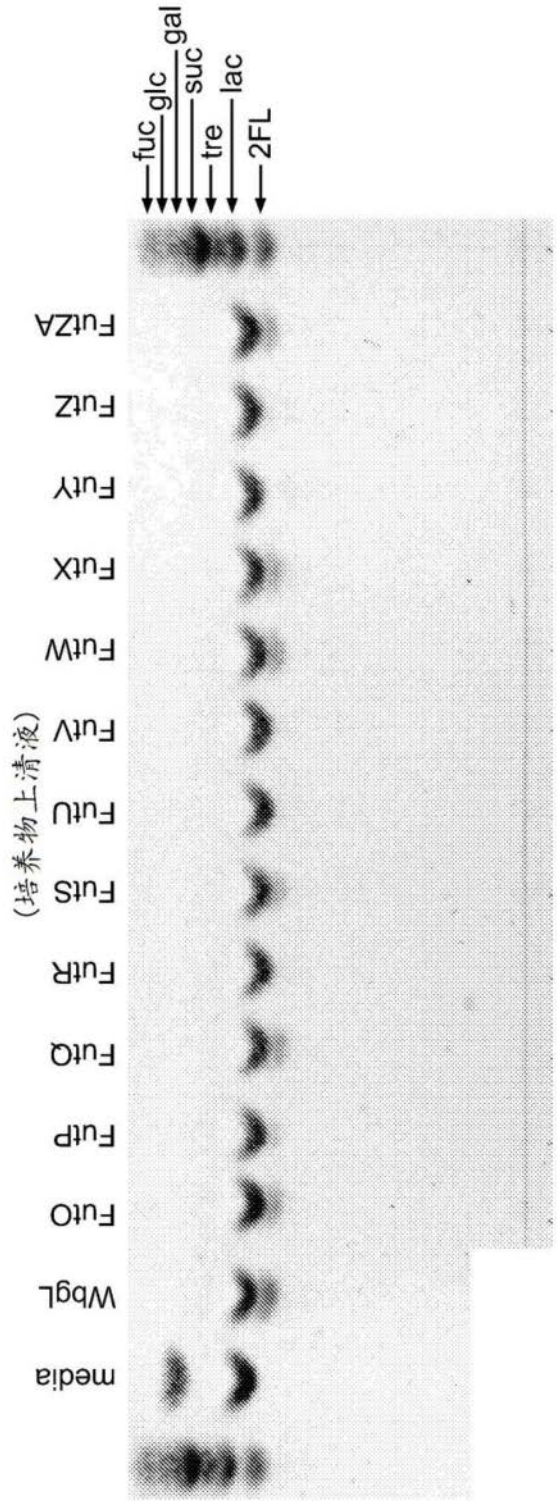

fuc
glc
gal
suc
tre
lac
2FL
FutZA
FutZ
FutY
FutX
FutW
FutV
FutU
FutS
FutR
FutQ
FutP
FutO
WbgL
media
(培养物上清液)

图6A

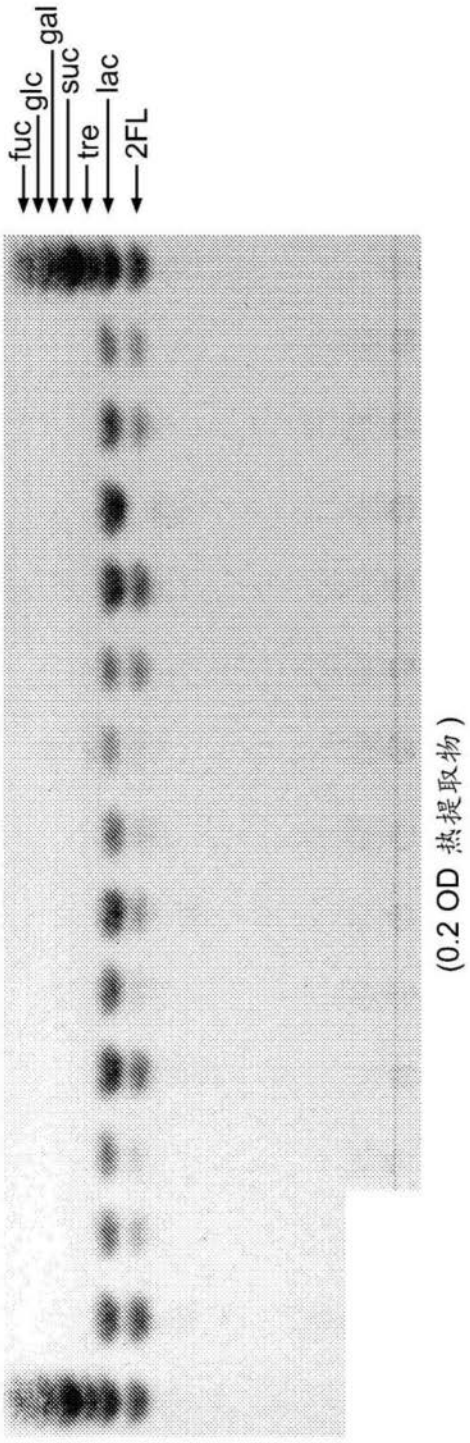


图6B

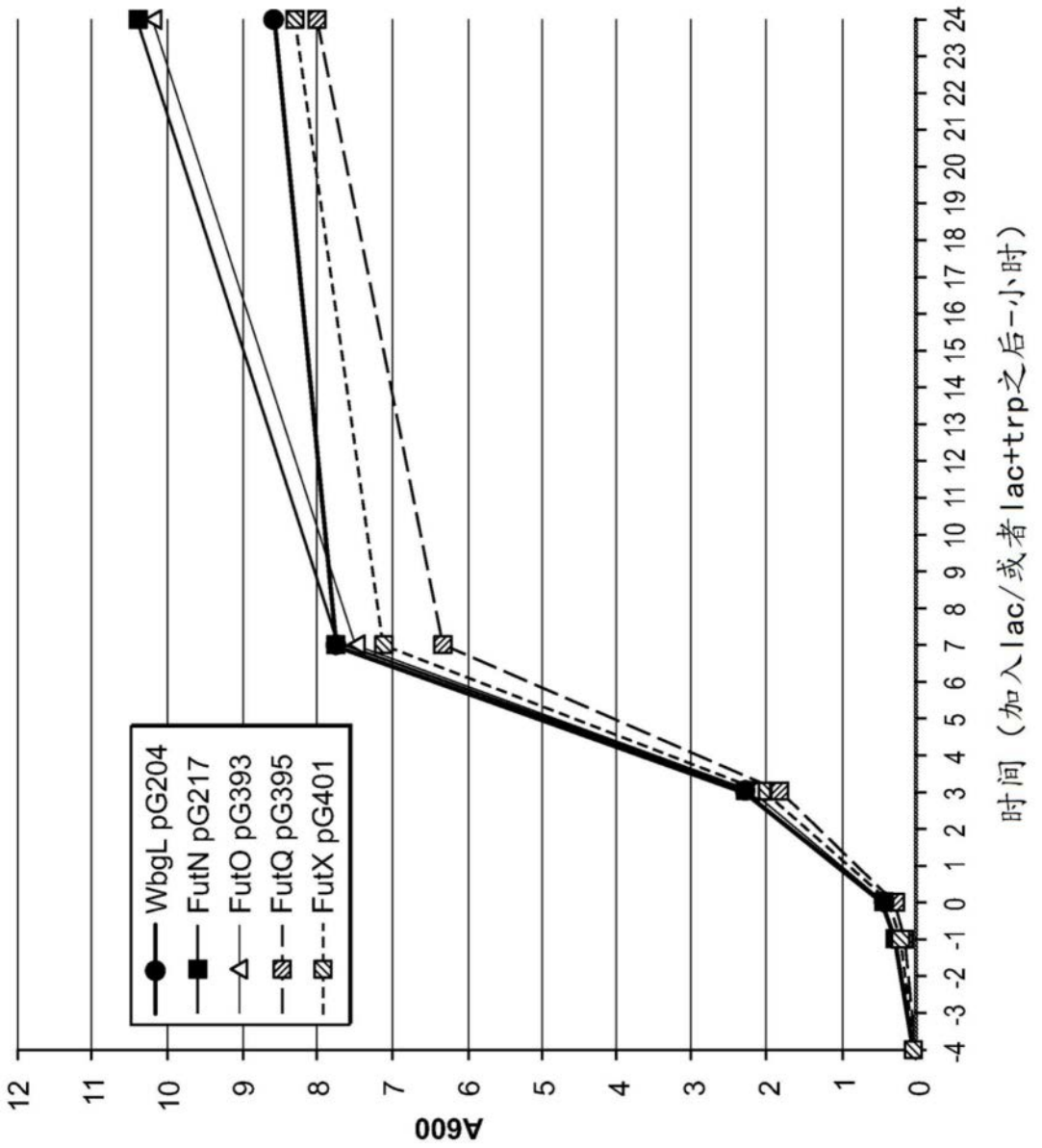

A600
12
11
10
9
8
7
6
5
4
3
2
1
0
-4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
时间（加入lac/或者lac+trp之后-小时）
WbgL pG204
FutN pG217
FutO pG393
FutQ pG395
FutX pG401

图7

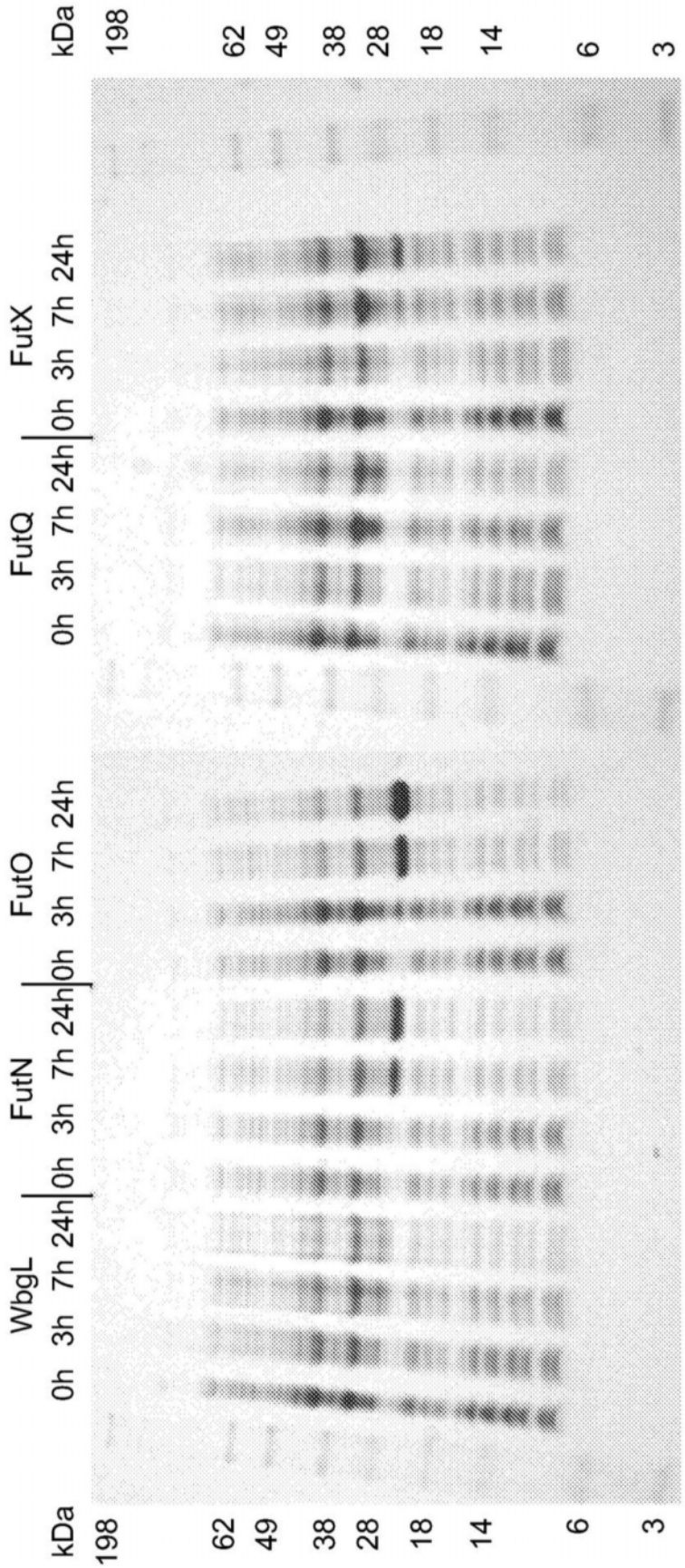


图8

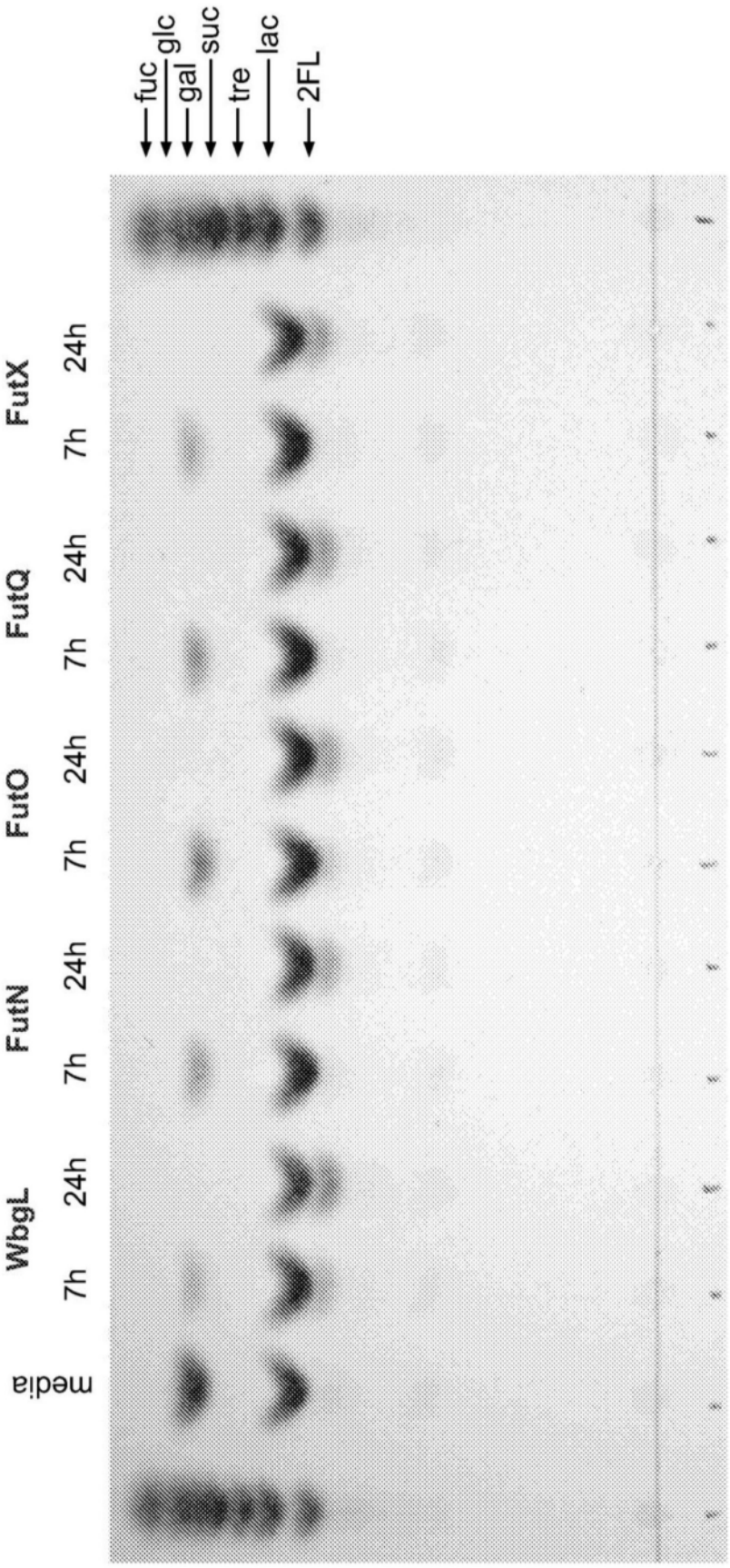

fuc
glc
gal
suc
tre
lac
2FL
media
WbgL
FutN
FutO
FutQ
FutX
7h
24h

图9A

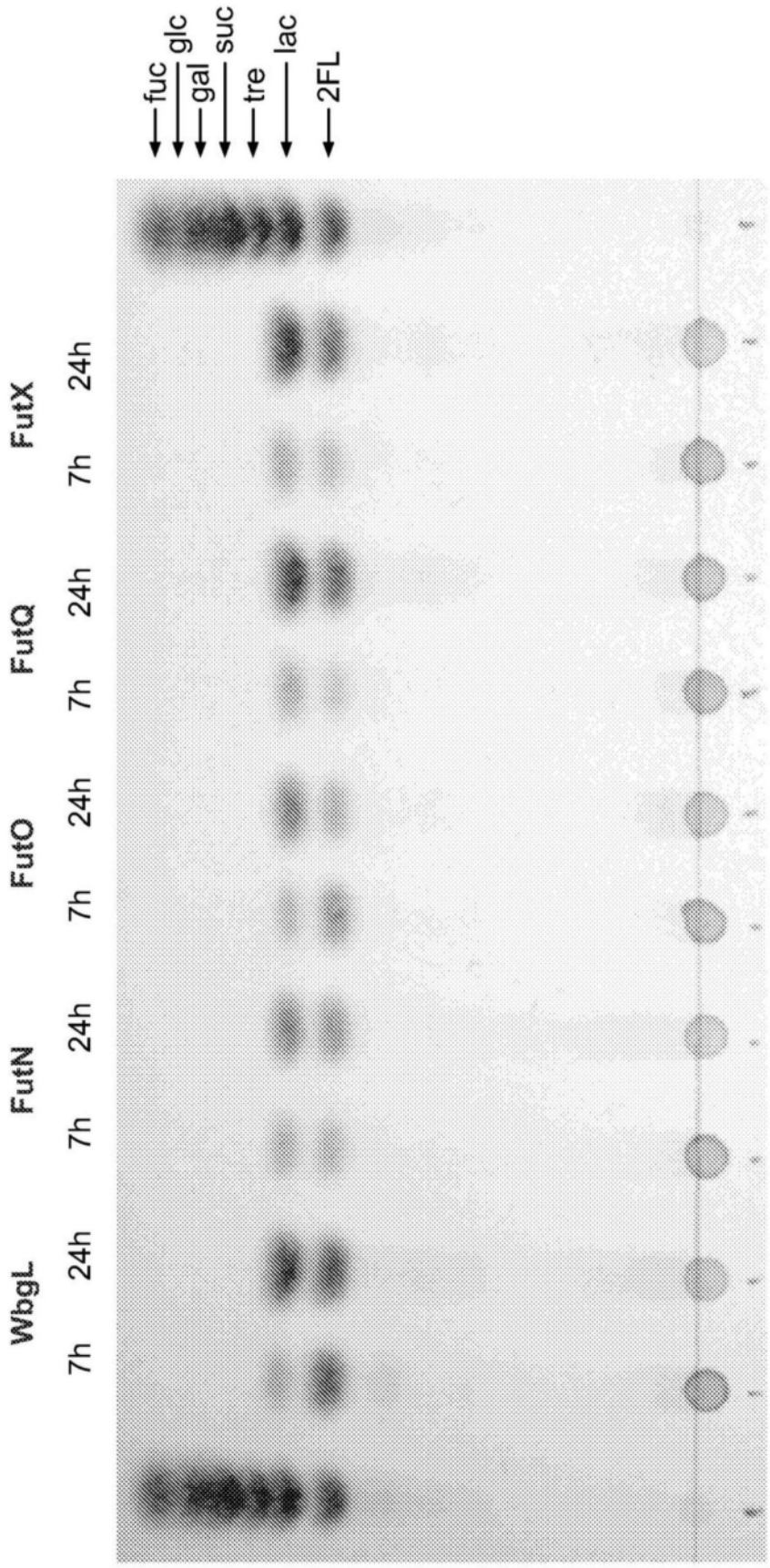


图9B

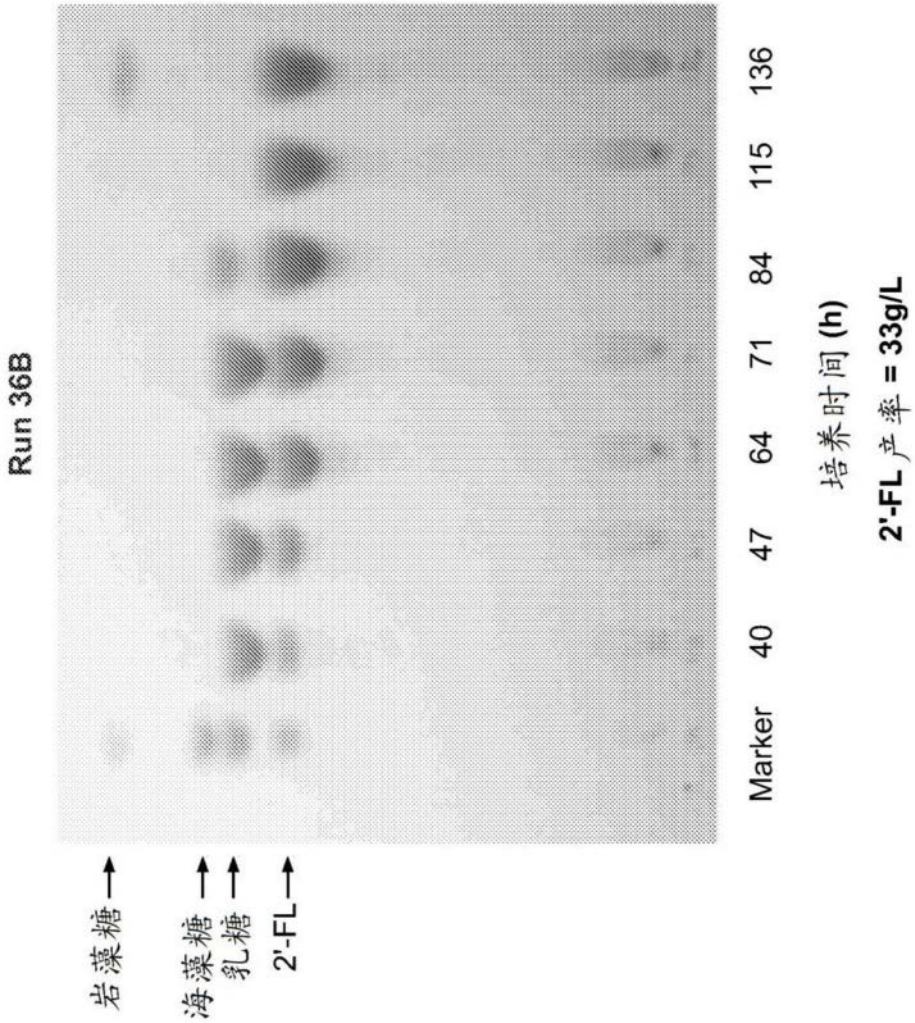

Run 36B
岩藻糖
海藻糖
乳糖
2'-FL
Marker
40
47
64
71
84
115
136
培养时间 (h)
2'-FL 产率 = 33g/L

图10A

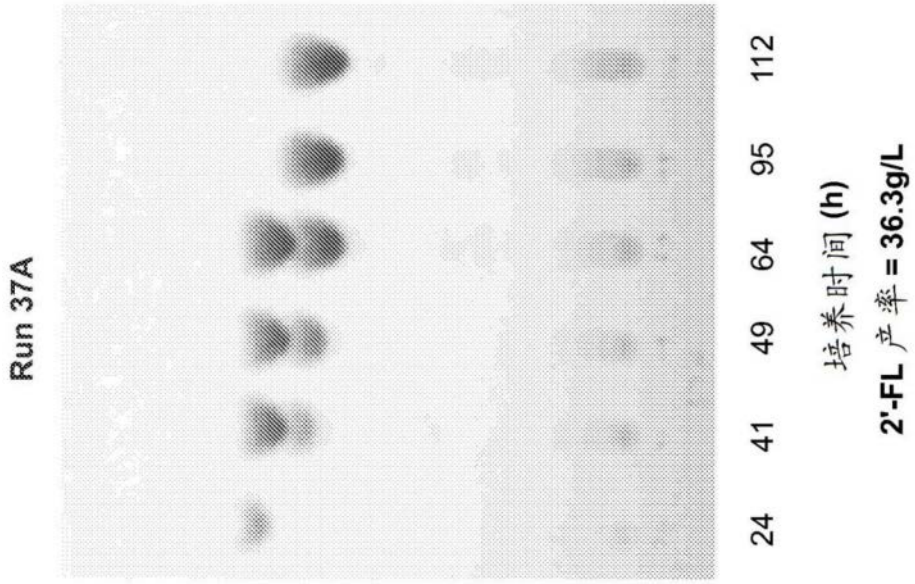


图10B

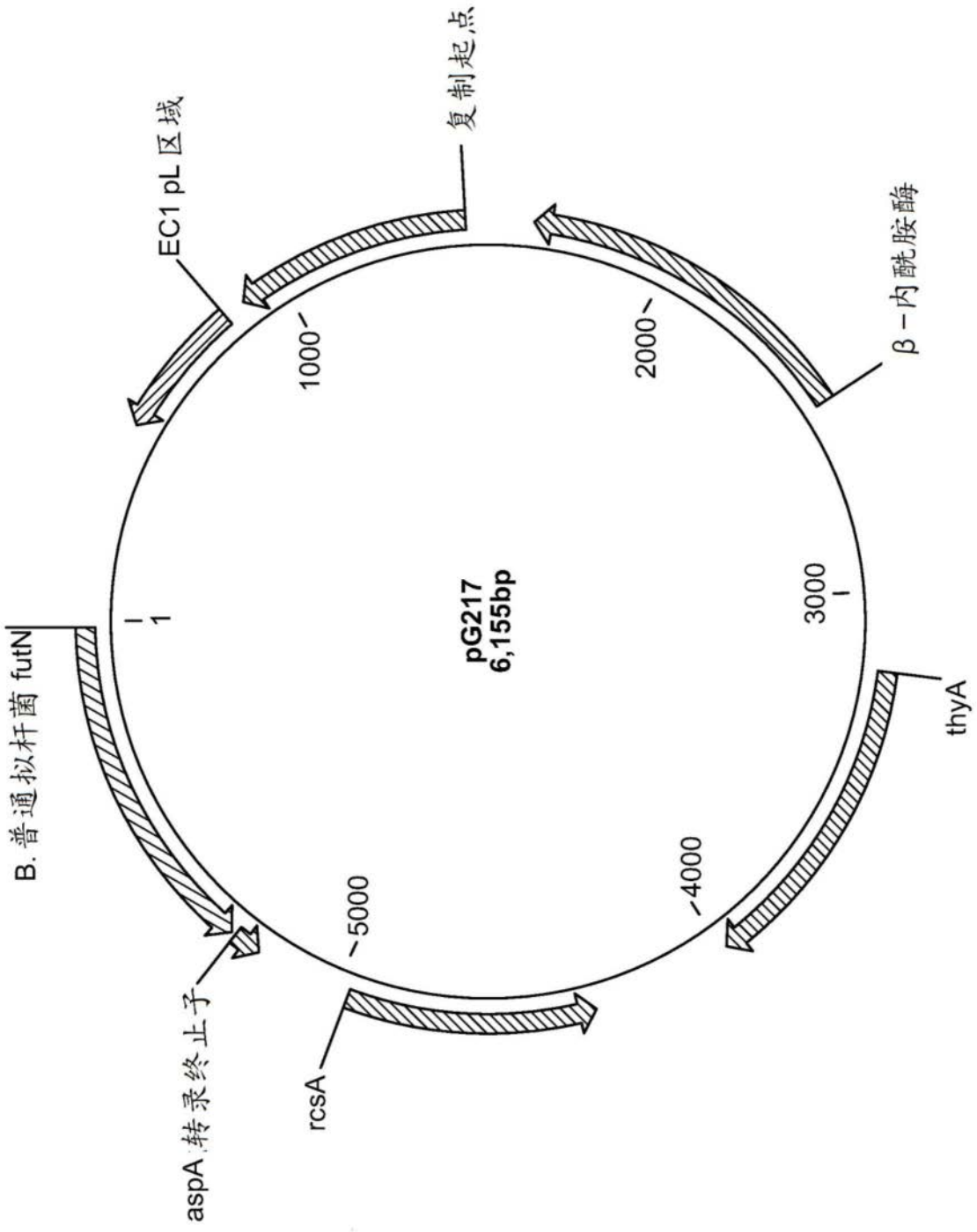

复制起点
EC1 pL 区域
β－内酰胺酶
B. 普通拟杆菌 futN
thyA
aspA 转录终止子
rcsA
pG217
6,155bp
1
1000
2000
3000
4000
5000

图11

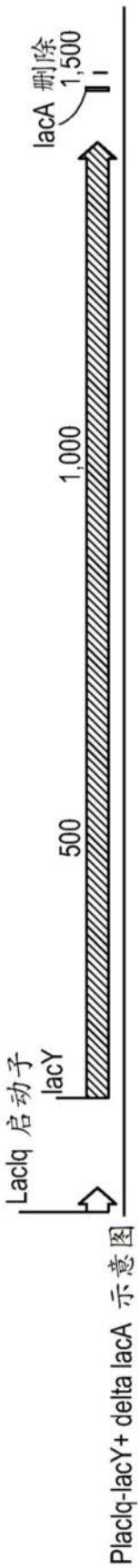

lacA 删除
1,500
1,000
500
lacY
Laclq 启动子
Placlq-lacY+ delta lacA 示意图

图12

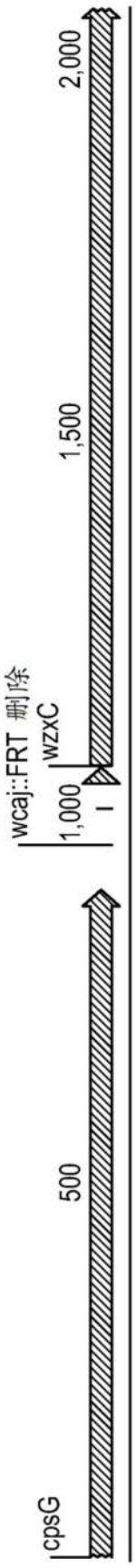


图13

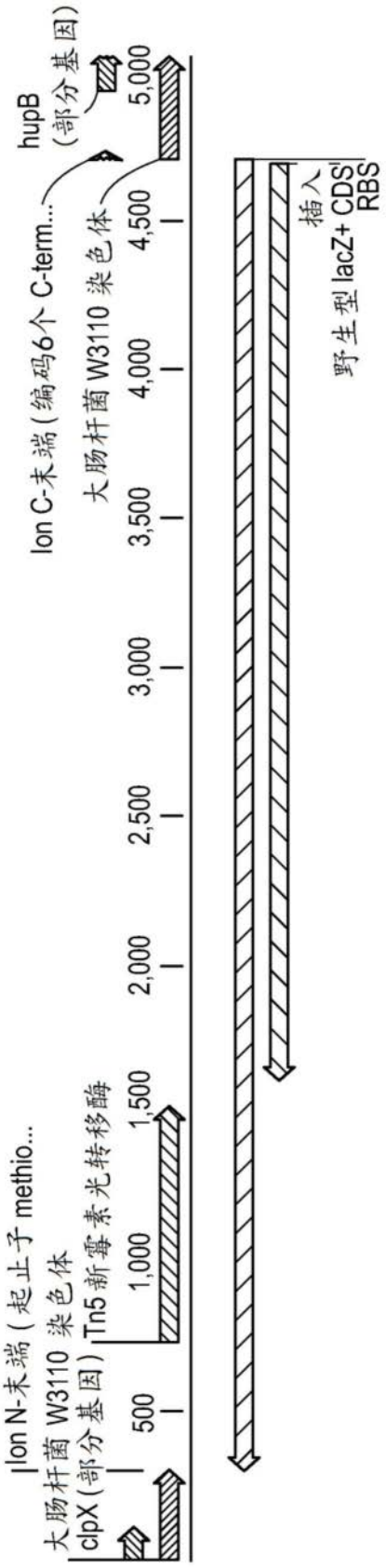

lon N-末端（起止于 methio...
大肠杆菌 W3110 染色体
clpX（部分基因）
Tn5 新霉素光转移酶
lon C-末端（编码6个 C-term...
大肠杆菌 W3110 染色体
hupB
（部分基因）
插入
野生型 lacZ+ CDS
RBS
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000

图14