

GLYCOBIOLOGY: GLOBAL MARKETS FOR DIAGNOSTICS AND THERAPEUTICS



BIO153A
September 2016

Marianna Tcherpakov
Project Analyst

ISBN: 1-62296-358-X



BCC Research
49 Walnut Park, Building 2
Wellesley, MA 02481 USA
866-285-7215 (toll-free within the USA),
or (+1) 781-489-7301
www.bccresearch.com
information@bccresearch.com

TABLE OF CONTENTS

TOPIC	PAGE NO.
CHAPTER 1 INTRODUCTION	2
STUDY GOALS AND OBJECTIVES	2
REASONS FOR DOING THIS STUDY	2
SCOPE AND FORMAT	2
METHODOLOGY AND INFORMATION SOURCES	3
INTENDED AUDIENCE	3
ANALYST'S CREDENTIALS	3
RELATED BCC RESEARCH REPORTS	3
BCC RESEARCH WEBSITE	4
DISCLAIMER	4
CHAPTER 2 SUMMARY	6
<i>SUMMARY TABLE GLOBAL MARKET FOR GLYCOBIOLOGY, BY SEGMENT, THROUGH 2021 (\$ MILLIONS)</i>	7
<i>SUMMARY FIGURE GLOBAL MARKET FOR GLYCOBIOLOGY, BY SEGMENT, 2014-2021 (\$ MILLIONS)</i>	7
CHAPTER 3 INTRODUCTION TO GLYCOBIOLOGY MARKET	9
OVERVIEW	9
GLYCOBIOLOGY DEFINITION	9
<i>TABLE 1 CLASSIFICATION OF CARBOHYDRATES</i>	9
SIGNIFICANCE OF GLYCAN	10
<i>FIGURE 1 SCHEMATIC PRESENTATION OF O- AND N-LINKED GLYCANS ON PROTEIN RECEPTOR</i>	11
N-Linked Glycans	11
O-Linked Glycans	12
Glycosaminoglycans	12
Glycolipids	12
Glycosylphosphatidylinositol Anchors	13
FUNCTION OF GLYCANS AND THEIR BIOLOGICAL SIGNIFICANCE	13
Structural Role of Glycans	14
Glycans as Specific Ligands for Cell-Cell Interactions	15
Glycans as Specific Ligands for Cell-Microbe Interactions	15
<i>TABLE 2 EXAMPLES OF GLYCOSYLATION DEFICIENCY AND THEIR PATHOLOGICAL EFFECT</i>	16
RESEARCH TOOLS FOR GLYCOBIOLOGY STUDIES	17
<i>TABLE 3 EXPERIMENTAL APPROACHES TO STUDYING GLYCANS</i>	18
Glycan-Binding Proteins or Antibodies	19
Metabolic Inhibition or Alteration of Glycosylation	19
<i>TABLE 4 EXAMPLES OF INHIBITORS/MODULATORS USED IN GLYCOBIOLOGY RESEARCH</i>	19
Finding Natural Glycan Ligands for Specific Receptors	20
Finding Receptors for Specific Glycans	20
Competition Studies Using Soluble Glycans or Structural Mimics	20
Eliminating Specific Glycan Structures by Glycosidases	21
Studying Natural or Genetically Engineered Glycan Mutants	21

TOPIC	PAGE NO.
Studying Natural or Genetically Engineered Glycan Receptor Mutants	21
STRUCTURAL ANALYSIS OF GLYCANS	21
<i>TABLE 5 SEPARATION AND IDENTIFICATION TECHNIQUES USED FOR GLYCAN ANALYSIS</i>	22
Detection of Glycans	23
Release, Profiling and Fractionation of Glycans	23
GLYCOMICS AS PART OF GLYCOBIOLOGY RESEARCH	25
Mass Spectrometry	25
Lectin and Antibody Arrays	25
Cell and Tissue Analysis Using Lectins and Antibodies	26
Imaging the Glycome by Metabolic and Covalent Labeling	26
CHEMICAL AND ENZYMATIC SYNTHESIS OF GLYCANS AND GLYCOCONJUGATES	26
BIOINFORMATICS AND DATABASE RESOURCES FOR GLYCOBIOLOGY RESEARCH	27
<i>TABLE 6 BIOINFORMATICS AND DATABASE RESOURCES FOR GLYCOBIOLOGY RESEARCH</i>	28
CHAPTER 4 GLYCOBIOLOGY THERAPEUTICS MARKET	31
OVERVIEW	31
SUBCATEGORIES OF GLYCOBIOLOGY THERAPEUTICS	31
GLYCANS AS COMPONENTS OF SMALL-MOLECULE DRUGS	31
<i>TABLE 7 GLOBAL MARKET FOR SYSTEMIC ANTIBIOTICS, THROUGH 2020 (\$ BILLIONS)</i>	31
SMALL-MOLECULE INHIBITORS OF INFLUENZA VIRUS NEURAMINIDASE	32
<i>TABLE 8 GLOBAL SALES OF RELENZA AND TAMIFLU, 2014 AND 2015 (\$ MILLIONS)</i>	33
THERAPEUTIC GLYCOPROTEINS	33
<i>TABLE 9 GLOBAL SALES OF ARANESP, 2014 AND 2015 (\$ MILLIONS)</i>	34
GLYCAN THERAPEUTIC APPROACHES TO METABOLIC DISEASES	34
Salvage versus De Novo Synthesis	34
Special Diets	35
Substrate Reduction Therapy	35
<i>TABLE 10 GLOBAL SALES OF ZAVESCA, 2014 AND 2015 (\$ MILLIONS)</i>	36
Lysosomal Enzyme Replacement Therapy	36
<i>TABLE 11 GLOBAL SALES OF CERAZYME, NAGLAZYME AND ALDURAZYME, 2014 THROUGH MARCH 2016 (\$ MILLIONS)</i>	37
Chaperone Therapy	37
THERAPEUTIC APPLICATIONS OF GLYCOSAMINOGLYCANS	38
<i>TABLE 12 GLOBAL SALES OF LOVENOX AND FRAGMIN, 2014 AND 2015 (\$ MILLIONS)</i>	39
CARBOHYDRATE-BASED VACCINES AND GLYCANS AS VACCINE COMPONENTS	40
<i>TABLE 13 GLOBAL SALES OF PREVNAR 13, 2014 AND 2015 (\$ MILLIONS)</i>	40
BLOCKING GLYCAN RECOGNITION IN DISEASES	42
TRANSFUSION AND TRANSPLANTATION REJECTION BY ANTIGLYCAN ANTIBODIES	42
<i>TABLE 14 EXAMPLES OF APPROVED GLYCOBIOLOGY-RELATED TREATMENTS AND CARBOHYDRATE-BASED DRUGS</i>	44
<i>TABLE 15 SALES OF GLUCOBAY, 2014 AND 2015 (\$ MILLIONS)</i>	45

TOPIC	PAGE NO.
GLYCOBIOLOGY THERAPEUTICS IN DEVELOPMENT	45
<i>TABLE 16 EXAMPLES OF GLYCOBIOLOGY-RELATED TREATMENTS AND CARBOHYDRATE-BASED DRUGS IN DEVELOPMENT</i>	45
Alectos Therapeutics	47
Amicus Therapeutics	47
Endotis Pharma	47
Galectin Therapeutics	48
Glixis Therapeutics	48
Glycan Biosciences	48
Glycan Therapeutics	49
GlycoGenesys	49
Glycomantra	50
Glycomar	50
GlycoMimetics	50
Glycomine	50
GlycoMira Therapeutics	51
Glycotope GmbH	51
Malcisbo AG	51
ProtAffin Biotechnologie AG	52
Siamab Therapeutics	52
VaxAlta	53
Vaxil Bio Therapeutics	53
EVALUATION OF GLYCOBIOLOGY THERAPEUTICS MARKET	53
OVERVIEW	53
Carbohydrate-Based Drugs	54
<i>TABLE 17 EXAMPLES OF APPROVED CARBOHYDRATE-BASED DRUGS</i>	54
Glycosylated Small Molecules	54
Glycoproteins as Therapeutics	55
Glycan Therapeutic Approaches to Metabolic Diseases	55
Blocking Glycan Recognition in Diseases	55
Carbohydrate-based Vaccines and Glycans as Vaccine	55
<i>TABLE 18 GLOBAL MARKET FOR GLYCOBIOLOGY THERAPEUTICS, THROUGH 2021 (\$ BILLIONS)</i>	56
<i>FIGURE 2 GLOBAL MARKET FOR GLYCOBIOLOGY THERAPEUTICS, 2014-2021 (\$ BILLIONS)</i>	56
MARKET LANDSCAPE	56
<i>TABLE 19 EXAMPLES OF CARBOHYDRATE-BASED DRUGS APPROVED AS CANCER ADJUVANTS IN COUNTRIES OUTSIDE THE U.S.</i>	57
<i>TABLE 20 GEOGRAPHICAL DISTRIBUTION OF GLYCOBIOLOGY THERAPEUTIC MARKET, 2016 (%)</i>	57
MARKET TRENDS IN GLYCOBIOLOGY THERAPEUTICS	60
PROTEIN AND GLYCAN GLYCOENGINEERING TO ENHANCE EFFICACY AND THERAPEUTIC VALUE	60
ENGINEERING GLYCANS AND GLYCAN MIMICS AS THERAPEUTIC AGENTS	62
Glycan Small Molecule Drugs	62
Polyvalent Glycan Structures and Inhibitors	62
GLYCOBIOLOGY AND DRUG DELIVERY	63
<i>TABLE 21 GLOBAL MARKET FOR DRUG DELIVERY, THROUGH 2020 (\$ BILLIONS)</i>	64
OLIGOSACCHARIDE LIBRARIES FOR DRUG DISCOVERY RESEARCH	64

TOPIC	PAGE NO.
GLYCONUTRIENTS AS THERAPEUTICS	65
Glucosamine and Chondroitin Sulfate	65
Xylitol and Sorbitol in Chewing Gum	65
Milk Oligosaccharides	66
Chitosan	66
<i>TABLE 22 GLOBAL MARKET FOR NUTRACEUTICALS, THROUGH 2019 (\$ BILLIONS)</i>	67
CHAPTER 5 GLYCOBIOLOGY DIAGNOSTICS MARKET	69
OVERVIEW	69
GLYCOBIOMARKERS AND AUTOIMMUNITY	70
GLYCOBIOMARKERS IN INFLAMMATORY BOWEL DISEASE	70
AUTOANTIBODIES AGAINST NEURONAL GLYCANS IN CERTAIN NEUROPATHIES	70
AUTOANTIBODIES AGAINST TN ANTIGEN IN TN-POLYAGGLUTININ SYNDROME	71
GLYCOBIOLOGY MARKERS IN CARDIOVASCULAR DISEASES	71
ROLE OF GLYCANS IN THE HISTOPATHOLOGY OF ALZHEIMER'S DISEASE	71
GLYCOBIOMARKERS AND ASTHMA	72
GLYCOBIOMARKERS IN INFECTIOUS DISEASE TESTING	72
<i>TABLE 23 EXAMPLES OF GLYCOBIOLOGY-BASED BIOMARKERS</i>	73
MARKET POTENTIAL FOR GLYCOBIOLOGY-BASED BIOMARKERS AND DIAGNOSTIC TESTS	73
<i>TABLE 24 CURRENT U.S. MARKET POTENTIAL FOR DIAGNOSTIC TESTS BASED ON GLYCOBIOLOGY BIOMARKERS (MILLIONS/\$ MILLIONS)</i>	74
GLYCOBIOLOGY-BASED CANCER BIOMARKERS AND DIAGNOSTIC DEVELOPMENT	75
<i>TABLE 25 EXAMPLE OF GLOBAL CANCER STATISTICS, 2012</i>	75
<i>TABLE 26 FDA-APPROVED CANCER BIOMARKERS CURRENTLY USED IN CLINICAL PRACTICE</i>	76
a-Fetoprotein (AFP)	77
Prostate-Specific Antigen (PSA)	78
MUC16 (CA125)	78
Human Epididymis Protein 4 (HE4)	78
MUC1 (CA15-3/CA27.29)	79
Human Epidermal Growth Factor Receptor 2 (HER2)	79
Carcinoembryonic Antigen (CEA)	80
Carbohydrate Antigen (CA19-9)	80
Thyroglobulin (Tg)	80
Potential Novel Biomarkers in Cancer Diagnostics	80
<i>TABLE 27 EXAMPLES OF POTENTIAL GLYCOPROTEIN CANCER BIOMARKERS</i>	81
Human Chorionic Gonadotropin (hCG)	81
Alpha-1-Antitrypsin (A1AT)	81
Fucosylated Haptoglobin (Fuc-Hpt)	81
YKL-40	82
Carbohydrates as Potential Serum Biomarkers	82
<i>TABLE 28 EXAMPLES OF CLINICAL TRIALS USING BLOOD/PLASMA OR SERUM CARBOHYDRATE ANALYSIS TO DIAGNOSE AND MONITOR CANCER</i>	83
<i>TABLE 29 GLOBAL MARKET FOR TECHNOLOGIES FOR CANCER PROFILING AND PATHWAYS, THROUGH 2018 (\$ BILLIONS)</i>	84

TOPIC	PAGE NO.
CURRENT GLYCOBIOLOGY-BASED DIAGNOSTICS ON THE MARKET	84
GLUCOSE MONITORING FOR DIABETES	84
<i>TABLE 30 GLOBAL MARKET FOR CONTINUOUS GLUCOSE MONITORING, THROUGH 2019 (\$ MILLIONS)</i>	85
GLYCOHEMOGLOBIN (HBA1C, A1C)	85
CARBOHYDRATE INTOLERANCE TEST	85
CARBOHYDRATE-DEFICIENT TRANSFERRIN (CDT)	86
<i>TABLE 31 GLOBAL MARKET FOR DRUG TESTING, THROUGH 2019 (\$ BILLIONS)</i>	86
COMPANIES WITH GLYCOBIOLOGY DIAGNOSTIC PLATFORMS AND PRODUCTS IN DEVELOPMENT	87
<i>TABLE 32 EXAMPLES OF COMPANIES WITH DIAGNOSTIC PRODUCTS IN DEVELOPMENT BASED ON GLYCOBIOLOGY RESEARCH</i>	87
GENOS GLYKO	88
GLYCODIAG	88
GLYCOMARK	88
GLUCOSENSE DIAGNOSTICS	89
GLYCOSENSORS AND DIAGNOSTICS LLC	89
GLYCOTECHNICA LTD.	89
GLYCOTEST DIAGNOSTICS	90
SIGMA DIAGNOSTICS	90
MARKET FOR GLYCOBIOLOGY-BASED DIAGNOSTICS	90
<i>TABLE 33 GLOBAL MARKET FOR CLINICAL BIOMARKERS USED IN METABOLOMICS, THROUGH 2020 (\$ MILLIONS)</i>	90
<i>TABLE 34 GLOBAL MARKET FOR GLYCOBIOLOGY-BASED DIAGNOSTICS, THROUGH 2021 (\$ BILLIONS)</i>	91
<i>FIGURE 3 GLOBAL MARKET FOR GLYCOBIOLOGY-BASED DIAGNOSTICS, 2014-2021 (\$ BILLIONS)</i>	92
CHAPTER 6 MARKET FOR TOOLS AND REAGENTS USED IN GLYCOBIOLOGY RESEARCH AND DEVELOPMENT	94
OVERVIEW	94
ANALYTICAL AND CHROMATOGRAPHY TECHNIQUES	94
GLYCAN ARRAYS	95
LECTIN ARRAYS	98
GLYCOBIOLOGY KITS	99
REAGENTS FOR GLYCOBIOLOGY RESEARCH	101
CARBOHYDRATES: MONOSACCHARIDES, OLIGOSACCHARIDES AND OTHER REAGENTS	102
<i>TABLE 35 EXAMPLES OF SUPPLIERS OF GLYCOBIOLOGY REAGENTS</i>	103
Agilent Technologies	104
AMSBIO	104
Biognosys	105
CEVEC Pharmaceuticals GmbH	105
GALAB Technologies	105
Genos Glyco	105
GlycoBac LLC	106
Glycobiotech GmbH	106
Glykos Analytics	107
GlycoScientific LLC	107

TOPIC	PAGE NO.
GlycoSelect Ltd.	108
Glycoseparations	108
GlycoTech	108
GlycoThera	109
IsoSep	109
LC Scientific Inc.	109
Ludger	110
New England Biolabs (NEB)	110
Omicron Biochemicals Inc.	110
Plexera	110
Prozyme	111
RayBiotech	111
R&D Systems	111
Robotic Labware Designs	112
Savyon Diagnostics	112
S-BIO	112
Sciex	113
Sigma-Aldrich	113
Sussex Research	113
Thermo Fisher Scientific	114
Vector Laboratories	114
Waters Corp.	114
<i>TABLE 36 PRICES FOR GLYCOBIOLOGY REAGENTS AND SERVICES (\$)</i>	115
<i>TABLE 37 GLOBAL MARKET FOR RESEARCH ASSAYS USED IN METABOLOMICS, THROUGH 2020 (\$ MILLIONS)</i>	115
MARKET FOR TOOLS AND REAGENTS FOR GLYCOBIOLOGY R&D	116
<i>TABLE 38 EXAMPLES OF ANNUAL REVENUES OF COMPANIES THAT OFFER GLYCOBIOLOGY RESEARCH TOOLS (\$ MILLIONS)</i>	116
<i>TABLE 39 GLOBAL MARKET FOR REAGENTS AND TOOLS FOR GLYCOBIOLOGY RESEARCH AND DEVELOPMENT, THROUGH 2021 (\$ MILLIONS)</i>	117
<i>FIGURE 4 GLOBAL MARKET FOR REAGENTS AND TOOLS FOR GLYCOBIOLOGY RESEARCH AND DEVELOPMENT, 2014-2021 (\$ MILLIONS)</i>	117
CHAPTER 7 PATENT ANALYSIS OF GLYCOBIOLOGY MARKET	119
OVERVIEW	119
<i>TABLE 40 NUMBER OF U.S. PATENTS AND APPLICATIONS ON GLYCOBIOLOGY RESEARCH</i>	119
<i>TABLE 41 NUMBER OF U.S. PATENTS ON GLYCOBIOLOGY RESEARCH, 2012-2015</i>	119
<i>TABLE 42 EXAMPLES OF PATENTS FILED ON GLYCOBIOLOGY RESEARCH</i>	120
<i>TABLE 43 NUMBER OF PATENTS IN GLYCOBIOLOGY RESEARCH BY PATENT HOLDER, 2012-2015</i>	124
CHAPTER 8 MARKET SUMMARY	126
<i>TABLE 44 GLOBAL MARKET FOR GLYCOBIOLOGY BY SEGMENT, THROUGH 2021 (\$ MILLIONS)</i>	128
<i>FIGURE 5 GLOBAL MARKET FOR GLYCOBIOLOGY BY SEGMENT, 2014-2021 (\$ MILLIONS)</i>	129
<i>TABLE 45 EXAMPLES OF MAIN MARKET PARTICIPANTS IN GLYCOBIOLOGY MARKET BY SEGMENT</i>	129

TOPIC	PAGE NO.
CHAPTER 9 OVERVIEW OF SELECT COMPANIES IN THE GLYCOBIOLOGY MARKET	133
BIOMARIN PHARMACEUTICAL INC.	133
GLYCOMIMETICS	134
GLYCAN BIOSCIENCES LLC	135
GLYCOSENSORS AND DIAGNOSTICS LLC	136
GLYCOTEST INC.	137
CHAPTER 10 DIRECTORY OF COMPANIES REFERRED TO IN THE REPORT	140
DIRECTORY OF COMPANIES	140

LIST OF TABLES

TABLE HEADING	PAGE NO.
SUMMARY TABLE GLOBAL MARKET FOR GLYCOBIOLOGY, BY SEGMENT, THROUGH 2021 (\$ MILLIONS)	7
TABLE 1 CLASSIFICATION OF CARBOHYDRATES	9
TABLE 2 EXAMPLES OF GLYCOSYLATION DEFICIENCY AND THEIR PATHOLOGICAL EFFECT	16
TABLE 3 EXPERIMENTAL APPROACHES TO STUDYING GLYCANS	18
TABLE 4 EXAMPLES OF INHIBITORS/MODULATORS USED IN GLYCOBIOLOGY RESEARCH	19
TABLE 5 SEPARATION AND IDENTIFICATION TECHNIQUES USED FOR GLYCAN ANALYSIS	22
TABLE 6 BIOINFORMATICS AND DATABASE RESOURCES FOR GLYCOBIOLOGY RESEARCH	28
TABLE 7 GLOBAL MARKET FOR SYSTEMIC ANTIBIOTICS, THROUGH 2020 (\$ BILLIONS)	31
TABLE 8 GLOBAL SALES OF RELENZA AND TAMIFLU, 2014 AND 2015 (\$ MILLIONS)	33
TABLE 9 GLOBAL SALES OF ARANESP, 2014 AND 2015 (\$ MILLIONS)	34
TABLE 10 GLOBAL SALES OF ZAVESCA, 2014 AND 2015 (\$ MILLIONS)	36
TABLE 11 GLOBAL SALES OF CEREZYME, NAGLAZYME AND ALDURAZYME, 2014 THROUGH MARCH 2016 (\$ MILLIONS)	37
TABLE 12 GLOBAL SALES OF LOVENOX AND FRAGMIN, 2014 AND 2015 (\$ MILLIONS)	39
TABLE 13 GLOBAL SALES OF PREVNAR 13, 2014 AND 2015 (\$ MILLIONS)	40
TABLE 14 EXAMPLES OF APPROVED GLYCOBIOLOGY-RELATED TREATMENTS AND CARBOHYDRATE-BASED DRUGS	44
TABLE 15 SALES OF GLUCOBAY, 2014 AND 2015 (\$ MILLIONS)	45
TABLE 16 EXAMPLES OF GLYCOBIOLOGY-RELATED TREATMENTS AND CARBOHYDRATE-BASED DRUGS IN DEVELOPMENT	45
TABLE 17 EXAMPLES OF APPROVED CARBOHYDRATE-BASED DRUGS	54
TABLE 18 GLOBAL MARKET FOR GLYCOBIOLOGY THERAPEUTICS, THROUGH 2021 (\$ BILLIONS)	56
TABLE 19 EXAMPLES OF CARBOHYDRATE-BASED DRUGS APPROVED AS CANCER ADJUVANTS IN COUNTRIES OUTSIDE THE U.S.	57
TABLE 20 GEOGRAPHICAL DISTRIBUTION OF GLYCOBIOLOGY THERAPEUTIC MARKET, 2016 (%)	57
TABLE 21 GLOBAL MARKET FOR DRUG DELIVERY, THROUGH 2020 (\$ BILLIONS)	64
TABLE 22 GLOBAL MARKET FOR NUTRACEUTICALS, THROUGH 2019 (\$ BILLIONS)	67
TABLE 23 EXAMPLES OF GLYCOBIOLOGY-BASED BIOMARKERS	73
TABLE 24 CURRENT U.S. MARKET POTENTIAL FOR DIAGNOSTIC TESTS BASED ON GLYCOBIOLOGY BIOMARKERS (MILLIONS/\$ MILLIONS)	74
TABLE 25 EXAMPLE OF GLOBAL CANCER STATISTICS, 2012	75
TABLE 26 FDA-APPROVED CANCER BIOMARKERS CURRENTLY USED IN CLINICAL PRACTICE	76
TABLE 27 EXAMPLES OF POTENTIAL GLYCOPROTEIN CANCER BIOMARKERS	81
TABLE 28 EXAMPLES OF CLINICAL TRIALS USING BLOOD/PLASMA OR SERUM CARBOHYDRATE ANALYSIS TO DIAGNOSE AND MONITOR CANCER	83
TABLE 29 GLOBAL MARKET FOR TECHNOLOGIES FOR CANCER PROFILING AND PATHWAYS, THROUGH 2018 (\$ BILLIONS)	84
TABLE 30 GLOBAL MARKET FOR CONTINUOUS GLUCOSE MONITORING, THROUGH 2019 (\$ MILLIONS)	85
TABLE 31 GLOBAL MARKET FOR DRUG TESTING, THROUGH 2019 (\$ BILLIONS)	86
TABLE 32 EXAMPLES OF COMPANIES WITH DIAGNOSTIC PRODUCTS IN DEVELOPMENT BASED ON GLYCOBIOLOGY RESEARCH	87

TABLE HEADING	PAGE NO.
TABLE 33 GLOBAL MARKET FOR CLINICAL BIOMARKERS USED IN METABOLOMICS, THROUGH 2020 (\$ MILLIONS)	90
TABLE 34 GLOBAL MARKET FOR GLYCOBIOLOGY-BASED DIAGNOSTICS, THROUGH 2021 (\$ BILLIONS)	91
TABLE 35 EXAMPLES OF SUPPLIERS OF GLYCOBIOLOGY REAGENTS	103
TABLE 36 PRICES FOR GLYCOBIOLOGY REAGENTS AND SERVICES (\$)	115
TABLE 37 GLOBAL MARKET FOR RESEARCH ASSAYS USED IN METABOLOMICS, THROUGH 2020 (\$ MILLIONS)	115
TABLE 38 EXAMPLES OF ANNUAL REVENUES OF COMPANIES THAT OFFER GLYCOBIOLOGY RESEARCH TOOLS (\$ MILLIONS)	116
TABLE 39 GLOBAL MARKET FOR REAGENTS AND TOOLS FOR GLYCOBIOLOGY RESEARCH AND DEVELOPMENT, THROUGH 2021 (\$ MILLIONS)	117
TABLE 40 NUMBER OF U.S. PATENTS AND APPLICATIONS ON GLYCOBIOLOGY RESEARCH	119
TABLE 41 NUMBER OF U.S. PATENTS ON GLYCOBIOLOGY RESEARCH, 2012-2015	119
TABLE 42 EXAMPLES OF PATENTS FILED ON GLYCOBIOLOGY RESEARCH	120
TABLE 43 NUMBER OF PATENTS IN GLYCOBIOLOGY RESEARCH BY PATENT HOLDER, 2012-2015	124
TABLE 44 GLOBAL MARKET FOR GLYCOBIOLOGY BY SEGMENT, THROUGH 2021 (\$ MILLIONS)	128
TABLE 45 EXAMPLES OF MAIN MARKET PARTICIPANTS IN GLYCOBIOLOGY MARKET BY SEGMENT	129

LIST OF FIGURES

FIGURE TITLE	PAGE NO.
SUMMARY FIGURE GLOBAL MARKET FOR GLYCOBIOLOGY, BY SEGMENT, 2014-2021 (\$ MILLIONS)	7
FIGURE 1 SCHEMATIC PRESENTATION OF O- AND N-LINKED GLYCANS ON PROTEIN RECEPTOR	11
FIGURE 2 GLOBAL MARKET FOR GLYCOBIOLOGY THERAPEUTICS, 2014-2021 (\$ BILLIONS)	56
FIGURE 3 GLOBAL MARKET FOR GLYCOBIOLOGY-BASED DIAGNOSTICS, 2014-2021 (\$ BILLIONS)	92
FIGURE 4 GLOBAL MARKET FOR REAGENTS AND TOOLS FOR GLYCOBIOLOGY RESEARCH AND DEVELOPMENT, 2014-2021 (\$ MILLIONS)	117
FIGURE 5 GLOBAL MARKET FOR GLYCOBIOLOGY BY SEGMENT, 2014-2021 (\$ MILLIONS)	129