Symbol Nomenclature for Glycans (SNFG)

Created: October 15, 2015; **Last Updated**: February 4, 2020

History and Citation

Symbol Nomenclature for Graphical Representation of Glycans, Glycobiology 25: 1323-1324, 2015. Citation link (PMID 26543186).

Updates to the Symbol Nomenclature for Glycans guidelines, *Glycobiology* 29:620-624, 2019. Citation link (PMID 31184695).

History of the SNFG

SNFG Support

Downloadable files available from online SNFG page (Appendix 1B):

- Drawing format file
- Presentation/Slide format file
- Notes (this document)
- **Examples**

Members of the SNFG Discussion Group

Organizations and Publications Adopting the SNFG

Software tools supporting SNFG (Link)

- **3D-Symbol Nomenclature for Glycans (3D-SNFG)**: Create 3D atomic models of glycans (preview)
  Direct weblink Citation link

- **DrawGlycan-SNFG**: Convert IUPAC input strings to sketches of glycans and glycopeptides (preview)
  Direct weblink App download Citation link

- **GlycanBuilder2-SNFG**: GlycanBuilder updated to handle SNFG (preview)
  App download Citation Link

SNFG update history

Click on a symbol to link to the corresponding PubChem entry. Symbols with PubChem links can be downloaded using either the online Table or Slide/Presentation file available at the SNFG main page.

Table 1. Monosaccharide symbol nomenclature

SHAPE	White (Generic)	Blue	Green	Yellow	Orange	Pink	Purple	Light Blue	Brown	Red
Filled Circle	Hexose 	Glc 	Man	Gal 	Gul 	Alt 	All 	Tal 	Ido 	
Filled Square	HexNAc 	GlcNAc 	ManNAc	GalNAc 	GulNAc 	AltNAc 	AllNAc 	TalNAc 	IdoNAc 	
Crossed Square	Hexosamine 	GlcN 	ManN	GalN 	GulN 	AltN 	AllN 	TalN 	IdoN 	
Divided Diamond	Hexuronate 	GlcA 	ManA	GalA 	GulA 	AltA 	AllA 	TalA 	IdoA 	
Filled Triangle	Deoxyhexose 	Qui 	Rha		6dGul 	6dAlt		6dTal		Fuc
Divided Triangle	DeoxyhexNAc	QuiNAc	RhaNAc			6dAltNAc		6dTalNAc		FucNAc
Flat Rectangle	Di-deoxyhexose	Oli	Tyv		Abe	Par	Dig	Col		
Filled Star	Pentose		Ara	Lyx	Xyl	Rib				
Filled Diamond	Deoxynonulosonate		Kdn				Neu5Ac	Neu5Gc	Neu	Sia
Flat Diamond	Di-deoxynonulosonate		Pse	Leg		Aci		4eLeg		
Flat Hexagon	Unknown	Bac	LDmanHep	Kdo	Dha	DDmanHep	MurNAc	MurNGc	Mur	
Pentagon	Assigned	Api	Fru	Tag	Sor	Psi				

Notes:

1. ***General***: The monosaccharide symbols presented here are from the Third Edition of the *Essentials of Glycobiology*. They are extended from the symbols in the Second Edition (Figure 1.5, Second Edition) to cover a wider range of monosaccharides found in nature. While previous versions allowed conversion of monosaccharide symbols to black and white representation, this is no longer possible. A listing of abbreviated, full, and complete names of all assigned monosaccharides is shown in Table 3. Selected examples depicting SNFG usage are presented below the footnotes, for various living organisms.

2. ***Drawing recommendations***: All downloadable symbols follow CMYK colors as shown in Table 2, which were generated in Adobe Illustrator. Recommended CMYK to RGB conversion is also provided. While there is no hard rule, glycans are typically sketched to orient their non-reducing end in either the left or upward direction.

3. ***Shape, color and orientation***: Shapes and colors are completely consistent with stereochemistry only for hexoses, hexosamines, N-acetylhexosamines, hexuronates, and pentoses. Shapes only are consistent for deoxyhexoses, deoxy-N-acetylhexosamines, dideoxyhexoses, and nonulosonates. Avoid rotating the symbols if possible.

4. ***Ring configuration***: A colored symbol encodes a defined monosaccharide (including D or L) independent of rotation or mirroring. Pyranose form is assumed by default for all monosaccharides except Api. A few monosaccharides have absolute configurations implicitly specified in their name (D for Abe, Bac, Dha, Kdo, Mur, Par, Tyv; L for Col; DD for Kdn, Neu, Leg, 4eLeg; LL for Pse, Aci). For all other residues, absolute configuration is assumed by default: L for Ara, Fuc, Ido, IdoA, Rha, Alt, AltA, Sor, Api; and D for other monosaccharides.

   Less common configurations need to be stated in a figure legend or by adding the letters inside the symbol (e.g., adding D or L to the symbol). Epimers at C8 of nonulosonates can be indicated by adding "8D" or "8L" inside the symbol. Furanose rings can be indicated by adding an italicized "f" inside the symbol, and alditols can be indicated with an italicized "o" inside the symbol.

5. ***Linkage presentation***: Anomeric notation and destination linkage can be indicated in IUPAC style in figures, with or without a dash and with or without the originating carbon number (but with no commas or spacing) (e.g., Neu5Acα2-3Galβ1-4GlcNAc, Neu5Acα3Galβ4GlcNAc, or equivalents in symbol drawings).

   All monosaccharide glycosidic linkages are assumed to originate from C-1—except for 2-ketoses, which are assumed to be linked from C-2. Linkages in the schematics should be sorted to appear in the clockwise order. Optionally, these may also follow the Oxford System that embeds both the specificity and anomericity of the monosaccharide linkages. Dual linkages (e.g., an outgoing linkage from an aldose in open form) can be shown by double lines. Linkages involving carbon-carbon bond (e.g., in C-glycosides) can be shown in different color. An internal phosphodiester can be shown with -P- between the symbols for the linked monosaccharides, with linkage positions if preferred.

6. ***Sialic acid***: Specific symbols are provided for the core sialic acids Neu5Ac, Neu5Gc, and Kdn, with modifications to be indicated in diagrams (e.g., 9Ac for 9-O-acetylation). A red diamond can be used for any Sia (sialic acid, type unknown, whether Neu5Gc or Neu5Ac, or any of the other >50 forms known to date).

7. ***Carbohydrate modifications***: Abbreviations for modifications (e.g., sulfate or O-acetyl esters) follow the style of the Figure 1.5 of the Third Edition of *Essentials*, using attached letters, with numbers indicating linkage positions, if known (e.g., 9Ac for 9-O-acetyl group; 3S for 3-O-sulfate group; 6P for a 6-O-phosphate group; 8Me for 8-O-methyl group; 9Lt for 9-O-lactyl group; or 4,6Py for 4,6-pyruvyl group, etc.; abbreviations for multiple modifications can be concatenated). The presence of variable amounts of substituents can be indicated using +/- symbol or by indicating % presence if known, e.g. "60% 3Ac" to indicate presence of 3Ac on 60% of a residue or repeating unit.

8. ***Amino substitution***: For N-substituted groups it is assumed that there is only one amino group on the monosaccharide, with an already known common position (e.g., NS for N-sulfate group on glucosamine is assumed to be at the 2-position). For amino sugars in which the nitrogen is not at the most common carbon, add a number to the N (e.g., Rha4N is shown as a green triangle with 4N attached). Additionally, atypical acetamido groups may be represented using NAc (e.g. Fuc4NAc is shown using red triangle with 4NAc attached).
9. ***Ambiguous linkage position and glycan mixtures***: Brackets (either straight or curly) indicate attachment of specific monosaccharides or structures to any residue within the glycan. Restrictions on the nature of attachment are specified by including linkage data on the bond outside the brackets. Constraints on attachment site are shown using asterisk followed by a number (*#), specified both on the bond and its attachment site(s). Such renderings are used to indicate ambiguity in the structure of a specific glycan. By extension, glycan mixtures may be depicted by including [number range] along the bond as shown in the examples.
10. ***Ambiguous monosaccharides***: White symbols based on the standard shapes designate monosaccharides with unknown/undefined stereochemistry (e.g., a white circle designates a hexose, type not defined, or a white diamond, any deoxynonulosonic acid). Other unknown or partially defined monosaccharides may be represented using a white flat hexagon.
11. ***Structures not present in table and non-glycan assignments***: Monosaccharides absent in Table 1 or modifications that cannot be represented using the above rules, may be indicated using a single non-italicized letter (A..Z) within an SNFG white symbol, with additional details provided in figure footnote or legends. The choice of white symbol to use should fit the generic type if possible: circle for hexose, triangle for deoxy hexose etc.; otherwise the white pentagon should be used. Any black shape can be used to depict non-monosaccharide structures and detailed definitions should be provided in figure legends. More complicated modifications of the SNFG are discouraged, and if these modifications are made should not be referred to as following the SNFG nomenclature.

Examples of Glycan Symbol Nomenclature (go back to the start)

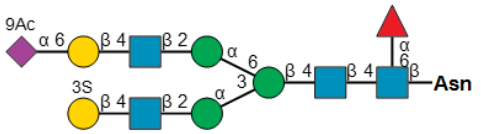
FULL REPRESENTATION

9-O-Ac-Neu5Ac*pα*2-6Gal*pβ*1-4GlcNAc*pα*1-2Man*pα1*
6
Fuc*pα*1
6
Man*pβ1-4*GlcNAc*pβ*1-4GlcNAc*pβ*1-Asn
3
3-O-SO_3Gal*pβ*1-4GlcNAc*pβ*1-2Man*pα1*

SIMPLIFIED REPRESENTATION

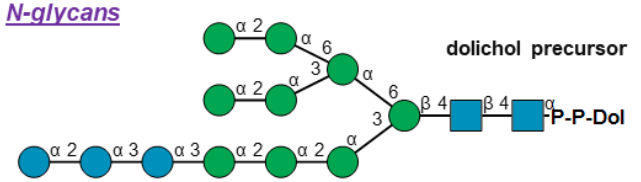
9-O-Ac-Neu5Ac*α*6Gal*β*4GlcNAc*α*2Man*α*
6
Fuc*α*
6
Man*β4*GlcNAc*β*4GlcNAc*β*-Asn
3
3-O-SO_3Gal*β*4GlcNAc*β*2Man*α*

SNFG REPRESENTATION



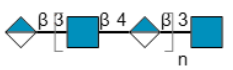
EXAMPLES FROM MAMMALS

N-glycans

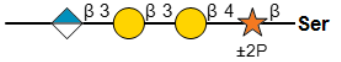


Glycosaminoglycans

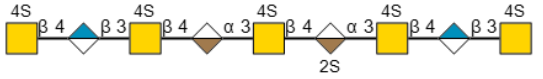
Hyaluronan



Chondroitin/heparin sulfate linkage to Ser

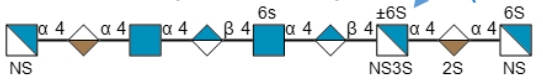


Chondroitin/Dermatan sulfate

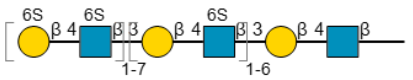


Heparan sulfate/Heparin

variable modification (see footnote 7)

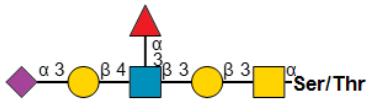


Keratin sulfate repeat structure

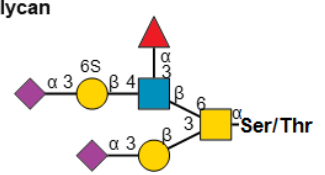


O-linked glycans (GalNAc type)

Extended core-1 glycan

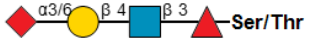


6'sulfo-sialyl Lewis-X on core-2 glycan

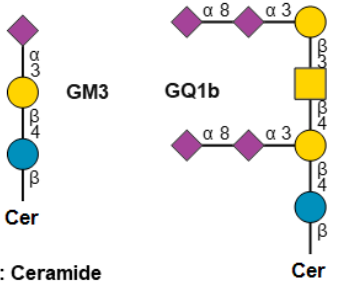


Sialyl Tn antigen

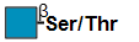
O-Fucose



Glycospingolipids



O-GlcNAc



O-Glucose

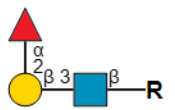
O-Mannose

alditol defined in footnote 4

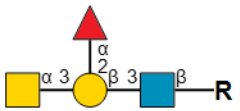
Selected terminal modifications

Blood group antigens:
H antigen on Type-1 lactosamine chain

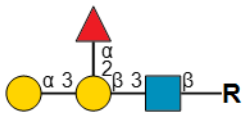
R=glycan backbone



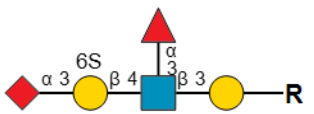
A antigen



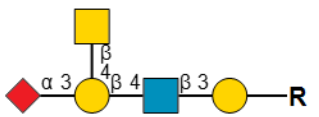
B antigen



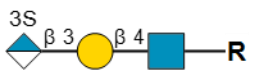
6'-sulfo sialyl Lewis-X



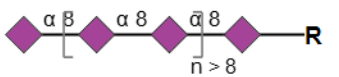
Sd[a] antigen



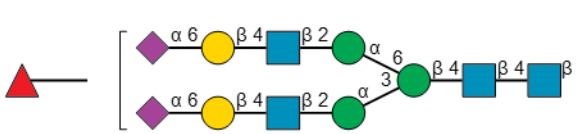
HNK-1 epitope



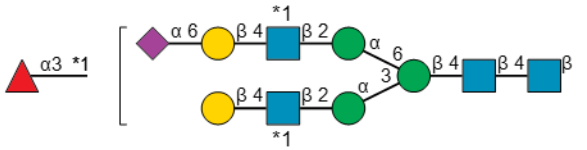
Polysialic acid



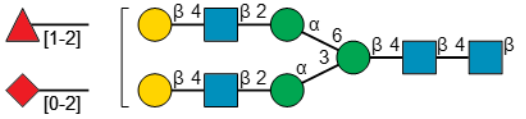
Ambiguous linkage position and glycan mixtures (footnote 9)



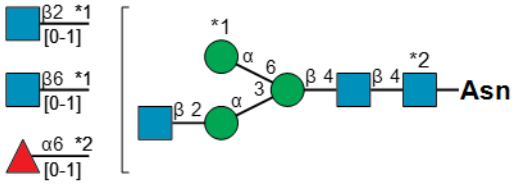
Single glycan with 1 Fuc at any location



Glycan with α1-3Fuc at one of two positions



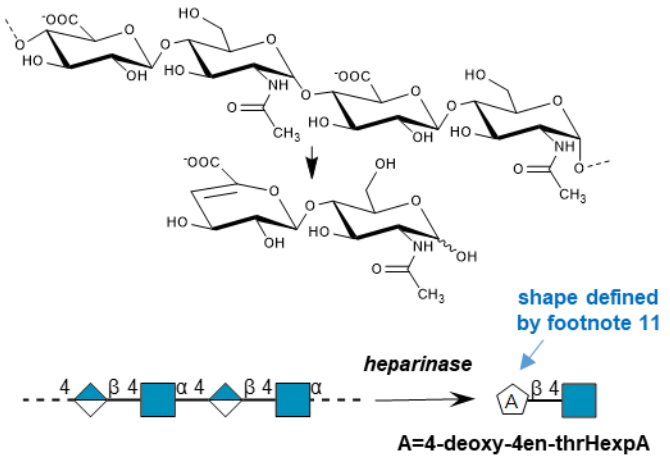
Mixture with 1 or 2 Fuc and/or 0 to 2 Sia, at any position



N-linked glycan mixture

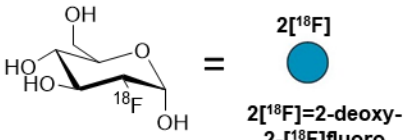
MISCELLANEOUS EXAMPLES

SNFG rendering of lyase reaction on part of heparin sulfate



A=4-deoxy-4en-thrHexpA

PET (Positron-emission tomography) tracer FDG

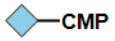


2[^{18}F]=2-deoxy-2-[^{18}F]fluoro

multiply (9-O-acetyl-8-O-methyl modified sialic acid

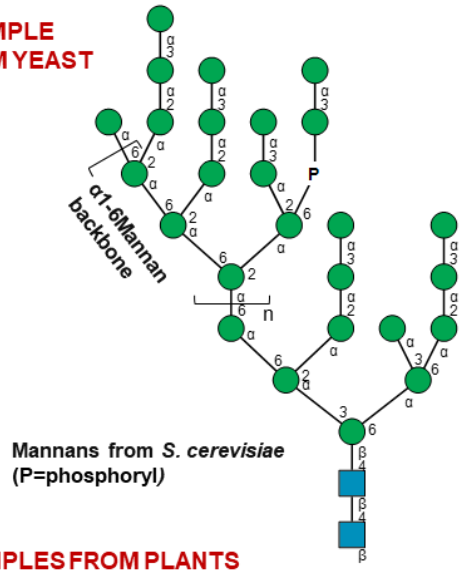
9Ac, 8Me

Nucleotide-sugars



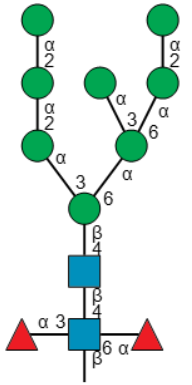
CMP-Neu5Gc

EXAMPLE FROM YEAST



Mannans from *S. cerevisiae*
(P=phosphoryl*)*

EXAMPLES FROM SLIME MOLD

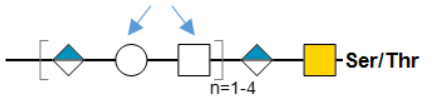


Asn

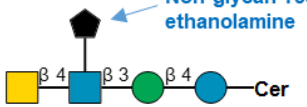
EXAMPLES FROM INSECTS

O-glycans and glycolipids from Drosophila & other insects

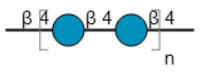
Hexose and HexNAc not specified



Non-glycan residue: ethanolamine



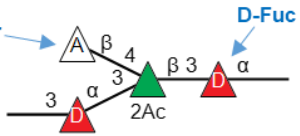
EXAMPLES FROM PLANTS



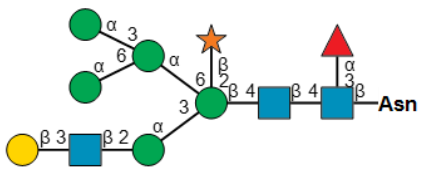
Cellulose

Starch

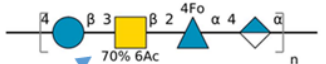
white shape with letter (see footnote 11)



A=4-deoxy-D-arabino-hexose
C. braakii

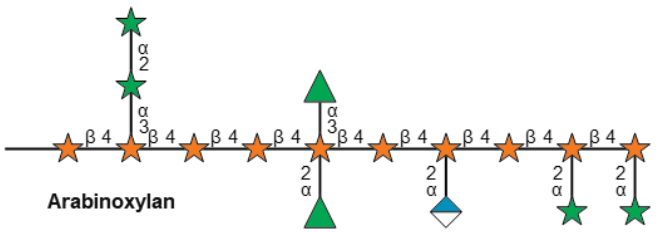


Hybrid N-glycan



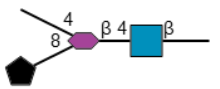
4Fo=4-formamido

variable modification (see footnote 7)



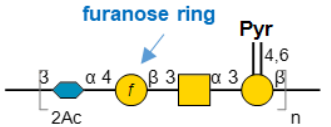
Arabinoxylan

EXAMPLES FROM BACTERIA

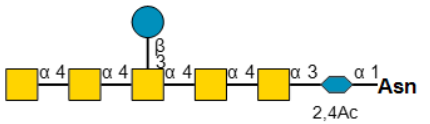


Non-glycan=L-Ala
P. alcalifaciens

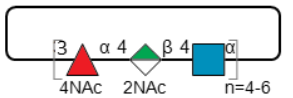
furanose ring



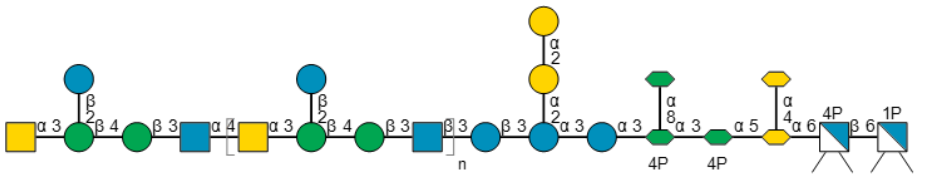
B. fragilis capsule



N-glycan from *C. jejuni*



Enterobacterial Common Antigen (cyclic glycan)



Bacterial Lipopolysaccharide from *E. coli*

(R=lipid)

Table 2. CMYK and RGB color assignments*

Color	CMYK settings	RGB settings
White	0/0/0/0	255/255/255
Blue	100/50/0/0	0/144/188
Green	100/0/100/0	0/166/81
Yellow	0/15/100/0	255/212/0
Light blue	41/5/3/0	143/204/233
Pink	0/47/24/0	246/158/161
Purple	38/88/0/0	165/67/153
Brown	32/48/76/13	161/122/77
Orange	0/65/100/0	244/121/32
Red	0/100/100/0	237/28/36

*** CMYK colors are presented as %**

Table 3. Monosaccharide abbreviations and names

Abbreviation	Short Name	Systematic name
4eLeg	4-Epilegionaminic acid	5,7-Diamino-3,5,7,9-tetradeoxy-D-glycero-D-talo-non-2-ulopyranosonic acid
6dAlt	6-Deoxy-L-altrose	6-Deoxy-L-altropyranose
6dAltNAc	N-Acetyl-6-deoxy-L-altrosamine	2-Acetamido-2,6-dideoxy-L-altropyranose
6dGul	6-Deoxy-D-gulose	6-Deoxy-D-gulopyranose
6dTal	6-Deoxy-D-talose	6-Deoxy-D-talopyranose
6dTalNAc	N-Acetyl-6-deoxy-D-talosamine	2-Acetamido-2,6-dideoxy-D-talopyranose
Abe	Abequose	3,6-Dideoxy-D-xylo-hexopyranose
Aci	Acinetaminic acid	5,7-Diamino-3,5,7,9-tetradeoxy-L-glycero-L-altro-non-2-ulopyranosonic acid
All	D-Allose	D-Allopyranose
AllA	D-Alluronic acid	D-Allopyranuronic acid
AllN	D-Allosamine	2-Amino-2-deoxy-D-allopyranose
AllNAc	N-Acetyl-D-allosamine	2-Acetamido-2-deoxy-D-allopyranose
Alt	L-Altrose	L-Altropyranose
AltA	L-Altruronic acid	L-Altropyranuronic acid
AltN	L-Altrosamine	2-Amino-2-deoxy-L-altropyranose
AltNAc	N-Acetyl-L-altrosamine	2-Acetamido-2-deoxy-L-altropyranose
Api	L-Apiose	3-C-(Hydroxymethyl)-L-erythro-tetrofuranose
Ara	L-Arabinose	L-Arabinopyranose
Bac	Bacillosamine	2,4-Diamino-2,4,6-trideoxy-D-glucopyranose
Col	Colitose	3,6-Dideoxy-L-xylo-hexopyranose
DDmanHep	D-glycero-D-manno-Heptose	D-glycero-D-manno-Heptopyranose
Dha	3-Deoxy-D-lyxo-heptulosaric acid	3-Deoxy-D-lyxo-hept-2-ulopyranosaric acid
Dig	D-Digitoxose	2,6-Dideoxy-D-ribo-hexopyranose
Fru	D-Fructose	D-arabino-Hex-2-ulopyranose
Fuc	L-Fucose	6-Deoxy-L-galactopyranose
FucNAc	N-Acetyl-L-fucosamine	2-Acetamido-2,6-dideoxy-L-galactopyranose
Gal	D-Galactose	D-Galactopyranose
GalA	D-Galacturonic acid	D-Galactopyranuronic acid
GalN	D-Galactosamine	2-Amino-2-deoxy-D-galactopyranose
GalNAc	N-Acetyl-D-galactosamine	2-Acetamido-2-deoxy-D-galactopyranose
Glc	D-Glucose	D-Glucopyranose
GlcA	D-Glucuronic acid	D-Glucopyranuronic acid

GlcN	D-Glucosamine	2-Amino-2-deoxy-D-glucopyranose
GlcNAc	N-Acetyl-D-glucosamine	2-Acetamido-2-deoxy-D-glucopyranose
Gul	D-Gulose	D-Gulopyranose
GulA	D-Guluronic acid	D-Gulopyranuronic acid
GulN	D-Gulosamine	2-Amino-2-deoxy-D-gulopyranose
GulNAc	N-Acetyl-D-gulosamine	2-Acetamido-2-deoxy-D-gulopyranose
Ido	L-Idose	L-Idopyranose
IdoA	L-Iduronic acid	L-Idopyranuronic acid
IdoN	L-Idosamine	2-Amino-2-deoxy-L-idopyranose
IdoNAc	N-Acetyl-L-idosamine	2-Acetamido-2-deoxy-L-idopyranose
Kdn	3-Deoxy-D-glycero-D-galacto-nonulosonic acid	3-Deoxy-D-glycero-D-galacto-non-2-ulopyranosonic acid
Kdo	3-Deoxy-D-manno-octulosonic acid	3-Deoxy-D-manno-oct-2-ulopyranosonic acid
Leg	Legionaminic acid	5,7-Diamino-3,5,7,9-tetradeoxy-D-glycero-D-galacto-non-2-ulopyranosonic acid
LDmanHep	L-glycero-D-manno-Heptose	L-glycero-D-manno-Heptopyranose
Lyx	D-Lyxose	D-Lyxopyranose
Man	D-Mannose	D-Mannopyranose
ManA	D-Mannuronic acid	D-Mannopyranuronic acid
ManN	D-Mannosamine	2-Amino-2-deoxy-D-mannopyranose
ManNAc	N-Acetyl-D-mannosamine	2-Acetamido-2-deoxy-D-mannopyranose
Mur	Muramic acid	2-Amino-3-O-[(R)-1-carboxyethyl]-2-deoxy-D-glucopyranose
MurNAc	N-Acetylmuramic acid	2-Acetamido-3-O-[(R)-1-carboxyethyl]-2-deoxy-D-glucopyranose
MurNGc	N-Glycolylmuramic acid	3-O-[(R)-1-Carboxyethyl]-2-deoxy-2-glycolamido-D-glucopyranose
Neu	Neuraminic acid	5-Amino-3,5-dideoxy-D-glycero-D-galacto-non-2-ulopyranosonic acid
Neu5Ac	N-Acetylneuraminic acid	5-Acetamido-3,5-dideoxy-D-glycero-D-galacto-non-2-ulopyranosonic acid
Neu5Gc	N-Glycolylneuraminic acid	3,5-Dideoxy-5-glycolamido-D-glycero-D-galacto-non-2-ulopyranosonic acid
Oli	Olivose	2,6-Dideoxy-D-arabino-hexopyranose
Par	Paratose	3,6-Dideoxy-D-ribo-hexopyranose
Pse	Pseudaminic acid	5,7-Diamino-3,5,7,9-tetradeoxy-L-glycero-L-manno-non-2-ulopyranosonic acid
Psi	D-Psicose	D-ribo-Hex-2-ulopyranose
Qui	D-Quinovose	6-Deoxy-D-glucopyranose
QuiNAc	N-Acetyl-D-quinovosamine	2-Acetamido-2,6-dideoxy-D-glucopyranose
Rha	L-Rhamnose	6-Deoxy-L-mannopyranose
RhaNAc	N-Acetyl-L-rhamnosamine	2-Acetamido-2,6-dideoxy-L-mannopyranose
Rib	D-Ribose	D-Ribopyranose
Sia	Sialic acid	Sialic acid residue of unspecified type

Sor	L-Sorbose	L-xylo-Hex-2-ulopyranose
Tag	D-Tagatose	D-lyxo-Hex-2-ulopyranose
Tal	D-Talose	D-Talopyranose
TalA	D-Taluronic acid	D-Talopyranuronic acid
TalN	D-Talosamine	2-Amino-2-deoxy-D-talopyranose
TalNAc	N-Acetyl-D-talosamine	2-Acetamido-2-deoxy-D-talopyranose
Tyv	Tyvelose	3,6-Dideoxy-D-arabino-hexopyranose
Xyl	D-Xylose	D-Xylopyranose

Clicking on the abbreviation leads to the corresponding entry in PubChem

History of the SNFG (go back to the start)

Issues regarding nomenclature are more controversial than scientific ones, as there is never one correct answer, and some aspects are matters of opinion and taste. In 1978, Kornfeld presented a system for symbolic representation of vertebrate glycans, which enjoyed popular use and was eventually adopted and standardized for the first edition of the *Essentials of Glycobiology* textbook (1999). While this adoption increased usage, the system had limitations and inconsistencies, and did not use color. Anticipating upcoming work on a second edition, the editors developed an updated nomenclature, which was made available to the community in 2004 before publication, and was adopted and widely disseminated, especially by the NIGMS-funded Consortium for Functional Glycomics (sometimes resulting in the incorrect term "CFG Nomenclature"). Moreover, even after the final publication of the Second Edition in 2009, acceptance by the community remained incomplete, and individual variations began to appear. Anticipating preparation of a third edition, a reorganized group of *Essentials* editors (supported by the NHLBI-funded Programs of Excellence in Glycoscience) agreed on an updated symbol nomenclature that went beyond vertebrate glycans, considered input from others using related systems, coordinated with the IUPAC Carbohydrate Nomenclature committee, linked each monosaccharide symbol to the corresponding entry in PubChem at NCBI/NLM, and initiated coordination with other long-term online resources. The system became an online advance Appendix to the Third Edition of *Essentials*. New symbols were added, but to ensure compatibility with prior publications, no changes were made to symbols in the Second Edition. For this historical reason, shapes and colors are internally consistent only for some monosaccharides. Symbol colors are specified in CMYK and RGB settings. Linkages can be shown as in the Second Edition system using IUPAC style, with the originating carbon assumed, and hyphens (not commas) used as an option. The Oxford system of angled monosaccharide linkages with embedded specificity and anomericity can also be used. Details on all aspects can be found in the notes to the *Essentials* Appendix at NCBI, which also contains many other useful links. Symbols also have embedded information such as links to PubChem, and are available in downloadable files as high quality objects.

Realizing the need for a standard acronym, the *Essentials* editors then suggested SNFG: Symbol Nomenclature For Glycans. This generic name recognizes the fact that while the update arose from the editors' need to standardize a previous system for the third edition of a textbook, many others eventually contributed towards its final creation, and the system thus belongs to the community. Accordingly, a broadly representative SNFG Discussion Group now works with the NCBI on periodic updates. If the system gains wide acceptance in the literature and is adopted by major journals, there is a possibility of a separate SNFG Website, likely linked to PubChem. This is another step towards mainstreaming of glycan bioinformatics, to become an integral part of the molecular and cellular bioinformatics of all living systems.

Following the initial release in 2015, the SNFG discussion group has worked with the NCBI and Pubchem to generate the updates as shown here.

Members of the SNFG Discussion Group (go back to the start)

- **Discussion Leader**: Sriram Neelamegham, State University of New York at Buffalo, USA

- Aebi, Markus, ETH Zürich, Switzerland
- Aoki-Kinoshita, Kiyoko F., Soka University, Japan
- Bernard, Henrissat, Centre National de la Recherche Scientifique (CNRS), France
- Bolton, Evan, National Library of Medicine (NLM), USA
- Campbell, Matthew, Institute for Glycomics, Griffith University, Australia
- Carolyn, Bertozzi, Stanford University, USA
- Cummings, Richard, Harvard Medical School, USA
- Darvill, Alan, University of Georgia, USA
- Dell, Anne, Imperial College London, UK
- Edwards, Nathan, Georgetown University, USA
- Etzler, Marilynn, UC Davis, USA
- Frank, Martin, Biognos AB Göteborg, Sweden
- Freeze, Hudson, Sanford-Burnham-Prebys Research Institute, USA
- Hart, Gerald, Johns Hopkins University School of Medicine, USA
- Kanehisa, Minoru, Kyoto University, Japan
- Kinoshita, Taroh, Osaka University, Japan
- Knirel, Yuriy, Russian Academy of Sciences, Russia
- Kornfeld, Stuart, Washington University in St. Louis, USA
- Lisacek, Frederique, Swiss Institute of Bioinformatics (SIB), Switzerland
- Luetteke, Thomas, ITech Progress GmbH, Ludwigshafen, Germany
- Marth, Jamey, UC Santa Barbara, USA
- Mazumder, Raja, The George Washington University, USA
- Narimatsu, Hisashi, Research Center of Medical Glycoscience, Japan
- Packer, Nicolle, Macquarie University, Australia
- Paulson, James, Scripps Research Institute, USA
- Perez, Serge, French National Centre for Scientific Research, France
- Ranzinger, Rene, University of Georgia, USA
- Rudd, Pauline, National Institute for Bioprocessing Research & Training, UK
- Sayle, Roger, NextMove Software, USA (PubChem collaborator)
- Schnaar, Ronald, Johns Hopkins University School of Medicine, USA
- Seeberger, Peter, Max-Planck-Institute of Colloids and Interfaces, Germany
- Stanley, Pamela, Albert Einstein College of Medicine, USA
- Taniguchi, Naoyuki, Riken Global Research Cluster, Japan
- Tiemeyer, Michael, University of Georgia, USA
- Toukach, Philip, Zelinsky Institute of Organic Chemistry, Russia
- Varki, Ajit, UC San Diego, USA
- Vliegenthart, JFG, Bijvoet Center, Netherlands
- Woods, Rob, University of Georgia, USA
- Yamada, Issaku, The Noguchi Institute, Japan
- York, William, University of Georgia, USA

Organizations and publications adopting the SNFG (go back to the start)

A universal symbol nomenclature for the graphical representation of glycan structures (SNFG; https://www.ncbi.nlm.nih.gov/glycans/snfg.html) has been proposed[1] to facilitate the standardization of how glycans are visually depicted.

This page lists current initiatives, databases, journals, societies, or publishers that have thus far accepted or recommend the use of this SNFG nomenclature. Additional adoptions can be reported to Nicolle Packer (nicki.packer@mq.edu.au), for potential inclusion in future updates to this online listing.

A suggested text for journal "Instructions to Authors" is "The Press/Society/Journal/Database encourages/recommends/requires that all figures depicting glycans with symbols for monosaccharides follow the shapes and colors presented in the current version of the Symbol Nomenclature for Glycans (SNFG) that can be found here. Please cite *Glycobiology* 25: 1323–1324, 2015. doi: 10.1093/glycob/cwv091 (PMID 26543186) and/or *Glycobiology* 29: 620-624, 2019. doi.org/10.1093/glycob/cwz045 (PMID 31184695)"

Standardization Initiatives

IUPAC (International Union of Pure and Applied Chemistry): https://iupac.org/

MIRAGE (Minimum Information Required for a Glycomics Experiment): http://www.beilstein-institut.de/en/projects/mirage/aims

Journals

Analytical and Bioanalytical Chemistry: https://link.springer.com/journal/216
Carbohydrate Research: https://www.journals.elsevier.com/carbohydrate-research
Glycobiology: http://glycob.oxfordjournals.org/
Glycoconjugate Journal: http://link.springer.com/journal/10719
Journal of Biological Chemistry: http://www.jbc.org/
Journal of Cell Biology: http://jcb.rupress.org/
Journal of Experimental Medicine: http://jem.rupress.org/
Journal of General Physiology: http://jgp.rupress.org/
Journal of The American Society for Mass Spectrometry: https://www.springer.com/chemistry/analytical+chemistry/journal/13361
Life Science Alliance: http://www.life-science-alliance.org/
Molecular & Cellular Proteomics: http://www.mcponline.org/

Databases

Consortium for Functional Glycomics Gateway: http://www.functionalglycomics.org/
CSDB (Carbohydrate Structure Database): http://csdb.glycoscience.ru/database/
GLYCAM-Web: http://glycam.org/
GLYCOSCIENCES.de: http://glycosciences.de/
GlycoStore: http://glycostore.org/search
Glyco3D: http://glyco3d.cermav.cnrs.fr/home.php
GlycoPedia: http://www.glycopedia.eu/e-chapters/the-plant-cell-walls/article/polysaccharide-diversity
Glycomics@ExPASy: https://www.expasy.org/glycomics
Glygen: https://www.glygen.org
GlyTouCan: https://glytoucan.org/
JCGGDB (Japanese Consortium for Glycobiology and Glycotechnology DataBase): http://jcggdb.jp/
MonosaccharideDB: http://monosaccharidedb.org/

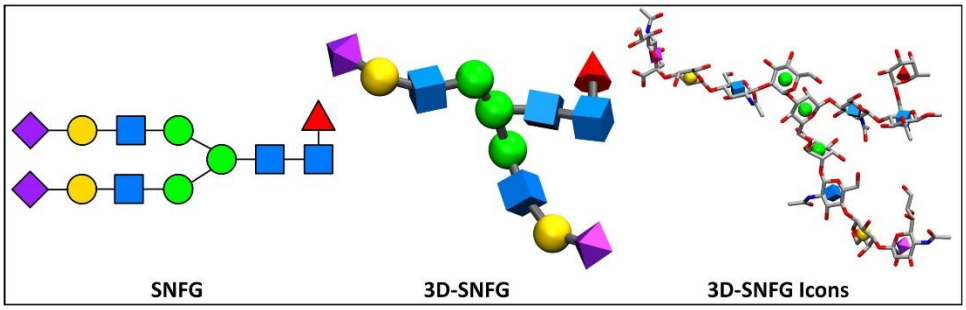
SugarBindDB (Pathogen Sugar-Binding Database): http://sugarbind.expasy.org/
UniCarb-DB: http://unicarb-db.expasy.org/
UnicarbKB: http://unicarbkb.org/

Footnotes

[1] Varki A, Cummings RD, Aebi M, Packer NH, Seeberger PH, Esko JD, Stanley P, Hart G, Darvill A, Kinoshita T, Prestegard JJ, Schnaar RL, et al. 2015. Symbol nomenclature for graphical representations of glycans. *Glycobiology* **25**: 1323–1324.

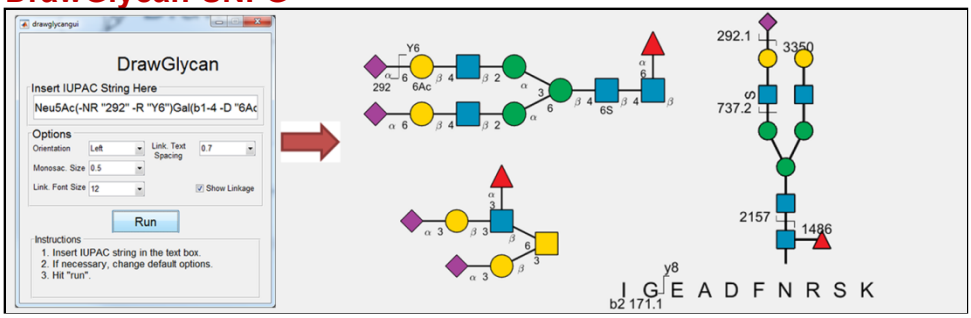
Software preview (go back to the start)

3D-SNFG



Description: 3D-SNFG is a cartoon representation for atomic models of carbohydrates. The glycan can be depicted with large shapes, or icons centered within the rings.
Weblink: http://glycam.org/3d-snfg
Citation: Thieker, D. F., Hadden, J. A., Schulten, K., & Woods, R. J., "3D implementation of the symbol nomenclature for graphical representation of glycans", Glycobiology 2016.
https://doi.org/10.1093/glycob/cww076

DrawGlycan-SNFG

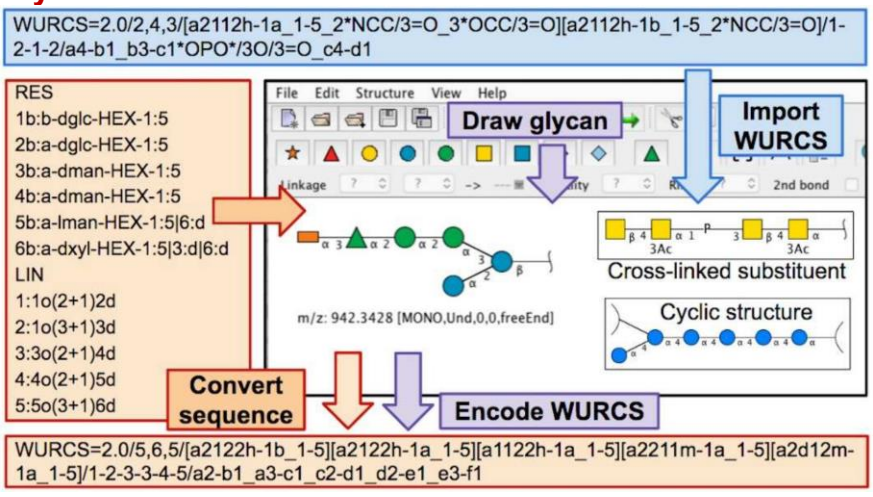


Description: DrawGlycan-SNFG uses IUPAC-condensed string inputs to generate glycan and glycopeptide drawings. Bond fragmentation and other glycan descriptors can be included.

Weblink: http://www.virtualglycome.org/DrawGlycan/

Citation: Cheng, K., Zhou, Y., Neelamegham, S., "DrawGlycan-SNFG: a robust tool to render glycans and glycopeptides with fragmentation information", Glycobiology, 2016. https://doi.org/10.1093/glycob/cww115

GlycanBuilder2



Description: GlycanBuilder2 is an updated version of GlycanBuilder which supports the building of structures to and from WURCS2.0, drawing cyclic glycans and specifying glycans with cross-linked substituents. It also supports SNFG symbols.

Weblink: http://www.rings.t.soka.ac.jp/downloads.html

Citation: S. Tsuchiya, N.P. Aoki, D. Shinmachi, M. Matsubara, I. Yamada, K.F. AokiKinoshita, H. Narimatsu, Implementation of GlycanBuilder to draw a wide variety of ambiguous glycans, Carbohydrate Research (2017), doi: 10.1016/j.carres.2017.04.015.

Updates (go back to the start)

February 4, 2020

1. Rules added for specification of symbol and bond orientation.

November 20, 2019

1. SNFG now provides guidelines to depict ambiguous linkages and glycan mixtures using bracket notation.

May 9, 2019

1. Footnote 7 modified to accommodate variable modifications.
2. More SNFG usage examples added.

January 22, 2019

1. SNFG page reorganized with new examples from mammals, yeast, slime mold, insects, bacteria and plants.
2. The new examples focus on how to present carbohydrate symbols in diverse organisms and ambiguous monosaccharide assignments.
3. Number of footnotes reduced from 28 to 10, and thematically organized in order to simplify usage.
4. Single non-italicized letter is now allowed in white symbols to help describe monosaccharides that are not part of the SNFG table and that cannot be described using existing footnotes.
5. SNFG Discussion Group list updated.

June 5, 2017

1. SNFG Discussion Group Listing added.
2. White diamond now indicates any deoxynonulosonic acid.
3. Flattened diamond introduced for any dideoxynonulosonic acid.
4. Additional symbols added for 6dGul, 6dAltNAc, 6dTalNAc, Pse, Leg, Aci and 4eLeg.
5. Drawglycan-SNFG and Glycanbuilder 2-SNFG adopted, link to web site provided.
6. Updates to Appendix 52A. Organizations and publications adopting SNFG.
7. RGB color code provided in addition to CMYK.
8. Multiple minor corrections and additions to nomenclature and rules of display.

August 31, 2016

1. Link to new Appendix 52A. Organizations and Publications Adopting SNFG.
2. Red diamond introduced for Sia (sialic acid, type unspecified). White diamond indicates any nonulosonic acid.
3. A 3D Symbol Nomenclature for Glycans (3D-SNFG) adopted, link to web site provided.
4. Multiple minor corrections and additions to nomenclature and rules of display.