Lectin

Lectins are carbohydrate-binding proteins that are highly specific for sugar groups of other molecules. Lectins have a role in recognition on the cellular and molecular level and play numerous roles in biological recognition phenomena involving cells, carbohydrates, and proteins.[1][2] Lectins also mediate attachment and binding of bacteria and viruses to their intended targets.

Lateral hemagglutinine

Lectins are ubiquitous in nature and are found in many foods. Some foods such as beans and grains need to be cooked or fermented to reduce lectin content. Some lectins are beneficial, such as CLEC11A, which promotes bone growth, while others may be powerful toxins such as ricin.[3]

Lectins may be disabled by specific mono- and oligosaccharides, which bind to ingested lectins from grains, legumes, nightshade plants, and dairy; binding can prevent their attachment to the carbohydrates within the cell membrane.[4] The selectivity of lectins means that they are useful for analyzing blood type, and they have been researched for potential use in genetically engineered crops to transfer pest resistance.

Contents

Etymology

Table of the major plant lectins [5]			
Lectin Symbol	**Lectin name**	**Source**	**Ligand motif**
Mannose-binding lectins			
ConA	Concanavalin A	*Canavalia ensiformis*	α-D-mannosyl and α-D-glucosyl residues branched α-mannosidic structures (high α-mannose type, or hybrid type and biantennary complex type N-Glycans)
LCH	Lentil lectin	*Lens culinaris*	Fucosylated core region of bi- and triantennary complex type N-Glycans
GNA	Snowdrop lectin	*Galanthus nivalis*	α 1-3 and α 1-6 linked high mannose structures
Galactose / N-acetylgalactosamine binding lectins			
RCA	Ricin, Ricinus communis Agglutinin, RCA120	*Ricinus communis*	Galβ1-4GalNAcβ1-R

PNA	Peanut agglutinin	*Arachis hypogaea*	Galβ1-3GalNAcα1-Ser/Thr (T-Antigen)
AIL	Jacalin	*Artocarpus integrifolia*	(Sia)Galβ1-3GalNAcα1-Ser/Thr (T-Antigen)
VVL	Hairy vetch lectin	*Vicia villosa*	GalNAcα-Ser/Thr (Tn-Antigen)
N-acetylglucosamine binding lectins			
WGA	Wheat Germ Agglutinin, WGA	*Triticum vulgaris*	GlcNAcβ1-4GlcNAcβ1-4GlcNAc, Neu5Ac (sialic acid)
N-acetylneuraminic acid binding lectins			
SNA	Elderberry lectin	*Sambucus nigra*	Neu5Acα2-6Gal(NAc)-R
MAL	Maackia amurensis leukoagglutinin	*Maackia amurensis*	Neu5Ac/Gcα2,3Galβ1,4Glc(NAc)
MAH	Maackia amurensis hemoagglutinin	*Maackia amurensis*	Neu5Ac/Gcα2,3Galβ1,3(Neu5Acα2,6)GalNac
Fucose binding lectins			
UEA	Ulex europaeus agglutinin	*Ulex europaeus*	Fucα1-2Gal-R
AAL	Aleuria aurantia lectin	*Aleuria aurantia*	Fucα1-2Galβ1-4(Fucα1-3/4)Galβ1-4GlcNAc, R2-GlcNAcβ1-4(Fucα1-6)GlcNAc-R1

in 1954 William C. Boyd alone and then together with Elizabeth Shapleigh[6] introduced term 'lectin' in 1954 from the Latin word *lego*- 'chosen' (from the verb *legere* 'to choose' or 'pick out').[7]

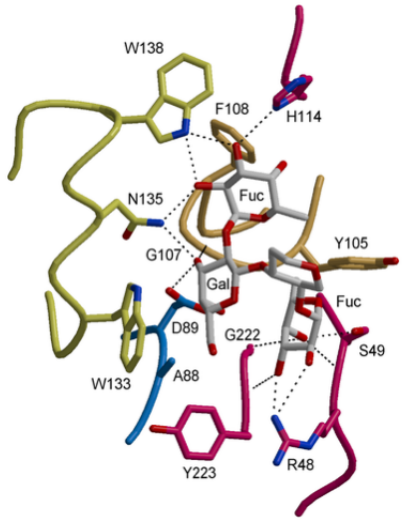
Biological functions

Lectins occur ubiquitously in nature. They may bind to a soluble carbohydrate or to a carbohydrate moiety that is a part of a glycoprotein or glycolipid. They typically agglutinate certain animal cells and/or precipitate glycoconjugates. Most lectins do not possess

enzymatic activity.

Animals

Lectins have these functions in animals:



An oligosaccharide (shown in grey) bound in the binding site of a plant lectin (*Griffonia simplicifolia* isolectin IV in complex with the Lewis b blood group determinant); only a part of the oligosaccharide (central, in grey) is shown for clarity.

- The regulation of cell adhesion
- The regulation of glycoprotein synthesis
- The regulation of blood protein levels
- The binding of soluble extracellular and intercellular glycoproteins
- As a receptor on the surface of mammalian liver cells for the recognition of galactose residues, which results in removal of certain glycoproteins from the circulatory system
- As a receptor that recognizes hydrolytic enzymes containing mannose-6-phosphate, and targets these proteins for delivery to the lysosomes; I-cell disease is one type of defect in this particular system.
- Lectins are known to play important roles in the innate immune system. Lectins such as the mannose-binding lectin, help mediate the first-line defense against invading microorganisms. Other immune lectins play a role in self-nonself discrimination and they likely modulate inflammatory and autoreactive processes.[8] Intelectins (X-type lectins) bind microbial glycans and may function in the innate immune system as well. Lectins may be involved in pattern recognition and pathogen elimination in the innate immunity of vertebrates including fishes.[9]

Plants

The function of lectins in plants (legume lectin) is still uncertain. Once thought to be necessary for rhizobia binding, this proposed function was ruled out through lectin-knockout transgene studies.[10]

The large concentration of lectins in plant seeds decreases with growth, and suggests a role in plant germination and perhaps in the seed's survival itself. The binding of glycoproteins on the surface of parasitic cells also is believed to be a function. Several plant lectins have been found to recognize noncarbohydrate ligands that are primarily hydrophobic in nature,

including adenine, auxins, cytokinin, and indole acetic acid, as well as water-soluble porphyrins. These interactions may be physiologically relevant, since some of these molecules function as phytohormones.[11]

Bacteria and viruses

Some hepatitis C viral glycoproteins may attach to C-type lectins on the host cell surface (liver cells) to initiate infection.[12] To avoid clearance from the body by the innate immune system, pathogens (e.g., virus particles and bacteria that infect human cells) often express surface lectins known as adhesins and hemagglutinins that bind to tissue-specific glycans on host cell-surface glycoproteins and glycolipids.[13]

Use

In medicine and medical research

Purified lectins are important in a clinical setting because they are used for blood typing.[14] Some of the glycolipids and glycoproteins on an individual's red blood cells can be identified by lectins.

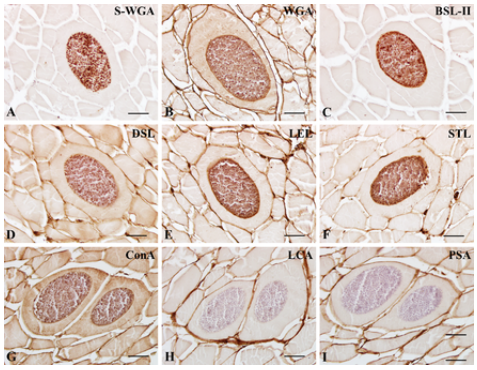
- A lectin from *Dolichos biflorus* is used to identify cells that belong to the A1 blood group.
- A lectin from *Ulex europaeus* is used to identify the H blood group antigen.
- A lectin from *Vicia graminea* is used to identify the N blood group antigen.
- A lectin from *Iberis amara* is used to identify the M blood group antigen.
- A lectin from coconut milk is used to identify *Theros* antigen.
- A lectin from *Carex* is used to identify R antigen.

In neuroscience, the anterograde labeling method is used to trace the path of efferent axons with PHA-L, a lectin from the kidney bean.[15]

A lectin (BanLec) from bananas inhibits HIV-1 *in vitro*.[16] Achylectins, isolated from *Tachypleus tridentatus*, show specific agglutinating activity against human A-type erythrocytes. Anti-B agglutinins such as anti-BCJ and anti-BLD separated from *Charybdis japonica* and *Lymantria dispar*, respectively, are of value both in routine blood grouping and research.[17]

In studying carbohydrate recognition by proteins

Lectins from legume plants, such as PHA or concanavalin A, have been used widely as model systems to understand the molecular basis of how proteins recognize carbohydrates, because they are relatively easy to obtain and have a wide variety of sugar specificities. The many crystal structures of legume lectins have led to a detailed insight of the atomic interactions between carbohydrates and proteins.



Lectin histochemistry of fish muscles infected by a myxozoan

As a biochemical tool

Concanavalin A and other commercially available lectins have been used widely in affinity chromatography for purifying glycoproteins. [18]

In general, proteins may be characterized with respect to glycoforms and carbohydrate structure by means of affinity chromatography, blotting, affinity electrophoresis, and affinity immunoelectrophoreis with lectins, as well as in microarrays, as in evanescent-field fluorescence-assisted lectin microarray.[19]

In biochemical warfare

One example of the powerful biological attributes of lectins is the biochemical warfare agent ricin. The protein ricin is isolated from seeds of the castor oil plant and comprises two protein domains. Abrin from the jequirity pea is similar:

- One domain is a lectin that binds cell surface galactosyl residues and enables the protein to enter cells.
- The second domain is an N-glycosidase that cleaves nucleobases from ribosomal RNA, resulting in inhibition of protein synthesis and cell death.

Lectin-free diet

Lectins are ubiquitous in nature and many foods contain the proteins. Because some lectins can be harmful if poorly cooked or consumed in great quantities, "lectin-free" diets have been proposed, most based on the writing of Steven Gundry. A typical lectin-free diet excludes a range of foods, including most grains, pulses, and legumes, as well as eggs, seafood, and many staple fruits and vegetables.

Toxicity

Lectins are one of many toxic constituents of many raw plants, which are inactivated by proper processing and preparation (e.g., cooking with heat, fermentation).[20] For example, raw kidney beans naturally contain toxic levels of lectin (e.g. phytohaemagglutinin). Adverse effects may include nutritional deficiencies, and immune (allergic) reactions.[21]

Hemagglutination

Lectins are considered a major family of protein antinutrients, which are specific sugar-binding proteins exhibiting reversible carbohydrate-binding activities.[22] Lectins are similar to antibodies in their ability to agglutinate red blood cells.[23]

Many legume seeds have been proven to contain high lectin activity, termed hemagglutination.[24] Soybean is the most important grain legume crop in this category. Its seeds contain high activity of soybean lectins (soybean agglutinin or SBA).

Leucoagglutinin is a toxic phytohemagglutinin found in raw *Vicia faba* (fava bean).

History

Long before a deeper understanding of their numerous biological functions, the plant lectins, also known as phytohemagglutinins, were noted for their particularly high specificity for foreign glycoconjugates (e.g. those of fungi, invertebrates, and animals)[25] and used in biomedicine for blood cell testing and in biochemistry for fractionation.

Although they were first discovered more than 100 years ago in plants, now lectins are known to be present throughout nature. The earliest description of a lectin is believed to have been given by Peter Hermann Stillmark in his doctoral thesis presented in 1888 to the University of Dorpat. Stillmark isolated ricin, an extremely toxic hemagglutinin, from seeds of the castor plant (*Ricinus communis*).

The first lectin to be purified on a large scale and available on a commercial basis was concanavalin A, which is now the most-used lectin for characterization and purification of sugar-containing molecules and cellular structures. The legume lectins are probably the most well-studied lectins.

See also

- *Bacillus thuringiensis*
- Con A *Proteopedia 1bxh (http://www.proteopedia.org/wiki/index.php/1bxh)*, pokeweed lectin *Proteopedia 1uha (http://www.proteopedia.org/wiki/index.php/1uha)*, *Artocarpus* lectin *Proteopedia 1toq (http://www.proteopedia.org/wiki/index.php/1toq)*, *Pterocarpus* lectin *Proteopedia 1q8v (http://www.proteopedia.org/wiki/index.php/1q8v)*, *Urtica* lectin *Proteopedia 1en2 (http://www.proteopedia.org/wiki/index.php/1en2)*
- Lectin pathway, ficolin
- Toxalbumin

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External links

- Major Lectins & Conjugated Lectins from different natural sources (http://www.bio-world.com/glycobiology/lectins.html)
- Functional Glycomics Gateway (http://www.functionalglycomics.org/), a collaboration between the Consortium for Functional Glycomics and Nature Publishing Group
- **Proteopedia** shows more than 800 three-dimensional molecular models of lectins, fragments of lectins and complexes with carbohydrates (http://www.proteopedia.org/wiki/index.php/Main_Page)
- EY Laboratories, Inc., Lectin and Lectin Conjugates manufacturer (http://www.eylabs.com/)
- Recombinant Protein Purification Handbook (http://www.gelifesciences.com/handbooks)
- Immobilized lectins, chromatography media (http://legacy.gelifesciences.com/webapp/wcs/stores/servlet/CategoryDisplay?categoryId=11449&catalogId=10101&productId=&top=Y&storeId=11253&langId=-1)
- Medicago AB, Lectin and Lectin Conjugates manufacturer (http://www.medicago.se/)
