

# Hierarchy Structure of Root's Plant: The Part-Whole Relation in Corpus Linguistics

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**Abstract** This study deals with lexical semantics field of hierarchical part-whole relation of root's plant lexeme, using a corpus linguistic approach to screen the data and statistically find out the frequency of co-occurrence of each root-related lexeme and its collocations. The analysis was carried out by employing Cruse's notion of lexical configuration to build hierarchical levels. Additionally, a concordance analysis was also employed to determine the meronymy among each lexeme that is part of the root. In Wikipedia Corpus, three dominant elements of plant are found, namely root, stem, and leaf. However, for the purpose of conclusiveness, this study only focuses on root, particularly the collocations of each of its parts as seen in Wikipedia Corpus. This study is expected to contribute to references in lexical semantics, especially in determining the paradigmatic relation of hierarchical formation in a concrete and structured manner, by employing corpus linguistics and taking account of scholar descriptions.

**Keywords:** *root anatomy, meronymy, collocation, concordance*

## 1. Introduction

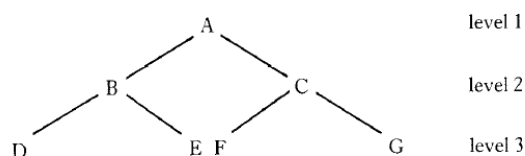
The notion of syntagmatic and paradigmatic relations has been widely known in studies of structural linguistics. This study, however, focuses on paradigmatic relation in particular. According to Murphy [1], words that have a paradigmatic relation have the same part of speech and characteristics. In a paradigmatic relation, words are closely linked in a way that can be seen from the relationships between the lexemes, one of which is expressed as a part-whole relation. Meronymy, on the other hand, is an asymmetric relation, as, for instance, seen in *stanza* and *poem*, with *stanza* being a meronym of *poem* and *poem* being a holonym of *stanza* [2].

Cruse [3] already mention about transitivity of the part-whole relation and this view is affirmed by Cruse [4], Croft & Cruse [5] that state that meronymy is a relation between meaning, in which the part-whole relation connects two individual entities. This relation between meronym and holonym form a hierarchy. Meronymy is a part/portion-whole relation applied to two individual entities to illustrate the notion of containment, as, for example, seen in *finger-hand*. Using this *finger-hand* pair as the example, Croft & Cruse [6] describes the notion of containment by explaining that *finger* is a meronym of *hand*, because *finger* is an original construal found in *hand* and essentially can be defined as part of *hand*.

Following the same cognitive framework as suggested by Croft & Cruse, meronymy can be defined as follows: if A is a meronym of B in a particular context, then any member a of the extension of A maps onto a specific member b of the extension of B of which it is constructed as a part, or it potentially stands in an intrinsically constructed relation of part to some actual or potential member of B.

Cruse uses the notion of lexical configuration in constructing a hierarchy, arguing that a lexical configuration is formed as a consequence of semantic relation between lexical items. Cruse further divides lexical configuration into three types, namely taxonomic hierarchies (hyponymy), part-whole hierarchies (meronymy), and non-branching hierarchies. A meronymy has its own form of hierarchy in constructing the structure of part-whole relation under the framework of Cruse's lexical configuration.

Each element of such hierarchy is arranged on a certain level, based on the relationship of each lexeme: whether a lexeme is directly related to the main domain, whether it needs other lexemes as an intermediary to be related with the main domain, and whether such a lexeme is not directly related but still connected in any way with the main domain. Here, the leveling follows the following rule: the first element occupies the 1st level, all elements directly related to the first element occupy the 2nd level, all elements directly related to the second element occupy the 3rd level, and so on. For non-branching hierarchies, there is only one element on each level.



**Fig1.** Each Element of a Hierarchy on a Certain Level  
Cited from Cruse's

Hierarchies of part-whole relations of lexeme *root* cannot be properly analyzed by only visually observing the object in question. In this sense, corpus linguistics offers a more convenient methodology in lexical semantic studies by observing the occurrence frequency of lexeme *root* and its collocations. Corpus linguistics is a research approach that has been developed over the last few decades to support the empirical changes in language variation and language use, thus allowing more generalized findings with higher validity [7]. This claim is supported by Riemer [8] that states that corpora are very useful in semantic analyses as they can show unexpected collocational patterns or unusual word combinations, which are often overlooked.

## 2. Research Method

This study employs a corpus linguistic approach and uses the notion of lexical semantics in analyzing the object of study. In other words, this study integrates the qualitative method and the quantitative method into a mixed-methods approach. According to Greene [9], a mixed-methods approach is useful to produce a comprehensive finding and provide valid answers to the research questions.

The data used was Wikipedia corpus that were taken from the BYU, an online corpora query system created by Davies [10]. With about 1.9 billion words taken from about 4.4 million web pages, Wikipedia corpus (<https://corpus.byu.edu/wiki>) that was released in early 2015 has the richness and diversity to be used as research data. Before the hierarchical meronymy was constructed, the resulting collocates should be defined based on the descriptions provided by experts in plant botany such as Beck [11]; [12]; [13], in order to achieve scientifically valid and acceptable findings.

To construct the hierarchical meronymy of lexeme *root*, following Cruse's lexical configuration (1986). As previously mentioned, a lexical configuration is formed on each hierarchical level. Thus, Cruse's notion of lexical configuration does not adequately determine the parts of *root* meronymy on each hierarchical level. For that reason, this study integrates the corpus analysis that includes the collocation frequency, MI score, and concordance, and the scientific descriptions of parts of *root* as provided by experts in plant anatomy, in order to accurately determine which parts of root belong to each level of its meronymy hierarchy and to achieve a result that can be proven both linguistically and scientifically.

### 3. Results And Discussion

Root is the basest part of plant anatomy. It is the bottom part of a plant that grows in the soil and, therefore, is hard to observe. Nevertheless, root is the most important component of plants, especially those that live on land. The following is the number of lexeme *root* and its direct collocates found in Wikipedia Corpus.

Referring to the plant anatomy, a root is formed of several parts. As mentioned by Steeves and Sawhney, a root is formed of three tissue systems, namely dermal tissues, fundamental or ground tissues, vascular tissues and also root tip. Additionally, a root also has some outside part, namely bark.

#### 3.1 Root Bark

The analysis begins from the outermost part of root, namely *bark*. The data of Wikipedia Corpus show a high frequency of occurrence of lexeme *root* that directly collocates with *bark*.

**Table 1.** The number of occurrence of lexeme *root* collocating with *bark*

<b>Root</b>	<b>Collocate</b>	<b>Frequency</b>	<b>Overall</b>	<b>Percentage</b>	<b>MI</b>
	bark	236	17187	1.37	5.07

*Root* is found to appear collocating with *bark* in 236 occurrences. The MI score of 5.07 shows a significantly close relationship between root and its meronyms. Further, the concordances result is as follows.

This **bark** beetle feeds on the developing **bark on** and **around** the **root** crowns of tree seedlings, especially the phloem with mycelial sheaths of the fungus beneath the **bark of** the **root** colla  
The **root bark** and stem are analgesic, antiphlogistic, antirheumatic, hypoglycaemic and tonic

The part-whole relation in bark-root meronymy is marked by the prepositions *on*, *of*, and the prepositional adverb *around*. In the context, *this bark beetle feeds on the developing bark on and around the root*, the verb *develop* is found that denotes the meaning of *bark* growing around a *root*. This verb makes evident that *bark* is part of *root* that grows around it. These

contexts found in the concordance of root collocating with bark indicate that bark is part of root and forms a meronymy with it.

### 3.2 Root Epidermis

Epidermic layers, or referred to by Steeves & Sawhney as dermal tissues, are parts of root that come after *bark*. According to Steeves & Sawhney, an epidermal cell has a thin layer of cuticle on the outside that thickens as the root ages. This definition can also explain *bark*, which is indeed a thick layer on the skin of older roots, resulting from epidermal cells in the epidermis. This affirms Cutler, et al. that mention that on all roots of plant, except those that grow on the soil or water, root hairs are usually found not far from the area where the roots grow, and they develop from rhizodermis or root epidermis.

The above descriptions are confirmed in the data, in which the words *epidermal cells*, *cuticle*, and *root hairs*, are found to collocate with the lexeme epidermis.

**Table 2.** The number of occurrence of lexeme *epidermis* and its collocates that denote parts of *root*

	Collocate	Frequency	Overall	Percentage	MI
Epidermis	hair	58	78771	0.07	5.62
	root	42	108537	0.04	4.69
	cuticle	39	1286	3.03	10.99
	epidermal cell	27	1252	2.16	10.49

The resulting concordances, starting from *root* that collocates with *epidermis*, are as follows.

The cells of the **root epidermis** grow at a right angle to the axis of the **root** to allow them  
In plants with secondary growth, the **epidermis** of **roots** and stems is usually replaced by a periderm

The part-whole relation between epidermis and root is marked by the preposition *of* and the verb *grow*. In the context, *the cells of the root epidermis grow at a right angle to the axis of the root*, the verb *grow* is found to denote the meaning of epidermal tissues growing on the root axis. This verb proves that *epidermis* is part of *root* that grows on the root tissues. These contexts found in the concordance of *epidermis* collocating with *root* indicate that epidermis is part of root and forms a meronymy with it. From this analysis, a branching hierarchy of meronymy can be constructed as follows.

### 3.3 Root Cortex

*Cortex* comes after epidermis as a part of *root*. Cortex, or referred to by Steeves & Sawhney as a *ground tissue*, is located right below the epidermis. The deepest layer of cortex is a special cellular layer called the endodermis. These cells form suberin strips where fatty materials are deposited in the radial and transverse walls. These suberin strips are called the casparian strips Steeves & Sawhney. In the data, the collocates of cortex are as found as follows:

**Table 3.** The number of occurrence of lexeme *cortex* and its collocates that denote parts of *root*

	Collocate	Frequency	Overall	Percentage	MI
Cortex	root	37	10732	0.34	3.08
	endodermis	13	10732	0.12	11.13
Endodermal	casparian strip	3	97	3.09	17.05

The resulting concordances, starting from *root* that collocates with *cortex*, are as follows.

the **cortex** is the outermost layer of the stem or **root** of a plant, bounded on the outside by the epidermis  
They introduce necrosis in the **cortex** of the **root** which is detrimental to the plant

The part-whole relation between *cortex* and *root* is marked by the preposition *of* and the adjective *outermost*. The context, *the cortex is the outermost layer of the stem or root of a plant* denotes the meaning that *cortex* is located on the most outer side of *root*. The preposition *of* is also found in the context, *the cortex of the root*, denoting the meaning that *cortex* is part of *root*. These contexts found in the concordance of *root* collocating with *cortex* indicate that *cortex* is part of *root* and forms a meronymy with it.

### 3.4 Root Stele

After the *ground tissues* come the *vascular tissues* that are more known as *stele*. In some dicotyle plants, the middle part of the root may all be made of xylem, but in monocotyle plants and some other dicotyle plants the root, especially on the primary root, may contain some ground tissues that consist of parenchymas with a thin or thick wall called the *pith*. Eventually, xylem and phloem (and pith), with an addition of the pericycle, constitute the whole vascular tissues. In Wikipedia corpus, each of these parts of vascular tissues are found as follows.

**Table 4.** The number of occurrence of lexeme *vascular tissue* and its collocates that denote parts of *root*

<b>Vascular tissue</b>	<b>Collocate</b>	<b>Frequency</b>	<b>Overall</b>	<b>Percentage</b>	<b>MI</b>
	root	11	108537	0.01	5.75
	xylem	5	504	0.99	12.36
	phloem	3	415	0.72	11.90
	pericycle	1	24	4.17	14.43
	pith	1	643	0.16	9.68

The resulting concordances, starting from *root* that collocates with *vascular tissue*, are as follows.

This results in discolored or necrotic **vascular tissue** in the **root**, and the tissue bordering root hair, epidermis, epiblem, cortex, endodermis, pericycle and lastly the **vascular tissue** in the centre of a **root** responsible for most water transport through the **vascular tissue** in stems and **roots**

The part-whole relation between *vascular tissue* and *root* is marked by the preposition *in* and the noun *centre*. In the context, *most water transport through the vascular tissue in stems and roots*, the preposition *in* creates the meaning that *vascular tissue* is located inside the *root*. These contexts found in the concordance of *root* collocating with *vascular tissue* indicate that *vascular tissue* is part of *root* and forms a meronymy with it.

### 3.5 Root Tip

The tip of root is called *root apex*, or simply known as *root tip*. There are several parts of the root tip, namely *root cap*, *quiescent center*, *protoderm*, and *meristem*. In Wikipedia corpus, the following data are found.

**Table 5.** The number of lexeme *root* and its collocates regarding *root tip*.

<b>Root</b>	<b>Collocate</b>	<b>Frequency</b>	<b>Overall</b>	<b>Percentage</b>	<b>MI</b>
	root tip	55	108537	0.05	10.24
	root cap	5	108537	0.00	7.78
	quiescent center	1	108537	0.00	7.40

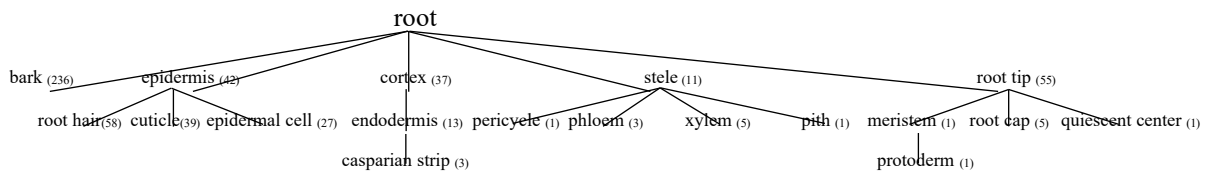
<b>R</b>	<b>Collocate</b>	<b>Frequency</b>	<b>Overall</b>	<b>Percentage</b>	<b>MI</b>
<b>Root tip</b>	meristem	1	8	12.50	18.19
<b>Meristem</b>	protoderm	1	372	0.27	16.53

The lexeme *root* directly collocates with *root tip*, *root cap*, and *quiescent center*. In the data, although *protoderm* is not found to directly collocate with *root tip*, it is found to collocate with *meristem*. This conforms the description by the experts in plant anatomy that *protoderm* is the first layer on the *meristem*. Meanwhile, the resulting concordances, starting from *root apex* or *root tip* that collocates with *root*, are as follows.

Removal of the **root tip** can lead to inhibition of secondary **root** formation tissues of the **root**, first undergoing elongation, a process that pushes the **root tip** forward in the growing medium release zoospores, which infect plant roots by entering the **root behind** the **root tip**

The part-whole relation between *root tip* and *root* is marked by the prepositional adverb *behind*. In the context, *plant roots by entering the root behind the root tip*, the adverb *behind* denotes the location where the *root tip* is located on the *root*. This context indicates that *root tip* is part of *root* and forms a meronymy with it.

From the analysis performed on each co-meronymy of lexeme *root* in relation with plant, a hierarchy of *root* meronymy can be formed from the combination of each part of the root as follows.



**Fig 2.** Hierarchy structure of lexeme *root*

## 4. Conclusion

As made evident from the BYU, *root* is a dominant part of a plant. In the root hierarchy, the second level is occupied by lexeme *bark*, *epidermis*, *cortex*, *stele* or *vascular tissue*, and *root tip* or *root apex*. The third level of the hierarchy is occupied by *root hair*, *cuticle*, *epidermal cell*, *endodermis*, *pericycle*, *phloem*, *xylem*, *pith*, *meristem*, *root cap*, and *quiescent center*. Finally, the fourth level is occupied by *casparian strip* and *protoderm*. Overall, the hierarchy formed on each lexeme of root consists of four levels, the arrangement of which is based on the descriptions made by experts in plant botany and the data in Wikipedia Corpus.

In line with the characteristics of Cruse's meronymy, the hierarchy constructed in this study contains the same elements related to the lexeme *root* and directly or indirectly collocating with it. For instance, lexeme *xylem* and *phloem* are both part of root but do not directly collocate with *root*. Instead, both are related to root by directly collocating with *stele* or *vascular tissue*, based on the descriptions provided by experts in plant anatomy. This shows that not all lexeme related to root in Wikipedia corpus are found to directly collocate with it.

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