Name Your Poison: More Set Theory for Language Learners

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In this paper, I give a rationale for using diagrams to explain vocabulary and some examples of how I use them in class. Diagrams can sometimes help students get a clearer understanding of vocabulary, are easily drawn on a chalk board, and provide learners with another effective way to study new words. Often, students at the university level are left to decide for themselves how to study vocabulary since it is assumed that most of them have learned effective ways to do so in junior and senior high school. From my observations and questioning of students in class, however, most simply look up words in an English/Japanese dictionary and write down the first translation they see. Seems the obvious, and perhaps to some, the only thing to do, and it is at least quick and efficient. Nonetheless, as the examples given here show, this can cause not only misunderstanding, but also prevents students from really learning the language. So, students are encouraged to make diagrams to both reinforce their understanding of vocabulary and to check their understanding of the words they have learned.

Rationale

For visual learners, a picture explains much better than words. Even for learners who prefer a verbal explanation, a diagram helps to clarify and reinforce the explanation given in words. In a previous paper[1] I showed how diagrams can be used to summarize a text. Diagrams can also be used to study vocabulary and to show how words are grouped into sets by meaning. Furthermore, and especially for students of science, a diagram has the force of logic.[2] The simple example here shows how general and specific terms can be pictured.

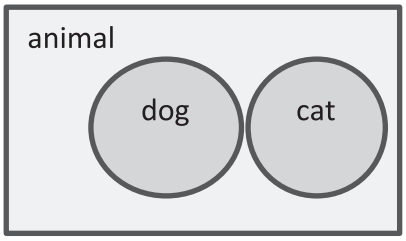

Diagram 1

The diagram shows the relationship between *cat* and *dog* in the semantic field of *animal*. Other information could be added to the diagram, for example to show that both words have mean-

[1] Messerklinger, J. 2014. Set Theory for Language Learners. Toho Liberal Arts Review, vol. 46, pp. 1–8.
[2] according to Wikipedia: "A Venn diagram or set diagram is a diagram that shows all possible logical relations between a finite collection of different sets. Venn diagrams were conceived around 1880 by John Venn. They are used to teach elementary set theory, as well as illustrate simple set relationships in probability, logic, statistics, linguistics and computer science." https://en.wikipedia.org/wiki/Venn_diagram (retrieved August 5 2015)

ing outside of animal[3] the circle for each could be extended outside the box *animal*; likewise, another circle could be drawn around *dog* and *cat* and then labelled *pet* to show that they are both usually kept as pets, etc. But for the sake of clarity the diagram only shows that *cat*—a small furry animal that says meow and catches mice—and *dog*—a four legged animal that barks and is commonly kept as a pet—are specific kinds of animals and so belong to the set animal, and learners can see at a glance and understand that *cat* refers to one kind of animal and *dog* another.

While the diagram and explanation in this case may seem obvious and therefore unremarkable, worth noting is how children intuitively create such sets when learning their native language. They may first call all four legged animals "doggie" for example, but soon they learn to distinguish cats from dogs from other animals and understand that the first two terms are usually used to identify subsets of the category *animal*. Learners of a foreign language should also do this when learning the language they are studying; otherwise, as we will see, they can easily make fundamental mistakes in interpreting the meaning of a text written in a foreign language.

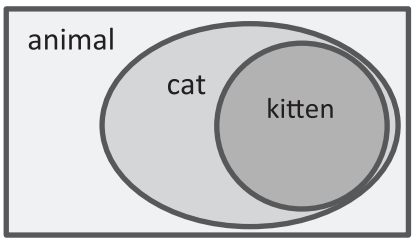

Diagram 2

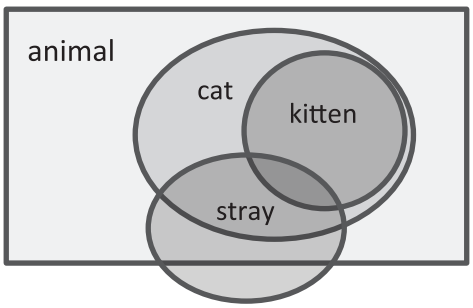

Diagram 3

Taking the diagram one step further, we can show the relationship between *cat*, *kitten* and *animal* this way:

The diagram shows that *cat* itself has a subcategory *kitten*[4], "a young cat."[5] And if we want to complicate things a bit more, we can add a modifier to these nouns such as *stray*:

Animals other than cats and kittens can be stray, stray dogs for example, and things like bullets and strands of hair can also be described as stray. But the point of these simple examples is to show how words make sets and how these sets can be pictured.

[3] For example: "I invested in an Internet start-up but it turned out to be a real dog." http://www.macmillandictionary.com/dictionary/british/dog_1 (retrieved August 10 2015)

[4] And here again, just as there are uses for the word cat outside animal, there are uses for the word kitten that fall outside both cat and animal, eg. to have a kitten is to have a nervous fit.

[5] http://www.merriam-webster.com/dictionary/kitten (retrieved August 5 2015)

Use in Class

This simple concept of diagramming is useful in class. Our students, for example, should know the difference between *drug* and *medicine*. The two concepts can be diagrammed like this:

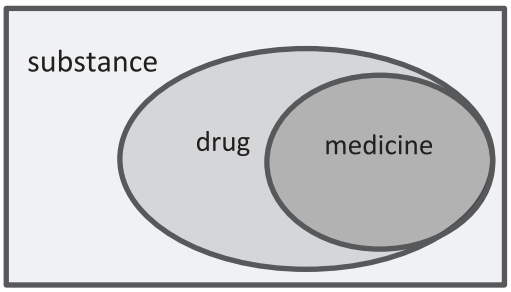

Diagram 4

The diagram shows the semantic relationship between *drug* and *medicine* in the semantic field of *substance*. *Substance* is a very broad field that contains many other ideas; in this case it is a fancy way to say *physical thing*. This diagram, like the previous examples, also leaves aside other uses of the words *drug* and *medicine*[6] and focuses on the concepts most commonly found in our reading, a drug being a chemical substance that affects the body and a medicine more specifically a drug used in the treatment of disease. In many texts, the terms appear to be used interchangeably, yet there are important differences. So, students must learn not only the meanings associated with each word, but also their collocations, how they form a semantic field,[7] and how each word's meaning and use differentiates it from the other.

As with the simple example of *cat*, *kitten*, and *stray* used in the introduction, details can be added to Diagram 4 to show other differences between the two words *drug* and *medicine*. For example, we usually say *drug store*, but not *medicine store* and more often than not *pain medicine* and not *pain drug*. Likewise, while we speak of *strong medicine*, we usually refer to *powerful drugs*. Diagram 5 shows how we might diagram the collocations between *drug*, *medicine*, *pain*, *strong*, and *store*.

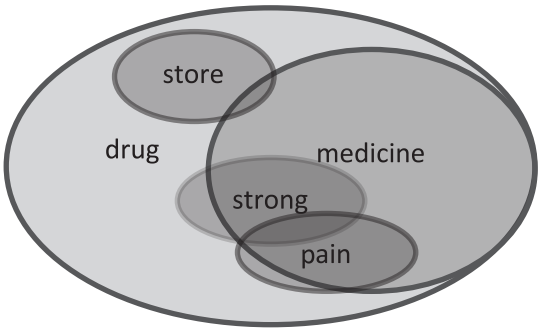

Diagram 5

The diagram shows the collocations among the words and gives a rough indication of how commonly they are used. For example, a verbatim google search of "*pain medicine*"

[6] For example, Roxy Music's 1975 song, *Love Is the Drug* or the lyric from the Gorillaz 2010 song *On Melancholy Hill*, "'Cause you are my medicine/when you're close to me."

[7] That is, how they are grouped by meaning. For example, words related to colours such as red, blue, yellow, etc. belong to a semantic field.

returned over 18 million hits while a verbatim search of "*pain drug*" returned fewer than 300,000. Likewise, the phrase "*drug store*" returned 17.5 million hits while "*medicine store*" fewer than 350,000; "*strong medicine*" nearly 450,000 and "*strong drug*" just over 100,000. So, we can predict that *strong pain medicine* will be much more common than *strong pain drug*, and indeed, a verbatim google search returns nearly 23,000 hits for the former and fewer than 4,000 for the latter.

Like diagramming paragraphs and reports, which can help students see the main idea and important supporting details of a paragraph or report[1], diagramming words can help students understand the core concepts of the vocabulary. In addition, just as dictionaries give examples to explain the meaning of a word, examples can be added to a diagram to help make the concept clear. Here, *nicotine* is added to the diagram of *medicine* and *drug*.

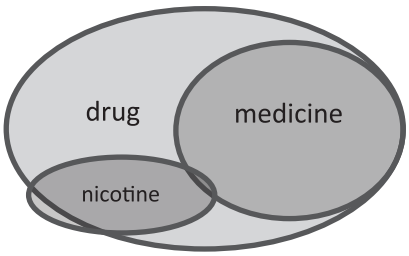

Diagram 6

The diagram shows that *nicotine* is commonly thought a drug but not a medicine[8]. While substances such as aspirin are commonly thought of as medicines, things like alcohol, caffeine[9], cocaine and nicotine, strictly speaking, are classified drugs. The reason for the classification of these substances becomes clear when we understand that although they are all chemical substances that affect the body, we do not think of them as being used to treat disease, even if some people may relieve stress with nicotine or alcohol. Calling them medicines in most contexts is humorous because doing so violates the everyday idea of *medicine* while implying that these drugs are somehow beneficial to health.

Name Your Poison

The joke is easily missed unless we understand the difference between *drug* and *medicine*. And misunderstanding the core concept of these words can result in humorous translations. For example, machine translation into Japanese of the statement, *Nicotine is a drug*[10], becomes:

？ニコチンは薬です。[11]

We can easily understand how this mistake happens when you look up the word

[8] But see: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2014383/ and http://www.ncbi.nlm.nih.gov/pubmed/11238724 (retrieved August 15, 2015) Nicotine may have medicinal uses after all.

[9] "Caffeine is a commonly used drug that …. is often added to … cold medicines." http://www.webmd.com/migraines-headaches/guide/triggers-caffeine (retrieved September 7, 2015)

[10] From: "Nicotine is a potent parasympathomimetic alkaloid found in the nightshade family of plants (Solanaceae) and is a stimulant drug." https://en.wikipedia.org/wiki/Nicotine (retrieved August 10 2015)

[11] https://translate.google.com/#en/ja/Nicotine%20is%20a%20drug and http://honyaku.yahoo.co.jp/ (retrieved August 4 2015)

drug in an English/Japanese dictionary. Machine translations, which rely on this over simplification, substitute *drug* for *薬* resulting in the error. Ironic, since we expect that statistical-based machine translation such as google translate to have the relationship between these terms mapped as in Diagram 7, which shows clearly that the correspondence between *drug* and *くすり* is not one to one:

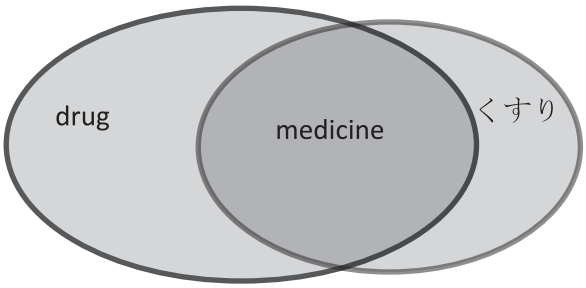

Diagram 7

The diagram shows that the concept *くすり* in its most common and simplest sense overlaps with the idea *drug* only in the sense of *medicine*: 病気や傷の治療のために、あるいは健康の保持・増進に効能があるものとして、飲んだり、塗ったり、注射したりするもの。[12] However, the diagram also shows that *くすり* can include other concepts depending on the context. And indeed, when looking at the definition for *くすり*, we see that it includes, for example, insecticide and herbicide: 殺虫剤・除草剤など、動植物に対して主に毒性を働かせるもの。 Nonetheless, the most common translation of drug into Japanese is *くすり*, *薬* or *薬物*[13].

Such errors in translation can be avoided by understanding the relationship between concepts in the source language, English, and how they correspond to similar concepts in the target language, Japanese, and also by being aware that in Japanese the kanji for *くすり*, *薬*, combines with other Chinese characters to clarify which aspect of *くすり* is meant. In Japanese, the relationships can be diagrammed this way:

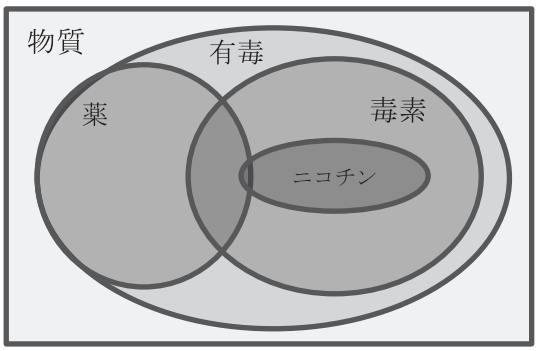

Diagram 8

Diagram 8 shows that, properly speaking, all drugs and medicines can be poisonous[14], 有毒, and that in Japanese, some things called *薬* are what we commonly think of as poisons/toxins, e.g. insecticides, 害虫の防除に用いる薬剤。砒酸鉛（ひさんなまり）・ニコチン・DDT・BHC など。[15] *Nicotine*, ニコチン, fits into the diagram here because its definition says: ニコチン（nicotine）は、アルカロイドの一種の

[12] http://dictionary.goo.ne.jp/leaf/jn2/61567/m0u/（retrieved August 12, 2015）
[13] http://dictionary.goo.ne.jp/leaf/jn2/160756/m0u/ and http://ejje.weblio.jp/content/drug etc.
[14] https://www.sciencebasedmedicine.org/all-medicines-are-poison/ and https://www.nlm.nih.gov/medlineplus/ency/article/002542.htm（retrieved August 25, 2015）
[15] http://dictionary.goo.ne.jp/leaf/jn2/88466/m0u/（retrieved August 15, 2015）

有毒物質である。[16] It is also fits here based on the definition of *insecticide* given above[17]. The area where 薬 and 毒素 overlap might include things such as 農薬 for example. The area where ニコチン and 薬 overlap is specifically 殺虫剤[18].

However, in Japanese, *薬* is a general term that is often qualified as in the definition of ニコチン above. The gloss given by translation software is misleading unless the context and the qualifications are understood. In other words, the term *薬* encompasses the concept of *medicine* as well as other concepts such as narcotics, *麻薬*, and pottery glaze, *釉薬*.[19] The exact translation of the word is very heavily context dependent. Therefore, it is incorrect to translate the definition of 殺虫剤 given above as:

* Drug to be used in the control of pests.[20] Or
* The medicine used for disinfestation of a harmful insect.[21]

In English, insecticide is defined as "any toxic substance that is used to kill insects,"[22] or "a chemical substance that is used to kill insects."[23] The definition contrasts with drugs which, although they can be used to kill, are usually used to alter the state of the body but not to the point of death, and with medicines which are drugs used to treat disease. For example, people use the drug alcohol to alter their mood and the medicine aspirin to relieve a headache.

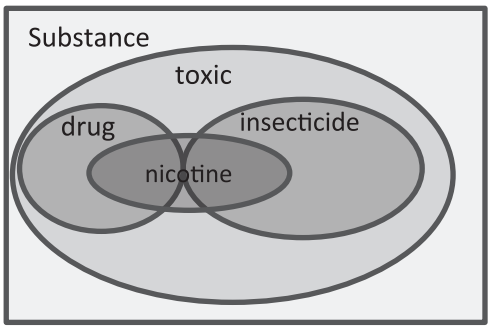

Diagram 9

A diagram of *insecticide* alongside *drug* and *nicotine* looks like this:

The diagram shows that an insecticide is never called a drug even if, as with nicotine, it can be used as one.[24] This is perhaps because it is assumed that a drug is a substance that is used on humans unless specified that it is for animal use, in which case it may be referred to as

[16] https://ja.wikipedia.org/wiki/%E3%83%8B%E3%82%B3%E3%83%81%E3%83%B3 (retrieved August 10 2015)
[17] In fact, nicotine and tobacco can be used as a pesticide. See: http://www.acs.org/content/acs/en/pressroom/presspacs/2010/acs-presspac-october-27-2010/tobacco-and-its-evil-cousin-nicotine-are-good-as-a-pesticide.html (retrieved August 20, 2015)
[18] The relationship between 薬 and 剤 is beyond the scope of this paper.
[19] Some of which may not be poisonous http://www.sfsu.edu/~ceramic/manual/ceramictoxicology.htm (retrieved August 25, 2015)
[20] https://translate.google.com/#ja/en/%E5%AE%B3%E8%99%AB%E3%81%AE%E9%98%B2%E9%99%A4%E3%81%AB%E7%94%A8%E3%81%84%E3%82%8B%E8%96%AC%E5%89%A4%E3%80%82 (retrieved August 13, 2015)
[21] http://www.excite.co.jp/world/english_japanese/ (retrieved August 13, 2015)
[22] http://www.britannica.com/technology/insecticide (retrieved August 14, 2015)
[23] http://www.merriam-webster.com/dictionary/insecticide (retrieved August 13, 2015)
[24] See: https://en.wikipedia.org/wiki/Hippolyte_Visart_de_Bocarm%C3%A9 (retrieved August 26 2015)

an "animal drug."[25] But when a drug is used in a different context, such as when it is used as a poison, it is identified using a different label.

Indeed, context is very important, and we can think of the diagrams as showing context, in the case of drug the overall context is *substance* and when used in a specific context we think of drugs as medicines. A more common example of how something is defined by the way it is used is the tomato. In a strictly biological context, it is a fruit, but when used in most kinds of cooking it is commonly thought of as a vegetable.[26]

Word Study

Admittedly, the type of diagram presented so far works less well when the label being studied is used to identify complex concepts. For example, although it at first seems simple, the concept of *poison* is actually quite complex. Poison is commonly defined as "a substance that through its chemical action usually kills, injures, or impairs an organism."[27] However, this also includes water and oxygen since "All things are poison and nothing is without poison; only the dose makes a thing not a poison."[28] Ordinarily, however, we never think of water or oxygen as poisons. More commonly, a poison is a substance that "in relatively small"[29] amounts harms the body. Using this more common definition, we can diagram the concept with examples this way:

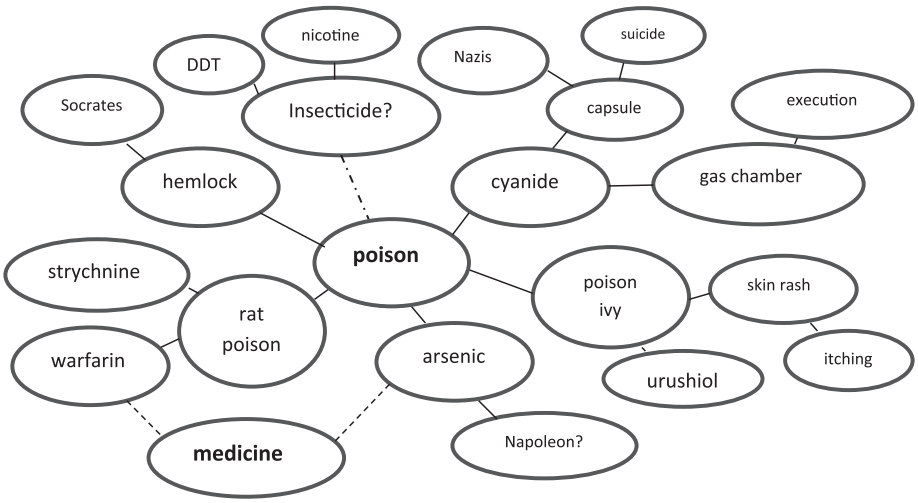

Diagram 10

[25] http://www.fda.gov/AnimalVeterinary/ResourcesforYou/ucm268128.htm (retrieved September 3, 2015)
[26] http://www.oxforddictionaries.com/words/is-a-tomato-a-fruit-or-a-vegetable (retrieved September 3, 2015) However, when used for jam, we might think of the tomato as a fruit after all: https://en.wikipedia.org/wiki/Tomato_jam (retrieved September 26, 2015.)
[27] http://www.merriam-webster.com/medical/poison (retrieved August 27, 2015)
[28] https://en.wikipedia.org/wiki/The_dose_makes_the_poison (retrieved August 27, 2015)
[29] http://medical-dictionary.thefreedictionary.com/poison (retrieved August 27, 2015)

Unlike the diagrams presented so far, this diagram, in the form of a semantic net, provides a visualization of one English user's intuitive sense of *poison* by showing what other words it is associated with. The first group of words around *poison* are general examples, *insecticide*, *poison ivy*, *rat poison*, and more specific examples, *arsenic*, *cyanide*, *hemlock*. These examples, in turn, are associated with even more specific details. For example, cyanide was commonly used in gas chambers[30] in the US to execute criminals[31]. It was also used in capsule form by Adolf Hitler, Heinrich Himmler and Hermann Goering to commit suicide.[32] Hemlock is famous as the poison that killed Socrates, and a well-known insecticide is DDT.

However, we might question whether to include *insecticide* in the context of *poison*. While they do fit the definition in that they harm organisms, other chemicals which also harm organisms are not included, for example antibiotics. Like insecticides, which specifically harm insects but may also harm other organisms such as birds or humans[33], they are specific poisons which are meant to harm bacteria with the intention of treating an illness caused by a bacterial infection. Often, as the diagram otherwise suggests, poisons cause harm to vertebrate animals, especially humans. And in fact, the non-human "poisons" mentioned, the so-called rat poisons strychnine and warfarin, are also drugs used in humans, strychnine a recreational and performance enhancing drug[34] and warfarin an anticoagulant[35]. We also might question whether poison ivy should be included in the diagram, but anyone from the American Midwest with experience with this plant knows the annoying effects of urushiol.

So, while the diagram above, Diagram 10, shows one way of understanding the concept poison, other language users will draw different diagrams with different examples depending on their experiences with the concept. For instance, while the English Wikipedia page[36] mentions cyanide, execution, gas chambers, suicide, and Socrates, the Japanese Wikipedia page for 毒, the most common gloss for poison, uses sugar and salt as examples of substances that can be poisonous but are not considered poisons and mentions thalidomide (as having weak toxicity), sarin, and fugu.[37]

On the other hand, Diagram 11 shows how we might diagram, and therefore understand, for example, warfarin:

[30] https://en.wikipedia.org/wiki/Cyanide (retrieved September 7, 2015)
[31] http://missourideathrow.com/doc-history/gas-chamber/ (retrieved September 7, 2015)
[32] https://en.wikipedia.org/wiki/Cyanide_poisoning#Suicide (retrieved September 7, 2015)
[33] http://www.cdc.gov/niosh/idlh/50293.html (retrieved September 26, 2015)
[34] https://en.wikipedia.org/wiki/Strychnine#Performance_enhancer (retrieved September 7,2015)
[35] https://en.wikipedia.org/wiki/Warfarin
[36] https://en.wikipedia.org/wiki/Poison
[37] https://ja.wikipedia.org/wiki/%E6%AF%92

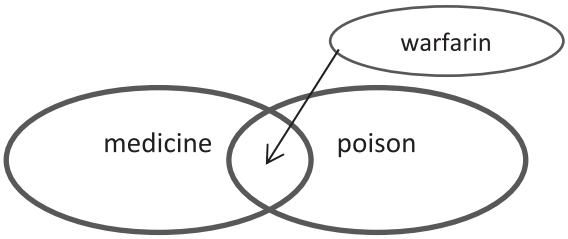

Diagram 11

In one context, warfarin is a medicine used to prevent blood clots[38] while in another it is used as rat poison. To interpret a text discussing this chemical substance it is necessary to know the context in which it is being used. And if nicotine ever becomes an accepted medicine used to treat some illness, we will also have to think of it as a medicine in one context, an insecticide in other contexts, and yet in another context a mood altering drug referred to as a "medicine" only as a joke.

Making Connections

When translating, it is not the language that we remember but only the meaning. So, if students are to use the language itself, they need to understand not just the meaning of the text they have just read, but also notice how the words in the target language are connected and how their meanings change in other contexts. Looking at the texts used, rather than asking what does it mean and then being happy with that, students should also question why that word was used in that context, why that particular construction, and begin to make their own semantic nets and word diagrams.

Making mental connections between words, whether the written or spoken forms, and their meaning and usage is how languages are learned. And while the verbal definitions found in dictionaries are still certainly valuable and perhaps the most convenient way to explain vocabulary, they remain abstractions unless the learner makes mental connections between concepts and words. So, the value of diagrams is that 1) they can explain the concept behind the words as they are understood in the mind, and 2) they can help students make mental connections to the vocabulary and therefore help them to understand and remember the words.

And it is the making of connections, logical and categorical, that will help students learn the language.

[38] https://www.nlm.nih.gov/medlineplus/druginfo/meds/a682277.html (retrieved October 20, 2015)