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Mnemonics Devices in Science

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Anna Juranska

For all my past and future school students.

Małgorzata Krzeckańska



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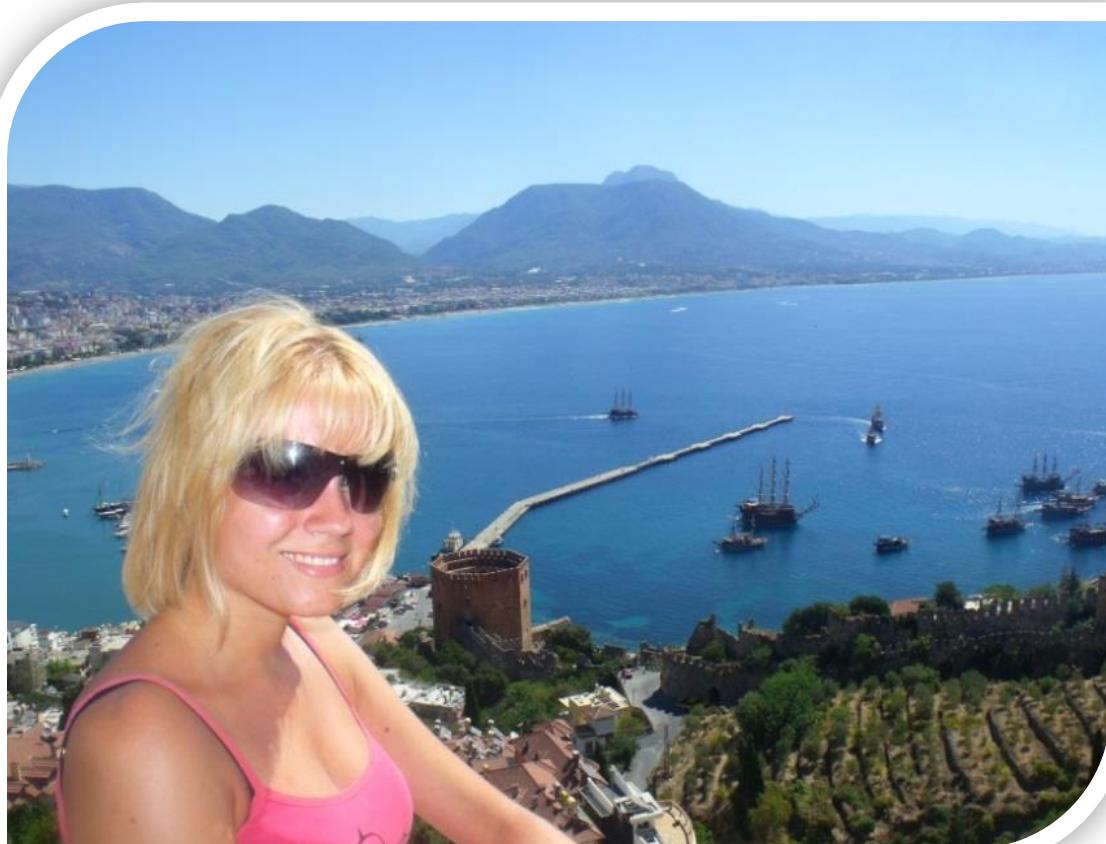
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- Oxidation states and oxidation-reduction reactions according to organic chemistry and biochemistry;
- The methodics of the multimedialistic presentations;
- The didactics and the methodics of the toxicology;
- Methods of the chemical education, resources didactic and scenic tools;
- Methods of the activation.



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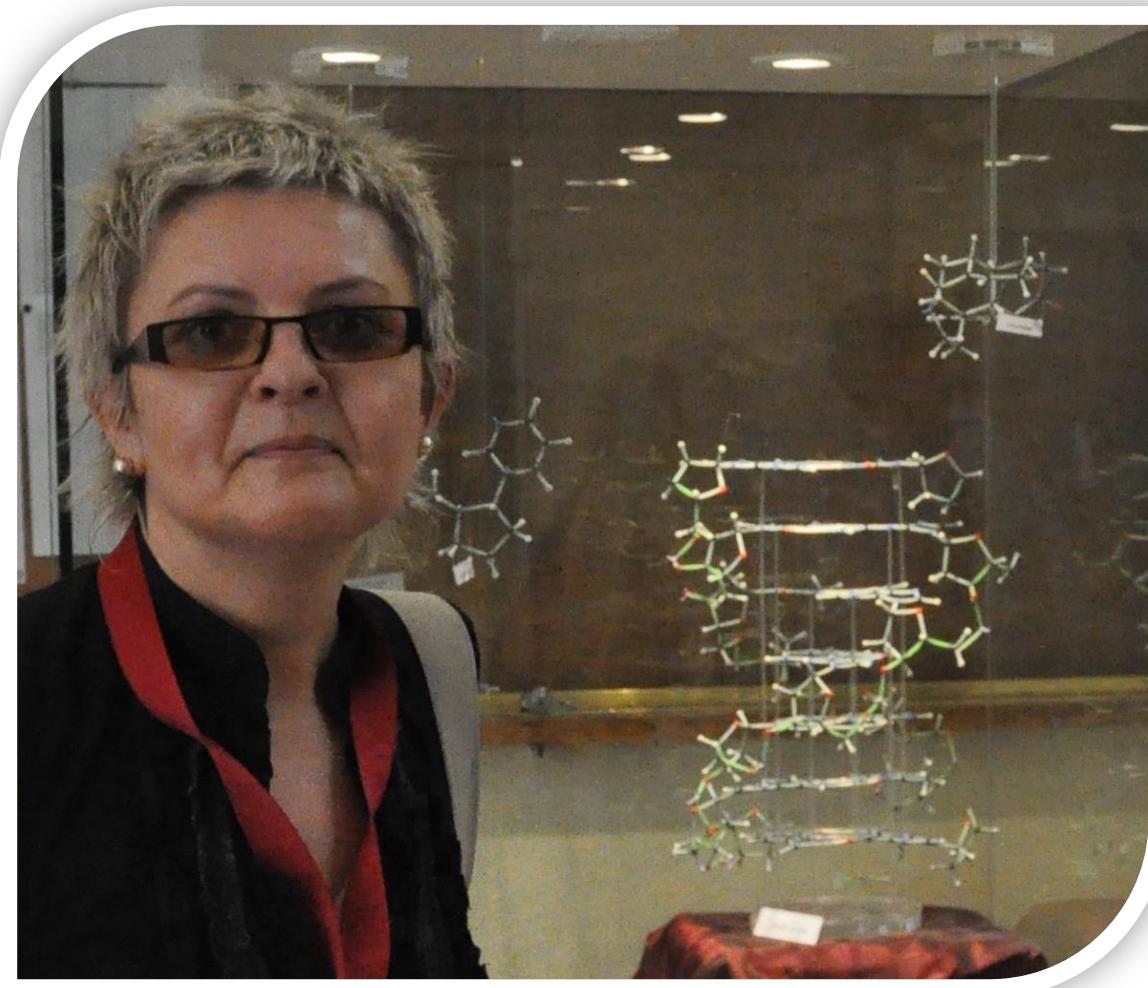
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Still improves her knowledge and experiences... All daily challenges are the results of passion; are a real pleasure and a challenge. Free time devotes to biking, listening to classic music and... writes poems.

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1

Introduction

1.1. Etymology of word “Mnemonics”

The word “mnemonics” derives from the μνημονικός (*mnēmonikos*), means “of memory”, or “relating to memory” and is connected to Mnemosyne - the Greek titan, goddess of memory that represented memory (“remembrance”) in Greek mythology. Mnemosyne was the daughter of Uranus - god of the Sky, and Gaia - Mother of Earth. Additionally, Mnemosyne was the mother of the nine muses, all of whom were fathered by Zeus. What is more, mnemonics also is derived from “*mnemon*”, which means “remembering or mindful” and from “*memne*” - which means “memory, record, or epitaph”. This word is based on “*mnasthai*” - “to remember”, which comes from “*men-*”, which means “to think”. Both of mentioned words are derived from μνήμη (*mnēmē*), “remembrance, memory”. Mnemonics (“nee-moh-nicks”) techniques, also called a *mnemonics strategies*, *mnemonics devices*, *mnemonics techniques/method* or *mnemonics*, are systematic procedures designed to improve our memory. On the other hand, the general name of mnemonics, or *memoria technica*, was the name applied to devices for aiding the memory, enabling the mind to reproduce a relatively unfamiliar idea, and especially series of dissociated ideas, by connecting it, or them, in some artificial whole, the parts of which are mutually suggestive.

1.2. A brief about mnemonics history

Mnemonics has a rich history, possible dating back to prehistoric times when it most likely aided in record and storytelling. A Greek poet Simonides was purported to have created the first system of memory aids in 477 BC, however many investigators believe that, his technique dates much further back into history. Simonides said that, he has remembered every person in a large banquet hall sat, thus helping identify bodies after the building collapsed. Presumably, Simonides had created a space in his mind and had filled it with all of the people. Not far later, was written a *Dialexeis*. Even though, the excerpt on memory within it was short, the author discussed

memory aids for objects, for words and also discussed the technique of rote memorization. The concept of memory increased techniques spread to the Romans, as almost all things were divided among those two cultures.

The *Rhetorica* and *Herennium* - also known as "*Rhetoric: For Herennius*", formerly attributed to Cicero but of unknown authorship, is the oldest surviving Latin book on rhetoric, dating from the 90s BC. This book is focused on problem how Roman's viewed memory aids and discusses how people wishing to enhance their memory should create a place in their mind, such as a building, what is known as a loci. The next step is creation an image related to the thing that wish to remember and put it in the formed location (this method will be discussed in *Multiple use paragraph*). On the other hand, another area of *Ad Herennium* by Patten in 1990 refers the use of exceptionalizing an image in our mind, in order to increase retention of a memory. The application of e.g. large jewels, lively colors, or hideous creatures in an image according to the author, can make the image easier to recall.

In turn, Plato and Aristotle try to explain a memory over the interaction of the soul in the creation and permanence of memory. However, Plato discussed memory as an act of the soul, while Aristotle believed memory was physiological and empirical. Unfortunately, after the fall of the Roman Empire, the art of memory was forgotten. However, works of Aristotle were kept alive within the confines of monasteries and in the 13th century, Thomas Aquinas valued soul and memory connection. At that time, memory aids began applied into the classrooms of younger students – e.g. in the 1500s it was common to be used for learning grammar and more complex ideas, such as the alphabet, visual images were used to help recall memory on a specific topic. Hence, mnemonics were frequently used to encourage integrity and played a starring role in education.

Ignatius of Loyola in the 16th century wrote the work about application of all five senses when developing a memory in order to increase the longevity of the memory. Additionally, during this same time, was introduced the peg system, where a given set of images are associated with serial numbers. These images serve as pegs. Once these are memorized, any list can be quickly memorized by placing visuals of the list into the given pegs (this method will be discussed in *Extrinsic cuing (Peg type) methods*). Then was developed the phonetic system. In this kind of complex system, numbers are represented by letter sounds; these sounds are used to form words, the words are used for the person to form related images and these images are placed into a loci, for later retrieval. Probably, memory systems relayed on the same basic practices and remained virtually unchanged until the 19th century.

In the late 19th century, mnemonics once again makes a comeback as the field of psychology. This lead some scholars to reexamine the ancient works and methods already discussed. These works most likely fell into these researchers' hands by the very invention that aided in the demise of mnemonics, the printing press.

What is interesting is that, the e.g. first letter mnemonics, acrostics, links, and also alphabetism are all examples of relatively new forms of mnemonics. But why alphabetism is connected with mnemonics devices? For example mnemonics acronyms are acronyms that use the first letter from each word in a list, to create a

new easy to remember word, what is very similar to alphabetism, which uses the first letter of each word in a phrase to make a corresponding word (see also *Application of mnemonics methods in learning students with disabilities and behavior problems*).

While many of the mnemonics listed above revolve around the use of acronyms, there are many other forms, Atkinson in 1975 proposed linking an acoustic mnemonics to a imagery mnemonics in order to help students learn Russian (see also *Application of mnemonics devices in second language learning*). Shortly after the release of Atkinson's paper, researchers started to study the application of mnemonics as teaching aids for educationally handicapped students (students with disabilities and behavior problems – see also *Application of mnemonics methods in learning students with disabilities and behavior problems*). For example, Joel Levin with Thomas Scruggs and Margo Mastropieri were some of the forefathers of this area of research. Each produced a copious number of studies on the relevance of mnemonics for teaching learning disabled individuals.

On the other hand Higbee and Kunihira in 1985 described Yodai methods that have been taught in Japan since the mid-20th century. These mnemonics were created by a man named Masachika Nakane, who developed a process of mnemonics known as Yodai. His concept revolved around the idea that all subjects can be condensed down to a few select key elements. If these elements are taught, the rest of the subject content will be easy to learn.

Since the 1970's and 80's, mnemonics devices have once again begun to appear in school practice. Bright colored pictures are often found in handbooks to aid in learning the material. Posters are strung up around classrooms. Kindergarten classes have alphabet letters that look like the object that they are associated.

As was mentioned in abstract, in nowadays there is a lack of suitable article related to mnemonics strategies, if they exist - most of these were over a decade old. What is more, almost all of these were in relation to teaching vocabulary, except for those referring to children with learning disabilities. So, how can teachers be adequately applying traditional mnemonics to instruction in typical classrooms, if research about this area does not popular or are not exist? This was also our subject of research in Polish schools.

1.3. What mnemonics devices are?

The concepts of mnemonics devices are: 1) application in developing better ways to encode information; 2) much easier to remember (retrieve) information. Hence, mnemonics devices ought to be understood, as learning strategies which can often enhance the learning and later recall of information. The main idea in mnemonics strategies is to find a connection between new information to information students have already locked in long-term memory. If people make an enough strong connection, the memory will last a very long time, because the mnemonics strategies had carefully connected with things that will be very familiar according to these procedures can be powerfully effective. Moreover, the mnemonics devices can be

incorporated for the thinks that require recall. These strategies are also veryuseful way of improving memory in students, who exhibit difficulty with remembering things. Hence, the mnemonics devices are not an educational panacea, but can be an important part in improving memory for learning or teaching processes.

1.4. Nomenclature and classification of mnemonics methods

There are a various types of mnemonics methods can be described, but there is a lack of suitable classification and nomenclature system of those methods. For this problem very important is that, the basic distinctions between mnemonics that primarily involve organizing operations and those that primarily involve encoding operations. Hence, an organizing operation is one that associates or relates in memory units of information that at first appear unrelated. Furthermore, an encoding operation transforms a unit of information into some other form, that can be fit into some organizational scheme. Mnemonics devices have been differently classified by different authors, for example Thompson in 1987 arranges mnemonics strategies into five classes: linguistics, spatial, visual, physical response and verbal methods. On the other hand, Oxford in 1990 identifies four major strategies: namely, creating mental linkage, applying images and sounds, reviewing well, and employing action. In turn, Baddeley in 1999 described that mnemonics devices can be classified into visual imagery strategies and verbal strategies. However, in this article we decided to classification adopts the one from Bellezza in 1981 – Fig. 1. article, which sounds to be more comprehensive in our opinion.

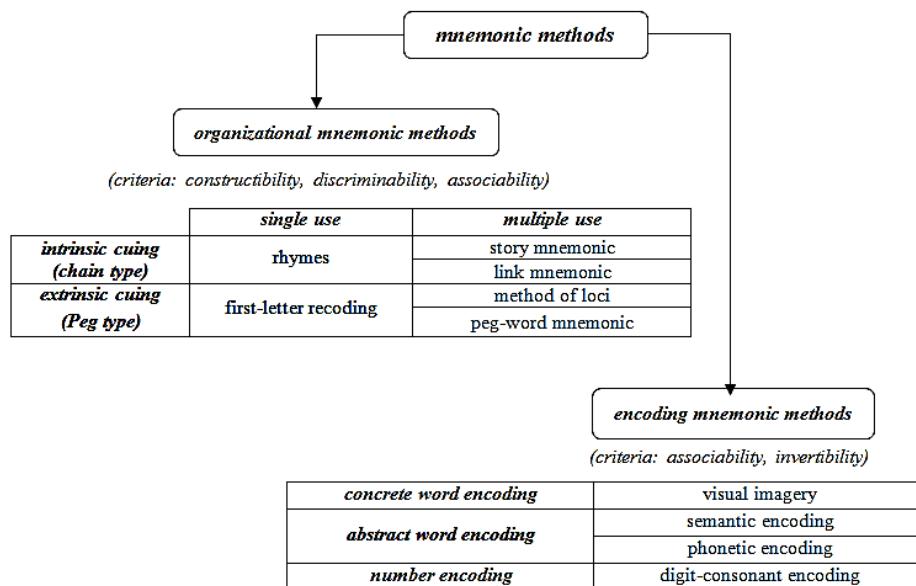


Fig. 1. Classification of mnemonics methods - based on literature.

As presented in Fig. 1, the mnemonics methods can be divided in two groups: (1) *organizational mnemonics methods*; and (2) *encoding mnemonics methods*.

1.4.1. Organizational mnemonics methods

In some types of organizational mnemonics, it is important to memorize a set of mental cues, which then become part of the mnemonist's repertory of memory locations to be used as needed. New information can be associated to these cues and thus be remembered. The organizational mnemonics methods can be divided in two general types: (1) *intrinsic cuing* (or the chain-type mnemonics) and; (2) *extrinsic cuing* (or the peg-type mnemonics). Both of them are characterized by unitizing information into some connected hole in memory so that it can be better retrieved. The retrieval process takes place by self-cuing on the part of the user.

In an intrinsic cuing mnemonics, a recall is based on cues which themselves are part of the list to be remembered. In turn, in an extrinsic cuing mnemonics, a recall is based on cues extrinsic to the information being recalled.

1.4.2. Intrinsic cuing (chain type) methods

As was presented in Fig. 1, the intrinsic cuing methods or chain type methods can be considered as single use or multiple use methods. Below we described all of these methods.

1.4.2.1. Single use

Rhymes method

This method was first described by Bower and Bolton in 1969. The main idea of this method is that, the information needed to be remembered is made up into a rhyme. Well known example of application this method is approach to remembering the number of days in each month: "Thirty days has September, April, June, and November, ..." By forcing the information into rhyme, it becomes easier to remember because the alternatives that will fit when the material is reconstructed at the time of recall are limited in number. This method can be additionally applied to remembering numbers – e.g. in mathematics for remember the value of pi number up to 10 decimal places which the number of letters in each word of the rhyme gives each successive digit, what was described by Baddeley in 1976.

1.4.2.2. Multiple use

Story mnemonics method

A story mnemonics method was first described by Bower and Clark in 1969. What is interesting is that, the guides for using the story mnemonics method usually do not emphasize in special way, the application of visual imagery and in the story mnemonics the cuing structure seems to be primarily verbal. The mnemonist adapt each following word on a list into a story that he or she creates as the items are presented. The main point is that, the story is later recalled, little difficulty is

experienced in distinguishing what words were the words presented in the list and also what words were added to make up the story. What is more, all created stories are usually enough different from the others, hence interference does not occur and a number of lists of words can be retained in memory at the same time. The story themes made up for various lists are different and depend on the particular words in the list for their unique content. The hierarchical structure of the particular story created provides the mental cues necessary for recall of the presented words. However, if some words are forgotten, then parts of the hierarchy of the story acting as mental cues may not be retrieved, resulting in the inability to recall some words occurring in the list. Moreover, visual imagery and manipulating verbal elaboration independently is usually a difficult task, and it can be possible that the creation of a story is automatically accompanied by visual imagery. In turn, application of the story mnemonics may not result in a linear organization of words in memory.

Link mnemonics method

The idea of this mnemonics method is to form a visual image associated with the first and second word of the list, then form a completely different visual image connecting the second and third word, then the third and fourth word, and etc. The overlapping series of images associating the sequence of pairs of items in the list act like interlocking links in a chain. Hence, a visual image is used to link Word 1 to Word 2, a second visual image is used to link Word 2 to Word 3, and so on until N-1 visual images have been used to link the N words in the list. Application of this method make possible the cognitive cuing structure created consists of a series of overlapping visual images. Furthermore, if any one word in the list is forgotten, recall of the rest of the words is adversely affected. The chain is only as strong as its weakest link, so if any link in the chain of images is forgotten, then it may not be possible to recall any of the words following in the chain.

1.4.3. Extrinsic cuing (Peg type) methods

1.4.3.1. Single use

Single-use method can help us, how much information needs to be remembered. Sometimes these mnemonics are not very good at cuing responses, but are good at ordering information already well known. This mnemonics consists of one method: *first-letter recoding*. Associating first letters of word is the most popular mnemonics procedure reported for a variety of learning tasks. In this method words are remembered by arranging their first letters either in alphabetical order or so that they form a word. The array of letters is then supposed to act as a cuing structure for the words in the list. For example the letters in the word *homes* representing the names of the five Great Lakes (Huron, Ontario, Michigan, Erie, Superior) and indicate the first letter in each of their names.

1.4.3.2. Multiple use

The method of loci and the peg-word mnemonics provide the learner with a cognitive cuing structure that is permanently stored in memory and can be used when needed for both associating information to it and later recalling that information by a process of self-cuing. What is more, the method of loci and the peg-word can be used repeatedly. This cuing structure, such as a series of loci or a series of peg words, is usually first memorized before the mnemonics system is put to use. The method of loci and the peg-word mnemonics are usually referred as *peg-type* mnemonics method, due to the fact that they resulted in essentially identical recall performance under a variety of test conditions.

Method of loci

One of the oldest mnemonics method mentioned in introduction, is the *method of loci* – method of location. Probably this method was first described in Roman rhetoric books, but it may have begun many years before. In this method, mnemonist must have prememorized the images of a sequence of locations, so this method needs a number of stages. If the part of information to be memorized is not a list of words, but e.g. a text, it must be reduced to a sequence of essential words that represents an outline of the text. Hence, each of all words are associated to its corresponding location using visual-imagery mediation. The loci method organize information by providing a ready-made memory structure for it, and within the structure are a number of places, such us distinctive containers, for the items of information to be stored. This process makes possible the items to be recalled in a specific order: recall from Locus 1, then from Locus 2, and etc. Method of loci is not only giving the possibility a great deal of information to be recalled, but additionally is connected with serial organization on it. Sometimes, this organization is not necessary but sometimes it is - e. g. when the method of loci is used to memorize the names in the correct order. Furthermore, the same set of loci could be used over and over again for different images from new speeches. Therefore, application of this method, retroactive interference occurs. However, not much proactive interference seems to occur unless the retention interval is long with respect to the time between learning the two different sets of images. As was mentioned earlier, this method was used in ancient times to memorize speeches, so it is not surprising that researchers are looking at possibility, which can be used to better remember the content of prose passages.

Peg-word mnemonics method

In this method, the images of the concrete objects are applied as the pegs to which the images to be remembered are attached. What is interesting, rather than using images of physical locations as mental cues, images of familiar objects are

used as cues in this method. What is interesting is that, the most of peg-word form is that, there is a method for remembering the peg words and also their order. For example, the well-known rhyme "*one is a bun, two is a shoe, three is a tree, four is a door, five is a hive, six is sticks, seven is heaven, eight is a gate, nine is a fishing line, and ten is a hen*" represents a way of remembering ten peg-words, so later a list of ten items can be memorized by associating them with the peg-words. What is more, in the rhyming peg-word, each peg word rhymes with the number indicating its position in the list. In more complex peg-word systems a formal scheme such as the digit-consonant encoding mnemonics is used to associate a peg word with its ordinal position in the list. Moreover, this method can be used also to learning a second-language vocabulary.

1.4.4. Encoding mnemonics methods

The main function of an encoding mnemonics is to recode new information. After using an encoding mnemonics on each item the encodings can be associated later with another one or become part of a more complex cuing structure. Hence, the major criterion for evaluating any cuing structure created by an encoding mnemonics is degree of associability.

1.4.4.1. Concrete word encoding method

Visual imagery method

Idea of a visual images is based on imagine, not on immediate perception, is an example of visual imagery method. The imagery process is an encoding process that enhances memory performance. However, the given word representing something well-known (e.g. place, person, thing etc.), can causes difficulty with forming a visual image of what the word represents. Moreover, by imaging the person is somehow activating or retrieving from memory sensory information associated with the referent of a word when only the word itself is presented. What is interesting, the visual imagery is besides important as an organizational mnemonics. For example, if two words are to be associated in memory, a composite, interacting image of the two referents should be formed. Moreover, forming two separate but simultaneous images will result in a much weaker association. Additionally, another types of sensory imagery such as tactile and auditory seems to be strengthen associations.

1.4.4.2. Abstract word encoding method

Abstract word encoding method is another kind of encoding mnemonics methods. It seems that, abstract words are more difficult to remember than concrete words due to the fact that they are more difficult to visually image. The possible approach is to apply an encoding procedure based on the meaning of the word to transform each abstract word into a visual image or into another word that is higher in imagery value

than is the original word. In this method the cognitive cuing structure created consists of a separate and independent cue for each item. The decoding of each image back into its associated abstract word is usually not as simple a labeling process as is. Hence, when the same image that was formed at encoding is retrieved at recall, it acts as an effective recall cue for the presented word regardless of the inherent relation between what the image represents and the meaning of the word that it was used to encode. Another approach in this method is based on phonetic encodings rather than semantic ones. The application of punning technique make possible that, an abstract word can be transformed into the concrete word. Such prepared word in mind can then be visually imaged.

1.4.4.3. Number encoding method

Last method of encoding mnemonics methods is number encoding method using digits or numbers. This is method is not difficult, due to the fact that forming visual images of digits or to form sentences using numbers are not sophisticated. However, even if digits and numbers may be imageable, they have little "meaning" and are not easily associated with one another or with the cuing components of an organizational mnemonics. The procedure recommended by writers is a system described first by Winckelman. This system use encoding the numbers into words by translating each digit into a predetermined consonant sound. Due to the invertibility of the digit-consonant encoding mnemonics any pronunciation of a word can be translated into a string of digits. Moreover, this system is based on pronunciation but not on spelling.

1.5. The mnemonics methods as didactic tools

1.5.1. Different countenances of mnemonics methods in didactics

It must be emphasize that, the mnemonics methods are not an overall teaching method or curricular approach. The idea of mnemonics strategies is so specific, that they are intended to be used to enhance the recall of the components of any lesson for which memory is needed. What is more, from didactic point of view, the mnemonics strategies are memory strategies, and not comprehension strategies. As was mentioned earlier, many articles evidence that application of mnemonics method by students or pupils increases the results in comprehension tests – but why? This situation occurs, because they remember more information which can be applied on comprehension tests. For example, Chase and Ericsson described that regular college students can attain world-class memory performance after extensive practice and proposed skilled-memory theory as an account for how ordinary people can acquire exceptional memory. On the other hand, due to the exceptional memory performance, Wilding and Valentine described that the skilled-memory theory did indeed account for truly exceptional memory performance involving specific types of materials, such as digits. Moreover, those authors also proposed evidence for the

existence of naturally superior memory, where some people's memory, for specific materials, was never truly exceptional, but consistently well above average for several different materials tested. Besides, these subjects reported that they did not use mnemonics encoding strategies. Based on this observation, it can be ascertained that mnemonics strategies are not comprehension strategies, but only memory strategies/methods.

Overall, the mnemonics devices are not the teaching methods. It was also proved that mnemonics strategies can be used to enhance science learning, when the curriculum involves a lecture, textbook format or when the curriculum involves a hands-on, inquiry learning format. However, in spite of many advantages it is possible to obtain a wrong conclusion that mnemonics devices inhibit comprehension. In turn, the mnemonics methods are very good way to understanding science in school, but in academic content those strategies may be an important instructional component. It was also observed that, when students generate their own strategies, instruction may proceed at a much slower rate and students' performances may be lower than in situation when teachers supply the strategies. On the other hand, some studies indicated that students who have been taught strategies for creating their own mnemonics outperform comparison students in free-study conditions. This problem can be summarized that, everyone needs individual developed strategy, but it seems that combination of student-generated and teacher created mnemonics strategies is the best way.

1.5.2. The role and the meaning of mnemonics methods in learning and teaching in different fields of study

It is very probable that people forget what they have learned very quickly, if they have not enough strong connection between think and something very close/personal. Due to this fact, people need tools to aid recall. It is imperative that learners elaborate on new information to commit the new material to long-term memory. Elaboration occurs when the learner constructs a memory link between a bit of new information and some related information already held in long-term memory. In the best situation, the learner pauses for a moment and determines how to fit the new piece of information into the existing framework. The elaboration process is complete when the learner successfully fits the new information into their existing mental structures or schemata.

In this case, the mnemonics methods can be effective in generating associations between otherwise "meaningless" or unrelated information, such as dates and names. Hence – undeniably, mnemonics devices have been proven to be extremely effective in helping people remember things. Many people wrongly account that individuals are able to recall large amounts of information seemingly effortlessly most people will infer that they must have a naturally superior memory that is qualitatively different from ordinary adults. Moreover, memory performance for those types of meaningless materials can be dramatically improved by mnemonics training.

Mnemonics methods are effective because they transform nonmeaningful/nonsensical information into concrete, meaningful proxies.

Mnemonics methods are unlikely to benefit memory in skilled everyday activities, however, where memory encoding must be task specific and appropriate for the relevant tasks. During skilled everyday activity information needs to be encoded to allow direct access to domain-specific knowledge necessary to complete the task. It is proper to pay attention that these methods have a wide applications in problems connected with the memory of older persons e.g. remembering of the shopping list, face-name association learning.

From the point of view of education, many sources evidence that pupils and student, who are using mnemonics method, also perform better on comprehension tests. Moreover, using of mnemonics devices often results in very high levels of recall performance. These methods operate by the use of cognitive structures, but on the other hand these methods are characterized by low or lack of relation to the conceptual content of the material being learned and also they are focused only on certain aspects of their operation.

1.6. Application of mnemonics devices in learning and teaching of science subjects

Approaches to science learning are very different mnemonics strategies can be incorporated for the elements that require recall. Educationally, mnemonics methods can have a significant impact on study or teaching important information, and can improve recall and bolster the student's self-confidence, which in the science field is important because the ability to recall new information is often more difficult due to the unfamiliarity of the content. Mnemonics procedures and materials are valuable in classroom teaching, but there is some question as to how effective self-initiated mnemonics strategies are for all learners.

Mastropieri and Scruggs in 1998 have found, that mnemonics strategies can be used to enhance science learning when the curriculum involves a handbook/lecture format or when the curriculum involves a hands-on, inquiry learning format. Even though these approaches to science learning are very different mnemonics strategies can still be incorporated for the elements that require recall.

In science subjects (chemistry, biology, physics and mathematics also) there is a lot of mnemonics example, but describing those examples are not idea of this book. However, we decided to list of chosen popular examples of mnemonics devices in science subjects for interested readers in Table 1.

Table 1. Examples of mnemonics devices applications in science subjects teaching and learning.

Science subject	Example	Reference(s)
chemistry	Monosacharides	Stewart (1945), Leary (1955), McMurry (2004)
	Thermodynamic functions	Christie (1957), Yen (1954), Phillips (1987)
	Gas laws	Midgley (1950), De Milt (1951).
	Indicator Colors	Banks (1941), Wellings (1956).
	Mole and Molarity	Margo, et al. (2005)
	Electronic configurations of atoms	Nerea & Manuel (1995), Mabrouk (2003), Pilar (1978)
biology	Vertebrates: Fish, Amphibians, Reptiles, Mammals, And Birds	Mastropieri & Scruggs (1998) Scruggs et al (2010)
	The Krebs cycle	Yeoh (2012), Kozliak (1999), Siqueira, et al. (1988)
	The Calvin Cycle	Miranda (2013)
	The order of taxa in biology	Wallace, et al. (1986) Staff (2011)
physics	Color coding on electronic resistors	Prakash (2006) Katzin (1992)
	The colors of visible light (colors of the rainbow)	McCabe, et al. (2013) Morris & Cook (1978)
	Speed of light in meters per second	Parkinson (2007)
	Maxwell relations in thermodynamics	Zhao (2009)
	Metric prefixes	Kleinheksel & Summy (2003)
mathematics	Pi number	Bellezza (1981) Barcroft (2013)
	Correct order of operations of an algebra	DeLashmutt (2007)
	Number for sequences	Eckler (2008)
	Trigonometry	Hunt (2010) Lesser (2011)

1.7. Application of mnemonics methods in learning students with disabilities and behavior problems

There is no doubt that, mnemonics strategies organize and integrate the transformation of difficult to remember information into something that is more meaningful for individuals to recall at a later date by using associations between new and previously learned information in long-term memory. Mnemonics strategy instruction for students with learning disabilities and other mild disabilities has been studied experimentally for almost 20 years. Students with learning disabilities and other special needs may be at particular risk for failure in school. As was described by Mastropieri et al. in 1998 teachers should teach students *how* to remember as well as *what* to remember. This can be done by a variety of strategies, but most useful have been the keyword method, the pegword method, and letter strategies. Systematic instruction using mnemonics methods for important information to remember, as well as systematic instruction in independent use of mnemonics strategies, can be important factors in determining school success for students with learning and memory problems.

For example, as was described by Mastropieri et al. in 2005, the pegwords method is usually easy for students with learning disabilities to learn and can be mastered by simply practicing the list a few times. Then, substitute a pegword for a number within interactive illustrations with the to-be-associated information, just as in the keyword illustrations. The example can be approach how to learn that insects have six legs. Mastropieri described that in first step, we must teach the pegword sticks for six, next teach students to think of an insect walking on sticks or show an interactive illustration of the information. Finally, we can ask "How many legs does an insect have?" - students are taught to think of "insects" and what was happening in the picture with the insects in it, recall that the insects were walking on sticks, remember that sticks represented six, and respond with the number six. This approach is also related with this, that researches have indicated that learning is greatly facilitated for students with learning disabilities when combinations of facts are integrated within one illustration.

What is more students with learning disabilities have been taught to successfully generate mnemonics strategies independently, research findings indicate that they learn more content in shorter instructional time periods when mnemonics strategies are developed and presented by teachers. However, this does not indicate that teachers should not encourage students to develop strategies independently but it does imply that teachers should think carefully about the allocated time for specified subject areas and content-to-be-covered. Hence, if there is sufficient time for students to learn to develop and generate their own strategies, encourage them to do so. Additionally, very important is that, the once mnemonics materials are developed, they can be used again and again.

Literature review indicates that mnemonics are very effective for meeting one critically important aspect of school learning. It is also important that teachers can be successful

at developing and implementing these strategies, and that both teachers and students appreciate their value.

1.8. Application of mnemonics devices in second language learning

What is interesting, the encoding technique relying on phonetic encoding has been used effectively and very often in teaching a second-language vocabulary. This example of use seems strange and difficult, however it is very easy. In this approach a foreign word is presented and its English translation must be remembered. The English word, the "keyword," is found that sounds like some part of the foreign word to be learned. This is possible, when the phonetic encoding of the stimulus unit occurs. Next step is forming a mental image of the keyword interacting with the English translation of the foreign word. Hence, the correlation between the foreign word and its English equivalent can be based on two associations: 1) phonetic (acoustic) and 2) visual imagery.

The application of mnemonics studies in second language learning by phonetic (acoustic) association was first described by Atkinson in 1975. He proposed linking an acoustic mnemonics to a imagery mnemonics in order to help students learn Russian. The students were given an English word that sounded similar to the pronunciation of the Russian word. Then, students were told to imagine that word interacting with the true definition of the word. Not only did this spark interest in mnemonics as an aid to teaching language, due to his successful results, but his final remarks in the paper, where he stated that this technique might be very useful for those students that find language learning especially challenging, lead to a whole new application of mnemonics.

1.9. Why mnemonics devices are effective?

From a cognitive perspective, mnemonics strategies are effective because they form an effective acoustic-imaginal link between the stimulus and response. Undeniably, the mnemonics devices are characterized by numerous advantages; however there are also some disadvantages. On the one hand, mnemonics are not comprehension strategies, but on the other hand, there are procedures for intensification a memory. As didactic tool, they are extremely effective in helping people to remember things; however there is a lack of relationship between the conceptual content and the material being learned. What is interesting is that, the educational research indicate that, the own prepared mnemonics by students outperform the results in comparison to students in free-study conditions, but also students' performances may be lower than when teachers supply the strategies. Due

to the information point of view, mnemonics techniques often better enables information to be retained in memory, however they are focused only on certain aspects of their operation and they are not dependent as a memory schema. And at last – mnemonics devices are memory strategies but they are not a teaching and learning methods, they can be only considered as didactics tools.

According to all mentioned earlier and discussed aspects of mnemonics devices, in Table 2. we present advantages and disadvantages of mnemonics methods.

Table 2. Advantages and disadvantages of mnemonics strategies.

disadvantages	advantages
<ul style="list-style-type: none"> ▪ are not a comprehension strategies; ▪ low or lack of relationship between the conceptual content and the material being learned; ▪ students' performances may be lower than when teachers supply the strategies; ▪ are focused only on certain aspects of their operation; ▪ are not a teaching and learning methods; 	<ul style="list-style-type: none"> ▪ procedures for intensification a memory; ▪ extremely effective in helping people to remember things; ▪ own prepared mnemonics by students outperform the results in comparison to students in free-study conditions; ▪ often better enables information to be retained in memory; ▪ memory strategies; ▪ is not as dependent as a memory schema;

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2

Mnemonics devices in biology

2.1. Mnemonics method - how to remember the bowel components?

- Duodenum
- Sigmoid
- Cecum
- Rectum
- Colon
- Jejunum
- Appendix
- Ileum

Dublin Sisters Ceramic Red Colored Jewelry Apparently Illegal

From proximal to distal:

- Duodenum
- Jejunum
- Ileum
- Appendix
- Colon
- Sigmoid
- Rectum

Dow Jones Industrial Average Closing Stock Report

To include the **cecum**:

Dow Jones Industrial Climbing Average Closing Stock Report

2.2. Mnemonics method - how to remember the diaphragm apertures: spinal levels?

"**3 holes**, each with **3 things** going through it":

Aortic hiatus: aorta, thoracic duct, azygous vein.

Esophageal hiatus: esophagus, vagal trunks, left gastric vessels.

Caval foramen: inferior vena cava, right phrenic nerve, lymph nodes.

or

Aortic hiatus = 12 letters = T12

Oesophagus = 10 letters = T10

Vena cava = 8 letters = T8

2.3. Mnemonics method - how to remember the aorta and vena cava, which is on the right and which is on the left?

Aorta and **right** each have **5** letters, so aorta is on the right.

Vena and **cava** and **left** each have **4** letters, so vena cava is on the left.

2.4. Mnemonics method - how to remember the causes of aortic regurgitation?

- **Congenital**
- **Rheumatic damage**
- **Endocarditis**
- **Aortic dissection/Aortic root dilatation**
- **Marfan's**

CREAM

- **M**arfans
- **A**nykylosing spondylitis
- **R**heumatic fever
- **R**heumatoid arthritis
- **I**nfective endocarditis
- **S**yphilis

MARRIS

2.5. Mnemonics method - how to remember the aortic dissection?

Risk factors **ABC**

Atherosclerosis/ **A**geing/ **A**ortic aneurysm

Blood pressure high/ **B**aby (pregnancy)

Connective tissue disorders (eg Marfan's, Ehlers-Danlos)/ **C**ystic medial necrosis

2.6. Mnemonics method - how to remember the aortic stenosis characteristics?

- **S**yncope
- **A**ngina
- **D**yspnoea

SAD

2.7. Mnemonics method - how to remember the aortic arch?

Major branch order "Know your **ABC'S**":

Aortic arch gives rise to:

Brachiocephalic trunk

left **C**ommon **C**arotid

left **S**ubclavian

2.8. Mnemonics method - how to remember the spinal cord nerve origins?

Sensory - **A**fferent

Motor - **E**fferent

Dorsal - **A**fferent

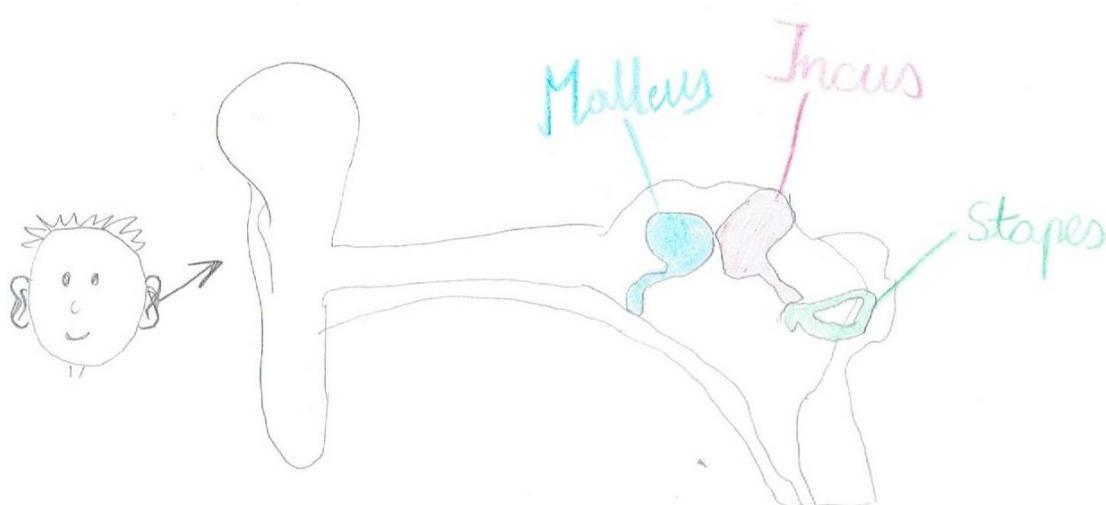
Ventral - **E**fferent

SAME DAVE

2.9. Mnemonics method - how to remember the inner ear bones?

- **M**aleus
- **I**ncus
- **S**tapes

never **MISS**



2.10. Mnemonics method - how to remember the heart valves?

- **T**ricuspid
- **P**ulmonary
- **M**itral
- **A**ortic

Turn **P**ike **M**any **A**ccidents
Try **P**ulling **M**y **A**orta

2.11. Mnemonics method - how to remember the excretory organs of the body?

- **S**kin
- **K**idneys
- **I**ntestines
- **L**iver
- **L**ungs

SKILL

2.12. Mnemonics method - how to remember the functions of blood?

- **O**xxygen (transport)
- **C**arbon Dioxide (transport)
- **F**ood
- **H**eat
- **W**aste
- **H**ormones
- **D**isease
- **C**lotting

Old **C**harlie **F**oster **H**ates **W**omen **H**aving **D**ull **C**lothes

2.13. Mnemonics method - how to remember the organ systems?

- **C**irculatory
- **I**mune
- **N**ervous
- **R**eproduction

- **R**espiratory
- **U**rinary
- **M**uscle
- **D**igestive
- **I**ntegumentary
- **E**ndocrine

Sir, I'm Nervous about **Reproducing** with the **Rest. Uri Must Dig Into the End**

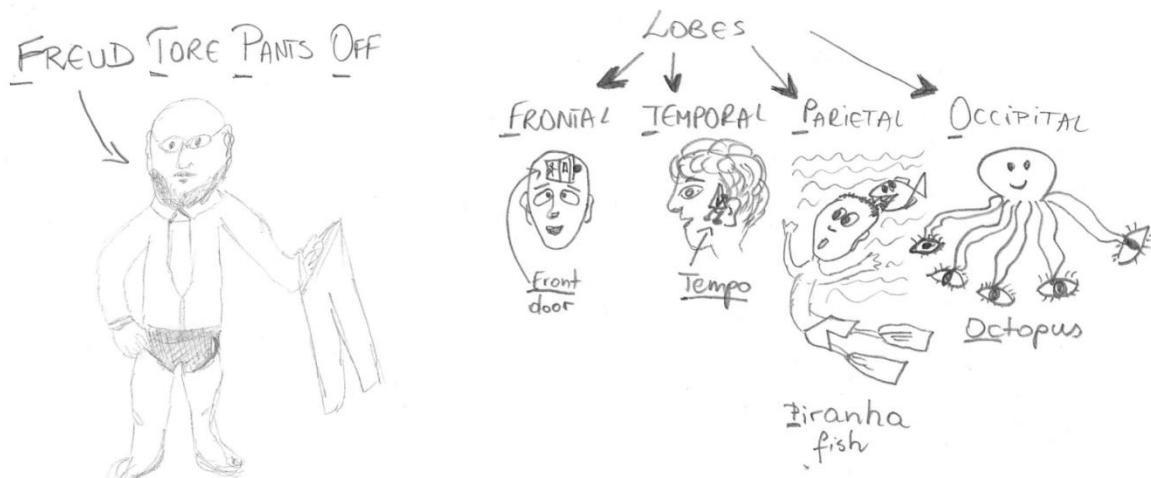
2.14. Mnemonics method - how to remember the 4 lobes of the brain?

The **Frontal Lobe** is where complex thinking occurs. Mnemonic how to remember this lobe is to draw “front door” and put it on forehead with Einstein (complex thinker) behind the door.

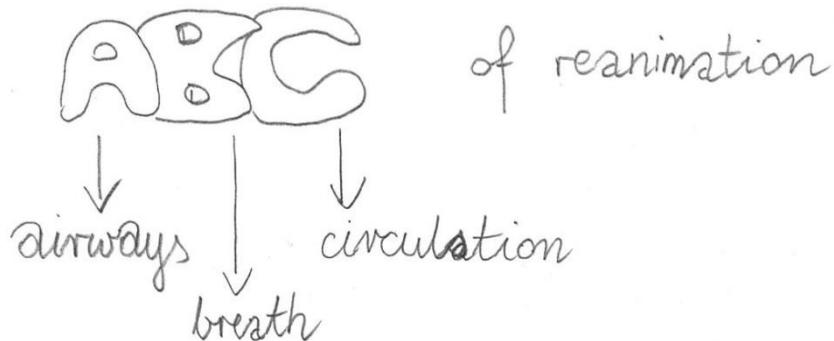
The **Temporal Lobe** is where auditory processing occurs. Mnemonic how to remember this lobe is to draw a metronome above the ear (where the temporal lobe is located).

The **Parietal Lobe** is where sensory information processing occurs. Mnemonic how to remember this lobe is to draw “piranha” fish which bites the top of the head (where the parietal lobe is located).

The **Occipital Lobe** is where visual information processing occurs. Mnemonic how to remember this lobe is to draw octopus and the eyeballs instead of suckers on the tentacles.

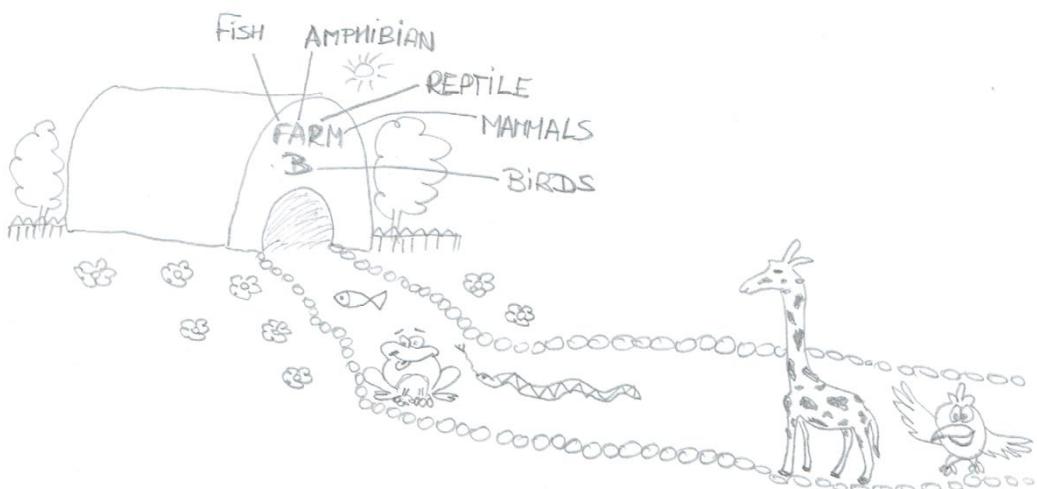


2.15. Mnemonics method - how to remember the ABC of reanimation?



2.16. Mnemonics method - how to remember the five classes of vertebrate animals?

In this case the acronym “FARMA-B” is very useful. This example of course is based on abstract word encoding the method. The acronym “FARMA-B” represents the five classes of vertebrate animals: fish, amphibian, reptile, mammal, and bird. However, the “B” letter for bird does not really fit, but it can be “smartly” added to end of acronym.



2.17. Mnemonics method - how to remember the seven aspects of life?

- **G**rowth
- **R**eproduction
- **I**rritability
- **M**ovement
- **E**xcretion
- **N**utrition
- **D**eath

GRIM END

2.18. Mnemonics method - how to remember the characteristics of life?

- **C**ells
- **O**smoregulation
- **R**eproduction
- **D**eath
- **N**utrition
- **G**rowth
- **E**xcretion
- **R**espiration
- **M**ovement
- **S**ensitivity

CORD 'N' GERMS

2.19. Mnemonics method - how to remember the fat soluble vitamins?

- Vitamin **K**
- Vitamin **A**
- Vitamin **D**
- Vitamin **E**

KADE

2.20. Mnemonics method - how to remember the vitamin 'B' names?

Vitamin 'B' names in increasing order:

- **T**hiamine (B1)
- **R**iboflavin (B2)
- **N**iacin (B3)
- **P**yridoxine (B6)
- **C**obalamin (B12)

The **R**hythm **N**early **P**roved **C**ontagious

2.21. Mnemonics method - how to remember the signs and symptoms of hypervitaminosis A?

- **H**eadache / **H**epatomegaly
- **A**norexia / **A**lopecia
- **R**eally painful bones
- **D**ry skin / **D**riness

Increased vitamin A makes you **HARD**

2.22. Mnemonics method - how to remember the types of Immunoglobulins?

- IgG
- IgM
- IgA
- IgD
- IgE

German MADE

2.23. Mnemonics method - how to remember the stages in development?

- Morula
- Blastula
- Gastrula

Must Be God/Good

2.24. Mnemonics method - how to remember the four phases/stages of Mitosis?

- Prophase
- Metaphase
- Anaphase
- Telophase

PMAT

I Passed My Algebra Test

ProMote Another Tadpole

In Paris, Men Are Transvestites

I Propose Men Are Toad

2.25. Mnemonics method - how to remember the phases of Prophase I in Meiosis?

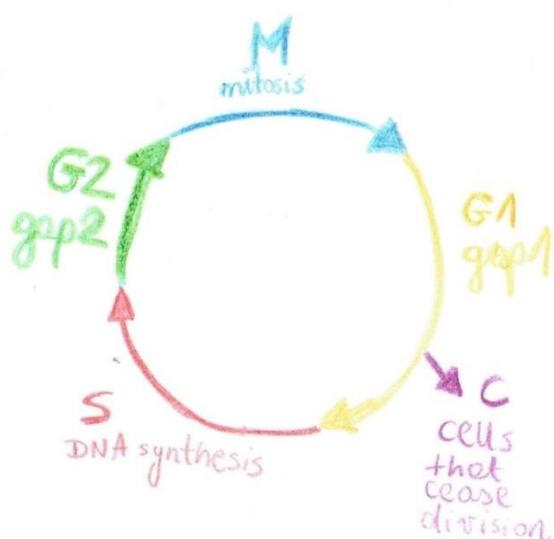
- **L**eptotene
- **Z**ygotene
- **P**achytene
- **D**iplotene
- **D**iakinesis

Lazy **Z**ebras **P**onder **D**ire **D**isasters

2.26. Mnemonics method - how to remember the stages of the cell cycle?

G1, **S**, **G**2, **M**, and **C**
Go **S**ally **G**o! **M**ake **C**hildren!

M, **G**1, **S**, and **G**2
Mahatma **G**andhi **S**onia **G**andhi

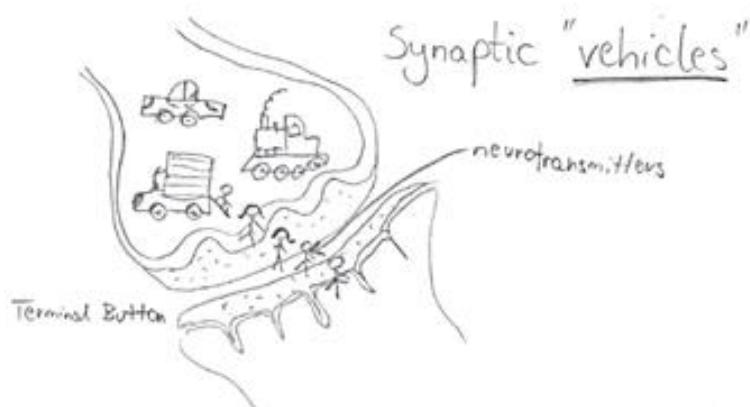


2.27. Mnemonics method - how to remember the number of insect legs?

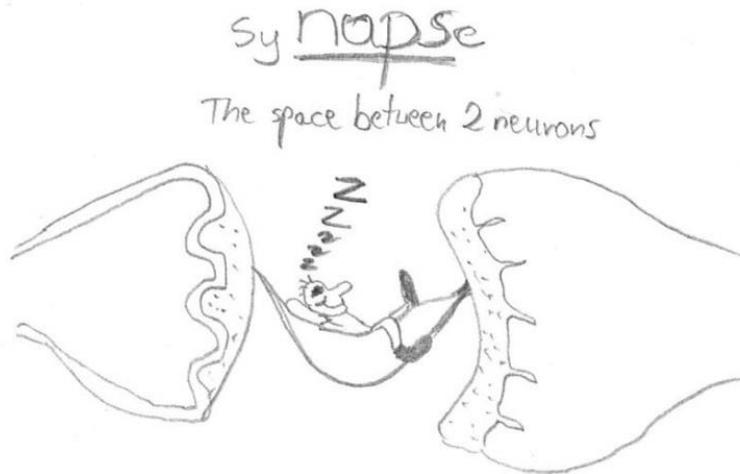


2.28. Mnemonics method - how to remember the terms - synaptic vesicles and synapse?

The **synaptic vesicles** are found at the end of the axon (which is sometimes called the terminal button). The synaptic vesicles contain the neurotransmitters. In this example we can go with the obvious (i.e. "testicles"), but also with "vehicles" and the people in the vehicles can be the neurotransmitters.



The **synapse** is found at the end of the axon; there is the space between two neurons or between one neuron and a muscle. The visual connection between the "naps" - part of the word "synapse" and picture with someone who taking a nap between two neurons has been drawn.



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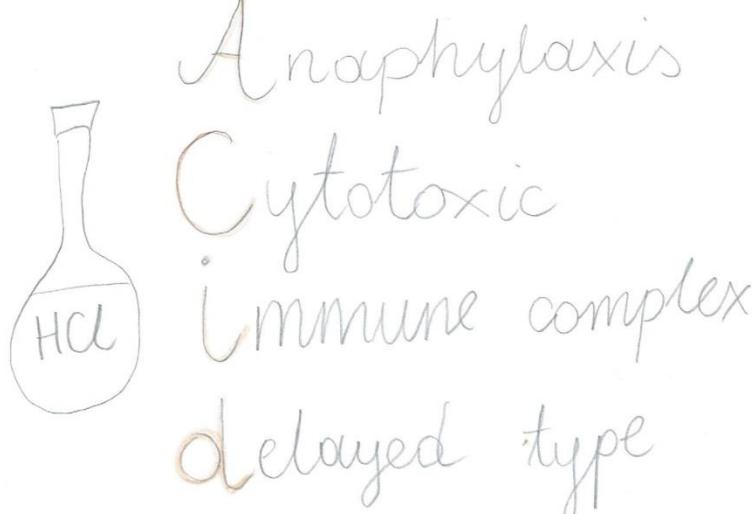
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3

Mnemonics devices in biochemistry

3.1. Mnemonics method - how to remember the biochemical properties of hydrochloric acid?



3.2. Mnemonics method - how to remember the glycolysis steps?

- **G**lucose
- **G**lucose-6-P
- **F**ructose-6-P
- **F**ructose-1,6-diP

- **Dihydroxyacetone-P**
- **Glyceraldehyde-P**
- **1,3-Biphosphoglycerate**
- **3-Phosphoglycerate**
- **2-Phosphoglycerate (to)**
- **Phosphoenolpyruvate [PEP]**
- **Pyruvate**

Goodness **G**racious, **F**ather **F**ranklin **D**id **G**o **B**y **P**icking **P**umpkins (to) **P**repare **P**ies

'**Di**', '**Bi**' and '**Py**' tell you the first part of those three: **di**-, **bi**-, and **py**-.

'**PrEPare**' tells location of PEP in the process

3.3. Mnemonics method - how to remember the ten essential amino acids?

- **Threonine**
- **Tryptophan**
- **Arginine**
- **Phenylalanine**
- **Lysine**
- **Valine**
- **Histidine**
- **Leucine**
- **Isoleucine**
- **Methionine**

The **T**en **A**cid **P**ods **L**iked **V**ery **H**ot **L**acies **I**n **M**ini-skirts

PVT. **TIM HALL** always argues, never tires

Always argues: the A is for Arg, not Asp

Never tires: T is not Tyr, but is both Thr and Trp

3.4. Mnemonics method - how to remember the base pairing?

Adenine pairs with **T**hyamine

Guanine pairs with **C**ytosine

At **T**he **G**irl's **C**lub = **AT** + **GC**

3.5. Mnemonics method - how to remember the Kreb's Cycle?

- **A**cetyl CoA
- **C**itrate
- **I**socitrate
- **S**uccinyl CoA
- **S**uccinate
- **F**umarate
- **M**alate
- **O**xaloacetate

A **C**razy **I**nsurgent **S**hot **S**omeone **F**or **M**aking **O**atmeal

Citrate **I**s A **S**our **S**ubstance **F**or **M**ost **O**rganisms

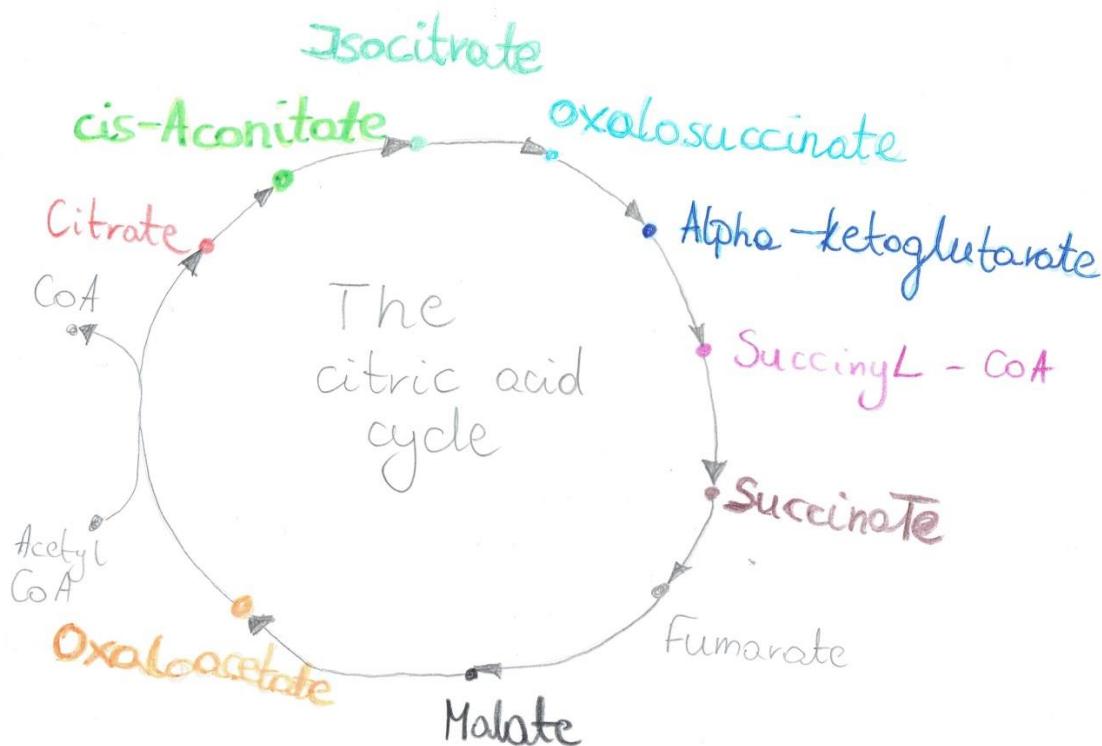
3.6. Mnemonics method - how to remember the citric acid cycle compounds?

- **O**xaloacetate
- **C**itrate
- **A**conitate
- **I**socitrate
- **O**xalosuccinate
- **A**lpha-ketoglutarate

- Succinyl-CoA
- Succinate
- Fumarate
- Malate

Oh Citric Acid Is Of (course) A Silly STupid Funny Molecule

Silly and STupid used to differentiate Succinyl and Succinate



3.7. Mnemonics method - how to remember the neurotransmitters action?

The low level of **serotonin** in the brain is connected with depression. Figure A presents how to remember the action of low level of serotonin. In the picture is “Sir Rotten” in a rotten mood (depressed).

Acetylcholine is involved in helping contract our muscles. Figure B helps to memorize how acetylcholine works in muscle - ACE flexing his muscles as mnemonic.

Dopamine has different action depending on the level. High level is connected with schizophrenia – figure C. It presents an useful idea based on a skiing tall dwarf (“ski-zophrenia”). Low level is associated with Parkinson’s disease. Mnemonic how to remember this fact is to draw the small dwarf “dopey” when he is parking (low – small, parking – Parkinson) - figure D.



3.8. Mnemonics method - how to remember the amino acids forming acetylCoA and acetacetylCoA?

- **A** = AcetylCoA or Acetoacetyl CoA
- **Ly** = Lysine
- **Tr** = Tryptophan
- **Le** = Leucine
- **Is** = Isoleucine

A Lighter Lease
 (A LyTr LeIs)

3.9. Mnemonics method - how to remember the classification of enzymes?

- Oxidoreductases
- Transferases
- Hydrolases
- Isomerases
- Ligases
- Lyases

Over The HILL

Enzymes get reaction over the hill - see diagram.



3.10. Mnemonics method - how to remember the Na⁺/K⁺ pump: movement of ions and quantity?

K⁺ and in each consist of 2 characters, so so 2 K⁺ are pumped in.
Na⁺ and out each consist of 3 characters, so 3 Na⁺ are pumped out.

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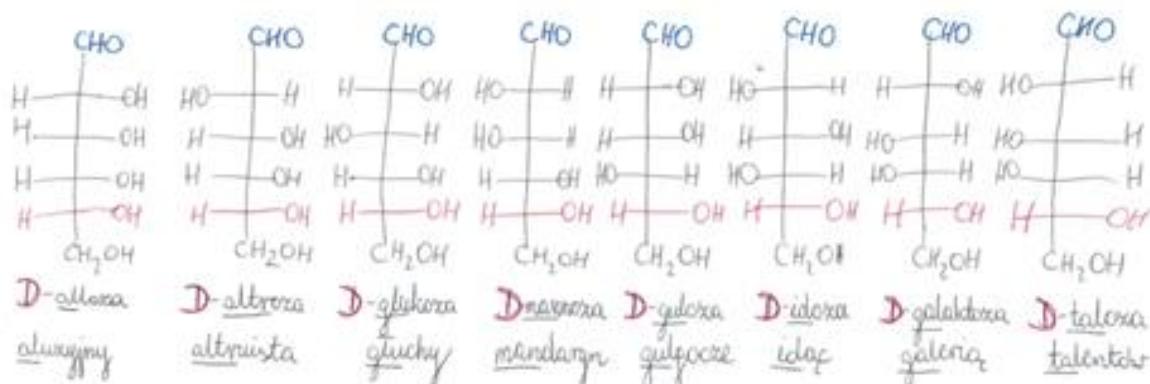
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4

Mnemonics devices in chemistry

4.1. Mnemonics method - how to remember the eight D-aldohexoses?

This mnemonic is used also in Poland. The first few letters of each sugar are used to pose poem: Aluzyjny altruista, głuchy mandaryn gulgocze idąc galerią talentów.

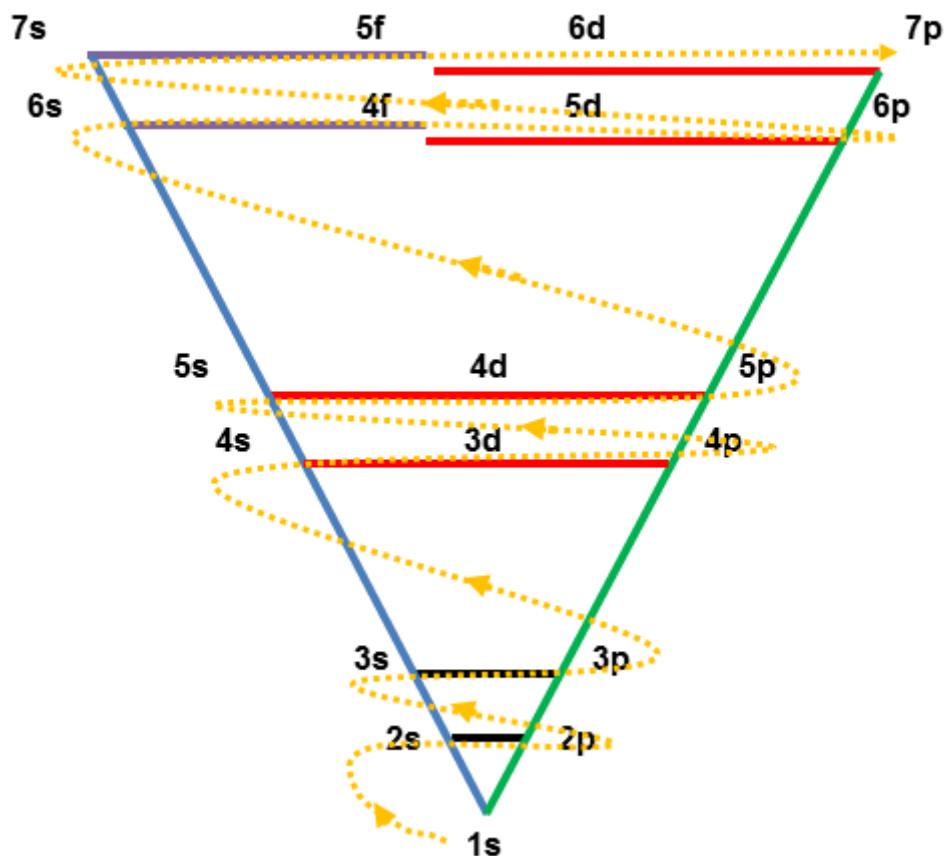
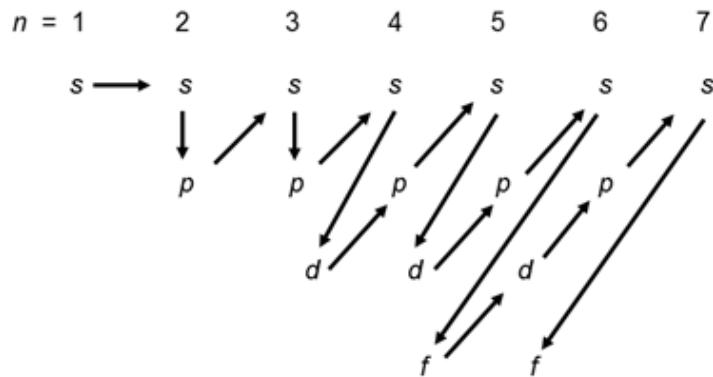


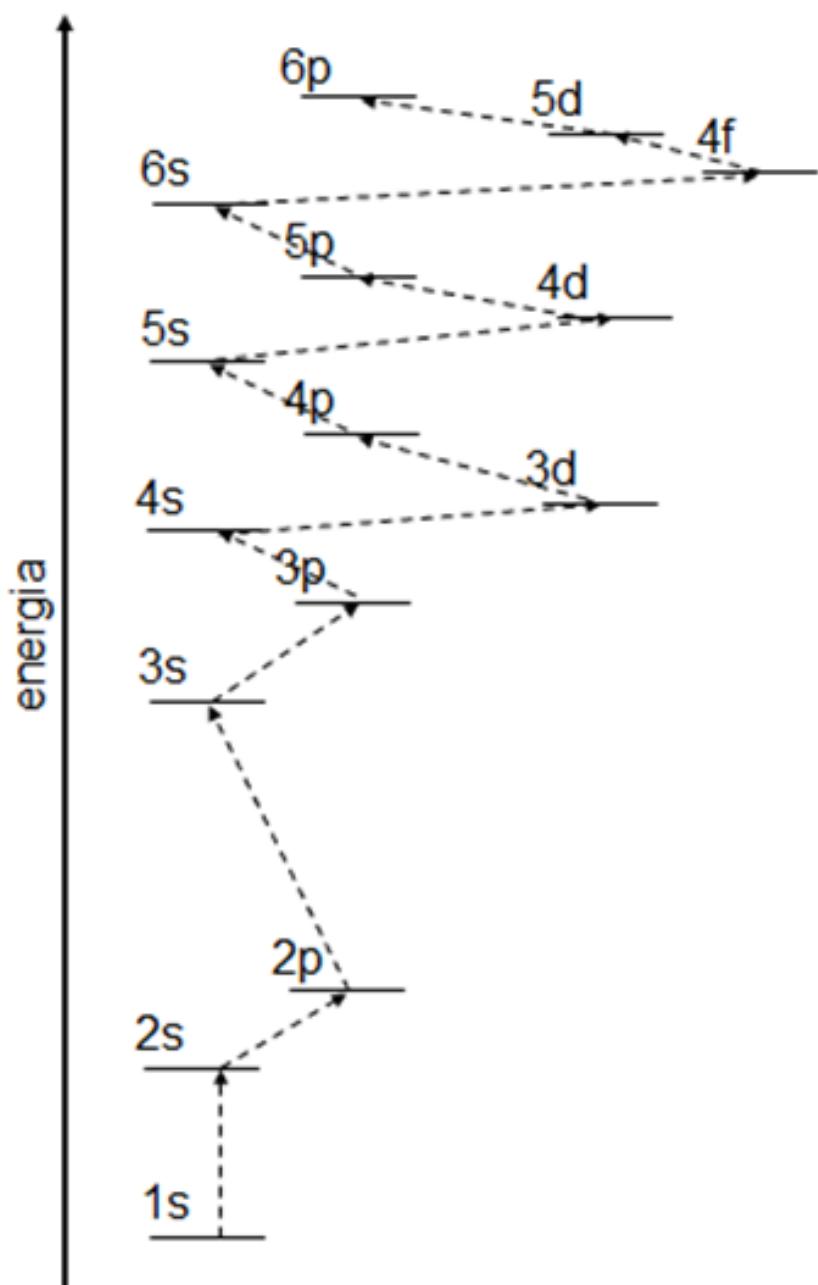
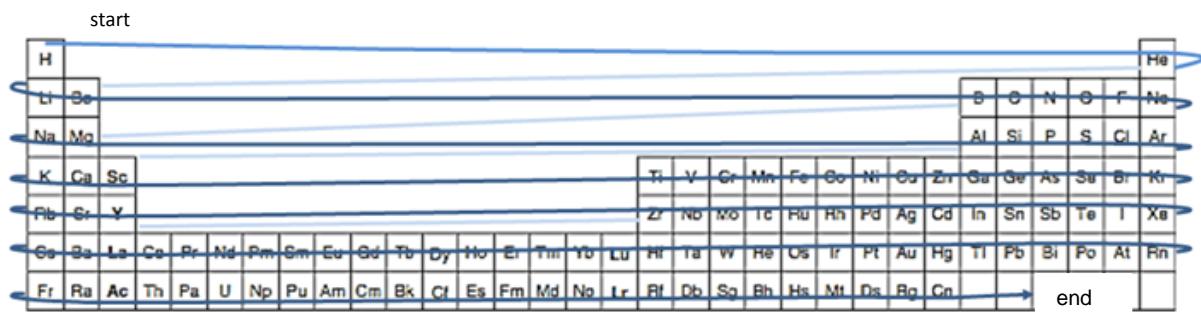
The English version:

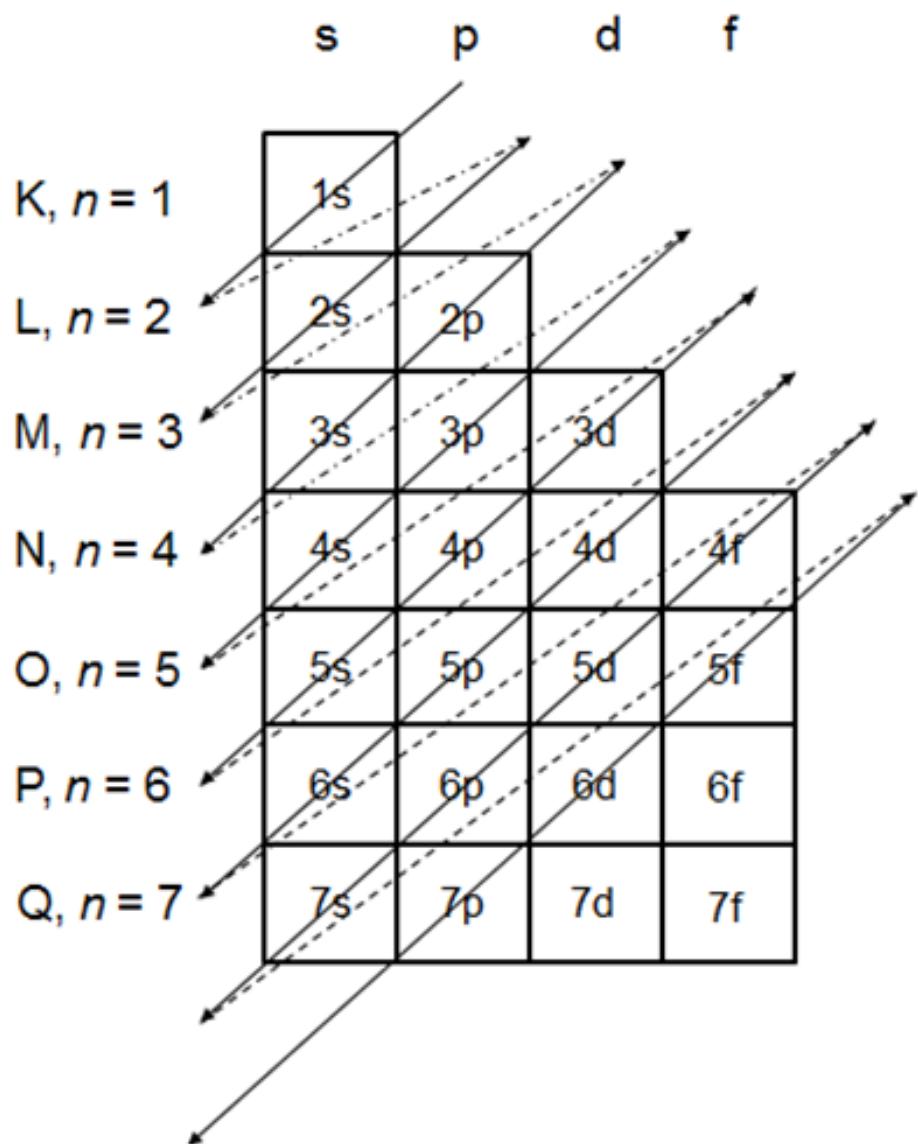
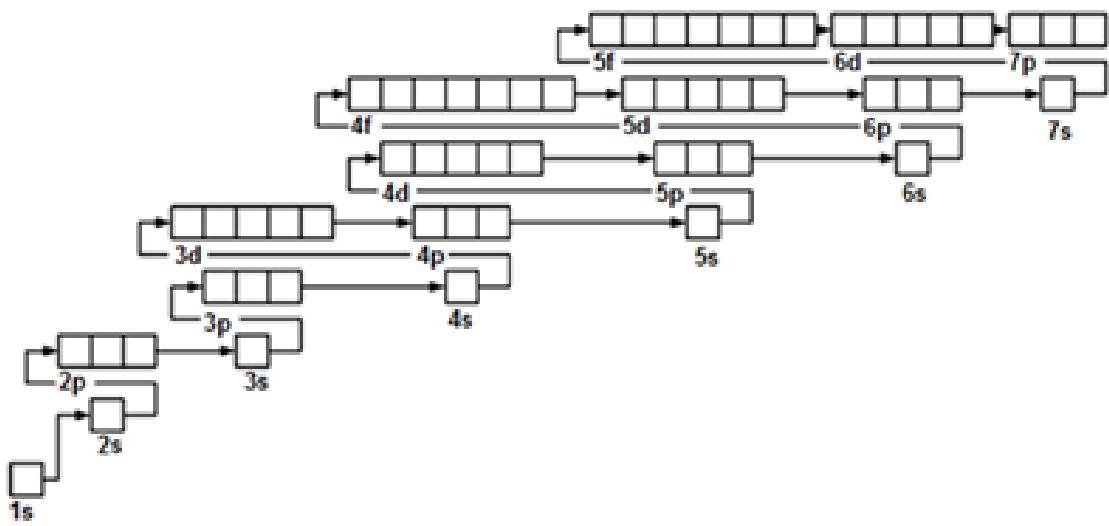
- **Allose**
- **Alrose**
- **Glucose**
- **Mannose**
- **Gulose**
- **Idose**
- **Galactose**
- **Talose**

All Altruists Gladly Make Gum In Gallon Tanks

4.2. Mnemonics method - how to remember the order of filling of subcoatings?





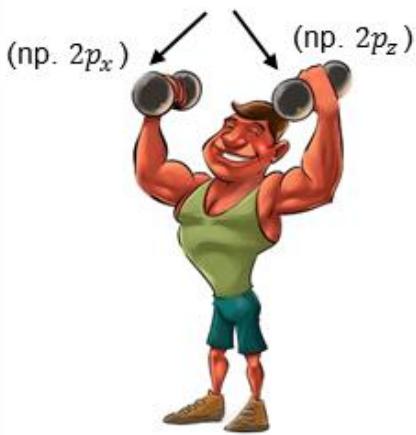


4.3. Mnemonics method - how to remember the information about orbitals?

A) example of shape of the 1s orbital



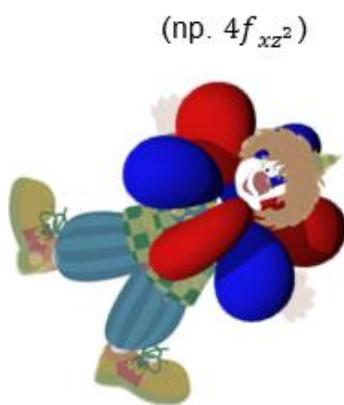
B) example of shape of the 2p orbital



C) example of shape of the 3d orbital



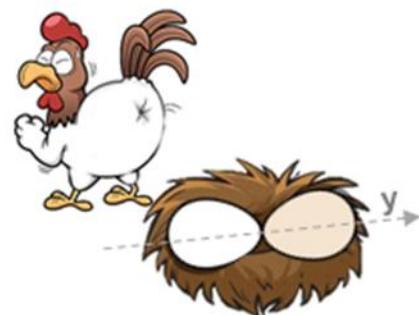
D) example of shape of the 4f orbital



The shapes of orbitals can be imagining as shape of items applied in circus. For example, the shape of s-orbital can be imagining as the inflatable ball kicked by the elephant (A). On the other hand, the shape of p-orbitals can be imagining as dumbbells picked up by the weight-lifter (B). Another example can be d-orbital shape as circus skittles used by the juggler (C). The f-orbital shapes are usually very sophisticated, hence it can be imagine as the ruff at the neck of the clown (D).

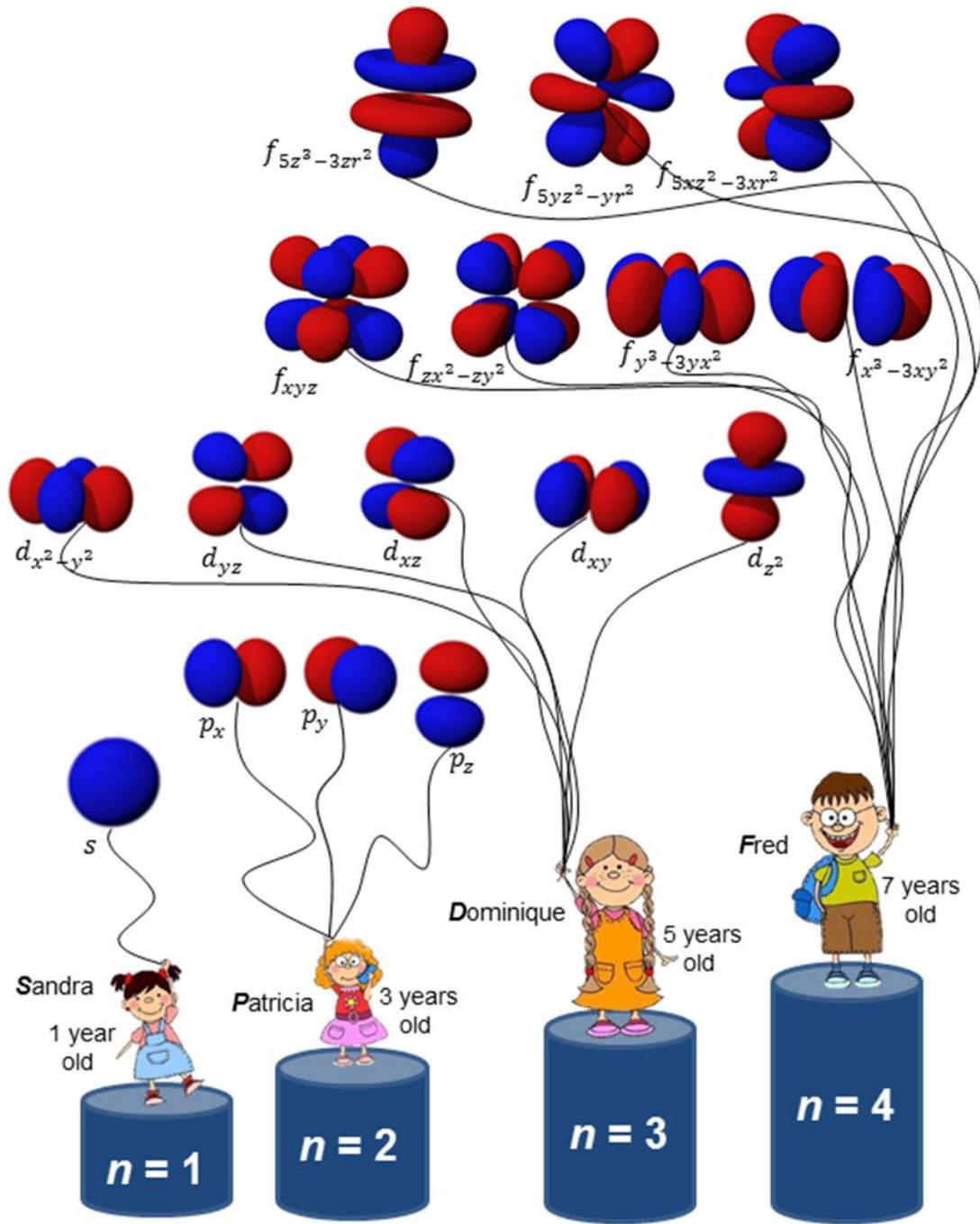


super chicken

p_ygmy chickendi_zzy chicken

fantastic chicken

The shapes of orbitals can be imagining as four situations according to the chicken taking down of the egg or eggs. The **s**-orbital shape is similar to egg from **super chicken**, because the egg has a spherical shape (like the sphere). On the other hand, the **p_y**-orbital can be imagining as a shape of two eggs from **p_ygmy chicken** (very small chicken – pygmy, gives two eggs lying along the axis **y**). The **d_z** orbital shape can be similar to eggs from **di_zzy chicken**. The **f**-orbital shape can be imagining as eggs from **fantastic chicken**.



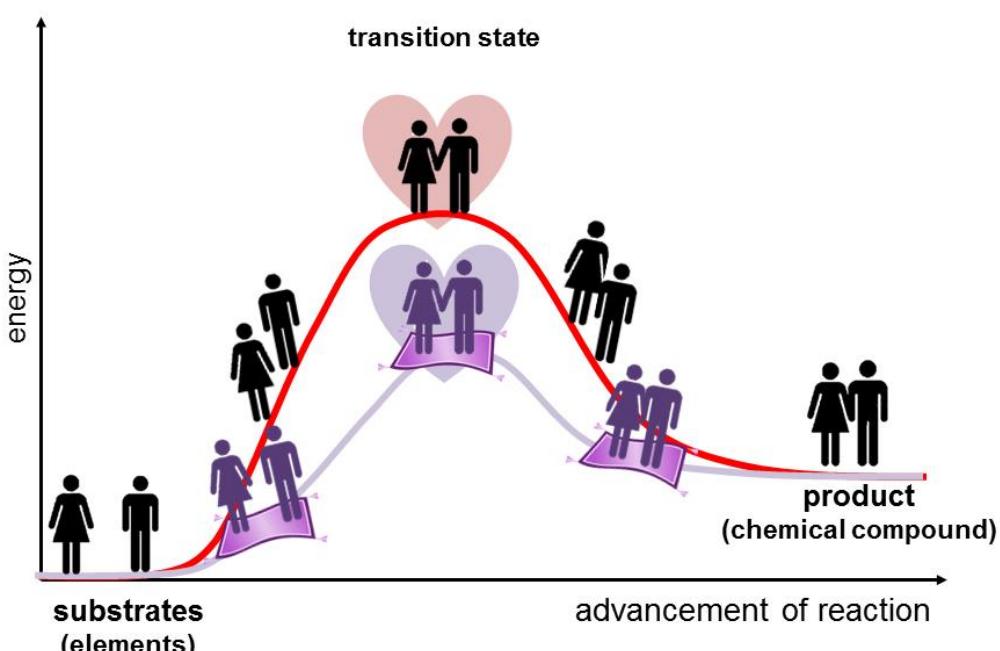
Simple pictures showing orbital shapes are intended to describe the angular forms of regions in space where the electrons occupying the orbital are likely to be found. To memorize the contour shape of orbitals it is possible to imagine orbitals as birthday-balloons held by children. The number of balloons (possible orbital shapes) is connected with age of children. The number of podium stage is connected with principal quantum number (n). The first letter of children name is a symbol of orbital. Hence, e.g. the shape of s-orbital can be imagining as one spherical balloon held by Sandra. Because Sandra is 1 year old, and she is on 1st place, there exist one orbital (1 years old), and one kind of shape ($n = 1$).

4.4. Mnemonics method - how to remember the order of atomic orbitals?

The order of atomic orbitals - **s,p,d,f,g,h,i,k...**

Sober **P**hysicists **D**on't **F**ind **G**iraffes **H**iding **I**n **K**

4.5. Mnemonics method - how to remember the role of catalyst?



This mnemonic method could be very useful for remembering the role of a catalyst. A catalyst is a substance that changes (mostly speeds up) a chemical reaction, but is not consumed by the reaction. When we applied men and women as substrates (elements), sometime later (the advancement of reaction) they become the lovebirds. The lovebirds can be an analogy to a transition state in chemistry. Sometime later (the advancement of reaction), after lovebirds (transition state), they become a couple.

(product – chemical compound). If they want to be lovebirds more quickly, they need more romantic atmosphere... Hence, they can apply flying carpet (like Aladine and Jasmine). In this context, the flying carpet play a role of catalyst – it speeds up an interaction between men and women (speeds chemical reaction), but is not consumed by the men and women (not consumed by the reaction).

4.6. Mnemonics method - how to remember the series of alkanes?

- Methane
- Ethane
- Propane
- Butane
- Pentane
- Hexane

My **E**normous **P**enguin **BP**retty **H**igh

- Methane
- Ethane
- Propane
- Butane
- Pentane
- Hexane
- Heptane
- Octane
- Nonane
- Decane

Memorize **E**ternal **P**ropositions, **B**ut **P**ension **H**ectic **H**appy **O**ccult **N**onsensical **D**eclarations

4.7. Mnemonics method - how to remember the products of fractional distillation of crude oil?

These products are:

- **R**efinery gases
- **G**asoline
- **N**aphtha
- **K**erosene
- **D**iesel oil
- **F**uel oil
- Lubricating fraction
- **B**itumen

Really **G**reat (and **N**oble) **K**ings **D**on't **F**orget (**L**adies') **B**irthdays

4.8. Mnemonics method - how to remember the information about oxidation and reduction – losing and gaining electrons?

Losing **E**lectrons is **O**xidation, **G**aining **E**lectrons is **R**eduction
"LEO said GER"

or

Oxidation **I**s **L**oss, **R**eduction **I**s **G**ain
OIL RIG

4.9. Mnemonics method - how to remember the Gibb's free energy?

In thermodynamics, the Gibbs free energy is a thermodynamic potential.

It measures the process-initiating work obtainable from a thermodynamic system at a constant pressure and temperature.

$$\Delta G = \Delta H - T\Delta S$$

$$\Delta \text{G} = \Delta \text{H} - \text{T}\Delta \text{S}$$

Good **H**oney **T**astes **S**weet

4.10. Mnemonics method - how to remember the Henderson-Hasselbach equation?

The Henderson–Hasselbalch equation describes the derivation of pH as a measure of acidity.

$$\text{pH} = \text{pKa} + \log_{10} \left(\frac{[\text{A}^-]}{[\text{HA}]} \right)$$

$$\text{pH} = \text{pKa} + \log 10 ([\text{A}^-]/[\text{HA}])$$

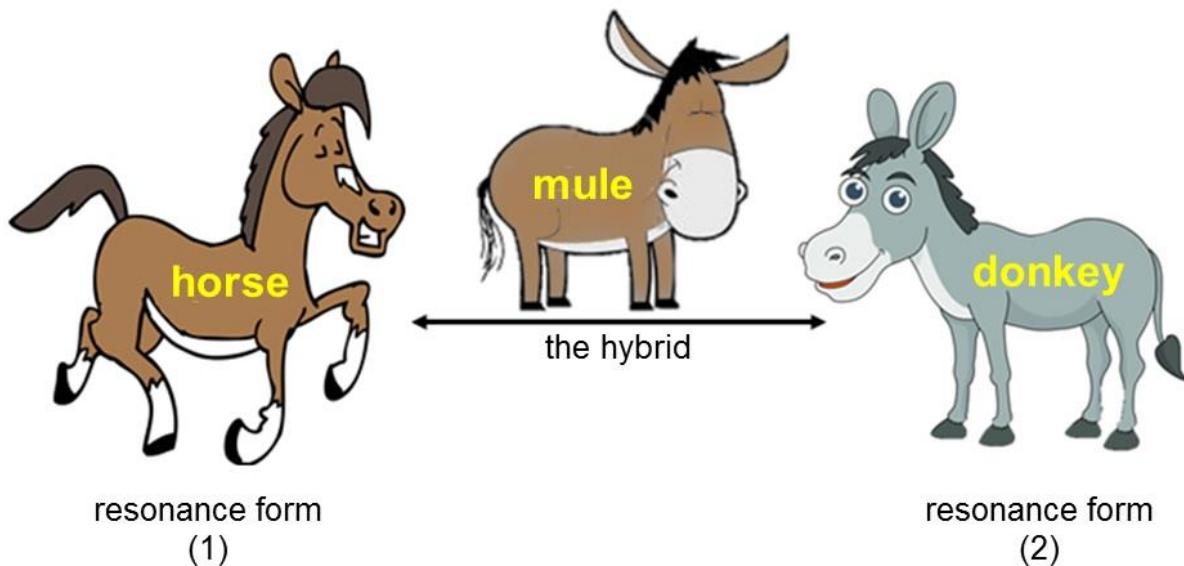
Hong **K**ong + **A**merican **H**ospital **A**sociation

HK + **AHA**

4.11. Mnemonics method - how to remember the resonance forms?

The concept of resonance forms in chemistry can be imagining as a situation in biology according to mule. A mule is the offspring (hybrid) of a male donkey and

a female horse. Horse and donkey are different species like resonance form; however the mule is a hybrid such as Lewis structure. In this mnemonic method exists one exception – the horse and donkey are real (they exist); however the resonance forms are imagine structures.



4.12. Mnemonics method - how to remember the periodic table of the elements?

Song to remember all 118 elements of the periodic table.

How **H**e **L**ives **B**eggars **B**elief, **C**onstantly **N**icking **O**ld **F**oreign **N**ecklaces. **N**athan **M**agee **A**lways **S**its **P**atiently, **S**eeing **C**learly **A**round, **K**nowing **C**areless **S**ecurity **T**itillates **V**ery **C**riminal **M**inds. **F**elons **C**onspire **N**ightly. **C**ute **Z**en **G**ardens **G**et **A**ssaulted **S**eriously. **B**rothers **K**aramazov **R**ob **S**orry **Y**ouths. **Z**orro **N**abs **M**ostly **T**acky **R**ubbish. **R**hoda **P**ederson **A**ugments **C**addying **I**ncome **S**natching **S**iberian **T**erriers. **I** **X**erox **C**ashiers' **B**adges. **L**ately **C**elia **P**roclaimed **N**oddy's **P**oems **S**mashed **E**uropean **G**odfearing **T**aboo**s**: **D**ying, **H**omo**E**roticism – **T**imid **Y**obbos! **L**utetia **H**offman **T**ampers **W**ith **R**ed **O**scilloscope. **I**rresponsible **P**oet-Author **H**ugo **T**ells **P**ublic **B**ig **P**orkies **A**t **R**andom **F**rench **R**ave. **A**ctually **T**he **P**arty **U**pset **N**ippers, **P**uking **A**mply – **C**amilla **B**bakes **C**offeecake, **E**sther's **F**amily **M**ade **N**othing. **L**ord **R**affles **D**aubs **S**uggestion: **B**ehold **H**is **M**ethod – **D**ashing **R**oguish **C**unning. **W**itless **F**latulent **W**hippet **L**oves **W**istful **W**oman.

H																		He
Li	Be																	Ne
Na	Mg																	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br		Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I		Xe
Cs	Ba	La*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At		Rn
Fr	Ra	Ac**	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Uut	Fl	Uup	Lv	Uus		Uuo

*)	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu			
**)	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr			

Mnemonics method how to remember all 18 groups (columns) of the periodic table

1 - He Likes Naked Kisses and Rubs Cuz he's French

He Licked Nala's Krotch, Rubbed Cassy's Front

Hi LiNa: Kare to Rub and Copulates like the French do?

2 - Beryl Might Call Strong Barry

Betcha Maggie Can Stretch Balls Rapidly (ouch!)

Being Magnificent Can Sure Bad Radical

3 - ScantY Ladies Acting

4 - Tight Zipper and Harmful

Titz're a Handful

5 - Vixens Nubile and Tantalizing Doubt

6 - Cro Magnon Women Sag

7 - Men Touching Repulsive and are Brash

8 - Feel Ruth Oscillate

9 - Cold Rhoda Irritates the Most

10 - Nipples Paid for Plates

11 - Cum Again, Auuuuu!

12 - Zena's a Cold Hag

Zinc-plated **C**adillacs and **M**ercury's

13 - Bouncing All Gals In Television

Big **A**l **G**azes **I**nto **T**e telephone

Boning **A**l **G**alns **T**helma

14 - Carl's Silent, Gena Snores in Pub

Can **S**illy **G**ena **T**in **P**lums?

Car **S**ick **G**ermans in **T**iny **P**ub

15 - Nighties and Panties Are Still Big

Nice **P**hurry **A**ss, **S**tubby **B**eard

16 - Odie Smith Selling Telephone Poles**17 - Feeling Clara's Brassiere, I Attack****18 - He Never Argues or Kries eXcept when it Rains**

4.13. Mnemonics method - how to remember the order of addition of acid and water?

Acid to Water; All is Well.

Water to Acid; What an Accident!

It is OK to add acid to water, but you may get an explosion from the excess heat created by reversing the order of mixing the two.

or

Do like an otter, add acid to water

4.14. Mnemonics method - how to remember which elements form diatomic molecules?

- Bromine (Br_2)
- Iodine (I_2)
- Nitrogen (N_2)
- Chlorine (Cl_2)
- Hydrogen (H_2)
- Oxygen (O_2)
- Fluorine (F_2)

BrINCIHOF

Diatomc elements in order size:

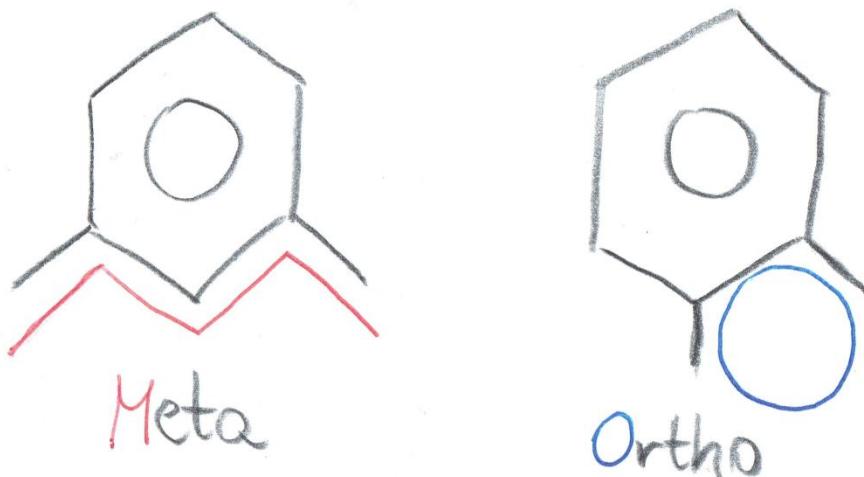
- Hydrogen (H_2)
- Nitrogen (N_2)
- Oxygen (O_2)
- Fluorine (F_2)
- Chlorine (Cl_2)
- Bromine (Br_2)
- Iodine (I_2)

Horses Need Oats For Clear Brown (i) Eyes

4.15. Mnemonics method - how to remember the order of substituents in benzene ring?

Meta: the two sticks representing functional groups make a capital letter **M** with the ring.

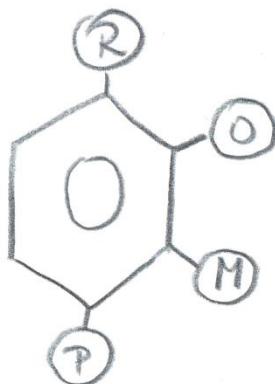
Otho: can close the top of the functional groups and make a boxy capital letter **O**.



Benzene likes to **ROMP**

From R group moving around the ring:

- **R** group
- **Ortho**
- **Meta**
- **Para**



4.16. Mnemonics method - how to remember the order of substituents in benzene ring?

Benzene likes to **ROMP**. We **HOPED** she's be safe, but now she's knocked up.
ADOPt or **WEDD'M**?:

- **ROMP**: Substituents in order: **R**-group, **Ortho**, **Meta**, **Para**.
- **HOPED**: Halogens are **Ortho**, **Para**, **Electron withdrawing**, **Deactivating**.
- **ADOPt**: **A**dditive substituents **D**irect **O**rtho and **P**ara.
- **WEDD'M**: **W**ithdrawing **E**lectrons **Deactivates, **D**irects **M**eta.**

4.17. Mnemonics method - how to remember the charge of anion and cation?

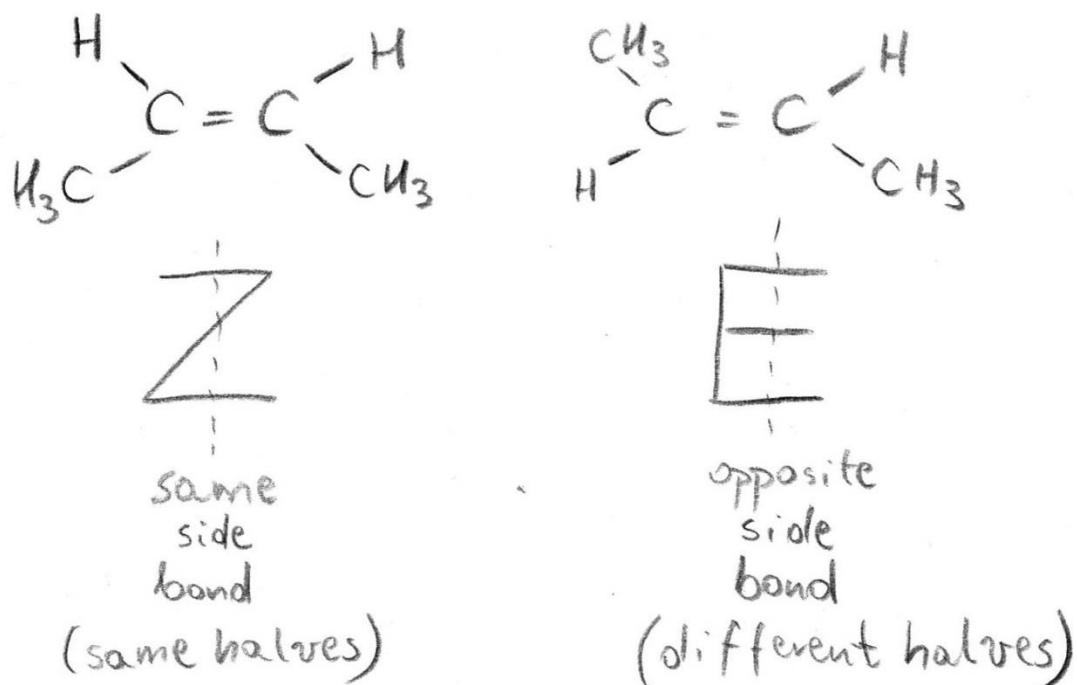
ANion is **A** Negative ion.

The **t** in cation looks like a plus sign: "ca**+**ion" - cation is positive.

4.18. Mnemonics method - how to remember the cis/trans (Z/E) geometric isomer nomenclature?

Zame **Z**ide. **E**pposite

Z is the **2** functional groups on the same side of double bond. **E** is for opposite sides.



4.19. Mnemonics method - how to remember the ideal gas law?

$$\text{pV} = \text{nRT}$$

Pure Virgins Never Really Tire
 Pine Valley is Not Real Time

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5

Mnemonics devices in physics

5.1. Mnemonics method - how to remember the FBI rule and prediction of direction of flux density?

- The Thum**rb** represents the direction of **M**otion resulting from the force on the conductor (**F**)
- The **F**irst finger represents the magnetic **F**lux density (**B**)
- The **S**econd finger represents the direction of the **C**urrent (**I**)

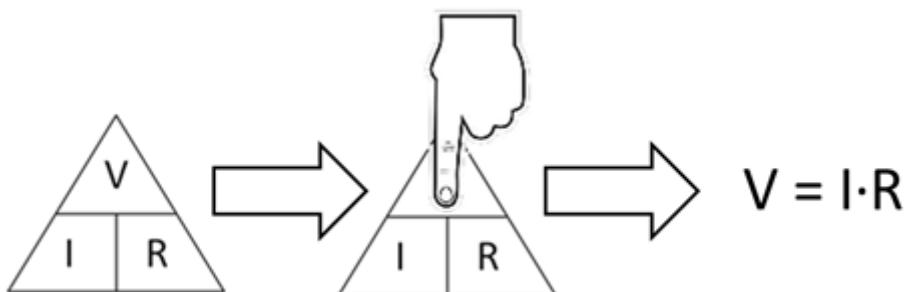


This mnemonics shows that the current (**I**) flows in the direction of the thumb



5.2. Mnemonics method - how to remember the transformation of formulas?

A very popular and simple way in Polish schools to algebraically rearrange some formulas is to use a “magic triangle” and fingertip. It can be used to quickly check for errors. For example a formula such as Ohm’s law: $V = I \cdot R$ can be arranging it in the parts of a triangle as shown below:



5.3. Mnemonics method - how to remember the seven steps in the scientific method?

The seven steps in the scientific method:

- Problem
- Research
- Hypothesis
- Experiment/data
- Analyze
- Conclusion
- Communicate

People **R**eally **H**ate **E**ating **D**onuts **A**nd **C**old **C**ider

5.4. Mnemonics method - how to remember the levels of the atmosphere?

The levels of the atmosphere:

- **T**roposphere
- **S**tratosphere
- **M**esosphere
- **T**hermosphere
- **E**xosphere

The **S**traight **M**an's **T**e sticles **E**xploded

The **S**trong **M**an's **T**hermometer **E**xploded

The **S**tupid **M**onkeys **T**attled on **E**lephants

Tonight **S**nakes **M**ake **T**ea for **E**verybody

Typical, **S**uper **M**ario's **T**ime **E**xpired!

5.5. Mnemonics method - how to remember the color bands on resistors?

Numerically 0-9 to get the value of a resistor via the color coded bands.

- **Black** [0]
- **Brown** [1]
- **Red** [2]
- **Orange** [3]
- **Yellow** [4]
- **Green** [5]
- **Blue** [6]
- **Violet (Purple)** [7]
- **Gray** [8]
- **White** [9]

Bad Booze Rots Our Young Guts, But Vodka Goes Well

Bad Boys Rape Our Young Girls But Violet Gives Willingly

Better Be Ready Or Your Great Big Venture Goes West

Better Be Ready Or Your Great Big Plan Goes Wrong

Bill Brown Realized Only Yesterday Good Boys Value Good Work

5.6. Mnemonics method - how to remember the waves from longest to shortest?

- Radio
- Microwave
- Infrared
- **Visible (red, orange, yellow, green, blue, indigo, violet)**
- Ultraviolet
- X-ray
- Gamma ray

Raging Martians invaded Roy G. Biv using x-ray guns.

Roy G. Biv – red, orange, yellow, green, blue, indigo, violet

5.7. Mnemonics method - how to remember the electric units?

- Volts = Joules/Sec
- Amps = Coulombs/Sec
- Ohms = Volts/Amp
- Watts = Joules/Sec = Amps · Volts

Vaulting John Says: “Ann Can Sing OVA”. What Just Sing? And Vault

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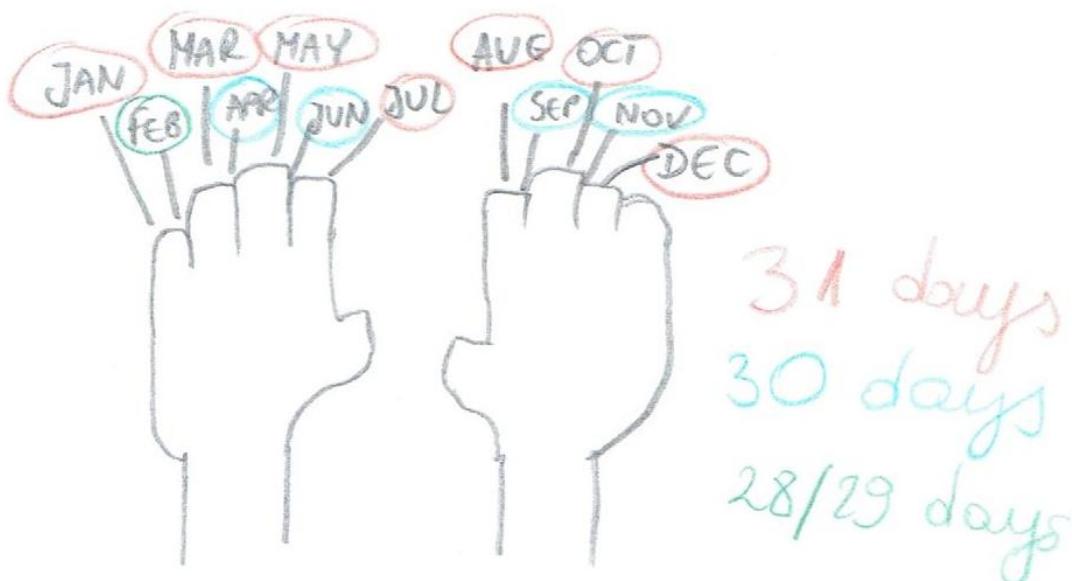
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6

Mnemonics devices in astronomy

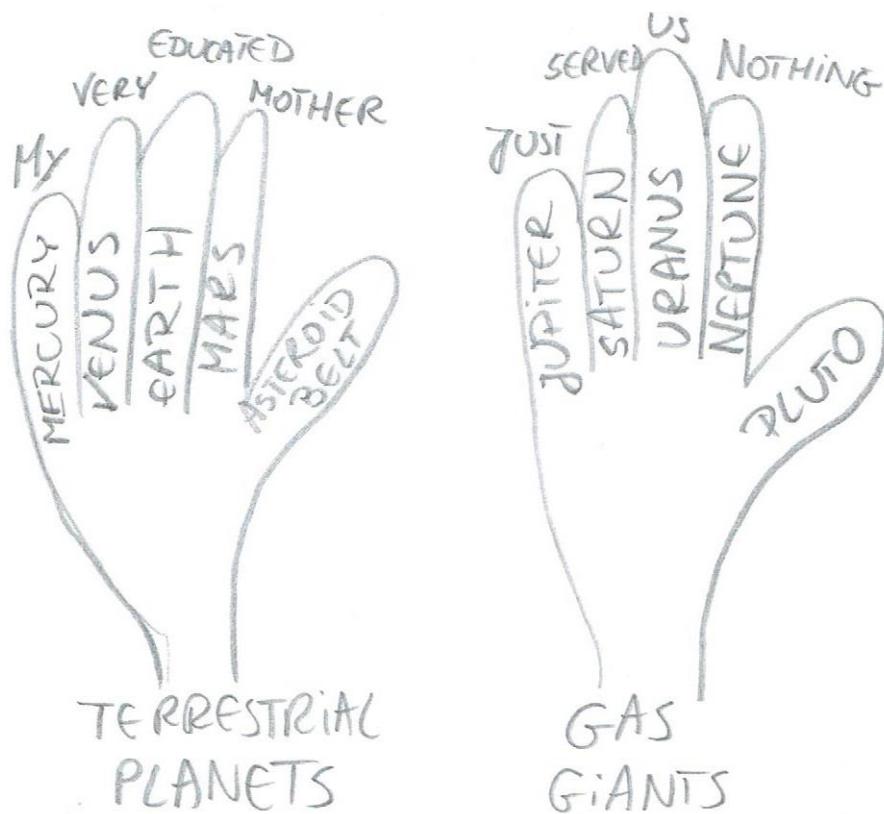
6.1. Mnemonics method - how to remember the number of days in each month?

For this purpose use the cubes on the palms. Record start from the left side of your left hand to the right side of your right hand. Between the cubes there are months that have 30 days (with the exception of February which has 28 or 29 days). On the cubes there are months that have 31 days.



6.2. Mnemonics method - how to remember the order of planets?

A visual mnemonic using the left hand to represent the terrestrial planets with the dwarf planet Ceres (/asteroid belt) and the right hand, palm turned upward, to represent the gas giants with the dwarf planet Pluto.



Below there are mnemonics which can help to remember the order of the planets: **M**ercury, **V**enus, **E**arth, **M**ars, **J**upiter, **S**aturn, **U**ranus, **N**eptune, **P**luto.

Men **V**ery **E**asily **M**ake **JS**erve **U**seful **N**eeds, **P**erhaps

My **V**ery **E**ducated **M**other **J**ust **S**erved **U**s **N**ine **P**

My **V**ery **E**nergetic **M**other **J**umps **S**kateboards **U**nder **N**ana's **P**atio

Mary's **V**iolet **E**yes **M**ake **J**ohnny **S**tay **U**p **N**ights **P**lenty

Mary's **V**iolet **E**yes **M**ake **J**ohnny **S**tay **U**p **N**ights, **P**ondering

My **V**ery **E**asy **M**ethod **J**ust **S**hows **U**s **N**ine **P**lanets

My **V**ery **E**fficient **M**emory **J**ust **S**tores **U**p **N**ine **P**lanets

My Very Easy Method Just Speeds Up Naming Planets

However, many of these mnemonics were made obsolete by the 2006 definition of planet, which reclassified Pluto (as well as Ceres and Eris) as a dwarf planet.

6.3. Mnemonics method - how to remember the lunar moon phases?

The most common mnemonic method used to memorize the phases of the moon is “**D****O****C**”. With this you can understand which part of the moon is lit up at different stages in the lunar cycle.

- The capital “**D**” has an arch to the right. The right-hand side is illuminated: First Quarter Moon.
- The capital “**O**” represents the full moon.
- The capital “**C**” has an arch to the left. The left-hand side is illuminated: Last Quarter Moon.

6.4. Mnemonics method - how to remember the largest moons of Jupiter?

Four largest moons of Jupiter in order by their distance from Jupiter:

- **I**o
- **E**uropa
- **G**anymede
- **C**allisto

I Eat Grandma's Cookies

6.5. Mnemonics method - how to remember the moons of Jupiter?

- **N**aiad
- **T**halassa
- **D**espina
- **G**alatea
- **L**arissa
- **P**roteus
- **T**riton
- **N**ereid

Neptune's **T**iny **D**ancing **G**irls **L**ook **P**retty **T**o-Night

6.6. Mnemonics method - how to remember the moons of Saturn?

- **M**imas
- **E**nceladus
- **T**ethys
- **D**ione
- **R**hea
- **T**itan
- **H**yperion
- **I**apetus
- **P**hoebe

MET **D**R **T**HIP

6.7. Mnemonics method - how to remember the size of the Planets?

	Equatorial diameter (km)
• Jupiter	142,800
• Saturn	120,000
• Uranus	51,200
• Neptune	48,600
• Earth	12,756
• Venus	12,104
• Mars	6,787
• Mercury	4,878
• Pluto	2,300

Smallest to largest:

Pete's **M**other **M**ade **V**al's **E**lephant **N**estle **U**nder **S**am's Jumper.

Pluto **M**ust **M**eet **V**enus **E**very **N**ight **U**ntil **S**aturn Jumps.

Plump **M**rs. **M**artian **V**oted **E**very **N**inth **U**nicorn **S**hould Jump.

Pop **M**usic **M**akes **V**ikings **E**ven **N**aughtier **U**ntil **S**axons **J**iggle.

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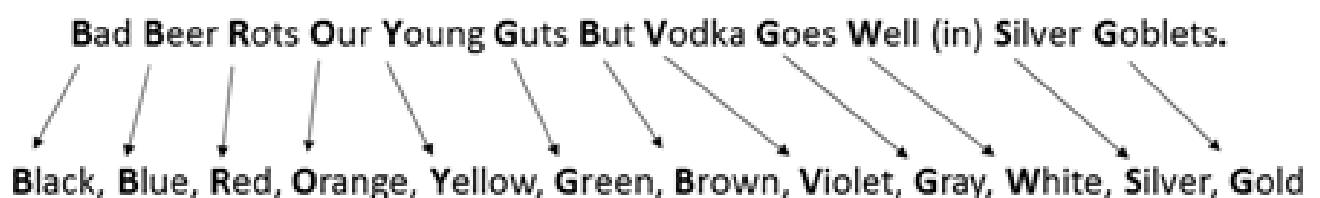
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7

Mnemonics devices in geography

7.1. Mnemonics method - how to remember the colors of the rainbow?



or

- **R**ed
- **O**range
- **Y**ellow
- **G**reen
- **B**lue
- **I**ndigo
- **V**iolet

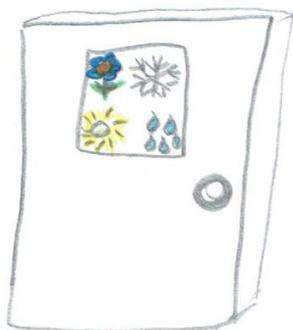
Reports **O**f **Y**oung **G**irls **B**anging **I**nside **V**atican

Richard **O**f **Y**ork **G**ave **B**attle **I**n **V**ain

Richard **O**f **Y**ork **G**ot **B**ugged **I**n **V**enice

Roy **G.** **Biv**

7.2. Mnemonics method - how to remember the number of all seasons?



all seasons are in the door
there are four

7.3. Mnemonics method - how to remember the countries in Central America?

How to remember the countries in Central America from North to South:

- **B**elize
- **G**uatemala
- **E**l Salvador
- **H**onduras
- **N**

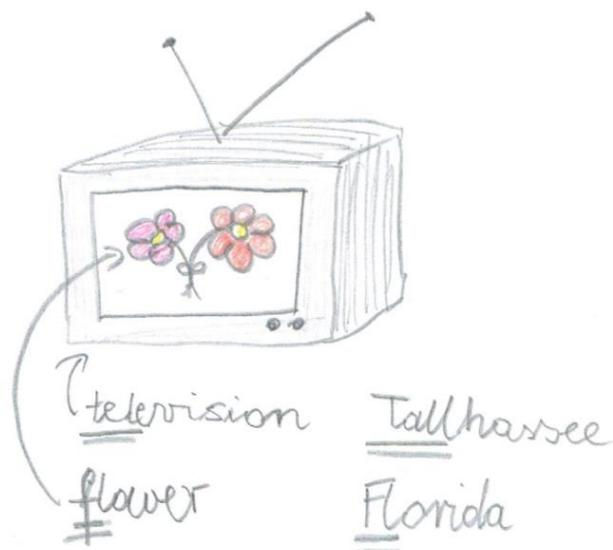
- Costa Rica
- Panama

Big **G**orillas **E**at **H**otdogs **N**ot **C**old **P**izza

Big **G**orrillas **E**at **H**otdogs **N**ot **C**orn **P**ops

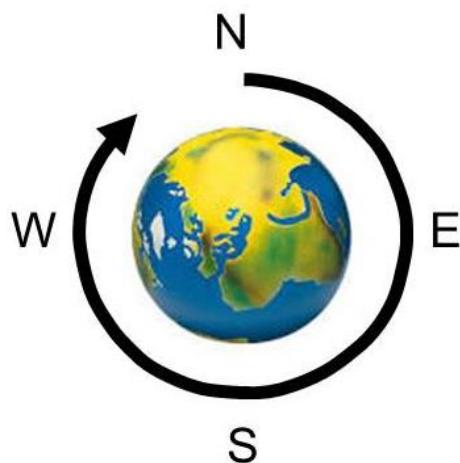
Beat **G**randma **E**very **H**our, **N**ow **C**atch **P**apar

7.4. Mnemonics method - how to remember the capital of Florida?



7.5. Mnemonics method - how to remember the information about North, East, South and West?

North **E**ast **S**outh **W**est: the cardinal wind directions in clockwise order



Naughty **E**lephants **S**pray **W**ater

Never **E**at **S**limy **W**orms

Never **E**at **S**alty **W**orms

Never **E**at **S**hredded **W**heat

Never **E**ver **S**moke **W**eek

Never **E**at **S**oggy **W**eatabix

Never **E**at **S**oggy **W**afers

7.6. Mnemonics method - how to remember the names of continents?

North America married **South America** and they went to **Europe** for their honeymoon. Soon after, they had quadruplets, who all had names: **Africa**, **Australia**, **Asia** (who was the biggest, even though he had the shortest name) and **Antartica**, the coldest child.

Another mnemonic method:

- **Europe**
- **Asia**
- **Africa**

- **Australia**
- **Antarctica**
- **North America**
- **South America**

Eat An Apple As A Nighttime Snack

or

- **Asia**
- **Europe**
- **Australia**
- **Africa**
- **South America**
- **Antarctica**
- **North America**

Always Eat An Apple, Says A Nurse!

7.7. Mnemonics method - how to remember the countries in North Africa?

How to remember five countries in North Africa, from West to East:

- **Morocco**
- **Algeria**
- **Tunisia**
- **Libya**
- **Egypt**

Many African Tourists Like Elephants

7.8. Mnemonics method - how to remember the original thirteen colonies?

- Connecticut
- Delaware
- Georgia
- Maryland
- Massachusetts
- New Hampshire
- New York
- New Jersey
- North Carolina
- Pennsylvania
- Rhode Island
- South Carolina
- Virginia

Cory Doesn't Give My Mom's New Noisy Nutty Neighbor, Pam, Rides in Sister's Van

7.9. Mnemonics method - how to remember the states of Argentina — in alphabetical order?

- Buenos Aires
- Catamarca
- Chaco
- Chubut
- Cordova
- Corrientes
- Entre Rios
- Formosa - Jujuy
- La Pampa
- La Rioja
- Mendoza
- Missiones - Neuquin

- **Rio Negro**
- **Salta**
- **San Juan**
- **San Luis**
- **Santa Cruz**
- **Santa Fe**
- **Santiago del Estero**
- **Tierra de Fuego**
- **Tucman**

Because **CC**arlos **C**an **C**onstantly **C**alculate **E**xact **FL**ike **L**ittle **M**ister **M**ath, nobody **R**eally **S**aw **S**imple **S**imon **S**ay **S**sixty, **S**six **T**imes **T**en.

7.10. Mnemonics method - how to remember the list of Oceans in order from greatest to smallest

- **Pacific**
- **Atlantic**
- **Indian**
- **Southern**
- **Arctic**

People **A**ttack **I**rritating **S**imple **A**rt

7.11. Mnemonics method - how to remember the Seven Hills of Rome?

- **C**apitoline
- **Q**uirinal
- **V**iminal
- **E**skiline

- Caelian
- Aventine
- Palatine

Can Queen Victoria Eat Cold Apple Pie?

7.12. Mnemonics method - how to remember the Northern European countries, from West to East?

- Norway
- Sweden
- Finland
- Russia

No Soup For Russia

7.13. Mnemonics method - how to remember the geological ages?

- Cambrian
- Ordovician
- Silurian
- Devonian
- Carboniferous
- Permian
- Triassic
- Jurasic
- Cretaceous
- Pliocene
- Eocene
- Oligocene
- Myocene
- Pileocene

- Pleistocene
- Recent

Camels **O**ften **S**it **D**own **C**arefully. **P**erhaps **T**heir **J**oints **C**reak. **P**ossibly **E**arly **O**iling
Might **P**revent **P**remature **R**heumatism

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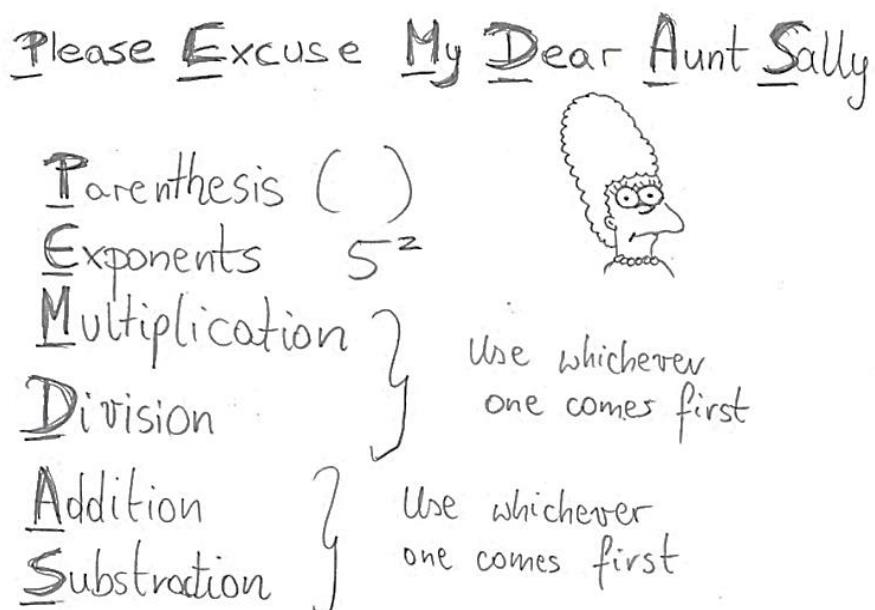
Mnemonics devices in mathematics

8.1. Mnemonics method - how to remember the order of operations?

Please Excuse My Dear Aunt Sally

The order of mathematical operations:

- Parentheses
- Exponents
- Multiplication/Division (left to right)
- Addition/Subtraction (left to right)



8.2. Mnemonics method - how to remember the area and circumference of a circle?

Find the Area and Circumference of a Circle.
 Tweedle-dee-dum and Tweedle-dee-dee,
 Around the circle is pi times d,
 But if the area is declared,
 Think of the formula pi "r" squared.

"Around the circle" is the circumference.
 Circumference = $\pi \cdot d$ (diameter).
 Area = $\pi \cdot r$ (radius) squared.

8.3. Mnemonics method - how to remember the area of a circle?

Apple **p**ie are **s**quare: $A = \pi \cdot r^2$
Apple **p**ie are **r**ound: $A = \pi \cdot r \cdot r$

8.4. Mnemonics method - how to remember the circumference of a circle?

Cherry **p**ie **d**elicious!
C = **p**i **d**iameter

8.5. Mnemonics method - how to remember the measures of angles in right triangles?

Find the Measures of Angles in Right Triangles

SOH: Sine = Opposite leg divided by the Hypotenuse.

CAH: Cosine = Adjacent leg divided by the Hypotenuse.

TOA: Tangent = Opposite leg divided by the Adjacent leg.

Silly **O**ld **H**arry **C**arried **A** **H**orse **T**o **O**ur **A**partment.

8.6. Mnemonics method - how to remember the roman numerals 1 to 1000 in order?

- **I** = 1
- **V** = 5
- **X** = 10
- **L** = 50
- **C** = 100
- **D** = 500
- **M** = 1000

I **V**iewed **X**erxes **L**oping **C**arelessly **D**own **M**ountains.

8.7. Mnemonics method - how to remember the first eight digits of pi?

The mnemonic method is to count the number of letters in each word of the phrase:

	May	I	have	a	large	container	of	coffee?
Number of letters	3	1	2	1	5	9	2	6

The first eight digits of pi: 3,1415926

8.8. Mnemonics method - how to remember the number of feet in a mile?

5,280 feet in a mile

5 tomatoes

5	to	(m)ate	oe(s)
5	2	8	0

8.9. Mnemonics method - how to remember the metric units of measure in order?

- **Kilo** (1000)
- **Hecto** (100)
- **Deca** (10)
- **Units** (1)
- **Deci** (0,1)
- **Centi** (0,01)
- **Milli** (0,001)

King **H**e**c**t**o** Doesn't **U**sually **D**rink **C**old **M**ilk

or for:

- **Kilo** (1000)
- **Hecto** (100)
- **Deca** (10)
- **Metric** (1)
- **Deci** (1/10)
- **Centi** (1/100)
- **Milli** (1/1000)

King **H**errod **D**ied **M**onday **D**rinking **C**hocolate **M**ilk

8.10. Mnemonics method - how to remember the multiplying negative numbers?

Minus times minus is plus,
The reason for this we need not discuss.

8.11. Mnemonics method - how to remember when multiplying by 9?

The digits of the answers always add up to nine.
For example:

$$2 \cdot 9 = 18 \quad (1 + 8 = 9)$$

$$3 \cdot 9 = 27 \quad (2 + 7 = 9)$$

$$4 \cdot 9 = 36 \quad (3 + 6 = 9)$$

and so on.

8.12. Mnemonics method - how to remember the information about mean, median, and mode?

Mode is **most** frequent

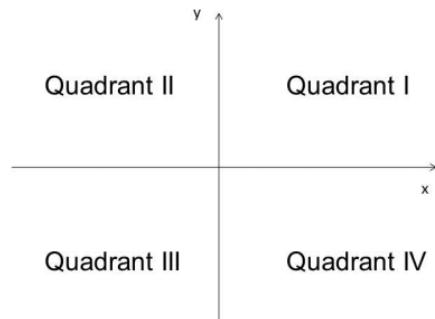
Median is in the middle -- like a median in the road

Mean is just average

8.13. Mnemonics method - how to remember which trigonometric functions are positive?

The sentence - All seniors take calculus - demonstrates which trigonometric functions are positive in each of the four quadrants of the Cartesian coordinate plane:

- Quadrant I: All functions are positive.
- Quadrant II: Only sine is positive.
- Quadrant III: Only tangent is positive.
- Quadrant IV: Only cosine is positive.



8.14. Mnemonics method - how to remember the information about gallon, quart and pint?

1 gallon = 4 quarts

1 quart = 2 pints

1 pint = 2 cups

King Gallon had 4 Queens (quarts). Each queen had 2 Princesses (pints). Each princess had 2 Cats (cups).

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9

The list of mnemonics devices

Mnemonics method - how to remember:

- the bowel components?
- the diaphragm apertures: spinal levels?
- the aorta and vena cava – which is on the right and which is on the left?
- the causes of aortic regurgitation?
- the aortic dissection?
- the aortic stenosis characteristics?
- the aortic arch?
- the spinal cord nerve origins?
- the inner ear bones?
- the heart valves?
- the excretory organs of the body?
- the functions of blood?
- the organ systems?
- the 4 lobes of the brain?
- the ABC of reanimation?
- the five classes of vertebrate animals?
- the seven aspects of life?
- the characteristics of life?
- the fat soluble vitamins?
- the vitamin 'B' names?
- the signs and symptoms of hypervitaminosis A?

- the types of Immunoglobulins?
- the stages in development?
- the four phases/stages of Mitosis?
- the phases of Prophase I in Meiosis?
- the stages of the cell cycle?
- the number of insect legs?
- the terms - synaptic vesicles and synapse?

- the biochemical properties of hydrochloric acid?
- the glycolysis steps?
- the ten essential amino acids?
- the base pairing?
- the Kreb's Cycle?
- the citric acid cycle compounds?
- the neurotransmitters action?
- the amino acids forming acetylCoA and acetacetylCoA
- the classification of enzymes?
- the Na^+/K^+ pump: movement of ions and quantity?

- the eight D-aldohexoses?
- the order of filling of subcoatings?
- the information about orbitals?
- the order of atomic orbitals?
- the role of catalyst?
- the series of alkanes?
- the products of fractional distillation of crude oil?
- the information about oxidation and reduction – losing and gaining electrons?
- the Gibb's free energy?
- the Henderson-Hasselbach equation?
- the resonance forms?
- the periodic table of the elements?
- the order of addition of acid and water?
- which elements form diatomic molecules?

- the order of substituents in benzene ring?
 - the order of substituents in benzene ring?
 - the charge of anion and cation?
 - the cis/trans (Z/E) geometric isomer nomenclature?
 - the ideal gas law?
-
- the FBI rule and prediction of direction of flux density?
 - the transformation of formulas?
 - the seven steps in the scientific method?
 - the levels of the atmosphere?
 - the color bands on resistors?
 - the waves from longest to shortest?
 - the electric units?
-
- the number of days in each month?
 - the order of planets?
 - the lunar moon phases?
 - the largest moons of Jupiter?
 - the moons of Jupiter?
 - the moons of Saturn?
 - the size of the Planets?
-
- the colors of the rainbow?
 - the number of all seasons?
 - the countries in Central America?
 - the capital of Florida?
 - the information about North, East, South and West?
 - the names of continents?
 - the countries in North Africa?
 - the original thirteen colonies?
 - the states of Argentina — in alphabetical order?
 - the list of Oceans in order from greatest to smallest
 - the Seven Hills of Rome?

- the Northern European countries, from West to East?
 - the geological ages?
-
- the order of operations?
 - the area and circumference of a circle?
 - the area of a circle?
 - the circumference of a circle?
 - the measures of angles in right triangles?
 - the roman numerals 1 to 1000 in order?
 - the first eight digits of pi?
 - the number of feet in a mile?
 - the metric units of measure in order?
 - the multiplying negative numbers?
 - when multiplying by 9?
 - the information about mean, median, and mode?
 - which trigonometric functions are positive?
 - the information about gallon, quart and pint?

10

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From the reviewer

The book by Kamil Jurowski, Anna Jurowska and Małgorzata Krzeczkowska is a very important compendium of knowledge on the application of mnemonic techniques in science. Its both academic and educational values should be noted. When it comes to academic values, the book provides a comprehensive overview of the various mnemonic techniques, with a competent commentary. The authors have mastered not only the sources from a domain of pedagogics and psychology, but also conducted a thorough historical investigation. In this aspect, the authors present both organizational mnemonics methods (e.g. single use rhymes or method of loci) and encoding mnemonic methods (e.g. visual imagery or abstract word methods). Didactic use of mnemonic techniques is an obvious fact, but in this book the topic has been treated in a holistic manner - the authors in an interesting and accessible way discuss mnemonic techniques that can be useful in disciplines such as biology, biochemistry, chemistry, physics, astronomy, geography and mathematics. The book is not only a review of the literature, but thanks to its rich graphical material and the illustrations has enormous practical significance. I would like to emphasize that this work is unique not only on the Polish publishing market. The book deserves the attention of many groups: teachers, psychologists, students in these disciplines, students preparing for exams and all those who are interested in improving the efficiency of learning. Finally, I strongly recommend this book to all those interested in the nature of mind and memory.

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From the publisher

The **Scientiae et Didactics** the first time in Poland, delivers to Readers the monograph in which the Authors described mnemonics devices according to science subjects – biology, biochemistry, chemistry, physics, astronomy, geography and mathematics. The Readers can find out the information about - etymology, history, nomenclature, classification and application of mnemonics devices. This work contains a lot of different and original examples of mnemonics devices for pupils and students.

This monograph was written by researchers from the Faculty of Chemistry of the Jagellonian University in Kraków.

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